JYU DISSERTATIONS 540

Kirsi Aaltola

Modern Learning Environments in the Acquisition of Skills

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF INFORMATION TECHNOLOGY

JYU DISSERTATIONS 540

Kirsi Aaltola

Modern Learning Environments in the Acquisition of Skills

Esitetään Jyväskylän yliopiston informaatioteknologian tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Agora-rakennuksen auditoriossa 2
heinäkuun 1. päivänä 2022 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Information Technology of the University of Jyväskylä,
in building Agora, auditorium 2, on July 1, 2022 at 12 o'clock noon.

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2022

Editors
Marja-Leena Rantalainen
Faculty of Information Technology, University of Jyväskylä
Ville Korkiakangas
Open Science Centre, University of Jyväskylä

ISBN 978-951-39-9337-5 (PDF)
URN:ISBN:978-951-39-9337-5
ISSN 2489-9003

Permanent link to this publication: http://urn.fi/URN:ISBN:978-951-39-9337-5

ABSTRACT

Aaltola, Kirsi
Modern Learning Environments in the Acquisition of Skills
Jyväskylä: University of Jyväskylä, 2022, 117 p. (+included articles)
(JYU Dissertations
ISSN 2489-9003; 540)
ISBN 978-951-39-9337-5 (PDF)

This dissertation focuses on the acquisition of expert skills in modern learning environments (MLEs). The overall goal is to discover the effects of MLEs on expert learning and to find meaningful ways to integrate the use of MLEs into training and education. The technological revolution has created the overall need and opportunity to adapt the use of technologies and effective methods to facilitate learning experiences and enhance learning outcomes.

To understand the effects of MLEs on skills acquisition and the transfer of skills and knowledge to real life, four research papers (Articles I, II, III, and VIII) are presented in this dissertation. To understand knowledge transfer, potential gaps, and methods of improving technology integration in education and training, four additional research papers (Articles IV, V, VI, and VII) are presented in this dissertation. This dissertation proposes tentative frameworks for the design and implementation of sustainable, motivating, and engaging solutions. The Model for Integrating Immersive Learning Content into Adult Training follows the study's findings on skills acquisition and expertise development and uses them as an educational foundation; the Human-Centered Design Model offers a framework for the development of online learning tools; the Systematic Integration Approach emphasizes motivation in the integration of technology into higher education; and the Societal Impact Assessment Toolkit and Evaluation Framework facilitates network collaboration and information sharing.

The findings of this research can accelerate the understanding of knowledge and skills acquisition in MLEs designed for expertise development. The research provides domain-specific results for peacebuilding and cybersecurity training communities. Proper skills acquisition through training can have direct and indirect impacts on the success of operations and on resilience in risk situations. Facilitating cognitive skills acquisition, as well as presenting findings on expertise development and theories on the integration and design of MLEs in professional training, could open new frontiers in designing methods and implementing practices that will foster more effective and impactful learning and performance in different realities and in real life.

Keywords: skills acquisition, expertise development, performance, modern learning environment, augmented reality, virtual reality, immersive learning content, peacebuilding, cybersecurity, cyber-physical systems

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Aaltola, Kirsi
Nykyaikaiset oppimisympäristöt taitojen hankinnassa
Jyväskylä: University of Jyväskylä, 2022, 117 p. (+included articles)
(JYU Dissertations
ISSN 2489-9003; 540)
ISBN 978-951-39-9337-5 (PDF)

Tämä väitöskirja keskittyy taidon hankkimiseen ja asiantuntijuuteen moderneissa oppimisalustoissa. Tavoitteena on selvittää modernien oppimisympäristöjen vaikutuksia ihmisten oppimiseen ja taitojen hyödyntämiseen todellisessa työympäristössä. Teknologinen siirtymä on nostanut uudenlaisia tarpeita oppimiskokemusten järjestämisen kannalta sekä oppimistavoitteiden saavuttamisen osalta.

Tähän väitöskirjaan liitetyt artikkelit I, II, III ja VIII tarkastelevat modernien oppimisympäristöjen vaikutuksia oppimiseen ja tietotaidon siirtämiseen todelliseen työelämäkontekstiin. Artikkelit IV, V, VI ja VII tarkastelevat tiedon siirtämistä ja teknologiaintegroinnin mahdollisia haasteita ja menetelmiä. Tutkimustuloksiin perustuen tässä väitöskirjassa ehdotan (1) alustavia lähestymistapoja kestävien, motivoivien ja sitouttavien ratkaisuiden suunnitteluun ja käytännön toteutukseen, (2) immersiivisen oppimissisällön integrointimallia aikuiskoulutuksessa, (3) ihmiskeskeistä suunnittelumallia verkko-oppimistyökalujen kehittämiselle, (4) motivaatiopainotteista systemaattista lähestymistapaa teknologian integroimiseen korkeakoulutuksessa ja (5) yhteiskunnallisen vaikuttavuuden työkalu- ja arviointikehikkoa verkostoyhteistyölle ja tiedon siirtämiselle.

Tämän väitöskirjan tutkimustuloksia voi hyödyntää koulutuksissa ja asiantuntijuuden kehittämisessä, jossa oppiminen keskittyy tiedon ja taidon hankkimiseen moderneilla oppimisalustoilla. Tämän väitöskirjan osatutkimukset ovat toteutettu rauhanrakentamisen ja kyberturvallisuuden asiantuntijakonteksteissa. Hyvä taidon hankkiminen koulutuksessa voi vaikuttaa suorasti tai epäsuorasti operatiiviseen asiantuntijatoimintaan riski- ja turvallisuustilanteissa. Kognitiotieteisiin perustuva taidon hankkiminen ja asiantuntijuuden kehittyminen moderneilla oppimisalustoilla voi avata yhä uusia metodeja ja käytäntöjä tehokkaalle ja vaikuttavalle oppimiselle ja kouluttamiselle eri todellisuuksissa ja työelämäkonteksteissa.

Avainsanat: taidon hankkiminen, asiantuntijuuden kehittyminen, suorituskyky, modernit oppimisympäristöt, modernit oppimisalustat, augmentoitu todellisuus, virtuaalitodellisuus, immersiivinen oppimissisältö, rauhanrakentaminen, kyberturvallisuus, kyberfyysiset järjestelmät

Author

Kirsi Aaltola
Faculty of Information Technology
University of Jyväskylä
Finland
ORCID: 0000-0002-2048-5151

Supervisors

Professor Pertti Saariluoma
Faculty of Information Technology
University of Jyväskylä
Finland

Professor Martti Lehto
Faculty of Information Technology
University of Jyväskylä
Finland

Reviewers

Professor Antti Oulasvirta
School of Electrical Engineering
Aalto University
Finland

Professor (Associate) Antti-Tuomas Pulkka
Department of Leadership and Military Pedagogy
National Defence University
Finland

Opponent

Professor Cedric de Coning
Norwegian Institute of International Affairs
Norway

PREFACE

Modern learning environments (MLEs) include immersive and affective learning content in new digital forms, social media, augmented or virtual realities (AR/VR), 3D environments, and gaming. These immersive features provide new opportunities for learning and skills acquisition. Nevertheless, the use of digital technologies in training and education contexts has been stationary. The obstacles derive from the domain-specific needs related to the learning content, a lack of effective design and pedagogical practices, competence gaps among instructors, and institutional and policy interests. Among the scientific community, there has been interest in understanding the acquisition of knowledge and skills (e.g., Ericsson & Charness, 1994), the experiences that can be produced in the interaction between humans and technology (e.g., Saariluoma & Jokinen, 2015), the study of human-centered design practices (e.g., Giacomin, 2014), and, recently, how skills and expertise are transferred from different technology-supported realities to real life (e.g., Williams, Ward, & Chapman, 2003).

This dissertation is the result of over seven years of research undertaken as part of the European Commission H2020-funded projects to investigate the acquisition of knowledge, skills, and expertise and develop learning environments in the domains of peacebuilding and cybersecurity. The research began with theoretical and empirical examinations of the design of MLEs (research IV) and the integration of MLEs into training and education (research V). As the research progressed and new studies were undertaken, the focus shifted from the aspects of design and integration toward a more holistic acquisition of knowledge in a network community (research VI, VII, VIII) and acquisition of skills and expertise (research I), as well as the role of experiential learning in improving human performance (research III). Following this, a specific study of cybersecurity learning environments, cyber ranges (CRs), raised the question of how likely the current capabilities and features are to support the acquisition of skills (research II).

Two questions that kept emerging during the analysis were as follows: *"What are the effects of MLEs on knowledge and skills acquisition in the development of expertise?"* and *"How can MLEs be designed to ensure the acquisition of skills and their integration in a meaningful way into training and education?"* Both quantitative and qualitative data were collected to provide insights into experiences in playing with learning technologies, knowledge about the effects of MLEs on skills acquisition, and information about pedagogical and integration practices in training and education. Two MLE design cases demonstrated an understanding of design research and human-centered design models. The empirical studies also showed the potentials and challenges of integrating technologies into training and education environments. To yield a holistic understanding of the effects, potential assessment methods for analyzing societal impacts were reviewed.

ACKNOWLEDGEMENTS

This PhD dissertation is the result of seven years of research into the acquisition of knowledge and skills in modern learning environments and design perspectives, including human–technology interaction and the integration of technology into training and education. The topic and perspectives arose through several European projects and collaborations with many insightful people and teams. I truly want to thank everyone who took the time to participate and collaborate with me in the process. Thanks to the University of Jyväskylä, HAUS Finnish Institute of Public Management, VTT Technical Research Centre of Finland, and Laurea University of Applied Sciences. I would like to thank my supervisor, Prof. Pertti Saariluoma, for all his insights and guidance throughout this work. Also, big thanks to my other supervisor, Prof. Martti Lehto, especially for his guidance during the finalization of this dissertation.

Likewise, I would like to thank the research colleagues of Improving the Effectiveness of Capabilities in EU Conflict Prevention (IECEU) and the establishments Gaming for Peace (GAP) and the European Network of Cybersecurity Centers and Competence Hub for Innovation and Operations (ECHO) for their open collaboration and stimulating studies. I have also had the pleasure of meeting and carrying out discussions with some extremely insightful professionals over the past years, including members of the IECEU, GAP, and ECHO projects, coauthors Dr. Harri Ruoslahti, Dr. Jorma Jokela, Mr. Petteri Taitto, Mrs. Kristina Henriksson, and colleagues Mrs. Mascia Toussaint, Mrs. Maria Mekri, Adj. Prof. Rauno Pirinen, Adj. Prof. Jyri Rajamäki, Dr. Jarmo Heinonen, Dr. Päivi Mattila, Dr. Riitta Molarius, and Dr. Kyösti Väkeväinen who gave me helpful hints and support throughout the process.

Many thanks to the HAUS Finnish Institute of Public Management, VTT Technical Research Centre for Finland and Laurea University of Applied Sciences for the opportunity to link the research projects with my study area, as well as to the European Commission Horizon2020 funding program for funding the IECEU, GAP, and ECHO projects among others. Thanks to the University of Jyväskylä for providing me with knowledge and an academic baseline since 2007. I would also like to thank the reviewers, Prof. Antti Oulasvirta and Prof. Antti-Tuomas Pulkka, very much for taking the time to read and comment on this dissertation.

My immense thanks to Prof. Mika Aaltola, my husband and great inspiration. Lastly, I would especially like to thank my family, friends and our dogs for being there and supporting and believing in me. My family in Finland are the best, and their determined solidarity in the progress of this project pushed me toward my goal. Also, the numerous discussions I've had with colleagues and friends have kept the ball rolling. This dissertation coincides with the birth of my Son, to whom I own the tranquility for being able to finish this work.

Jyväskylä June 1, 2022
Kirsi Aaltola

LIST OF INCLUDED ARTICLES

I Aaltola, K. (2020). New technologies shaping learning? AR learning experiences and integration model. In R. Zheng (Ed.), *Cognitive and Affective Perspectives on Immersive Technology in Education*, pp. 195–214. IGI Global.

II Aaltola, K. (2021). Empirical study on cyber range capabilities, interactions and Learning features. In T. Tagarev, K. T. Atanassov, V. Kharchenko, & J. Kacprzyk (Eds.), *Digital Transformation, Cyber Security and Resilience of Modern Societies,* pp. 413–428. Studies in Big Data, 84. Springer, Cham.

III Aaltola, K., & Taitto, P. (2019). Utilising experiential and organizational learning theories to improve human performance in cyber training. *Information & Security, 43*(2), 123–133.

IV Hyttinen, K. (2017). Human-centered design model in the development of online learning tools for international security training: CASE IECEU new media based learning application (NMLA). In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management – ISE*, pp. 275–282.

V Hyttinen, K., Ruoslahti, H., & Jokela, J. (2017). Model for effective integration between research, work life and higher education in international security studies. In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management – ISE*, pp. 299–306.

VI Aaltola, K., & Ruoslahti, H. (2020). Societal impact assessment of a cyber security network project. *Information & Security, 46*(1), 53–64.

VII Henriksson, K., Ruoslahti, H., & Hyttinen, K. (2018). Opportunities for strategic public relations: Evaluation of international research and innovation project dissemination. In S. Bowman, A. Crookes, Ø. Ihlen, & S. Romenti (Eds.), *Public Relations and the Power of Creativity: Strategic Opportunities, Innovation and Critical Challenges*, pp. 197–214. Emerald Publishing.

VIII Ruoslahti, H., & Hyttinen, K. (2017). A co-created network community for knowledge and innovations: Promoting safety and security in the Arctic. In *Engaging People in a Disengaged World, Proceedings of the 23th International Public Relations Research Symposium BledCom*, pp. 100–106. University of Ljubljana.

Previous articles have been published under the author's former surname Hyttinen.

FIGURES

TABLES

CONTENTS

1 INTRODUCTION

1.1 Research Context and Significance

Throughout evolution, humans have used physical tools that increase their sensorimotor abilities, such as pencils, stone tools, hammers, and knives (Osiurak, Navarro & Reynaud, 2018). Technology has organized and influenced human life, communication, and learning in a new way (Firth et al., 2019; Roztocki, Soja, & Weistroffer, 2019; Siemens, 2014). Emerging technologies such as artificial intelligence (AI), machine learning (ML), and autonomous systems have radically recontextualized the human dimensions of organization (Aaltola & Taitto, 2019; Dwivedi et al., 2019) and are expected to change our way of working (Leikas, Koivisto & Gotcheva, 2019), for example, by the replacement of humans in many information-processing tasks (Saariluoma, Kujala, Karvonen & Ahonen, 2018). At the same time, strategic-level changes reveal critical societal vulnerabilities in the use of information technologies, such as cyberthreats and disinformation campaigning. They can impact humanity at all levels, from individual to societal (Aaltola, M. 2020).

Due to digitalization and emerging technologies, the effects of everyday technologies have recently become the object of intense theoretical and empirical scrutiny. Digital transformation—the adaptation of companies and actors to the new digital reality—requires constant investment in management and skilled personnel (Aaltola & Ruoslahti, 2020; Nadkarni & Prügl, 2021) and the digital culture of organizations by continual learning and the encouragement of experiments (Kane, 2019). It has been stressed that digital education and training is much more than a technical concern because new learning environments change the dynamics of time and space to create learning cultures, geographic boundaries, and social interactions (Penprase, 2018). Covid-19 influenced educational practices quickly by reorganizing them online at all educational levels (Agasisti & Soncin, 2021).

The research contexts of this dissertation relate to peacebuilding and cybersecurity education and training that aim to contribute, by way of expertise

development, to the overall goals of preventing and responding to crisis and disaster situations by the establishment of risk mitigation processes, preparedness, and expertise. The domains of peacebuilding and cybersecurity construct the domain-contextual environment for this study. An understanding of the nature of these domains is relevant. Peacebuilding and cybersecurity interventions take place either before a disruption (for example, a violent conflict or cyber-attack) occurs or after it ends. Whereas peacebuilding addresses deep-rooted or structural causes of conflict and aims to build and support the local authorities in becoming peaceful, stable communities and societies at local and national levels (UNESCO, 2015), cybersecurity aims to build resilience against cyber threats and protect citizens and infrastructures (European Commission, 2020). Security, humanitarian work, and peacebuilding work are multidimensional and complex phenomena.

The complex reality of security requires committed people to be prepared and trained with knowledge, skills, and competences before entering the conflict, security, or peacebuilding area. Both peacebuilding and cybersecurity highlight the role of training and education as crucial ways to influence human performance during disruptions. Moreover, peacebuilding interventions have revealed the need to present the impact and relevance of the selected allocation of resources and to maximize performance in the field effectively (Edjus & Juncos, 2018; Zupančič, Pejič, Grilj & Peen Rodt, 2018). Presenting evidence of the effectiveness and success of peacebuilding interventions has been of interest in the political, operational, and academic fields (van der Lijn, 2009; Zupančič & Pejič, 2018). Peacebuilding missions analyze their effect on the knowledge, attitudes, and behavior of the people and organizations involved to optimize their activities at the political and leadership levels (De Coning, 2020). In the conflict mediation and peacebuilding context, individual skills training, beyond donations or infrastructure building, is the area where the most impact has been identified (De Coning, 2020; Topcu & Sigri, 2018). For example, peacebuilding includes a variety of responses to a range of crisis situations and has recognized several key areas of expertise, such as negotiation (Stage, 2020) and managerial skills (Topcu & Sigri, 2018). Human expertise plays a crucial role in building stability, managing crises, and securing cyber-physical environments.

Digitalization has also influenced peacebuilding and cybersecurity domain-specific education and training by increasing the use of modern learning environments (MLEs) and technology as pedagogical methods. Generally, expertise development and learning take place partially or entirely over the Internet. New technologies reveal modern opportunities for new ways of physical and cognitive capabilities, even beyond what is biologically possible. First, computers made possible the delivery of education and its materials both in print and in electronic media (Moore, Dickson-Deane & Galyen, 1990); then the capabilities of tablets and smartphones were considered to be a key development in the field of education and training, especially in the European countries (Sevillo-Garcia & Vázquez-Cano, 2015). As early as 2008, enrollment in online courses was growing faster than general higher education enrollment

(Allen & Seaman, 2008). Simulations are seen as useful for training and practicing professional expertise and performance, such as in medical surgery (Law, Atkins, Kirkpatrick, Lomax & Mackenzie, 2004), piloting (Kasarskis, Stehwien, Hickox, Aretz & Wickens, 2001), and cybersecurity (Veksler, Buchler, Hoffman, Cassenti, Sample & Sugrim, 2018).

Expertise and expert performance research (Ericsson, 2006; Ericsson & Polson, 1988; Ericsson & Smith, 1991) have shown that experts' high-level performance is often acquired through experience and that the effect of deliberate practice on performance is greater than usually believed. The impact of learning is recognized in expertise development (Ericsson, 2006), human performance, and acquisition of skills and competences (Aaltola & Ruoslahti, 2020). The link between training and successful performance in crisis situations is recognized in the peacebuilding domain, and international agencies are increasingly aware of the need for peacebuilding training (Hallward & Tarkhani, 2019). Expertise development and skills acquisition are accomplished through a selection of the proper pedagogical methods, and domain-specific knowledge is based on cognitive processing such as problem-solving (Dane, 2010). Skills acquisition is studied by analysing perceptual processes as part of complex problem solving (Chase & Simon, 1973).

Researchers have addressed assumptions, models, methods, concepts, and cognitive aspects of digital technologies and their implications for human learning (Korte, 2020; Singh, 2021; Zwart, Van Luit, Noroozi & Lin Goel, 2017), but also for the ways of managing information (Hyttinen, 2017). Perspectives on and approaches to learning and skills acquisition in digital training design are only somewhat touched upon and studied, especially in peacebuilding and cybersecurity training. Effective crisis management and emergency preparedness rely on stakeholders working effectively together along with operational knowledge and skills (Ravyse, Blignaut, Leendertz & Woolner, 2017), and these elements open information-sharing connections with the use of new technologies. VR technologies have been identified as the most promising methods of training in the domain sectors, such as emergency and crisis response in managing accidents, disasters, and other crises (Gowing, Walker, Elmer & Cummings, 2017).

Technologies increasingly color our perceptions and behaviors in society, learning, and politics, and this increases research interest in understanding the differences among these perceptions and behaviors and their impacts (Crookall, 2010; Korte, 2020; Penprase, 2018). The increasing use of technologies has an impact on human lives, and we learn of the impact of their usage in different physical and cyber contexts all the time. The spread of immersive content technologies like AR or VR offers new interfaces between humans and computers (Fritsch, 2019) but also new considerations about skills acquisition and expertise development. To ensure effective learning, we have had much to study and learn about regarding how to use these kinds of technologies in education and training (Garrison, 2003).

1.2 Research objectives

Digital technology has recently emerged, and this has led to a substantial body of research empirically investigating the multiple potential pathways through which MLEs could affect learning and skills acquisition. This dissertation aims to contribute to the research on technology usage and design for expertise development, learning, and skills acquisition. The studies of this dissertation aim to contribute to the body of theoretical research that seeks to understand whether the rapidly changing digital world, with its multiple uses of different learning technologies, has critical implications for traditional learning approaches (Rauste-von Wright & von Wright, 1994). This dissertation aims to increase the understanding of MLEs and their design in expertise development training.

The overarching goal of this dissertation is twofold: to explore the influences of MLEs on skills acquisition and domain-specific expertise development; and to describe the integration models and improved design of MLEs in training and education. First, this dissertation aims to provide an understanding of the role and effects of MLEs in the acquisition of skills in expertise development. Second, to design meaningful MLEs for domain-specific expert training and education, this dissertation aims to increase the understanding of the experiences with technologies described by experts. Third, the design models of this dissertation aim to contribute to the integration of MLEs into learning and overcome the challenges related to this endeavor.

This research strives to contribute theoretically to meaningful MLE design for training and education. In the pursuit of these aims, the research objectives are as follows:

- Design theoretical frameworks for the acquisition of knowledge and skills in expertise development (Articles I, II, III, VI, VII, and VIII) and for the design and development of MLEs (Articles IV, V, and VI)
- Acquire empirical knowledge by collecting data and analyzing experiences of using MLEs in domain-specific training and education (Articles I, II, III, IV, and V)
- Articulate models and recommendations for the design of MLEs to ensure effective learning (Articles I, II, III, IV, V, and VI)

This dissertation deals with the acquisition of knowledge and skills in expertise development in the domain-specific environments of international crisis management, peacebuilding, and cybersecurity. This research contributes to the research agenda of designing proper MLEs to improve the acquisition of skills and expertise, and, finally, human performance, in real life. The theoretical framework of skills acquisition and expertise development highlights the roles of context-specific experience, problem-solving, reflection, and motivation.

1.3 Research components

The research followed an interactive process structure, aiming to respond to more detailed research questions in different study papers, which are published as peer-reviewed book chapters or peer-reviewed papers in scientific conference proceedings. Three of these eight papers were published as peer-reviewed book chapters, and five papers were published in peer-reviewed scientific conference proceedings (three are recognized as Jufo 1). The conferences were KMIS (International Conference on Knowledge Management and Information Sharing), DIGILIENCE (2019, 2020), and the 23rd International Public Relations Research Symposium BledCom (Ljubljana).

This author was the sole author of two book chapters (Articles I and II). She was also the sole author of Article IV presented at the International Conference on Knowledge Management and Information Sharing, published in the proceedings. In the following, the responsibilities of each coauthor of the coauthored papers are listed and described.

The author of this dissertation wrote Article III and designed the study in contact with the coauthor, Mr. Petteri Taitto. Taitto collected and reviewed the decision-making literature and provided insights for the discussion. This author compiled and wrote the paper and was the contact for correspondence with the editor and adaptation after reviews.

This author, Mr. Jorma Jokela, and Mr. Harri Ruoslahti coauthored Article V. This author designed the study and collected and analyzed the data. Jokela and Ruoslahti included data from two higher education courses and conducted the final analysis. This author mainly compiled and wrote the paper, while Jokela and Ruoslahti contributed parts of it. This author was the contact for correspondence with the editor and adaptations after the reviews.

This author and Ruoslahti coauthored Article VI. The research was designed jointly. The authors had specific areas of interest for theoretical and empirical work. This author focused on the analysis of expertise development, skills acquisition, and learning in societal impact assessment. This author was the contact for correspondence with the editor and adaptations after the reviews.

Henriksson, Ruoslahti, and this author coauthored Article VII. This author collected the data from relevant projects and analyzed the data based on the paper's design. This author had the special role of analyzing the technology-relevant information management systems and benefits of MLEs. This author conducted the adaptations after the reviews of her parts.

Ruoslahti and this author coauthored Article VIII. This author conducted a literature review of knowledge, tacit information, and organization learning. She also analyzed the data and wrote about the findings with regard to the potentials of online learning environments and relevant pedagogy in the Artic network communities.

2 THEORETICAL PROBLEM

Digitalized improvements are faster than ever before. People are asked to apply new ways of thinking immediately, sooner than ever before. The Covid-19 pandemic has led to large-scale behavioral changes and has had swift impacts on the field of training and education (Ferrel & Ryan, 2020). MLEs attempt to support the acquisition of knowledge (Allan & Clarke, 2007; Choi & Hannafin, 1995; Laszlo & Castro, 1995; Shrader & McCreedy, 2008) and skills, expertise development, and knowledge sharing. Technology plays a critical role in mediating between learning and the learner, and its role in mediating information can stimulate and reward a learning experience almost as in real life (Laszlo & Castro, 1995). In doing so, technological solutions mainly touch upon elements of human abilities and introduce new environments, such as features of augmented realities (AR), virtual realities (VR), and cyber-physical systems (CPSs). At the same time, information technology and computer scientists develop AI, ML, and robotics, aiming at reproducing human skills (Penprase, 2018); it has been argued that these technologies will have the effect of a decrease in basic skills acquisition in humans in the coming decades (Elliot, 2017).

The focus of training and education is on improving humans' real-life knowledge, skills, and expertise in performance. Training and education offer new avenues for the benefits of technologies with affective and immersive learning content. The prevalent learning paradigm has been described as changing in order to focus on the use of the new media to promote learning (Schrader, 2015).

The effectiveness of simulation methodologies has been scrutinized, and evidence has been given that web-based simulation programs are effective in teaching high school students problem-solving and negotiation skills (Brown, Lawless & Boyer, 2013; Cuhadar & Kampf, 2014). This dissertation combines previous research and studies and provides more specific empirical findings to increase the potential to improve practical and operational peacebuilding and cybersecurity effectiveness by enhancing training practices with the use of MLEs. The foundations for this positioning employ different scientific disciplines, such as cognitive science, adult education, information and communication

technology, and organizational and management theories and therefore aim for a multidisciplinary approach to the phenomenon. This dissertation brings together multiple cognitive science and educational understandings into a concise framework incorporating cognitive learning and acquisition of skills, expert performance, experiential learning, and human-centric design.

Researchers have already considered the need for multidisciplinary research, with a focus on multilevel adult education directions in security-related training and education (Berki, Valtanen, Chaudhary & Linfeng, 2018). MLEs and CPSs will not only increase safety and reliability requirements (Lee, 2008), but will also challenge strategic leadership (Lehto & Limnéll, 2020) and competence requirements with sets of skills (Abyshev, Yablochnikov & Mäkiö, 2020; Dworschak & Zaiser, 2014). In CPSs, the use codes, data, or logic with the aim of causing disruptive consequences that lead to accidents, threats, and cybercrime (Berki et al., 2018). The consequences of new realities and spaces have led to an increase in security threats from stolen hardware, identity theft, spoofing, system infiltration, and breach of access to direct message abuse. Beyond physical and syntactic cyberattacks, semantic cyberattacks are seen as more serious threats, since they target the human interface. (Schneier, 2000). Therefore, human performance is also a pertinent issue within the cybersecurity domain (McClain, Silva, Emmanuel, Anderson, Nauer, Abbott & Forsythe, 2015). Human and organizational factors both play a significant role in computer and information security vulnerabilities (Kraemer, Carayon & Clem, 2009). Beyond the critical organizations of security, peacebuilding actors have also identified evolving cybersecurity threats and digital changes and innovations (Fovino, Neisse, Lazari, Ruzzante, Polemi & Figwer, 2018).

Today, expertise development and skills acquisition benefit from digital solutions, such as different learning applications, web resources, web-based applications, and new collaboration technologies. Moreover, new types of hybrid approaches to the production of online training and education activities are increasing (Means, Toyama, Murphy, Bakia & Jones, 2009). The term "distance learning" has evolved into online learning, virtual learning, e-learning, mediated learning, web-based learning, gaming, and AR/VR-supported learning (Conrad, 2002). In the 21st century, empirical studies have captured collaborative practices in online learning (Siemens, 2014), and findings about connecting the use of social online learning tools and a social constructivist approach in e-learning have provided students with personal tools by engaging them in social networks (Dalsgaard, 2006). Dalsgaard (2006) also argued that emerging social software tools can allow learners to direct their own problem-solving process beyond the traditional learning management systems (LMSs). Modern advances in educational and training technology offer promising learning environments, including dimensional virtual worlds (Mantovani & Castelnuovo, 2003). MLEs also affect sensorimotor abilities, and their usage is slowly influencing human evolution. Visual capabilities in the form of immersion create opportunities to influence the human imagination and experience in MLEs.

Not only these technological resources, but also broadened educational and training goals with regard to lifelong learning, global interaction, and the acquisition of meta-cognitive knowledge and skills have changed the roles of students, teachers, and trainers, as well as led to a socio-constructivist paradigm of learning (Felix, 2005). Many people are enrolling voluntarily in online courses to enhance their skills and knowledge (Sofat & Sharma, 2020), and training and education institutes benefit from technologies—for example revising teaching methods, monitoring study progress, monitoring student learning, and facilitating distant and interactive collaboration among students (Gaebel, Kupriyanova, Rita & Colucci, 2014). At the same time, there have been difficulties in Europe in finding staff and personnel with the proper skills, and this has been argued to be a cause of unemployment (Cedefop, 2015). Policy-level work affects the level of practice in such a way that higher levels of skill and expertise demand proficiency in jobs (Cedefop, 2015).

Although there are certain studies on the benefits and limitations of using technologies for learning and skills acquisition, the long-term effects have not been extensively studied in academic practice. Participation in VR, AR, or other realities provides an experience of perception and audiovisual content. AR/VR/MR simulations enable users to practice skills and develop knowledge in a safe environment that closely replicates real-life practice (Cook, 2014). Human-interaction studies have analyzed the factors affecting human performance with technology, such as typing speed on a computer (Jokinen, Sarcar, Oulasvirta, Silpasuwanchai, Wang & Ren, 2017) or interface factors in usability (Bergström-Lehtovirta et al., 2009). In these studies, the focus has been on human skills acquisition in the interaction between humans and technology, so as to learn to use technology effectively for its purpose. Nevertheless, the transformative potential of MLEs in skills acquisition as part of expertise development often garners little attention in academic research.

The increased research interest in better understanding how MLEs and technologies should be designed arises from a pedagogical (Hyttinen, 2017) and skills acquisition point of view (Aaltola, 2020). The second research agenda of this study focuses on the design, development, and integration of technologies for training and education. Although achievements in learning technology development are rather exciting, there is a lack of commitment and engagement in training and education–related user communities. Moreover, even in attractive and immersive learning content influenced by the motivation to play, there are negative effects on learning performance due to high cognitive load (Cheng, She, & Annetta, 2015). In addition, the motivation is often based on whether the game is fun to play or use and whether the target audiences prefer to learn through game playing (Chen, Yang, Huang, & Fu, 2019).

As technological solutions are becoming more relevant to replacing or fine-tuning human work, including in training and education practices, progress should address relevant modelling and conceptual foundations (Kujala & Saariluoma, 2018). The range of instructional and methodological design opportunities is broad, and the selection of proper learning techniques supports

the adaption of new competences in different contexts (Marsick & Watkins, 2001). As with any use of learning methods, the use of technology in the classroom needs to be unified in terms of content, technology, and pedagogy (Mishra & Koehler, 2006).

2.1 Expertise development

> Expertise is a long-term developmental process, resulting from rich instrumental experiences in the world and extensive practice. (Feltovich, Prietula, & Ericsson, 2006, p. 46).

Understanding expertise development is crucial for the proper use and design of meaningful training and learning environments for adult learners. Chatham (2014, p. 43) argued that "the right kind of training can make enormous differences in performance," and Ericsson (1993, 2002) instructed students aiming to acquire expertise to avoid development associated with automatization and asserted that top-level performance requires practice to be well structured and deliberate. Proper learning strategies enable the recontextualization and transfer of knowledge and insights into practice and are vital to fully realize the improvement of human performance (Morley, Bettles, & Derham, 2010).

The theoretical framework of the expert performance approach by Ericsson (2006a) identifies the tasks of a superior performance, the application of standard cognitive methods to analyze the mechanisms to repeat the elicitation of the superior performance, and the critical situations in which immediate action needs to be taken. Studies of the superior performance of experts have shown that complex representations of domain-specific expertise are developed through extended exposure and practices such as repetition. Ericsson and Smith's (1999) approach to expert performance has been adopted in several domains, such as medicine, aviation, music, and sports, but few researchers have used it in design and simulation performance (Ward, Williams & Hancock, 2006).

The identification of the mechanisms of the expert-performance approach has been applied, for example, in surgical procedures, medical diagnosis, musical performance, writing, painting, and sports, such as volleyball, tennis, and rhythmic gymnastics. (Ericsson, 2006b). There are clear differences among top-level experts, intermediates, and novices. These differences can be utilized in simulation task environments to ensure skills acquisition. Feltovich et al. (2006) summarized the point, explaining that research on expertise and experts has shown that there are cognitive differences between experts and novices (Charness, 1976), and experts not only complete tasks and solve problems faster and better than novices, but often analyze and conduct their solutions in qualitatively different ways, and experts often spend more time in initial problem evaluation than do novices (Glaser & Chi, 1988). The study by Chase and Simon (1973) shows variations between novice and master chess players' perceptual

chunks. According to that study, the superior performance of stronger players derives from their ability to encode the position to larger perceptual chunks.

Important characteristics of experts' superior performance are acquired through experience, and the effect of practice on performance is highlighted. The concept of *deliberate practice* includes representative training with feedback and has shown evidence of the importance of the role of feedback in skills acquisition and learning for improved performance (Chatham, 2014; Ericsson, 2006a). The critical role of deliberate practice in the development of expertise emphasizes mechanisms such as repeated practice experiences and clear goals and the important role of feedback regarding the quality of attempts (Ericsson, Krampe, & Tesch-Römer, 1993). Ericsson et al. (1993) highlighted that the perquisite conditions for deliberate practice are the following: design of the task such that it considers the pre-existing knowledge of the learners (so that the instructions are correctly understood), reception of immediate informative feedback and knowledge of the results, and repetition of the same or a similar task. These conditions ensure that practice will improve speed and accuracy of performance of motor cognitive and perceptual tasks (Fitts & Posner, 1967).

In terms of transferring the acquired skills to an actual operating environment (Williams, Ward & Chapman, 2003), there is some evidence that this can be done effectively, but in the specifically improved performance, the roles of instructions and feedback have received only limited attention (Ward et al. 2006). The findings of research on expert performance behavior, such as the quicker picking up of meaningful information and monitoring, show the relevance of simulations as useful tools for assessing real-life performance under standardized conditions. Beyond the measurement of performance, there is evidence that simulations can be effective at improving performance, especially for specific skills whose nature is perceptual-cognitive. Deliberate practice maintains the continuity of improvement of performance (Ericsson, 2003; Ericsson et al., 1993).

2.1.1 Learning theories

> Learning is the combination of processes throughout a lifetime whereby the whole person – body (genetic, physical and biological) and mind (knowledge, skills, attitudes, values, emotions, beliefs and senses) – experiences social situations, the perceived content of which is then transformed cognitively, emotively or practically (or through any combination) and integrated into the individual person's biography resulting in a continually changing (or more experienced) person" (Jarvis, 2009, p. 25).

Learning is a basic human activity taking place everywhere (Rosenberg, 2006) and should not be limited to classroom facilities (Senge, 1990). Formal learning is typically institutionally organized and structured (Marsick & Watkins, 2001). In contrast to formal learning, informal learning "takes place outside the curricula provided by formal and non-formal educational institutions and programs" (Schugurensky, 2000, p. 2). Traditional classroom-based learning is formal and more structured, whereas informal learning is not typically structured, and the learning is in the hands of the learner (Marsick & Watkins, 2001). Education and

training are crucial parts of career development, and they also both try to assess and evaluate competence needs in cooperation with work life (Lawlor & Hornyak, 2012). Education has a traditional societal role and objectives (Hyttinen, Ruoslahdi & Jokela, 2017; Välimaa, 2004), and it aims to connect with work life needs (Teichler, 1998). Higher education is expected to impact society through research contributions and educated persons, as well as interact with the surrounding society (Raij, 2014). Training is a systematic process designed to impart skills, attitudes, knowledge, concepts, and rules to trainees and result in enhanced performance or organizational outcomes of value (Kraiger et al., 2014).

Learning can occur through one's own experiences (Kolb, 1984), through critical reflection (Mezirow, 1981), and problem-solving (Poikela & Poikela, 1991). Empiric, constructive, and rational learning approaches (Rauste-von Wright & von Wright, 1994) have influenced pedagogical methods instructional design, and teaching practices. While the view of rationalism focuses on the idea that knowledge is derived from reason without the aid of the senses, empiricism understands experience to be the primary source of knowledge acquisition (Schunk, 1991). These approaches influence questions about how to facilitate learning events and activities. The variety of learning theories shows the complexity of learning paradigms due to the content dimensions of what is learned. Learning is described as the acquisition of skills, competences, and knowledge, but also as performance, opinions, attitudes, values, behavior, meanings, methods, and strategies (Illeris, 2009).

Rationalism calls for a focus on the structure of information, and empiricism calls for a focus on facilitating experiences with the use of proper associations. Cognitivism emphasizes complex cognitive human processes such as thinking, problem-solving, concept formation, and information processing (Roszkowski & Snelbecker, 1983). The cognitive revolution in psychology around 1960 replaced behaviorism, and cognitive learning theories stressed the behavioral importance of metacognitive strategies, working memory, and prior knowledge (Kanselaar, 2002). Cognitive learning theories are unified by the importance of the learner's internal mental processes. The shift from behaviorism to cognitive theories is based on Piaget's work on cognitive development (1973), as well as that of Vygotsky (1978) and Bruner (1990). The key constructivist viewpoints are the theory of cognitive development (Piaget, 1936), the theory of experience (Dewey, 1938), and social constructivism (Vygotsky, 1986). Dewey (1938) asserted that the nature of learning is based on problem-solving and that humans are active learners. Piaget's cognitive development built the basis for constructive ways of thinking (Rauste-von Wright & von Wright, 1991), and he (1950) described how experience shapes intelligence. The role of interactions with others in a social-environmental context was highlighted by constructivist learning theory (Dewey, 1938). Learning can be seen as socially situated (Lave & Wenger, 1991). Schrader (2015) addressed the importance of active engagement with knowledge and social interaction in meaning making and learning.

Behaviorism and cognitivism are seen as more objectivistic in their philosophical assumptions and understand the world to be external to the learner.

Behavioral theories built the basis for competence-based curricula and training programs by understanding a stimulation in the context or environment to lead to changes in behavior (Skinner, 1954). The cognitive school of learning focuses on meaning and semantics and equates learning with creating meaning from experience (Bednar et al., 1991; Piaget, 1973; Vygotsky, 1978). Bruner (1990) modeled how the learner derives information from the environment. Learning is considered to include a cognitive understanding of mental activity in which the crucial idea is that new impulses can be included in mental organizations in multiple ways (Illeris, 2009; Piaget 1973). Fischer's (1980) alternative view of cognitive abilities as context-embedded skills understands knowledge to be organized within specific domains, such as particular tasks and contexts, spatial properties, social interactions, or music. However, some researchers have argued that cognitive skills can be transferred with almost the same logical principles as knowledge (Rauste-von Wright & von-Wright, 1991); others have offered a skill theory as the context-embedded conception of cognition (Fisher, 1980). Skill theory argues that it is easier to construct specific and context-embedded skills than general cross-contextual logical structures (Bidell & Fischer, 1992).

Constructivism focuses on the understanding that humans create meanings rather than acquire them. From the constructivist perspective, learners do not transfer information, knowledge, or skills to their mental models or memories; rather, they build individual interpretations based on individual experiences and interactions (Ertmer & Newby, 1993). Constructivist pedagogy includes methods in which students learn by working collaboratively with social influences (Vygotsky, 1978). Social constructivism is seen as a view of learning that leads to decision-making about training methods, pedagogy, andragogy, and curriculum design (Oldfather & West, 1999). Social and environmental contexts and interactions with others lead to individual development (Dewey, 1938), and learning thus becomes socially situated (Lave & Wenger, 1991). Dewey (1938) addressed the importance of an active role in learning and problem-solving. Other critical theories of learning highlight that knowledge and skills emerge in contexts in which they are relevant and that behavior and performance are situationally determined (Jonassen, 1991). Therefore, when the interaction between the learner and the environment creates knowledge (Ertmer & Newby, 1993), it is critical for learning to actually occur in realistic settings and contexts where the experiences are relevant for learning. Felix (2005) noted a shift to the constructivist learning paradigm as active and collaborative, in which knowledge is constructed from engagement with information in modern environments and technology. The change from physical library spaces to online library spaces has increased interest in understanding the relationships between spaces and their role in learning (Nitecki & Simpson, 2016).

Experiential learning theory and cycles (Kolb & Kolb, 2011) are dynamic approaches for pedagogy, training, and education. Kolb's (1984) dichotomy between actual doing and reflection after action has strongly influenced adult education and training practices (Wang & Newton, 2012). Experiential learning theory (ELT) is a dynamic perspective on learning that is relevant for adults,

performance improvement, and expertise development. It includes action with reflection and experience with abstraction. (Kolb & Kolb, 2011). The experiential learning cycle is used especially in the training and education domains (Kolb & Kolb, 2011). The original four-stage cycle was established by Kolb (1984) and includes the following steps:

1. A new experience or situation is encountered, or a reinterpretation of an existing experience occurs (feeling).
2. Reflection on the new or reinterpreted experience is particularly important for establishing inconsistencies between the experience and understanding (watching).
3. Abstract conceptualization through reflection offers new ideas or a modification of existing abstract concepts (thinking).
4. Active experimentation occurs in which the learner applies the idea to the actual life around them to see what happens (doing).

Kolb and Kolb (2011) offer evidence from the past twenty years of how experiential learning has influenced the improvement of the learning processes and pedagogical methods used by trainers and teachers. Experiential learning methods encourage taking the learners systematically through each learning step, where knowledge is created through the transformation of experience. The holistic approach to experiential learning includes cognition, emotions, and environmental factors (context). The combination of several scientific approaches, such as cognitive sciences, neuroscience, or other psychological theories, offers multiple options from which to choose (Aaltola, 2020). The use of constructive learning methods among adult learners has displayed competences and skills in doing, and Jarvis (2006) asserted that certain elements of learning must be presented: the person as a learner, the social situation within which the learning occurs, the experience that the learner has of the situation, and the process of transforming it and storing it within learners' mind.

Learning approaches are also related to employment, ideologies, politics, and different creative and interactive ways of living (Aspin & Chapman, 2007; Jarvis, 1998). Today, lifelong learning is described as a "high-individualized way of learning which is guided by the changes and new ways of life" (Field, 2006, p. 198). This concept of lifelong learning is developed into a broader concept to consolidate everyday life learning with the aim of improving knowledge, skills, and competences (Tissot, 2004) in knowledge societies (Boutsiouki, 2010). Lifelong learning is an important part of the Lisbon strategy of the European Union, by which the European Union aims to be the most dynamic knowledge-based area to lead to a more cohesive and inclusive society (European Commission, 2001).

Individual learning processes are dependent on social interaction (Bandura, 1971), culture (Bruner, 1990), and group membership, along with the acceptance of the values and culture of the group (Lewin & Grabbe, 1945). Social networks influence people's views and opinions (Katz & Lazarsfeld, 2006; Stevenson & Greenberg, 2000), and this influence results from the larger network structure in which the actors are embedded (Coleman, 1990). Social networks have

traditionally been seen as a link between the micro level (individual) and the macro level (culture, organization, collective norms, and system) (Coleman, 1990). Social learning has also been studied in management and organizational studies, using the concept of organizational learning (Argyris 1993; Argyris & Schon 1974, 1978). The German sociological critical theory of Habermas (1979) described social change as a process of social learning with cognitive and normative dimensions. Habermas' (1981) original ideas refer to a genuine exchange of arguments and ideas in such a way that perceptions lead to new social movements. Connectivism argues that a network of connections creates knowledge, and learning consists of exploring these networks (Downes, 2007; Kop & Hill, 2008; Siemens, 2005).

Knowledge creation theories from organizational and management studies strongly argue for the relevance of understanding knowledge as a socially constructed process. Polanyi's (1958) assumption about tacit knowledge was that some knowledge is difficult to articulate with language and may exist in the form of experiences. He (1966) argued that often "we know more than we can tell" and discussed the role of tacit knowledge in perception and thinking. According to him, our tacit knowledge is in relation to our personal interests, commitments, and society. According to Argyris and Schön (1974), the learning journey includes the reinterpretation of knowledge through different stages and assists in bridging the theory–practice gap, where experience is wedded with the theories learned in the training or education institute.

Individuals in organizations take action to develop and refine their cognitive maps as mental models (Senge, 1990) or as theories in use (Argyris & Schön, 1974). Senge (1990) proposed that learning organizations are based on the individual's ability to think systematically about their own organizations and make changes toward influencing results. One element that these researchers held in common was that they "advocate a cognitive approach to intervening in organizations to improve their adaptability and effectiveness" (Edmondson & Moingeon, 1998, p. 34). Expertise development theory also recognizes the transition from novice to expert through mentoring and participation in a community of practice. According to Nonaka and Takeuchi (1995), knowledge is defined in relation to actions and beliefs about meaningful messages and commitment. According to them, information is a flow of meaningful messages. The knowledge continues toward organizational learning in social interactions. As a synthesis of previous theories, Stenmark (2001) has argued that fact knowledge includes both forms of knowledge—explicit and tacit. Also relevant for higher education and training relationships and connections, Ruoslahti (2017) noted that the networks for knowledge and innovation cocreation always require facilitation in order to achieve the active participation of the stakeholders.

2.1.2 Knowledge and skills acquisition

> "Discussions of skills, dispositions, thoughtful action, and so on, seems to me appropriate in relation to ability to play well, but not in relation to knowing how to play" (Chomsky, 1986, p. 317)

Human skills acquisition such as reading, writing, and the use of a computer are the most recent developments in human history (Levy, 2010; Matthews, 2003). Skilled action is the ability to perform serially ordered acts (Bruner, 1973), and a skill enables one to modify performance when needed (Widmer, Ziegler, Held, Luft & Lutz, 2016). Skilled performance is, therefore, defined as error-free, fast, and effortless (Schneider & Fisk, 1983). Of course, genetic, and biological factors influence individual differences such as physical characteristics and anatomical attributes of the human body and its nervous system (Ericsson et al., 1993).

The acquisition of knowledge or a skill is described as an internal coding structure and mental activity, and learning is viewed as an active participant in the learning process (Ertmer & Newby, 1993). The cognitivist approach has influenced the use of the appropriate learning strategies relevant for the learner. Moreover, cognitivism focuses on information transfer in the most efficient way to accommodate the learners' memory. Fitts (1964) offered a three-phase characterization of skills acquisition called three-stage theory, including cognitive, associative, and autonomous phases. Anderson's adaptive control of thought (ACT) model can be interpreted as a kind of cognitive stimulus-response theory (Ellis & Shintani, 2013), which includes elements of both cognitive and behaviorist theories (Parziale & Fischer, 2009). The ACT model focuses on language learning as a process of human learning. In the first stage, the declarative stage, the learner produces an approximation of the skill by using general goal-oriented problem-solving strategies to interpret the basis about the skill. Performance at this stage is seen as slow, and the working memory load is high because the facts about the skills, such as the correct movements, need to be rehearsed. In the second stage, the procedural stage, declarative facts about the skill are converted into procedural knowledge through knowledge compilation.

Anderson (1982) claims that "…the mechanisms of skill acquisition basically function within the mold provided by the basic problem-solving character of skills," and Dekeyser presents a theory of skills acquisition such that

> The learning of a wide variety of skills shows a remarkable similarity in development from initial representation of knowledge through initial changes in behavior to eventual fluent, spontaneous, largely effortless, and highly skilled behavior, and that this set of phenomena can be accounted for by a set of basic principles common to acquisition of all skills. (Dekeyser, 2007b, p. 97)

A study by Anderson et al. (2018) shows that abstract knowledge is not enough for high-level human performance, and key drivers of learning in tasks involve receiving instructions and perfecting skills with experience. Human information processing from a cognitive theory perspective assumes key hierarchical layers of basic capacities, cognitive skills that are transformed from controlled to automatic processes and higher cognitive skills for goal setting and cognitive activity planning (Royer et al., 1993). Empirical and documented evidence shows that human cognitive processing is built on moving from smaller tasks toward larger tasks, and learning transfer occurs more efficiently in that way than only in a specific context (Stone & Clements, 1990).

Cognitive skills acquisition aims to develop the ability of problem-solving in information-rich tasks and is seen as important for individuals to meet the challenges of our modern, knowledge-driven society (Renkl & Atkinson, 2002). In movement skills, inputs from sensory and cognitive processes are important in choosing correctly, organizing, and adjusting movement. Environmental conditions, task requirements, and personal characteristics inflict constraints on what action a person may perform. Most motor skill schemes are based on experiences and are distinguished regarding skill structure, complexity, and level of familiarity and difficulty (Voelcker-Rehage, 2008). According to Eltovich et al. (2006), human cognition includes general abilities such as problem-solving, learning, reasoning, and concept formation, which correspond to abilities and capacities that can be studied independently of domain-specific environments. Schon (1983) recommended that practitioners be able to apply their learning creatively in order to be able to perform and make decisions.

Ericsson et al. (1993) highlighted the role of motivation in attending to a task in order to improve performance. In accordance with an evolutionary psychology perspective on the social intelligence hypothesis (Boyd & Richerson, 1996), humans have sophisticated social-cognitive skills for competing and cooperation, as well as evolved skills for creating different cultural groups, institutions, and social practices and operating with a set of artifacts and symbols (Herrmann et al., 2007).

Ignatow (2007) argued that knowledge is fundamentally "embodied," since bodily, emotional perceptions and sensations are disassociated from mental representations and are only later examined through a secondary process of abstraction. Embodied cognition addresses the observation that the features of cognition are shaped by aspects of the entire body of the organism. The bodily aspects include the motor system, the perceptual system, and interactions with and assumptions about the world. Embodied cognition theory addresses the importance of the body for problem-solving and thinking (Aaltola, 2020). Husserl (1997) studied the role of movement sense in visual perception and how visual objects activate the kinesthetic system in the form of bodily movements. Merleau-Ponty (2012) argued for the role of the body as perceiver and the concept of the body schema with dynamically bodily movements.

The evidence shows that physical exercise or sensorimotor cognitive activities increase brain functioning in different ways. Several studies have shown improvements in cognitive abilities, such as learning and memory, executive and attentional processes (Chieffi et al., 2017; Colcombe and Kramer, 2003; Fernandes et al., 2017; Grego et al., 2005; Kramer et al., 1999; Lista and Sorrentino, 2010; Pereira et al., 2007; Winter et al., 2007), through physical exercise. In humans, specific brain volume metrics can be correlated to cognitive performance, defining their functional neural efficiency. The indicators of structural changes correspond, for example, to brain volumes, such as measures of white matter integrity in neurotrophin levels (by correlation with trophic factors plasma levels) (Serra et al., 2011). Motor learning science has shown that expert-level skill performance involves high speed, accuracy, and smoothness of

movement in task execution (Fitts, 1964). Simple motor skill learning influences motor and movement abilities, such as posture or presentation (Aaltola, 2020). For example, human hand and eye–hand coordination processes are sufficient for expressing all human skills in piano playing. New visions and creativity beyond the routine manner of completing sensor-motor tasks require higher cortical processes, such as problem-solving and decision-making (Sloboda, 1991).

Successful and creative skill production requires practice, experiences, and starting from the simple versions of the task and increasing the level of complexity (Charter & Christiansen, 2018). Previous acquisition mechanisms affect the processes of skills acquisition. For example, transferring experiential visual perceptions into actual performance and movements requires a cognitive mental process. Different body parts must be coordinated during movement to produce the final movement skill. This skill builds the basis for new competence (Voelcker-Rehage, 2008). Learning a new skill or movement is a complex phenomenon in humans (Coker, 2017). As described in the learning theories section (Section 2.1.1.), Reinmann-Rothmeier & Mandl (1998) also define learning as an active, situated, self-regulated, constructive, and social process. The role of participation in certain contexts, situations, and environments is important, and the separation of the acquired knowledge does not happen by itself but requires explicit support (Mandl & Krause, 2003).

For humans to function effectively in the socio-cultural real-life context, children are required to learn communities' artifacts and tools to participate in societal practices that involve social-cognitive skills, communication, or the development of higher psychological skills (Herrmann et al., 2007; Vygotsky, 1978). The acquisition of competence combines the relationship between experience transformation, knowledge creation, and social constructions (Aaltola, 2020). Acting or behaving based on new knowledge by transforming the information into pre-existing knowledge, experiences, and understandings requires constructions and problem-solving. Chomsky's (1986) conception of cognitive competence specifies language, spatial relations, or mathematical abilities that are specific to certain domains. He also defined the differences between the ability to do something well and knowing how to do something. Some theories have differentiated the conceptions of cognition into domains or types of intelligence, such as verbal, spatial, or musical intelligences (Gardner, 1983).

It is essential not only to investigate cognitive abilities and the role of kinetic and sensorimotor experiences in new ways of organizing learning or the role of embodied cognition in driving skills acquisition and expertise development, but also to increase understanding of the effects of context on knowledge and skills acquisition (Aaltola, 2020). Simulation pedagogy understands that a simulation is an opportunity to bridge this gap between contexts and encourages learners to have the innovation and creativity to apply their original learning in the different context of real-life practice (Morley, 2015). Constructivists define the challenge of the applicability of skills and knowledge as the concepts of contextualization, recontextualization, and applicability (Prenzel & Mandl, 1993). Skills and

knowledge acquired at an education or training institution need to be transferred or "re-contextualised" to make them available and to enable learners to transfer their learning to a natural context (Evans et al., 2010). Studies in medication education show that the natural context led to significantly larger success rates in the transferring of skills than the simulated context (Ma, Trombly, & Robinson-Podolski, 1999).

In cognitive psychology, the concept of a domain represents the acceptance of a social basis of cognition (Säljö, 1999). The nature of expertise is domain-specific (Ericsson & Smith, 1991), and the attributes of experts are specific to time and place. Domains as bodies of knowledge are introduced in performance research to undertake domain-related tasks in laboratory conditions (Ericsson & Smith, 1991). Nevertheless, general expertise or general knowledge, such as logical reasoning, mathematical ability, or problem-solving, can serve as the basis for the transfer of knowledge to new situations and contexts (Weisberg, 2006). The constructivist conception of the problem of the applicability of skills and knowledge is elaborated as situated or contextualized cognition (Prenzel & Mandl, 1993; Resnick, 1989).

The importance of perceptual experiences (such as vision) for integration with the environment in which they normally arise is evident by sensorimotor approaches. The action, constraints of action, and goals of action need to be taken into account when designing perceptual mechanisms and representations. (Myin & Degenaar, 2014). Clark (1999, p. 350) wrote: "Embodied, environmentally embedded approaches have views to offer cognitive science. It is increasingly clear that, in a wide variety of cases, the individual brain should not be the sole locus of cognitive scientific interest. Cognition is not a phenomenon that can be successfully studied while marginalizing the roles of body, world and action. The major challenge for the vision of 'radical embodiment' described here lies with the class of 'representation-hungry' problems and the phenomena of off-line, abstract, and environmentally-decoupled reason".

2.1.3 Domain-specific skills in peacebuilding and cybersecurity expertise

> The domain-specific nature of experts' superior performance implies that acquired knowledge and skill are important to attainment of expert performance. (Ericsson, Krampe, Tesch-Romer, 1993, p. 365)

Expertise is seen domain-specific (Myllylä & Saariluoma, 2022). The changing nature of complex working environments may have increased the number of studies in relation to defining relevant skills in domain-specific work environments. Global peacebuilding and cybersecurity settings construct complex working environments in which humans are asked to conduct several activities incorporating knowledge and skills as competence areas. Effective response to crises or conflicts has been an agenda of governmental and international organizations since the end of the Cold War (OECD, 2012; UN, 2000). EU member states have domestic and international commitments to perform peacebuilding interventions. From the domestic perspective, there are

political, societal, legal, and economic factors. From an international perspective, there are security threats and questions of cooperation with other countries and international frameworks, such as NATO, the United Nations (UN), or the OSCE (Giegerich, 2017).

In post-conflict regions, there are many international actors that contribute to stability, security, peacebuilding, and development. As part of the EU's Common Foreign and Security Policy (CFSP) and the development of the European Security and Defence Policy (since 2009, the Common Security and Defence Policy, CSDP), the EU has taken action through its capacities for conflict prevention and crisis management (Hyttinen, 2017). EU engagements have been assessed from the perspective of the effectiveness of different conflict prevention and crisis management activities (European Parliament, 2012), including training and technology capabilities (Hyttinen, 2017; Hyttinen et al., 2018). Efforts and interventions have been complex and frustrating (Greene, 2006), and there is no clear understanding of how EU conflict prevention and peacebuilding are implemented in practice (Juncos & Blockmans, 2018). The Western Balkans have been a key to engagement for the EU (Blockmans, 2007) and have become a testing region for the EU's security and defense capabilities, as well as approach (Juncos & Blockmans, 2018). Globally, there has been an emerging need to show enhanced efforts, effective response, and human performance (OECD, 2007).

The EU peacebuilding community has not met its goals with an appropriate level of resources or suitably trained personnel in its peacebuilding missions (Pirozzi, 2019). Cross-cutting behavioral and professional skills and attitudes are needed to effectively operate and act as experts in real life. In these contexts, pedagogical challenges for adult training concern not only the design of methods, but also the understanding that professionals should perform with the capacity to cope with complexity and uncertainty and the awareness of multiple actors in conflict-affected settings (OECD, 2012). Lave and Wenger (1991), as well as Brown et al. (1989), addressed peripheral participation and conceptual representation as important, for example, for people entering a culture. Peripheral participation can be defined as the need to observe how qualified practitioners behave and to get a sense of what constitutes expertise. In the peacebuilding context, pre-deployment training sessions with context-specific and appropriate training methods are seen as essential to adapting knowledge and learning skills (Goodwin, 2005). More specific peacebuilding skills and cybersecurity expertise have proven exceedingly difficult to define.

Holohan (2019) analyzed the key challenges to peacekeeping training with regard to soft skills as related to the need for nuanced cultural awareness training, training in communication with populations, and enhancement of associations with gender topics. Experts need a set of skills that is effective in their roles, including more integrated skills, including characteristic qualities and traits of leadership, adaptability, creativity, trust, and teamwork. Holohan (2019) considered the diversity among peacebuilding experts in terms of organizations, gender, and culture to make cooperation and communication challenging. European peacebuilding training aims to tackle the greater part of the training

gap (Taitto, 2017), but Holohan (2019) argued that current training does not put enough effort into training critical skills in relation to communication, cultural awareness, and cooperation.

McCready et al. (2017) mapped the communication and cooperation skills for civilian, police, and military personnel onto performance criteria from standards and relevant knowledge, as well as understanding of the standards. Soft skills have been considered to include everything from nonverbal skills to communication skills, or from empathy and noncognitive skills to emotional skills, definitions are continuously contested in the literature (Hyttinen & Smith, 2019). Cimatti (2016) analyzed soft skills from the perspective of technology, processing, and engineering as transversal competences, including communication and language capability, social aptitudes, the ability to work in a team, and other personality traits that characterize relationships between people. Tadimeti (2014, p. 1) defined soft skills as "the non-technical skills, abilities and traits that one needs to function in a specific employment environment. They include various sets of workplace competencies: problem-solving, cognitive skills, oral communication skills, personal qualities, work ethics, interpersonal and teamwork." In addition, a study by Szilárd et al. (2018) argued for the need for skills such as innovation, problem-solving, creativity, and a learning mindset to be further improved among information and communication technology (ICT) professionals to support solutions to hiring challenges.

According to the theory of communication skills, media literacy skills play a vital role in handling and transforming knowledge. Beyond basic communication, the conflict area often requires the ability to engage meaningfully with the media in its various forms and to critically evaluate literacy content in various media forms (UNESCO, 2017). Notably, skills that are not only technical have an inherent personal import, as well as a more general outward function of engaging with others. Goleman (1998) recognized five components of demonstrating emotional intelligence (such as the ability to work with others and effectiveness in leading change) at work—self-regulation, self-awareness, empathy, motivation, and social skills. With social skills being those necessary for effectively bringing about change and expertly building and leading teams. Decision-making is seen as a dynamic process in which the interaction with the task environment contains limited information and uncertainty (Cooker et al., 2018). Conflict resolution and negotiation skills as key interpersonal competencies include conflict management, problem-solving, and compromising. The ability to solve interpersonal conflicts as an important competence may also influence individual well-being in work environments and teams (Klein, 2009).

The same digital transformation described in earlier chapters has led organizations to rapidly accelerate their digital business transformation (Campfield, 2021). Interest in cybersecurity expertise is increasing with the increase in incidents of cybercrimes and security breaches (Sohime et al., 2020). The elements of cybersecurity include aspects from information security,

network security, business continuity planning, disaster recovery, and training to security expertise and cloud security (Campfield, 2021). Traditional information security mainly focuses on the protection of information sources and the roles of humans in the security processes, while cybersecurity also sees humans as potential targets of cyber-attacks or participants in a cyberattack (von Solms & van Niekerk, 2013). Several reviews of cybersecurity might be completed under the classified domain, since CR work has been covered and funded strongly by the US military (Davis & Magrath, 2013). In information technology, technology and systems development have been the research focus (Hershberger, 2014), but human behavior plays a vital role in many cybersecurity incidents (Taylor-Jackson et al., 2021). Cybersecurity skills are seen as essential for businesses across all levels of the leadership and workforce (Adams & Makramalla, 2015) because the market does not have enough professionals with the required skill set (Cobb, 2018). Furnell and Bishop (2020, p. 6) argued that "understanding and recognising the knowledge, skills and abilities required to deliver cyber security is a blurry area."

Nevertheless, the established key cybersecurity skills-related frameworks, such as an international standard, are used as starting points by academic, industry, and professional communities (Furnell & Bishop, 2020). The necessary technical skills include the capability of choosing security settings for software or devices, setting up firewalls, setting up antivirus protection for security architecture, carrying out engineering, carrying out penetration testing, and using tools to monitor user activity. As for peacebuilding expertise, which is also within the cybersecurity domain, nontechnical or soft skills are prioritized over technical skills (Pedley et al., 2020). The domain lacks empirical results regarding teamwork, cognitive aptitudes, and communication skills relevant among cybersecurity professionals. Often, the focus in cybersecurity studies with regard to skills has been on dealing with cybersecurity skill gaps instead of on the actual relevant skills (Taylor-Jackson et al., 2021). To gain relevant cybersecurity skills, professional certification, role-based certification, and technology-specific certification are required beyond theoretical or general academic education (Furnell, 2021).

2.2 Modern Learning Environments (MLEs)

> Distance education holds greater promise and is subject to more suspicion than any other instructional mode in the 21st century. (Casey, 2008, p. 45)

Beyond traditional formal learning environments such as classrooms, learning may occur at a distance in digital environments and with the use of technologies. MLEs include LMSs, massive online open courses, applications, websites, social media, games, or simulations. Educational technologies were one of the key research areas in distance education studies between the years 2010 and 2015 (Bozkurt et al., 2015). In this research, the term *modern learning environment (MLE)*

aims to combine the current modern digital and technological solutions that are used for learning and skills acquisition purposes in training and education. MLEs provide a variety of opportunities to organize and facilitate teaching and utilize learning activities or cooperation in many different ways.

Emerging digital possibilities have enabled the rise of e-learning and information distribution around the globe (Zhang et al., 2004). Digital learning opportunities have become popular worldwide after the appearance of flexible access to content anywhere and anytime (IECEU-project, 2016b). The original term *distance learning* has evolved toward web-based learning, online learning, virtual learning, e-learning, and mediated learning (Conrad, 2002). Computers made the delivery of education possible, and the material was able to be delivered both in print and electronically (Moore, 1990; Moore et al., 2010). E-learning has been defined as "the use of information and computer technologies to create learning experiences" (Horton, 2006, p. 1). While e-learning is often described according to the use of a computer as a media-rich environment and is collaborative and more formal, mobile learning (m-learning) is defined as the use of mobile devices and is connected, networked, and informal (Laouris & Eteokleous, 2005). The evolution from e-learning into a wireless form and a new stage of distance learning has been described as the natural development of m-learning (Mostakhdemin-Hosseini & Tuimala, 2005). In the European countries, smartphones and tablets are considered to be important tools in the field of education (Eimeren & Frees, 2012). Often, both e-learning and m-learning are described as the practice in which learning is supported by a digital electronic tool (Pinkwart et al., 2003), device (Turunen, Syvänen & Ahonen, 2003), or technology (Traxler, 2005).

LMSs are technologies for sharing and engaging with digital resources and places for social interactions (Watson & Watson, 2007). A robust LMS includes tools for surveillance and evaluation of performance, and therefore also enables management to measure the impact, effectiveness, and overall costs (Ellis, 2009). LMSs are, in practice, online library spaces, including relevant documentation. Practitioners have pointed out that traditional methods of e-learning should move beyond the use of LMSs (Dalsgaard, 2006; Sevillano-García & Vázquez-Cano, 2015), and that learning components should be combined or blended, including face-to-face instruction, in order to provide more learning outcomes (Means et al., 2009). Substantive literature and research have been overwhelmingly in favor of gaming as an educational tool (Pivec & Dziabenko, 2004). Even though it has been argued that flexible media options for digital environments are not currently fully taken advantage of in e-learning contexts (Clark & Mayer, 2016), it has been suggested that collaborative learning tools can be used from both a cognitive constructivist and social constructivist perspective (Bonk & Cunningham, 1998). Empirical studies show that students more engaged in collaborative learning, for instance by interaction with teachers and peers, in using online social media have performed better in academic studies (Ansari & Khan, 2020).

Digital resources have changed from a library space into an environment for users to engage with digital knowledge (Bennett, 2009). In comparison, distance education and training have been defined as a form of telecommunication or an electronic device for instructional interaction between learners and teachers (Bruder, 1989). In some cases, online education is following the trend of using teaching technologies dating back to the 1950s (Kara & Sevim, 2013). The distance between actors increased with the development of the post office, radio, television, computer, satellite communications, and finally, the World Wide Web. Technological advancements began to provide enormous opportunities for academic, educational, and training institutions to meet learners' needs with a combination of web-based, online, and face-to-face instruction (Casey, 2008). Learners also expect more digital technologies to be employed as teaching and learning tools (Glover, 2013).

The dominance of the digital sector and innovative technologies in the 21st century has led to the phenomenon of incorporating modern technologies and big data into learning (Huda et al., 2018; Hyttinen, 2017; Wafta & Audi, 2015). For example, the training and education sector has increased the use of AR/VR and serious learning games (Mangina, 2017; Papadopoulou, 2019; Reynolds, 2020). While games are often associated with spare-time activities and entertainment, educators and trainers have looked at games as tools to support the achievement of particular learning objectives. Particularly serious games have been designed for educational and training purposes (Kapp, 2012; Ulicsak & Wright, 2010). Recently, AR and VR technologies and solutions have been widely applied in training and education (Huang et al., 2021). AR can enhance users' visualization of real life with virtual objects (Radu, 2014), whereas VR provides a virtual environment through visual simulations (Chang et al., 2020). AR game simulations immerse the player in the game, and immersion in the decision-making process of the game requires the player to learn the consequences of their decisions, and thus to be part of an active learning process (Kraiger, 2014). VR can display kinetic effects, which means that the image of real objects change according to motions performed by the user (Sutherland, 1968).

MLEs in cybersecurity are commonly understood as part of Cyber Ranges (CRs) (Ferguson, Tall & Olsen, 2014; Tam, Moara-Nkwe, & Jones, 2020; Ukwandu et al., 2020). CRs can address learning objectives, exercises (e.g., network forensics), social engineering, reverse engineering, and penetration testing and learning as self-directed or problem based (Raybourn et al., 2018). Game theories and simulation methods are acknowledged in CRs (Wang 2010). The purpose of CRs varies from identifying critical processes, running threat scenarios, and developing cyber experts' skills to testing organizations' environments. Simulations of the real world are augmented in CRs, including capabilities such as data traffic generation and capture, network environment, incident response, penetration testing, thread injection, patch levels, and network services to testing, interoperability assessment of devices, and applications. The augmented operations model responds to threat scenarios, using platform-based security tools, simulations of real applications, continuous updating, and upgradation.

CR can also implement mission refinement capabilities with the use of tools, techniques, and procedures, as well as electronic warfare, tests, and rehearsal (Priyadarshini, 2018).

2.2.1 Tehnology Design

The design and development of MLEs, games, or simulations is still a time-consuming and difficult process, which includes developing efforts, interactive experiences, interactions, details, quality graphics, and journey content (Knapp, 2012). Modern technologies enable new ways of narrating content (Hyttinen, 2017) and creating stories (Alexander, 2017), and developers attempt to augment the illusion of a virtual reality or world for the players or users through an immersive experience (Zyda, 2005). The understanding of physical and observational experiences is relevant when digital environments are developed and designed for learning (see for example Cross et al., 2009).

Everyday objects, such as office machines and light switches, are easy to interpret and understand when they are well designed (Norman, 2000). The first idea of Newell & Simon (1956), that computation could support humans by intelligent behavior, led to the idea that computers and their programs could stand as formal models of human cognition (Feltovich, Prietula, & Ericsson, 2006). In general, we aim to understand imitated systems in a variety of simulated environments. The relationship of program to environment opened up the role of computer simulation as a tool for understanding human behavior (Simon, 1996).

Cognitive science is more than simply meaning making and information processing, and cognitive processes are run in computational programs by realistically simulating the success of one's effort to understand, say, memorize, and attain a concept (Bruner, 1990). In addition, cognitive studies have shown the effect of perception speeds on performance level, and various forms of information (e.g., visual) are represented in a temporary memory store (Newell & Bröder, 2008). In cognitive automation or technologies, autonomous systems, robotics, and AI, the role of human intelligence, including mind and thinking, is seen as important. Empirical studies of human processing in intelligent thinking enable us to determine the best models of human thinking when programming intellectual machines (Saariluoma et al., 2019).

In the 1960s, the theoretical concept of mental representation to describe information as memories, thoughts, precepts, ideas, motor movements, emotions, and desires was accepted by modern psychology as an analytical concept (Saariluoma & Jokinen, 2014). The achievements of psychological research on the human mind should be applied in technology design practices to analyze and solve design challenges (Saariluoma, 2004). The analytical concept of mental representation contains a layer of cognitive sensory and memory information, as well as a layer of emotional and dynamic information. Mental representations have conscious and subconscious parts, and humans can explicitly describe certain actions, although it may not be possible to describe the emotional dimensions immediately after experience (Saariluoma & Jokinen, 2014). Myllylä

& Saariluoma (2022) argues that our perceptual and emotional systems provide immediate information based on our perceptual experience on the objects. After immediate information, our conceptual and memory systems enrich perceptual representations.

Schmidt et al. (2017) argued that the user-centered design approach, by connecting the principles of design theories and processes of learning design, "can help ensure that digital environments for learning are constructed in ways that best support learners' achievement of their learning goals." The overall purpose of human-centered design is to make technology, applications, or systems easy to use (ISO, 1999). The shift in focus from a technology-centered to a human-centered design approach creates technologies relevant to the learning objectives (Persson, 2017). These technologies are not designed merely according to the designer's own creative process, but are co-designed with people (Giacomin, 2014). The importance of developing an understanding of the users through close personal contact is recognized by different scholars (Lewis & Rieman, 1993). In human-centered design, the person is at the center of the design process in order to improve human engagement and human satisfaction and to make the product or service better. As McGonigal (2011) pointed out, experts and researchers from different disciplines work together in design processes. In human-centered design, people's needs, desires, and experiences are listened to. Saariluoma et al. (2016) discussed motivation as being relevant in explaining the use of technologies by humans, but, as previously described, there are also empirical findings on the importance of motivation in learning (see Section 2.1).

The goals of design are defined as the improvement of the quality of human life (Leikas, 2009) or the improvement of the work life of people who work with computerized systems (Clement, 1994). Actors and end-users are seen as relevant parts of the designing process because the designer cannot understand a certain form of life without immediate contact with representatives of that form (Clement, 1994; Leikas, 2009; Lowyck & Pöysä, 2001). This means that the engagement of end-users is essential for making the human–technology interaction (HTI) work toward its desired purpose. Torvinen and Ulkiniemi (2016) stated that there is a lack of proper tools for end-user engagement. They found that, even though engaging users might not have led to new innovative solutions, it increased user satisfaction. In the design of technologies, systems, or robotics, human and animal cognitive processes have been a source of imitation and mimicking (Kujala & Saariluoma, 2018).

Saariluoma et al. (2019) pointed out that explicating tacit or subconscious knowledge is a problem or challenge in mimetics. As a solution, tacit and subconscious knowledge could be explicated with the use of ontologies as a framework, for example, to describe thinking (Saariluoma et al., 2016; Saariluoma et al., 2019). Not only in design practices has narrating been a powerful human invention (Bruner, 1986) that involves experiences or perspectives for a purpose and in relation to a specific environment (Dauite, 2014). In crisis situations, narrating has served a therapeutic function (Drožđek et al., 2020), and in education and training, narrating can include socioemotional and cognitive

processes (Siller & Waibel, 2018). As crisis situations practices and education practices show, narrating and storytelling can be used as problem-solving activities to define and analyze experiences and reflections from specific situations (Dauite, 2020).

2.2.2 Human Technology Interaction

The use of technology has increased the interaction between humans and technology in learning activities. User psychological research aims to explain the interaction between people and technology (Saariluoma, 2004), and a full realization of user experience should be based on these psychological concepts and theories (Saariluoma, 2014). The commonly known theory of research on human–computer interaction (HCI) posits the importance of understanding and studying the interaction between humans and technology (Aaltola, 2021). Since digital computing began in the 1940s, HCI has been an issue to study (Fritsch, 2019). Jounghyun (2015) defines the goals of HCI as functional completeness, high usability, aesthetic appeal, and compelling user experience. HCI aims to enhance the quality of interaction between humans and computers, and as a design discipline, it applies knowledge about the purposes, capabilities, and limitations of both humans and machines (Norman, 2000).

The extended concept of HCI is described as human–technology interaction (HTI) (Dix, 2017). HTI research aims to support the design and development of usable technology for humans, especially in improving the quality of people's everyday lives (Saariluoma et al., 2016). HTI, in its broadest sense, covers forms of interaction between human and technical interfaces and includes all roles in the design process. The most emphasized aspect of HTI has been that difficult-to-use technology is easily rejected, and whether or not people find it easy to use the designed products and systems (Saariluoma et al., 2016), people should know how to use them (Leikas, 2009). The early focus of HTI has been how to design interaction and implement interfaces for high usability; it has been used for specific user communities (Hyttinen, 2017).

HTI's objective to better understand users' interactions with new interfaces can also allow for enhanced human performance with technology. For example, the analysis of variances in typing and motor performance in text entry allows for the prediction of search times and the design of visual patterns (Jokinen et al., 2017), and studying personality traits can reflect inter-individual differences in the interaction (Attig, Wessel, & Franke, 2017). Recently, researchers have shown growing interest in emotions as a crucial part of information processing and explaining people's behavior, which has influenced the need to understand emotions as a fundamental part of HTI (Saariluoma, 2020). Emotions play a crucial role in human thinking; therefore, their position in problem-solving, decision-making, and learning is critical (Kahneman et al., 2011). Often, technology designers focus on intuition and trust their own thinking and feelings instead of scientific objective research into user emotion (Saariluoma & Jokinen, 2014; Saariluoma & Maarttola, 2003).

MLEs, in particular, provide a platform for user experience that is interactive and fun while also contributing to learning or skills development. The learning experiences of humans in interaction with digital learning technology, when applied in appropriate ways, have been shown to enable positive learning experiences and improve learning outcomes (Carlson, 2013). The rise of interaction practices extends to representations of social systems and includes interactions between humans and technology in skills and knowledge acquisition. Formal learning practices are dedicated in MLEs, and informal learning takes place through social media and chat platforms (Szil'rd et al., 2018). They have been argued to mainly follow behaviorist and cognitivist theories of learning (Wilkinson, 2016).

The human ability to recognize information is sensitive to the way in which information is presented to the senses or to the memory (Larkin & Simon, 1987). Certain relevant facts about cognitive processing were outlined by Newell and Börder (2008) that the distinction between controlled and autonomous processing where the memory plays a role in capacity limitation, interaction, the ability to learn, the translation of cause-effect learning to the development of categorization and the regulation of cognition. Emerging technologies have several ways to enhance HTI and immersion (Martín-Gutiérrez et al., 2017). Recent technological developments have integrated technology into the human body. Integrating the human body and including human personal spaces to improve user experiences can extend to sensory, cognitive, and motor functions (Ihde, 1990).

The "reality-virtuality continuum," a term coined by Milgram and Kishino (1994), aims to describe the connections between humans in different realities. The real environment encompasses actual reality, and it also includes direct or indirect views of real scenes, such as through video displays. VR is computer generated, and real objects do not exist in VR. Users in VR interact through technological interfaces online. VR users can navigate and interact in real-time simulations using their own senses (Guttentag, 2010). In addition to this approach to a reality–virtuality continuum, an extended approach to realities has been defined as an independent dimension called "pure mixed reality" (PMR). In PMR, users interact simultaneously with both reality and virtual objects (Flavián et al., 2019). The continuum in different realities provides factors for humans to interact in the physical and virtual worlds.

Notably, establishing these factors can be expensive and not cost-effective, and it can also be time-consuming (Knapp, 2012). When this kind of technological embodiment increases, the technology becomes part of human actions, which also changes the HTI processes. The boundaries of digital realities raise interest in the knowledge area of the processes between humans and technologies, actions and interactions. Experiments on expert and simulation performance can be utilized for MLE design. Interestingly, fourth-year medical students who treated virtual patients successfully in a simulation game environment reported a higher level of self-efficiency and experienced less stress than students who were less successful in the game (Dankbaar et al., 2017).

In terms of designing interactions between humans and MLEs around learning experiences, Simon (1980) challenged us to focus on understanding how much and what kind of transfer of knowledge and skills we are expecting from the specific learning contents instead of being too optimistic in predicting students' specific future needs for knowledge and skills. Psychological views on learning as active highlight the idea that problem-oriented learning that focuses on acquiring knowledge in meaningful and real-life situations supports the effective transfer of knowledge to real-life situations (Mandl, Gräsel, & Fischer, 2000). Bonk and Cunningham (1998) argued that MLEs and tools support methods' application of methods from both a cognitive constructivist and social constructivist perspective. Several empirical studies have been eager to find proof of learning outcomes through the implementation of constructivist and cognitive methods. Therefore, the learning outcome needs to be SMART (specific, measurable, achievable, realistic, and time-based) and thus, the outcomes are defined in a constructive alignment process, where learning outcomes are defined using measurable results (Lawlor & Hornyak, 2012).

Immersive and affective content

The influence and potential of immersive content and virtual simulations for perceiving and skills acquisition, such as leadership or communication, in these learning environments have become an interest to study (Mantovani & Castelnuovo, 2003). In addition, the use of the full potential of MLEs in education and training is limited, even as immersive and visual experiences have become a new trend in other fields (Aaltola, 2020). This is because, in spite of the presented benefits that digital tools can provide to various training, they are not a substitute for face-to-face methods, but rather complement them by increasing constant interaction (Friedrich, 2013).

MLEs for training and education mainly include affective and immersive learning content that is perceived audio-visually. New media, immersive or affective content, and learning technology resources are based on principles of mobility, accessibility, collaboration, and active user participation. Ubiquity and mobility have become recurrent principles of educational performance in this century. (Sevillano-García & Vázquez-Cano, 2015). Learning games, animations, simulations, and communication technologies and applications have the potential to be important learning tools because they provide audiovisual content with problem-solving features, and they are learner-centered, interactive, and engaging and involve immersive activities (Teschner, 2016).

Surrounding users with AR or VR technologies with devices and sensors is often used to create immersion (Wu, Lui, Wang & Zhao, 2015). AR modifies users' real-life actual surroundings with virtual elements, such as live, direct, or indirect computer-generated input, such as videos, images, virtual, and other immersive items (Chavan, 2014). The merits of incorporating VR and AR design widely are that they can be used for solving real-world challenges, from societal problems to specific issues of conflict or climate change (McGonigal, 2011). AR technology allows interaction between a user and the real world, and it generates virtual or augmented information (Carrera, Perez & Cantero, 2018). Augmentation of the

real environment as perceived by the human senses, such as hearing, vision, feeling, and smell, is often enhanced with additional virtual information produced by suitable devices (Bimber & Raskar, 2005).

The rapid progression of computing capacities and graphic design has increased sophisticated visualizations (Betrancourt, 2005) beyond static graphics or written information. Perceptual and cognitive processes are involved when visual animations are observed (Schnotz & Lowe, 2003). From a learning perspective, animations can support the understanding and memorization of a phenomenon, but the benefits of animations may appear more clearly when the domain is abstract (Betrancourt, 2005). Within the peacebuilding domain, a real-life-based simulation of the conflict was used for a cross-cultural experimental design to assess whether participants can increase knowledge about a conflict and develop perspective-taking so as to learn about conflict and negotiations (Cuhadar & Kampf, 2014).

Simulations aimed at immersing the player in the game and the decision-making process require the player to understand the consequences of their decisions, and thus to feel like a part of an active process (Kraiger, 2014). Games are especially valuable, since they make it easy to communicate complex ideas in an accessible way to different audiences (Sou, 2018). Several approaches to e-learning exist, and despite the variation in online methods and measures that evaluate "success" in Internet-based instruction, commentators argue that e-learning has been shown to be as effective as more traditional teaching methods (Cook et al., 2008).

2.2.3 Technology Integration to Training and Education

From 2010 onwards, it has been recognized that a rapid shift in education is taking place from traditional classrooms to online and virtual environments (Allen & Seaman, 2010; Lindgren & Johnson-Glenberg, 2013). The paradigm shift in education to distance learning and teaching (Bozkurt et al., 2015), increase of online enrollment (Allen & Seaman, 2008), new pedagogical theories, and models such as blended learning (Means et al., 2009) have increased interest in studying models for integrating technology in a meaningful way. Moreover, there have been several challenges in integrating technologies into higher education and training activities.

The term *integration* in this dissertation is seen as a perspective for institutionalizing and facilitating crucial parts of training and education strategies and practices. The increased need for efficient technology integration in the field of training and education requires knowledge of subject content, pedagogy, and technology, as well as of their relationship with each other (Koehler, Mishra, & Yahya, 2007). The societal role of higher education has highlighted the necessity of connections and relationships with work life, companies, and industry. Educational and training institutes still vary greatly in their successful integration of relevant aspects, such as learning approaches, work life needs, industry, research, and partnerships, or networks for learning and teaching practices.

Technology cannot be seen as an optional aspect of or skill for training or educational professionals upon entering a teaching situation (US Department of Education, 2017). Even with the user-centric opportunities that technology can provide, researchers have seen the integration of technologies to support collaborative learning environments as a challenge (Zheng, 2014). The process of human-centered design does not yet guarantee the successful implementation of developed technologies into training curriculums and practices. The practices and design of MLEs can be based on learning objectives, target audience, access, and type of content (Moore & Dickson-Deane, 2011). The integration perspective for MLEs could be framed as student-centered, knowledge-centered, assessment-centered, and community-centered (Lowyck & Pöysä, 2001). Findings from age-related performance differences must be considered in the design of learning technologies for all. For example, researchers have shown that older adults rely more on visual control when acquiring and performing precision locomotor tasks (e.g., Van Hedel & Dietz, 2004).

As an example of integration in education, work-life sectors have influenced the education policies that encourage work-life-based strategies and relations between relevant actors (Hyttinen, 2014; Neuvonen-Rauhala, 2009). The integration of well-structured work-life connections is seen as crucial in order for students to be successfully employed after higher education studies (Kirjalainen, 2010). Currently, universities have many stakeholders and partnerships (Jongbloed, Enders, & Salerno, 2008), but Siegel et al. (2003) found that academics have a low level of interest in dealing with private sector companies and poor knowledge of technology processes. The practice of integrating expertise from different fields, such as external professionals into course implementations or recruitment of them for higher education teaching positions, has been identified as an activity in Finland that increases the fulfilment of work-life needs (Hyttinen, Hohenthal, & Gäddnas, 2011). Students' participation in projects is also seen as relevant for achieving advanced group participation results and impacting dissemination of international research, development, and innovation (RDI) projects. (Pirinen, 2008, 2015, 2018). Network-based RDI projects are envisioned according to the conceptual understanding of public participation, in which people with diverse personal and common interests become a community and must work together collectively to solve joint challenges or problems (Webler, Kastenholz, &Renn, 1995).

The challenges of successfully integrating technology into education and training are categorized as internal or external barriers. Internal barriers, such as trainers' or educators' personal understanding, beliefs, and perceptions associated with technology use, may cause a lack of user confidence. External barriers include the changing nature of technology, lack of technological support, or inadequate professional development. Reforming teacher education and professional development could be the answer to how to integrate technology into education. Teachers must be offered support and given opportunities to create student-centered learning. The best integration happens when pre-service teachers are exposed to technologies during their practicums, which allows them

to build confidence in using technology in education before they become "real" teachers. (Ryan & Bagley, 2015).

An important observation raised by the studies is that technology inclusion does not automatically improve pedagogy (Nelson & Hawk, 2020). Consequently, when considering learning with the use of MLEs, we automatically face pedagogical planning questions. Individual instructors or teachers may teach in ways that reflect their own learning styles, and therefore, teachers should encourage learners to use pedagogical learning principles, such as Kolb's learning stages of experiential learning (Healey & Jenkins, 2000). Scholars have developed pedagogical and theoretical models for improving the integration of digital learning technologies into education and training (Hew & Bush, 2007; Keillor & Littlefield, 2012; Mishra & Koeher, 2006). Different models can help explain technology usage in educational environments, but they are argued to be too limited in number to guide the decision-making process or achieve the organizational effectiveness of technology integration (Karaca et al., 2013). In the field of cybersecurity, it has been recognized that training programs often fail to fully address the psychological components of cybersecurity itself (Taylor-Jackson et al., 2021).

Statistical analysis has found that integration is more successful after principals receive training on technology integration (Dawson & Rakes, 2003). There are a number of aspects that can affect the successful integration of technology within the education and training domains. For example, technical aspects, such as user interface design and transparency, have influenced the adoption rate of a technology (Charalambos et al., 2004), but the value beliefs of teachers have also influenced their intentions to integrate technology (Nelson & Hawk, 2020). The instructional pedagogy discussion from 2010 onwards has concluded that ideally, online learning components should ensure the use of blended methods to achieve learning outcomes (Means et al., 2009). Nevertheless, the level of technologies integrated into training and education is still lower than those integrated into the commercial game industry.

2.2.4 Effects of MLE usage in learning

The effects of MLEs are interesting from several standpoints. Emerging technologies make education and training more accessible, and even students with disabilities can join virtual environments (Lange et al., 2010) as well as communities with access to the Internet. According to Nitecki and Simpson (2016), academic libraries should not be seen and communicated only as knowledge-gathering spaces, but also as informal learning environments to help students connect with their existing knowledge and new knowledge resources, as well as for social interactions. Web tools can support pedagogies and can be used effectively to provide structured guidance through tasks and through the provision of effective and timely feedback. (Conole & Alevizou, 2010). Research has also acknowledged that there is a "large diversity in the way that experimental research on digital games-based learning effectiveness assessment

is conducted, making comparison of results across studies difficult" (All, Castellar, & Looy, 2016, p. 91).

Even with the increased interest in the use of technologies in education and training, Bacca et al. (2014) completed a systematic literature review and found that there was, for example, no research evidence regarding the use of AR in master- or doctoral-level education between 2003 and 2013. The upsurge in interest in MLEs has not led to convincing evidence for conclusions about the role and effects of technologies in learning activities. In general, "interest has been speculative, discussing the potential to provide new methods for supporting learning" (Boyle et al., 2016, p. 178). Xu and Jaggars (2013) provided evidence that an online format in courses had a significantly negative impact on course grades and course persistence.

Nevertheless, the potential advantages of modern technologies, such as serious games and simulations, appear numerous. Studies have shown that using technology for skills acquisition and learning can increase motivation and provide positive and meaningful experiences (Costley, 2014; Hyttinen & Taitto, 2019; Vlachopoulos & Makri, 2017). Academic educational studies have shown that digital games are considered effective for motivating and engaging students (Boeker et al., 2013; de Freitas, 2006; Kirriemuir & McFarlane, 2004; Mitchell & Savill-Smith, 2004) and providing new kinds of learning environments. Learning games also offer an excellent opportunity to promote learning, for example, among people who have to cope with changes in their job work life and social responsibilities (Buendía-García, 2013).

Expertise research has noted that an account of the environmental circumstances (such as the duration and structure of activities) and the necessarily minimal biological attributes can lead to the acquisition of desired characteristics, skills, and performance (Ericsson, Krampe, & Tesch-Romer, 1993). Several methods and approaches have been established for the use of simulation, especially for medical and piloting training, that were developed to take advantage of cognitive science in developing effective training. An expert model proposed by Staszewski and Davison (2000) uses empirical evidence to determine how an expert performs a particular task and uses that evidence for the further development of the simulation. Positive research findings about skills acquisition in simulated environments have increased the use of simulation in clinical learning environments, such that perceptual-motor skills and domain-specific knowledge can be acquired in unison rather than in isolation (Colt et al., 2001; Ward et al., 2006).

A study conducted by the University of Colorado Denver Business School (2010) reported that workers gained a greater skill level and higher retention of knowledge with the use of online simulation than with formal classroom or web-based tutorials. Empirical studies have shown that immersive learning tools, such as games or simulations, enable positive experiences in which scenarios resembled real-life practice (Morley, Bettles, & Derham, 2018), and that the level of interactivity between learners, content, and instructor in the learning environment drives learning (Knapp, 2012). The more the learner interacts and

collaborates with others, the content, and the instructor, the more likely it is that learning will occur (Knapp, 2012). VR solutions simulate the physical presence of the user in a virtual environment, and these experiences are categorized as cognitive, sensory-motoric, or emotional (Björk & Holopainen, 2004). There is also evidence of potential negative impacts of immersive content. For example, one case shows that VR gameplay elicits strong negative emotional responses and could be harmful to users (Lavoie, Main, & King, 2021).

The increase of affective and immersive experiences through technology extends human perception and can affect motor and sense perceptual skills (Flavián et al., 2019; Tussyadiah et al., 2017), and emotional events are remembered best (Linton, 1982). Perception gives emerging technologies several ways to enhance HTI and immersion (Martín-Gutiérrez et al., 2017) as well as information processing and memory, thought, and emotional learning processes (Saariluoma, 2020). During the perception process, people select information to build memory representations (Saariluoma, 2020). Earlier research results have especially corroborated the benefits of MLEs for motivating students and improving their learning performance in a digital context (Di Serio et al., 2013; Liu & Chu, 2010).

The attractiveness of MLEs can also have more negative side effects. The latest research has begun to empirically investigate how the multiple media streams on the Internet affect our cognitive development and brain function. Multiple incoming media streams affect our attention, memory, knowledge, and social cognition (Firth et al., 2019). Situational awareness in CRs is seen as relevant in describing, measuring, and predicting human performance. It includes situation recognition (e.g., perception of the type of cyberattack, source of the attack, target of the attack), situation comprehension (e.g., understanding why and how the situation is caused and its impacts), and situation projection (the expectations of future locations and impacts) (Jajodia et al., 2010; Tadda et al., 2006).

Learning technologies are seen to support associative pedagogies and, when used effectively, provide structured guidance for tasks and effective and timely feedback (Conole & Alevizou, 2010). Learning technologies have raised the potential to model and teach complex cognitive competences in an engaging way (Dankbaar et al., 2017), and they provide practical and functional methods to train and educate meaningfully (Aaltola, 2021). For example, in peacebuilding, games can be used as problem-solving spaces and as exercises to better understand complex problems (Brynen & Milante, 2012). Farrell (2005) found that a simulation game in an international business course was a highly beneficial learning tool compared to traditional teaching methods (e.g., textbooks and cases).

Empirical studies have shown that the use of MLEs generates excitement and motivation by providing visual expressions (Dunleavy et al., 2009; O'Shea et al., 2011; Solak & Cakir, 2015; Vargas et al., 2020). De Freitas (2014) addressed the potential of immersive experiences for memory and learning: "Learning in the immersive worlds presents us with the ability to remember learning experiences

for longer, engaging and motivating us as learners." Kabil et al. (2018) argued that the use of cyber virtual environments raises situational awareness, and Piskozub et al. (2017) found that VR simulations can simulate and augment decision-makers' understanding of cyber-physical situational awareness. In addition, case studies have shown the effects of immersive and affective content that is integrated into training and education to enhance motivation and commitment (Di Serio et al., 2013; Harris & Reid, 2005; Kerawalla et al., 2006; Martin-Gutierrez et al., 2010). The International Committee of the Red Cross has worked with video game developers and concluded that "games can be an important avenue towards disseminating knowledge and awareness of international humanitarian law (IHL) and humanitarianism" (Mishori, Kureshi, & Fedowsian, 2017). There is proof that MLEs can enable positive learning experiences and improve learning outcomes (Carlson, 2013). The impacts and effects have been studied by researchers, and "The majority of studies discuss the beneficial impact of game-based learning (GBL) activities on knowledge acquisition and conceptual understanding, revealing positive cognitive outcomes in promoting knowledge, concept learning and deeper content understanding" (Vlachopoulos & Makri, 2017).

There are enormous prospects when it comes to the appropriate and effective use of MLEs as part of the learning methods used to educate and train different levels of experts to gain skills to perform and work in real life. The International Committee of the Red Cross, for instance, has worked with video game developers and concluded that these technological devices can be important in disseminating knowledge and awareness of international humanitarian law (Mishori et al., 2017). In addition, humanitarian, security, and justice actors working in conflict response and resolution have also recognized that the changing global digital landscape and the rapidly evolving role of ICTs represent new and important opportunities for preventing, mitigating, and responding to conflict (Brown, 2018). At the same time, some researchers and practitioners in the education field have pointed out that traditional methods of e-learning should move beyond LMS (Dalsgaard, 2006) and that online learning components should be combined or blended, for example, to produce hybrid methods that include face-to-face instruction, in order to produce greater learning outcomes (Means et al., 2009).

The influence of learning technologies and the potential of immersive content and virtual simulations for skills acquisition, such as leadership or communication, in these learning environments have become an interest for research (Mantovani & Castelnuovo, 2003). Immersive and affective content has shown its potential to influence human experiences and opportunities for reflection and adoption of knowledge in MLEs. Immersive features and devices are becoming an important part of training and education. Several studies (Philips et al., 2015; Šašinka et al., 2019) have shown the benefits of immersive content, such as an increase of motivation with regard to the learning environment and eagerness to gain even more realistic and comprehensive augmented visual experiences. The dynamics encompassing interactions

between humans and technology, and the combination of the different perspectives of designers, teachers, and users in concrete MLE design are valuable for creating meaningful impacts (Könings et al., 2010). Research results have especially corroborated the benefits of immersive and attractive learning content for motivating students and improving learning performances (Di Serio et al., 2013; Liu & Chu, 2010), but they can also offer an excellent opportunity to promote learning experiences (Buendía-García, 2013).

To be credible, perception in a virtual environment requires real-time interaction and feedback (Riva, 2006). Collaborative online learning methods allow students to engage with the subject matter and develop teamwork skills (Farrell, 2005).Radianti et al. (2020) drew categories of learning content from the literature by Anderson (1982) regarding the acquisition of cognitive skills and from the research by Crebert et al. (2004) regarding the development of generic skills. The categories of learning content in the use of VR are the following: 1) analytical and problem-solving, 2) communication, collaboration, soft skills, 3) procedural-practical knowledge, 4) declarative knowledge, 5) learning a language, and 6) behavioral impacts. According to their literature review findings, VR applications for higher education were most frequently used to teach procedural-practical knowledge (33%), declarative knowledge (25%), and analytical and problem-solving skills (12%). The other categories established based on the literature were collaboration, communication, and soft skills (10%), behavioral impact (6%), and learning a language (2%).

Expert performance studies, such as examinations by Doane et al. (2004) and Kasarskis et al. (2001), of simulation performance by pilots have shown the difference between expert and novice pilots' abilities, and experts were typically quicker, needed less time to extract relevant information, and were more sensitive to whether trials were consistent. Law et al. (2004) assessed expert surgeons' and novice students' perceptual-cognitive processes during performance in a simulated environment and found that experts pay different attention or perceptual strategies than novices, which enables their superior level of control. Several bodies of evidence have established that experts are better able to anticipate the consequences of the current situation, and that expertise is highly context-specific, especially with regard to particular aspects of the task (Ward et al., 2006).

The use of external sensors to capture users' movements in a VR environment provides a deeper immersive feeling (Martín-Gutiérrez, Mora, Añorbe & González-Marrero, 2017), but skill acquisition requires dependencies on perception, emotions, and movements in embodied cognitive processes (Aaltola, 2020). The theory of perception as a sensory outcome (Prinz, 1997) is important to address in the associative learning processes. The use of haptic bodysuits and headsets amplifies and mimics sensory feedback to match the visual scene in AR or VR environments. They ensure a feeling of being bodily present in bodily movement and provide responses to game events (Aaltola, 2020). Embodied self-representations in AR/VR provide an anchor for visual-motor tasks and can have behavioral implications (Borrego et al., 2019).

Reflection on the experiences can be facilitated with the use of socially constructive pedagogical methods (such as tasks, peer-to-peer discussions, or group discussions) in a classroom or informal learning environment. The use of these methods can inspire the students to create knowledge and to find the connections between abstraction or theory and practice (Aaltola, 2020). In addition, Rose and Church (1998) found that engaging in an actual performance and receiving feedback strongly affect learning behaviors and skills. According to them, proper practice, feedback, and reflection increase performance through high commitment, problem-solving, and metacognitive outcomes.

3 RESEARCH DESIGN AND METHODS

This chapter presents an overview of the research design and methods of the empirical research cases in this dissertation. More information about the empirical research can be found in the articles by the author, which present the different studies in detail.

3.1 Research Questions

The overarching assumption of this research is that MLEs provide technological support, especially in distance learning, for the acquisition of new skills and competences. In the context of using MLEs in the acquisition of skills, this dissertation aims to contribute to the research by studying the experiences of learners, current training practices, and the way in which technology is integrated into training and education. A consideration of cyber ranges (CRs) raised new thinking during the research process. The following main research questions were formulated to investigate approaches to the acquisition of skills and expertise using MLEs in training and education:

RQ1 What are the effects of MLEs on knowledge and skills acquisition in expertise development?

RQ2 How can MLEs be designed to ensure the acquisition of skills, and how can they be integrated meaningfully into training and education?

Subsequent research questions were as follows:

RQ3 What are the contents and capabilities of MLEs?

RQ4 How do experts experience the use of MLEs?

RQ5 How does the acquisition of skills happen in MLEs?

RQ6 How can MLEs and their immersive content be effectively designed?

3.2 Data collection methods

An inter- and multidisciplinary research spirit is fitting for studies on cognitive processes. The nexus between educational science, cognitive science, and the psychology of learning has led to research focusing on different stages of the acquisition of expertise (Hoffman & Gavan, 2006). The approach of researchers in this field has been explicitly one of eclecticism, as pointed out by cognitive scientists George Miller and Jerome Bruner, to negotiate ideas, words, and concepts about to negotiate ideas, words, and concepts in order to understand, in general, how people think (Cohen-Cole, 2007).

This dissertation utilized mixed research methods and included a selection of empirical methods in data collection, including in-depth semi-structured interviews, surveys, small group discussions, and observations in evaluation workshops. The analysis of the findings aimed to contribute to resolving the research challenge and problem and to provide in-depth knowledge from both the researcher's impressions and the respondents' experiences. Figure 1 shows the research approach utilized in this dissertation.

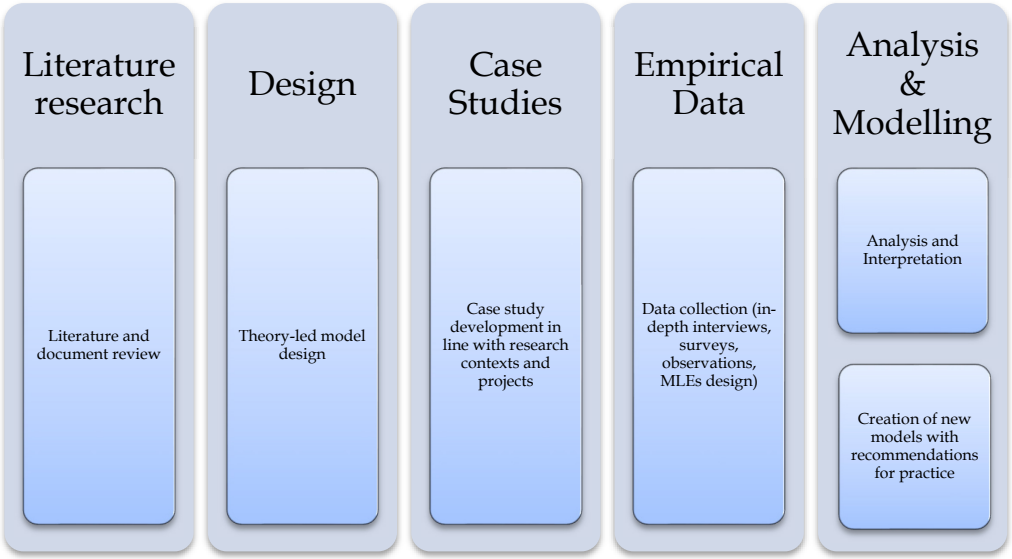

FIGURE 1 Research approach with methods

Mixed methods research is useful for comprehensively addressing the topic or process to be studied. Qualitative methods in psychology turned to intellectual language orientation to examine ways of talking and representing reality (Stainton-Rogers & Willig, 2017). Qualitative research methods are often inductive (Kaplan & Maxwell, 2005), and in this study, the hypothesis was developed while conducting the study and learning about the setting and people engaged in it. Patton (1999) identified the convergence of data from different sources and methods as a qualitative research strategy to test validity. He also established that studies have shown that using only one method can increase the

incidence of errors, but using multiple methods can provide data for cross-data validity checks. Combining complementary data can help researchers validate data; therefore, mixed research methods can be more comprehensive and can enrich the research results (Johnson & Onwuegbuzie, 2004).

Of the studies included in this dissertation that address the research questions presented in Section 3.1, the design studies provide insights from the design model perspective into RQ2 and RQ6, the interview study addresses RQ4 and RQ5, the learning application evaluation applies to RQ3, RQ5, and RQ6, and the learning game evaluation responds to RQ3, RQ5, and RQ1. Additionally, the studies presented only in this dissertation aim to contribute to RQ1, RQ2, RQ3, and RQ4. In Table 1, the study settings and relations are presented for clarification purposes.

TABLE 1 Study settings and their contribution to the research questions

Study	**Participants**	**Data collection**	**Contribution**
Design of Learning Application	Researchers, experts and private sector representatives	Survey, Observations, DSR, Model design during the process	RQ1–RQ6
Design of Learning Game	Researchers, experts and private sector representatives	Observations DSR and model design during the process Scenario creation Role-play design	RQ1–RQ6
Interviews	Peacebuilding experts	Semi-structured interviews	RQ2–RQ6
Learning Tool Evaluation workshop	The participants (n=62) were both men and women experts and with different professional backgrounds. educators, professors and trainers (n=5); end user or practitioner experts (n=14) higher education students (n=43)	Observations when users played with device (cell phone, iPad or laptop); Survey to describe user experiences; Semi-structured interviews to explore their thinking	RQ1–RQ4
Learning Game Evaluation workshops or sessions	The participants (n=65) attended the evaluations sessions, and 35% of the respondents were female. 29 of them represented police officers 27 of them represented military Nine (9) of them represented civilians.	Game playing observations; Survey responses before and after playing the game; Semi-structured interviews after playing the game	RQ1–RQ6
Cyber Ranges (CRs)	Experts (n=49) responding to survey about CRs' capabilities	Empirical data collection by survey (n=49) and observations	RQ2–RQ3

The empirical studies presented in this dissertation vary in their contextual domains, selected methods, and aims. The empirical studies included investigations in chronological order:

Literature and document review aimed to summarize existing information in a structured manner and make sense on the studied topics. According to Kitchenham (2004), "the systematic literature review is conducted in a three-step process including the following activities: identification of research, selection of primary studies, study quality assessment, data extraction and monitoring progress and data synthesis". The literature review in the studies in this dissertation focused on the identification and selection of primary research and studies.

Design Science Research (DSR) approach was followed in the theory-led design modeling work regarding MLEs: the learning application and the learning game. The study perspective focused on human-centered HTI principles during the design and development process. The DSR approach has been used for developing and evaluating internet technology (IT) artifacts in order to understand, explain, and improve them. Artifacts within DSR are constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (systems and services) (Hevner et al., 2004).

Semi-structured interview is a method for collecting in-depth information about people's experiences and opinions (McNamara, 1999). Qualitative research interviews are structured, semi-structured, lightly structured, or in-depth (Gill et al., 2008; Manson, 1994). Semi-structured interviews aim to shed light on actions, anticipations, metacognition, and action-deliberation, but also increase the reliability of the results. Semi-structured interviews take place within a specific context and have a key agenda, with some thematic questions, but also include open-ended questions. As these types of interviews are conducted only once per participant and with a duration of 30 minutes to over an hour (DiCicco-Bloom & Crabtree, 2006), the semi-structured interviews in this study were conducted individually with professionals, and the length of the interviews varied from an hour to an hour and half.

Surveys were conducted to collect data during the learning environment design processes in the evaluation sessions. A survey is an effective method of collecting information in a short time. The limitation of surveys often concerns the formulation of questions, which may lead to misunderstandings. It is beneficial to consider cognitive processes when designing survey questions (Gullickson, 1997). Moreover, the number of questions may influence the respondents may influence the depth of the responses. The first survey was conducted among users after they used the learning tool. It included multiple-choice and open-ended questions to capture the participants' opinions, attitudes, experiences, and knowledge. The survey focused on gathering first impressions and user experiences. Open-ended questions gave participants the opportunity to express their opinions freely. The second survey was conducted with regard to playing

an AR game in an evaluation workshop. The survey was provided in an online format. The aim of the survey was to collect players' thoughts before and after playing the game and to understand the differences in their thinking before and after playing the game. Closed questions with a Likert-style rating scale were used, in which participants were invited to express their level of agreement or disagreement with a statement (Albaum, 1997). The results were analyzed through quantitative and qualitative methods. In total, 65 participants attended the evaluations sessions, and 29 of them represented police officers, 27 of them represented military personnel, and nine of them represented civilians. Of the respondents, 35% were female.

Observations were made by the researchers while the experts were using the immersive learning tool and augmented learning game. Observations of the evaluation sessions provided valuable information about the embodiment and led to an analysis of the cognitive strengths and limitations of modern learning technologies. The researcher did not distract the users with questions during the observations of the activities but remained silent.

Semi-structured interviews were used to collect data about experiences in relation to domain-specific skills and their practice in the studied context and also to explore explanations of personal reason behind quantitative data, observed behaviors, and attitudes. This method was judged to be the most appropriate within this context to elaborate domain-specific soft skills and expertise, as well as depth of experience in training and in the use of MLEs.

There is no one accepted way to analyze collected data within the qualitative paradigm. Braun and Clarke (2013) argued that inter-rater reliability in a thematic analysis can only be ensured by the use of coders trained to code the data in the same way. The transcripts of the recorded semi-structured interviews (n = 29) were coded to identify the relevance of skills, experiences relating to expertise development, and actions taken in the context of the actual reality. In the analysis of the interviews on rich case studies in conflict and crisis settings, the coding helped the content to be categorized and placed the aspects and experiences on a timeline. All interviews were recorded, transcribed, and analyzed using content analysis methods. The analytical features of NVIVO software were used to analyze the transcript texts. Word frequency analysis was followed by manual thematic analysis. The interviews were further aligned in the research and development process as a basis for timelined and narration scenarios and role-playing and as typical decision-making procedures in AR game development.

The *triangulation* of different data (interviews, observations, and survey results) was selected as a method of analysis for interpreting the phenomena comprehensively. Triangulation as a method supports the development of an understanding of phenomena (Patton, 1999). The information collected in this dissertation comes from multiple sources and different times, and the additional findings are presented only in this dissertation in Section 4.1. Triangulation can increase the trustworthiness of an analysis when different perspectives are considered.

3.3 Research contexts

3.3.1 Improving the Effectiveness of Capabilities in EU conflict prevention

In 2015, the European Commission financed a project called the IECEU (Improving the Effectiveness of Capabilities in EU Conflict Prevention) of the EU Framework Programme for Research and Innovation HORIZON 2020. This project aimed to enhance conflict prevention capabilities by implementing comprehensive research and cooperation activities. The IECEU consortium (11 participants from seven different European countries) itself consisted of a diverse group of academic universities or research institutes and nongovernmental organizations, including both civilian and military organizations. The research of this project focused on answering several research questions over the three years of the project's implementation in collaboration with researchers. Studies were targeted toward civilian and military operations implemented under the EU Common Security and Defence Policy in different regional areas where the EU has carried out post-conflict, conflict prevention, and peacebuilding activities. The identification of best practices and the extraction of lessons allowed the written research to be more immersive and affective. One crucial part of IECEU was the development and design of the New Media based Learning Application (NMLA), which included research and evidence-based learning material. (Hyttinen et al., 2017a).

The regions selected in this research project were Kosovo, Bosnia and Herzegovina, Afghanistan, occupied Palestinian territories, Libya, the Central African Republic, South Sudan, and the Democratic Republic of Congo. Even though each context was different, commonalities were found between practices in peacebuilding settings (Hyttinen et al., 2017a). Societally and politically, there was strong interest in determining the effectiveness and impacts of these EU operations for the progress of these countries, as well as for EU citizens (Edjus & Juncos, 2018; Hyttinen et al., 2017; Zupančič et al., 2018). While effectiveness analysis often remains conceptual or political (Edjus & Juncos, 2018), empirical findings about peacebuilding interventions' effectiveness have addressed the role of human-skills-related lessons, such as the need for coordination of practices in operational conflict prevention (Zupančič et al., 2018).

3.3.2 Gaming of Peace (GAP)

The Gaming for Peace (GAP) project studied peacebuilding experts' soft skills and developed an AR game to teach relevant soft skills. The creation of a curriculum supported the integration of the AR game into peacebuilding training (McCready et al., 2016a). Within the competence areas of crisis management and peacebuilding expertise, the focus of the studies highlighted the importance of different soft skills when working in a conflict area (Holohan, 2019; McCready et al., 2016a).

Communication, cooperation, and trust building were identified as essential skills in peacebuilding operations (Devlin et al., 2017). It was determined that gaming is a relatively new field of potential when it comes to training in complex post-conflict and peacebuilding contexts. Nevertheless, significant research has been conducted in other arenas, including education, that could mirror some of the possible benefits for similar methods in adult training and skills training (Holohan 2019).

3.3.3 ECHO - the European network of Cybersecurity centres and competence Hub for innovation and Operations

The European Commission brought together cybersecurity scientists and experts by funding four pilot projects to develop a new educational ecosystem in cybersecurity (Blažič, 2021) and, finally, to contribute to European cybersecurity strategy (Aivatoglou et al., 2021). The consortium of the ECHO project aims to strengthen proactive cyber defense by enhancing Europe's technological sovereignty through effective and efficient multisector and multidomain collaboration. As an overall goal, this research, innovation, and network project aims to build a European-level ecosystem of competence centers (Aaltola & Ruoslahti, 2020) and a governance model (Tagarev & Davis, 2020) to support secure cooperation and development of the European market and, finally, to protect the citizens against cyberthreats and cyber crime incidents.

One key item on the research agenda of the ECHO network project is to build a cyber skills framework with an associated training curriculum and to introduce the federation model of CRs. CRs are an arena for hands-on education and training purposes, but also for advanced prototype development and cybersecurity certification testing (Oikonomou et al., 2021). Cybersecurity exercises and CRs have the key role of providing realistic, although fictive, environments for experiments, cyberattack exercises, prototype testing, and research (Aaltola & Taitto, 2019). These learning activities in a cyber-physical domain can enable a combination of multiple scenarios with a focus on the acquisition of skills and expertise. Cybersecurity is multi-sectoral, and the ECHO project focuses on sectors such as healthcare, energy, maritime transportation, and defense (Pappalardo et al., 2020).

4 RESEARCH FINDINGS

The overall goal of this research was to explore the effects of MLEs on skills acquisition and discover how to integrate MLEs in a meaningful way into training and education. The entire publications are presented in their original form at the end of this dissertation. The findings of nine research publications are presented in Sections 4.1–4.3. The publications were authored by this writer and published in scientific journals and channels.

These original publications provide research results and propose tentative frameworks for design and technological solutions in training and education. The Model to Integrate Immersive Learning Content into Adult Training aims to follow the study findings on skills acquisition and expertise development and base itself on educational underpinnings. The Human-Centered Design Model concerns the development of online learning tools. The Systematic Integration Approach emphasizes the importance of motivation in technology integration into higher education. The Societal Impact Assessment Toolkit and Evaluation Framework are directed at network collaboration and information sharing.

4.1 Article I: New Technologies Shaping learning? AR learning experiences and integration model

Aaltola, K. (2020). New Technologies Shaping Learning? AR Learning Experiences and Integration Model. In R. Z. Zheng (Ed.), *Cognitive and Affective Perspectives on Immersive Technology in Education: Advances in Educational Technologies and Instructional Design*, pp. 195–214. IGI Global

This chapter presented the findings of two studies conducted as part of the IECEU and GAP projects over the years 2015–2019. Empirical data collection and analysis aimed to provide knowledge through the researcher's impressions and the interviewees' experiences. Empirical data were collected by interviewing and observing the evaluation sessions. The semi-structured interview transcriptions

and evaluation observation notes were analyzed by the author. All interviewed experts had professional field experience in peacebuilding missions or operations.

Both studied MLEs offered affective and immersive content in digital forms to the learners. The research findings from eight different conflict regions provided evidence-based insights for designing the immersive learning tool. The training content included peacebuilding legislation, culture, and practices. A mutual characteristic of the MLEs was that they were created in a multinational, multi-professional, and multicultural design process.

The learning tool contained immersive content in multimedia form, including audiovisual animated stories and written documentation. Affective and gamified features such as questionnaires aimed to raise the motivation for playing it but also to implement problem-based pedagogy. Grading elements were included in the tool, and the learners answered question sets after the animation plays. After successful completion, the learners received certification. The certification was a concrete product, and it enabled the use of the learning tool as part of the training curricula, for example, as a pre-course task.

The second studied MLE was an online role-playing game. It was designed for training purposes for the acquisition of skills, especially for the professionals planning to work in peacebuilding operations. The learning game consisted of mimicked scenarios, role-playing, storytelling, and question sets for the individual learning path. It aimed to engage players through the use of 3D audio-visual elements (combining vision and hearing) in the form of animations with music and storytelling. After answering (by clicking) question sets, the player was led into the next scenario. The scenarios and storyline were based on the research conducted by the project consortium researchers. The overall research included in-depth interviews in different European countries, the establishment of learning outcomes, the co-creative design of vignettes and scenarios (by designers, practitioners, and researchers), the creation of question sets for decision-making and the rating of them by practitioners, and finally, an evaluation, including testing by potential users.

Main findings

The key interest was to study experts' play and experiences to provide a model for technology integration into peacebuilding training. The players' experiences during and after their use of the tool and game were analyzed to understand the tool's and game's potential for helping learners acquire skills and expertise. A literature review highlighted the relevance of cognition, emotions, and kinetics in skills acquisition. ELT provided the theoretical framework for modeling meaningful technology integration into peacebuilding training. The findings based on the empirical data collection and analysis were presented according to five themes: first impressions, experiential methods in game play, perceptions and embodiment, and HTI.

The importance of motivation was highlighted in the literature review in relation to both the use of technology and knowledge and skills acquisition. Evaluation data revealed that the users' first impressions were the most relevant for their motivation to continue to use the learning technology. The users of both

the learning tool and the game reported that they felt higher motivation and excitement when using the learning tool or game than when engaged in traditional learning methods, such as listening to a lecture. Moreover, the learning game users felt that the game was an interesting option as a new training method.

The audio-visual, affective, and immersive content was assessed by the users as bringing additional value. The audio-visual learning content, such as videos, animations, storytelling, actual life-based peacebuilding scenarios, maps, and structured reading material, was seen as important in helping the users adopt new knowledge more precisely and faster. The learning tool provided an audio-visual experience using animations captured from actual peacebuilding operational situations. Users also described how the audio-visual content increased their feeling of belonging to the context. One respondent reported that she did not feel like engaging in other activities at the same time as she was learning, as she normally would while reading or attending a lecture. (Aaltola, 2020).

The game offered a role-playing opportunity in a 3D gamified peacebuilding scenario, which was followed by the storytelling journey and scenarios according to the decisions made. The roleplaying was described as "eye-opening" by a few users. Playing a specific role increased the users' ability to examine their own assumptions about a profession, nationality, age, or gender. Several interviewees compared the augmented audio-visual experiences to real-life stories by colleagues who had previous experiences in some peacebuilding environments.

As previous studies have shown, learning requires thinking and reflection, and explicit conceptualization also plays a role. The users were not able to describe what they had learned immediately after using the tool or playing the game. Most of the interviewees could not say precisely whether they had learned anything new. Nevertheless, they placed high value on the tool and game as new learning technologies. More experienced experts were able to compare their experiences during the play to real-life situations and experiences. Nevertheless, after playing the game, the interviewees described their emotions and feelings. With regard to the music and voice-over audio, empirical data supported previous studies, especially with regard to music's ability to give rise to and affect our emotions. In the learning tool evaluation workshops, the sense of hearing was addressed as an important additional feature. In the game evaluation workshop, the users reported that music helped them get into the proper mood.

In terms of HTI, the users described their experiences and placed high value on the gamified features, smart-phone-friendliness, and multi-browser compatibility. The interaction with the technology varied according to whether the user played on a PC, Mac or iPad, or smartphone. On a laptop, the user used a mouse to interact, while on a smartphone or iPad, they could swipe with a finger. The tools and games did not employ sensors or joysticks, and involved only hearing, observing, and touch (Aaltola, 2020). In terms of the interaction between the users and technology during the learning game play, physical

movements focused on the use of a computer mouse or touchscreen, for decisions, and the use of a headset. In evaluations of both the learning tool and the game, it was observed that users mostly stayed in the same position while playing. Even though the learning game themes focused on soft skills such as communication, cooperation, trust building, and cultural and gender awareness, the game play did not connect with the human. There was a lack of actual bodily practice, which is relevant in skills acquisition and real-life performance, although, as described, perception plays an important role in the initial and reflective part of the acquisition of skills and improved performance.

The findings presented in this chapter address the importance of the integration of MLEs in a meaningful way into training and education. The experiences were connected to well-known experiential learning cycles (Kolb & Kolb, 2011) to model the integration of MLEs into peacebuilding training. This model can support not only trainers, instructors, and teachers, but also the training community, designers, and researchers. Peacebuilding experts highlighted the importance of user commitment and asserted that engagement plays a crucial role. The model is based on empirical data collected from the users, as well as combining educational and pedagogical underpinnings. "This integration model helps the trainers, teachers and learners to understand the entire process and select the use of technological parts meaningfully to reach learning outcomes" (Aaltola, 2020).

4.2 Article II: Empirical study on Cyber Range (CR) capabilities, interactions and learning features

Aaltola K. (2021). Empirical Study on Cyber Range Capabilities, Interactions and Learning Features. In: Tagarev T., Atanassov K.T., Kharchenko V., Kacprzyk J. (Eds) *Digital Transformation, Cyber Security and Resilience of Modern Societies,* pp. 413–428. Studies in Big Data, 84. Springer, Cham.

The connections between physical systems and the Internet have led to greater potential for safety-critical infrastructures to become targets of external threats and attacks. The cybersecurity industry has recognized the value of training, after accepting that users are often the weak link in the security of the cyber domain. Cybersecurity training aims to enhance human skills and competences to increase preparedness and ensure better performance in threat situations in cyberspace. However, human cognitive learning and human performance approaches in the design of the cybersecurity content of VR, AR, mixed reality (MR), and CR environments are only partially touched upon. One of the crucial challenges of cybersecurity training is the lack of open research evidence concerning relevant CR features and capabilities for users' learning, such as skills acquisition.

This study aims to improve the understanding of CRs' capabilities as learning platforms in order to improve human performance and provide insights into the enhancement of the design and impact of CRs as learning environments. First, this research reviews previous literature and clarifies some terminological concepts to establish limits and standardize the use of terms describing CRs' capabilities in the different realities and cyber-physical systems (CPSs). A theoretical framework of learning and skills acquisition provides the basis for a study of the role of cybersecurity learning environments from a skills acquisition perspective. Second, this article presents the findings from the survey and observation data collection about CR learning platform capabilities.

Different perspectives (technological, cognitive, and behavioral) are taken into account in the review, and the empirical findings provide additional knowledge about current forms of CRs. The findings reveal the features of CRs used for learning purposes, both desired and actual, by respondents representing different organizations. The practices used with CRs are elaborated, and commonalities with real-life security exercises, such as evaluation and debriefing, are described.

Main findings

Human and user errors are still often the weak link in cybersecurity systems. To avoid human errors, improvement of human performance in CPSs is needed. Virtual cyber environments can offer support, for example, by simulating and mimicking decision makers' situational awareness. This paper explains that the development of CRs has mostly been carried out by military organizations, which may have led to a lack of proper understanding of these technological developments within the public academic community.

According to the survey data presented in this article, CRs can be deployed on organizations' own physical premises or in the cloud or both. The technical capabilities varied, and in addition to custom-made tools, VMware, OpenStack, VirtualBox, and COTS were mentioned. The respondents saw SCADA scenario capabilities as the most relevant, but IoT and mobile devices were also mentioned. The respondents identified different scenarios within different domains and sectors, including supply chains, critical infrastructure, cloud service providers, healthcare, finance, and software development. Domain-specific knowledge and expertise were highly valued in CR and cyber-exercise design.

The capabilities of CRs used for skills acquisition and learning purposes were described as the production of a learning platform, including features such as attack and defense simulation, performance evaluation, traffic simulation, and real-time monitoring. Tasks included securing networks and services as well as collaboration with different actors. When studying the CRs, the commonly followed phases identified were reconnaissance, exploitation, escalation, and completion of the mission (for example, "shut-down" or "kill"). The evaluation features described by the survey respondents were hot wash-up, debriefing, feedback based on the training data, and debriefing by the company personnel after the use of the CR. With regard to development, respondents reported that they would like to further develop their sector-specific capabilities, provide

better automation for quicker development and deployment, and add automatic performance evaluation.

The study revealed that the CR exercise lifecycle could be outlined as follows: the production of a set of learning outcomes or objectives, including scenarios and tasks or design of the scoring (gamified features), repetition of the exercise with scenario and simulation tweaks, familiarization by the learners, execution of the exercise, hot wash-up, and possible internal organizational reflection processes. Afterward, the exercise evaluation and reflection in the real world among other professionals increases the possibility of achieving the learning outcomes.

Cognitive modeling aims to integrate memory dynamics to explain humans to predict a cyber-attack on the system. Cognitive models of network users interact with the same software with which humans interact to generate offline predictions and add simulated participants to training sessions. By doing so, this study concludes that CRs are a new addition to the AR/VR continuum framework because of their capabilities to model cognitive and behavioral interactions between CPSs and humans in cybersecurity MLEs.

4.3 Article III: Utilising Experiential and Organizational Learning Theories to Improve Human Performance in Cyber Training

Aaltola, K. & Taitto, P. (2019). Utilising Experiential and Organizational Learning Theories to Improve Human Performance in Cyber Training. *Information & Security: An International Journal 43*(2), 123–133.

This position paper aimed to capture current cybersecurity training practices and rethink the improvement of human performance through cybersecurity exercises and training sessions. This paper includes an analysis of potential practical and scientific implications and aims to move beyond current academic concepts of cybersecurity training. European cybersecurity actors have tried to create a shared taxonomy and language to better understand meanings as social constructions.

Desk study review methods were used to discuss different aspects that address the complexity of cybersecurity training and education. The paper addressed the current practices of cybersecurity exercises, focusing on skills areas within the exercises and techniques used from the pedagogical viewpoint. The research aligns a) concepts of cyber training and education, b) experiential and organizational learning theories, and c) design practices within cybersecurity training and exercises.

Main findings

Cybersecurity can be seen as a multidisciplinary and cross-cutting domain, affecting different functions of organizations all the way up to society. The nature

of cybersecurity focuses on increasing awareness and responding to threats and risks by building preparedness and resilience. Cyber exercises involve competitive events with teams, involving analysis skills, problem-solving, situational awareness, and decision-making. Human behavior and decision-making in particular play important roles in risk awareness, preparedness, and resilience in cybersecurity.

In the cybersecurity domain, as in any domain, much tacit knowledge is involved in learning about risks and ensuring competitiveness for organizations. Because there is a lack of pedagogical theories within the European cybersecurity domain, experiential and organizational learning theories were presented. Pedagogical theoretical understanding can provide common standards and principles for cybersecurity training and exercise systems. This paper challenged cybersecurity training to benefit from experiential and organizational learning principles for improving core skills in training and exercises.

The design of training sessions and education includes perspectives on setting new requirements and relevant learning objectives for cybersecurity training and exploits relevant pedagogical methods and human cognitive processes in the design of intelligent systems, such as CRs. Experiential learning through cybersecurity training and education can occur through methods such as simulated scenarios, role-playing, problem-solving, and visual observations. The design of CRs can benefit from simulating human cognitive and decision-making processes. Consequently, according to the results of the cybersecurity training practices, the authors discussed the relevance of the multidisciplinary research community in designing processes´ to study the more human aspects of cyber training from the perspectives of learning and cognitive behavior. (Aaltola & Taitto, 2019).

4.4 Article IV: Human-centered Design Model in the Development of Online Learning Tools for International Security Training: CASE IECEU New Media based Learning Application (NMLA)

Hyttinen, K., Ruoslahti, H., & Jokela, J. (2017). Model for effective integration between research, work life and higher education in international security studies. In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Vol. 3,* pp. 299–306.

The aim of this study was to analyze how learning technology can be better utilized for current training practices. Even though digitalization has happened quickly, there are several challenges that may occur during the design and development of MLEs, as well as in their integration into adult training. The purpose of the research was to provide evidence-based recommendations for the digitalization of peacebuilding training exercises.

The design process of the new media-based learning application (NMLA) was conducted as part of the IECEU project in the years 2015–2017. The learning application NMLA was designed to provide an MLE for the crisis management training community. The principles of selected design approaches, together with DSR, were followed during the learning technology design process. Empirical research data were collected. The DSR approach is seen as valuable when developing and evaluating meaningful IT artifacts to help humans correctly understand, explain, and potentially improve them (Hevner et al., 2004).

Human-centered and HTI design approaches were applied for better utilization of technologies among training and education communities. Moreover, the basis of experiential learning as a pedagogical model was utilized during the design process. Throughout the design process, user community representatives were seen as important in improving the learning application in the proper direction. The collected end-user data were fed into the final design NMLA.

Main findings

According to the analyzed data collected during the design process, it was recognized that e-learning and technologies such as learning tools were not systematically and broadly utilized within peacebuilding training communities. Additionally, the interview data showed that practitioners in peacebuilding training communities mainly look for technical instantiations that are easy to use without requiring further guidance.

The interaction between users and different technology devices (PC and mobile devices) was observed, and data were collected separately from the user groups playing with laptops. Generally, all users had a first impression of the crucial role that motivation plays in the continued use of the tool. The users focused on describing the functionality and completed interface of NMLA. The findings highlighted the importance of the functionality and completeness of the MLE and its relation to users' motivation to use the technology. When asked about the symbols and structure of NMLA, they responded that they were easy to understand. All in all, 17 out of the 19 users said that the NMLA was easy to use (Hyttinen, 2017). The users reported that the navigation system was clear and that the interaction structure between learners and the technology was smooth. The user group who used mobile devices addressed the importance of scaling with and around the learning content.

A comparison of the results between different backgrounds showed a variation among respondents of different educational levels. The master-level students saw the content as advanced and challenging to understand. Experts with previous peacebuilding experience focused on analyzing the media-rich learning content, especially video animations and visualizations. They judged the visual material of the NMLA to be successful, especially with regard to culturally sensitive topics. Both groups—master-level students and experienced experts—felt that the massive amounts of reading materials (such as research articles or research reports) were challenging to absorb. Respondents reported

that the animated videos, which were based on predefined scenarios, described the conflict setting well.

Interestingly, the necessity of updating content knowledge in line with the global situation was addressed in the group discussions. As a practical solution, the research could contribute to the content by providing evidence-based knowledge to update it. Moreover, the necessity of opportunities for feedback and reflection was addressed by more experienced experts. Additionally, the relevance of the guidance on using the technology solutions was studied before their actual use. According to the data, the experienced experts mentioned that learning tools should be easy to use without any further guidance.

The designed NMLA enabled the opportunity for experiential and problem-based learning. Based on previous studies and empirical data collection in NMLA design, the Human-Centered Model for Online Learning Tool Design was created. The design model of NMLA included six phases: 1) instantiation, 2) construction of framework, 3) quality assurance requirements, 4) iteration of methods, 5) creation of models to transfer the content, and 6) evaluation and assessment. It was suggested that the principles of adult education, user-centric approach, and HTI be followed in the design of modern learning environments for peacebuilding training.

4.5 Article V: Model for Effective Integration between Research, Work Life and Higher Education in International Security Studies

Hyttinen, K., Ruoslahti, H., & Jokela, J. (2017). Model for effective integration between research, work life and higher education in international security studies. In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Vol. 3,* pp. 299–306.

In this paper, the integration of research, work life, and higher education was studied to understand different practices and model effective integration. The study focused on analyzing three different international security courses in higher education with a view to understanding integration practices and collaborative learning activities. The focus was on how to successfully integrate research and projects into higher education programs or independent courses.

The authors completed a desk review of the research and studied three different courses of integration between research, work life, and higher education during the years 2016 and 2017. The literature review focused on previous research and practices for integrating research and development activities into higher education programs. The data were collected and analyzed from three independent higher education courses. The national- and European-level research projects' content and activities were integrated by different practices

into these courses, and the potential of learning technologies in the integration practices was studied.

Main findings

The integration practices of the higher education courses studied included reading material, video-based visual content, peer discussions, and group work in the course implementations. The pedagogical practices of self-reflection by the use of learning diaries and abstract thinking by alignment of theory with experiences were applied in the courses. One practice for integrating research into an education course focused on piloting the conceptual framework of the EU project in a bachelor's-level course. The bachelor's-level students applied the conceptual framework to analyze the effectiveness and capabilities of different private-sector organizations.

The master-level students in the first case reported that the opportunity to attend and be involved with the EU project network community raised their motivation with regard to the learning contents concerning external security and the international approach to peacebuilding. The course sessions led by external experts working on peacebuilding were seen as very important for sharing and transferring knowledge from the field and for future employment possibilities. The students in the second case also valued the motivating learning content and the opportunity to become familiar with an interesting topic through external speakers and professionals. In the third case, students applied the project objectives and conducted small studies as part of a national-level project. The activity was defined as active student integration. In the fourth case, the students gained competence in applying a research concept and different research methods (interviews, surveys, desk research) practically by using the conceptual framework established in the EU project.

The findings support the view that the integration of higher education with work life is crucial, especially for polytechnic schools and universities of applied sciences. Connections and activities between students and work life representatives can bring added value to learning and reaching set goals. The integration practices of linking research project contents and experts from the consortiums to higher education courses raised student motivation with regard to the learning themes. Motivation is important in achieving learning objectives, as well as increasing knowledge creation in peer groups and beyond. Through the integration practices, the students also felt a greater sense of involvement in larger research communities. The integration of international research projects into higher education courses may increase knowledge levels when external experts give lectures and provide current research results to bachelor's- and master's-level students. The findings show that integration practices may benefit from both content- and competence-related learning objectives and outcomes within the required EQF7–8 levels.

In conclusion, the authors highlighted the need to achieve integration with a systematic approach and to understand the research value according to pedagogical needs or objectives. Systematic and competence-based integration between research, work life, and education includes identifying the key actors

and integration practices with the purpose of meeting with success in learning and education delivery. In addition, the influence of integrating research projects, work life, and education can enhance the development of courses and programs in higher education. In addition to studying integration practices, the value of collaboration between research, work life, and education in knowledge creation was established. This integration shift in the teaching and learning paradigms creates further pressure for the management of projects, networks, and cocreation activities. Higher education professionals must further improve their knowledge regarding degree and program requirements and EQF objectives, but also competences in managing project and network-based integration.

4.6 Article VI: Societal Impact Assessment of a Cyber Security Network Project

Aaltola, K., & Ruoslahti, H. (2020). Societal impact assessment of a cyber security network project. *Information & Security,* 46(1), 53–64.

This article provides conceptual insights into network cocreation and organizational knowledge transfer, which can be linked to network projects to assess societal impacts. The paper is built on the dissemination framework presented in Henriksson et al. (2018). The literature review includes societal-level approaches to performing evaluation and assessment, network cocreation, and learning approaches relevant to expertise development. These concepts aim to contribute as indicators of societal impact assessment in a specific network project.

The theoretical concepts and creation of relevant indicators supported the development of a modeled toolkit for measuring impacts through a digital societal impact assessment (SIA). The use of the SIA toolkit can improve the quality of the value creation and show the evidence of the projects' value and impacts. The toolkit, with its conceptual framework, aims to go beyond traditional societal impact assessment and include co-creative innovation and performance outcomes in a practical matrix.

Main findings

Study expectations at the societal level for the implementation of European research and innovation projects have increased. It was acknowledged that European research and innovation network projects increasingly face the challenge of mobilizing knowledge in value creation and even more when assessing their impacts and effectiveness (North & Kumta, 2017). Scholars have addressed the need for reviewing the measurement criteria of the community and implementing a comprehensive impact assessment process that can deliver outcomes, without forgetting the importance of the learning and sharing of knowledge (Sánchez & Mitchell, 2017).

The theoretical construction of the evaluation and assessment, network cocreation, and learning approaches, together with project communication, dissemination, and exploitation evaluation, was reviewed with a view to building a societal impact assessment. In the evaluation of network research impacts, the quality measures and systematic documentation were recognized as good practices. Network cocreation highlights collaboration in knowledge creation, and learning approaches highlight the relevance of understanding knowledge creation as a socially constructed process and the role of experience in the processes. A summary of the literature review shows the approaches studied with key concepts and themes by different authors.

The key findings are presented as learning outcomes (acquisition of knowledge and skills, innovation cocreation and dissemination, development of behaviors and attitudes, and community norms and values). The study suggests that learning outcomes and evaluation outcomes should be seen as indicators in assessing the societal impacts of network research projects. The indicators are categorized as SIA-outcomes according to different levels and communication layers. The SIA outcome matrix summarizes specific outcomes from the literature review at the levels of society, the individual, the community, dissemination, and communication.

This kind of model goes beyond the traditional assessment of network projects, which focus mainly on dissemination and exploitation results. This model aims to contribute to the digital design of an AI-assisted toolkit for outcome-based data creation and could be utilized for any innovation and network project or organization that wishes to understand how its actions and solutions have influence at the societal level.

4.7 Article VII: Opportunities for Strategic Public Relations: Evaluation of International Research and Innovation Project Dissemination

Henriksson, K., Ruoslahti, H., & Hyttinen, K., (2018). Opportunities for strategic public relations: Evaluation of international research and innovation project dissemination. In S. Bowman, A. Crookes, Ø. Ihlen, & S. Romenti (Eds.), *Public Relations and the Power of Creativity: Strategic Opportunities, Innovation and Critical Challenges*, pp. 197–214. Emerald Publishing.

This chapter emphasized the ways and implementation of communication and dissemination as part of EU-funded research and innovation projects. Multidisciplinary network projects provide a new platform for strategic communication. The research purpose focused on effective and beneficial communication and dissemination in line with project funding requirements.

Dissemination and communication practices were studied within the internal and external communication cycles through three research and

innovation projects. The methodology included the alignment of quality dimensions and domains for the dissemination and communication evaluation frameworks. The authors participated in project work, and according to their findings, they created an evaluation framework for project dissemination.

Main findings

All the projects studied implemented their communication and dissemination activities among people who had substantial knowledge about the research topics of the projects. This means that only a few communication or public relations (PR) professionals were involved. It was established that proper PR skills should be ensured and developed within project consortiums as well and that PR experts jointly facilitate collaboration in cocreation activities.

The first project studied, ABC4EU, implemented its dissemination with traditional activities, but also included the creation of an end-user community and the establishment of a secured online platform. The second project studied, IECEU, established its indicators for dissemination evaluation in the early stages of the project. It implemented various engagement activities, such as policy dialogues, to engage the project's key stakeholders. Comprehensive employment of social media and technologies ensured the use of interactive methods. The third project studied, GAP, clearly divided internal and external communication and shared their responsibilities in terms of execution. It adapted a project communication plan, funding requirements, and reporting in the form of a media evaluation framework. This framework enables an emphasis on the self-generation of relevant activities, as well as accountability for communication.

Research and project communication and dissemination activities require new types of knowledge creation, competences, and evaluation practices to show the evidence of value and impacts. A selection of proper tools should be aligned according to target groups and communities. It was noted that new communication and dissemination resources may influence the professional skills and competences of experts working on project dissemination tasks. Joint agreement and early-stage commitment were observed to be relevant to achieving the set communication and dissemination objectives. Monitoring the achievements and shortfalls by evaluation based on selected indicators was seen as beneficial for determining whether the projects were moving in the desired direction. The demands for funders to require two-way communication, the use of digital technologies, and community-based cooperation in these kinds of projects were suggested by the authors.

4.8 Article VIII: A Co-created Network Community for Knowledge and Innovations: Promoting Safety and Security in the Arctic

Ruoslahti H. & Hyttinen K. (2017). A co-created network community for knowledge and innovations: Promoting safety and security in the Arctic. In *Engaging people in a disengaged world, Proceedings of the 23th International Public Relations Research Symposium BledCom*, pp. 100–106. University of Ljubljana.

The overall purpose of this paper was to contribute to long-term cooperation between higher education and practitioners in the form of a cocreation network. The still-disengaged domain of safety and security in the Arctic region is attempting to develop from its current state of scattered and unlinked programs and systems. The cocreation network aims to build an alignment of good practices.

This paper provides a suggestion for the process of cocreation for knowledge and innovation among network members. The value of digital platforms was analyzed in terms of facilitating the first information sharing, as well as enabling the cocreation processes toward knowledge and innovations among the network community.

Main findings

The cocreation network of safety and security in the Arctic can help to bring about long-term systems of information- and knowledge-sharing so as to change the improve the current state of programs and systems, which are scattered and unlinked (Ruoslahti & Aaltola, 2017). There is a need to demonstrate new knowledge of how cooperation should work in the future (for example, in search and rescue) as a process to improve and change the current attitude and mindset within this context. This cooperation is argued not only to address technical matters, but to be of benefit on the societal level to security and safety and therefore to fulfil human needs related to living, economics, and transport in the Arctic environment.

The value of cocreation ranges and streams, from the smallest innovation in product development to a wider theory of cocreation research streams (Galvagno & Dalli, 2014), was discussed. The nature of cocreation, which involves common goals and objectives to work in a joint direction, was addressed. Digital technologies involve an operational arena that is complementary to physical activities. The importance of contracts between collaborators (Bhalla, 2014) and value chain features was also addressed in the paper.

Thematic working groups in the Arctic network community were identified under the umbrella of safer, more secure, and cleaner seas through sustainable economic growth. The integration of the social dimension into technology was considered by the authors. A link between relevant pedagogical methods, such as Felix's (2005) synthesis of cognitive constructivist and social constructivist approaches, was further established.

5 DISCUSSION

The overarching goal of this dissertation was twofold: to explore the effects of the MLEs on knowledge and skills acquisition in expertise development; and to study the design of MLEs in training and education. The empirical results presented in this dissertation are based on both practical and design experiences to analyze the effects of MLEs in skills acquisition, as well as to improve the design of MLEs for adult learners. The findings support the practice of integrating modern technologies into training and higher education.

Section 5.1, in particular, aims to address the first two research questions of this dissertation:

RQ1 What are the effects of MLEs on knowledge and skills acquisition in expertise development?

RQ2 How can MLEs be designed to ensure the acquisition of skills, and how can they be integrated meaningfully into training and education?

Additionally, the limitations and validity of the research conducted (Section 5.2) and possible future research topics (Section 5.3) are discussed in this chapter.

5.1 Contribution to the research

In the wake of so much technological innovation and skills training through MLEs, how the use of MLEs influences knowledge and skills acquisition in expertise development has not been adequately assessed. In the studies of this dissertation, experts' experiences and learning situations when using MLEs, employers' expectations of MLEs, and domain-specific practices in the use of MLEs were analyzed to understand the immediate effects of the use of MLEs. Moreover, the practices of integration into higher education and human-centered design were studied to better understand how to meaningfully design and integrate MLEs into training and education. The interviews analyzed provided

unique results about MLEs and their immersive contents in the domain contexts of international security, peacebuilding, and cybersecurity.

MLEs are given different definitions, including e-learning platforms, LMSs, gaming, simulations, serious games, immersive learning simulation, digital game-based learning (Hyttinen & Smith, 2019), and CRs in the cybersecurity domain (Aaltola, 2021). MLEs engage with augmented or virtual information via wireless devices. In MLEs, learners may have an immersive experience, from a sensorimotoric opportunity and 2D perception or a 3D experience (Aaltola, 2020). The capabilities of the CRs studied for cybersecurity included the production of a learning platform, including features such as attack and defense simulation, performance evaluation, and traffic simulation or real-time monitoring. CRs include a tailored learning platform to help the user learn skills and improve performance in different scenarios and simulated exercises, with some immersive features (Aaltola, 2021).

Within the studied context domains of peacebuilding and cybersecurity, the contribution of psychological and education research in the planning of meaningful training sessions for experts is rather small. A literature review shows that learning approaches from different perspectives should be considered more thoroughly in the design and planning of MLEs for the skills acquisition of experts in training sessions. Behavioral, cognitive, or experiential perspectives are only partly touched upon and implemented in the design of security education and training, even though they are commonly used in both the theoretical and conceptual traditions of adult training and education. For example, peacebuilding communities have more frequently used and adapted management perspectives, such as organizational learning and performance assessment models, to analyze systems and impacts (Benner, Binder, & Rotmann, 2007; de Coning, 2020; Hirschmann, 2012).

The perspective in this dissertation focuses on cognitive learning, which is interested in understanding and analyzing how people process information received from MLEs, how they add it to their already-existing knowledge, and how they define their experiences. Cognitive learning is eager to understand this information processing based on experiences, and it focuses on cognitive processes such as acquisition of knowledge or skill, transformation into memory, thinking, problem-solving, and emotions (Carey, 1986; Newell & Rosenbloom, 1981; Saariluoma, 1995). In addition, the studies in this dissertation benefitted from the principles of the experiential learning theory framework. The role of experience is commonly acknowledged in the theoretical frameworks of expertise development, adult education, and cognitive science.

In the domains studied, the purpose of skills acquisition in education and training focuses on performing successfully in actual work roles. Commonly, the acquisition of skills and knowledge is stated as an objective or purpose for competence-based higher education and expert development training programs. Scholars have established that successful performance requires a set of knowledge, skills, and expertise, like any work. Within the domain context of peacebuilding environments, there is an emphasis on certain skills that personnel

deploy in peacebuilding operations (Curran, 2013; Holohan, 2019), including softer skills such as communication, cooperation, gender and cultural awareness, and trust building (McCready et al., 2016b). In the domain context of cybersecurity, it is recognized that technical skills, such as engineering, penetration testing, and using tools, but also non-technical skills or soft skills, are relevant for performing in cybersecurity work roles (Pedley et al., 2020).

The contributions of this dissertation are based on its emphasis on learners' experiences and behavior during and after playing with MLEs. Generally, the findings of this dissertation indicate that experts place a great deal of importance on domain-specific training, in relation to skills acquisition and successful performance in a fieldwork setting. Few experts with long-term experience in actual work environments felt that training sessions have improved over time but assert that the greater part of skills acquisition and learning is work-based and happens in real life through work experiences, since traditional training is so lecture-based. The peacebuilding experts studied in this dissertation highlighted the importance of domain-specific experience and the problem-solving nature of the work.

Empirical data results in this dissertation show that cases in higher education and training sessions are still in the early stages of integrating and benefitting from digital technologies in training and educational practices. Whether or not it is due to the latest global situation with the Covid-19 pandemic, there is an increased interest in developing MLEs for distance learning. Although the use of technologies has been rather innovative in security training and education fields, it seems that new forms of MLEs could be more effectively developed to meet user and pedagogical needs. A meaningful integration of learning technologies into training practices could support them in reaching diverse audiences and potentially reduce the cost of large training settings. The user perspectives indicate a desire to use MLEs as complementary tools and to support a blended learning approach in education and training. To support effective technology integration, the practices of integrating different aspects into security higher education were studied in article V, and an effective integration model was established.

RQ1: What are the effects of MLEs on knowledge and skills acquisition in expertise development?

Important aspects of the acquisition of knowledge and skills include processes of transforming information, holistic experiences, sensorimotor learning, and tacit knowledge creation. Peacebuilding and cybersecurity contexts are complex, sensitive, and hostile, and the development of crucial skills in training is strongly believed to facilitate effective cooperation, negotiation, and situational awareness in actual crisis situations. In the development of skills, automatic processing seems to be closely tied to extended practice (Newell & Rosenbloom, 1981), and superior individual performance as an expert requires practical intelligence and tacit knowledge (Cianciolo & Stenberg, 2018), deliberate practice, and a superior working memory (Ericsson, 2018).

Cyber security and peacebuilding domains have been used to implement exercises, simulations, roleplaying, and gamified pedagogical practices. In the cybersecurity domain, the training sessions include a planned event in which a cyber disruption scenario is simulated to test and enhance capabilities (Aaltola & Taitto, 2019; Happa, Glencross, & Steed, 2019). These digital environments provide the opportunity to train personnel across different organizational levels (Aaltola & Taitto, 2019) and practice skills such as defending networks, penetration testing, and responding to attacks (Davis & Magrath, 2013). CRs illustrate knowledge and skills acquisition in simulated scenarios by role-playing, problem-solving, and visual perceptions. Kabil et al. (2018) argued that the use of cyber environments raises situational awareness, and Piskozub et al. (2017) found that VR simulations can simulate decision-makers' situational awareness in cyber-physical domains. Whereas the studied MLEs provide audio-perceptual experiences, VR environments provide a sensory immersive experience for the user (Aaltola, 2021).

Earlier empirical studies have shown that the use of MLEs generates excitement and motivation by providing visual expressions (Dunleavy et al., 2009; O'Shea et al., 2011; Solak & Cakir, 2015; Vargas et al., 2020) and enhances the retention of memorized knowledge (De Freitas, 2014). Some authors have argued that the role of instruction and feedback has received only limited attention in studies focusing on motivation (Ward et al., 2006). The findings in this dissertation show the aspects that increased the motivation of the learners with regard to MLEs. When users were asked for their first impressions of the MLEs studied in this dissertation, they responded that the functionality of the learning tool influenced their motivation to keep playing with it. The complete and functional user interface was seen as important for continuing to use the learning tool.

The role of experience is a necessity in the learning process. Learning experiences can occur in formal or informal environments. They may also take place outside the classroom in daily life and informal forms (Aaltola, 2020). As in traditional learning environments, the importance of experience was seen as important in the use of the MLEs studied as technological solutions for skills and knowledge acquisition in expertise development. When users played with MLEs, real-life movement or sensorimotor activities focused on perceptual and visual attention and the interaction with the laptop by the fingers and hands. In the use of technology, simultaneous hand–eye coordination was observed MLEs studied. Playing with immersive content in MLEs enhances the engagement of individuals through interaction with technologies and provides experiences of seeing, feeling, and doing while playing. Audiovisual training and educational content, tutorial quizzes, and forms and surveys provide easy-to-use tools to support the work of teachers and instructors. The use of these types of content in MLEs can ensure immersive and perceptual experiences for the learners (Aaltola, 2020). The immersive content of MLEs can replace or add components to traditional storytelling, lecturing, or expert–novice mentoring. The learning technologies studied in this dissertation include different visual and immersive

contents. They connected scenarios, immersive and affective content, and some pedagogical methods.

The results of this dissertation support the thesis that MLEs can have a crucial role in facilitating perceptual and audiovisual experiences, especially to help retain the content learned and apply it in real-life context. A beneficial effect of MLEs was found in the creation of perceptual individual experiences that were facilitated when playing with the MLEs. Immersion increases the ability to remember experiences longer and engages and motivates the user (de Freitas, 2014), and simulations and games have the potential to teach complex cognitive skills at relatively low costs (Dankbaar et al., 2017). Several interviewees in the study of article 1 described how they were able to experience visual and audio perceptions with the use of MLEs instead of just using their imagination. It was established that the learning game content related to gender and cultural awareness gave rise to thoughts and emotions in the learners (Aaltola, 2020). Even though the MLEs studied in this dissertation provided mainly audio-visual experiences with opportunities for immersive and affective perceptions by the learner, the findings presented in Chapter 4 argue that MLEs provide more avenues for self-representation, expression, reflection, and more organized forms of collaboration and knowledge building. The interviewees described their thinking processes and emotions after playing with immersive and affective content and when playing with the learning game and using the learning tool. Interaction with the MLE content influenced to thinking process and increased the emotions of the learners. Moreover, the sense of hearing, used, for example, with music, was established as important to get users into the proper mood.

Nevertheless, based on the qualitative analysis presented in this dissertation, some negative effects appeared after using MLEs. These effects mainly focused on the personal cognitive challenges of adapting a great amount of written knowledge within a short timeframe. Also, the time reserved for reflection is often short in training sessions, and this was also noted by the players in their learning tool and game evaluations. The issue of the lack of reflection after MLE play was raised among the MLEs studied for peacebuilding, but the capabilities of CRs included separate debriefing or wrap-up sessions as reflection opportunities. According to the author's observations, the players mainly stayed in the same physical position while playing the game and using the learning tool. Setting aside time for reflection through discussions, hot wash-up, or debriefing should be considered to ensure appropriate learning and techniques for understanding the thinking of the learners. Beyond providing experiential opportunities, reflection and abstraction are essential for learning and the acquisition of skills. The trainers emphasized the importance of getting back to the learning contents, along with the importance of reflection, and they felt the duration of the learning game was rather long.

Learning effectiveness requires transferring the acquired knowledge and skills of expert performance in different situations to real life. Earlier studies of expert performance have presented good evidence of the benefits of training and education practices when the purpose focuses on knowledge and skills

acquisition. As concluded in article I, the way to transfer MLE-based experience to real life as expert performance is more difficult to decipher (Aaltola, 2020). Skills and knowledge acquisition in education and training need to be recontextualized or transferred to make them available and to enable learners to transfer their learning to a real-life context (Evans et al., 2010). Sensorimotor activities in MLE play are different from real-life skills that were skills that were practiced in the MLEs. This requires transferring and adapting the knowledge and skills to other contexts in real life. The relation between perception and action in skills acquisition was previously studied and further elaborated in article 1.

The use of MLEs in the contexts studied (peacebuilding and cybersecurity) had disadvantages, such as the lack of embodiment when used for the acquisition of skills, and there was a lack of proper problem-based reflection. As the findings in this dissertation show, there are considerable challenges in assessing and evaluating what "actual skills" are developed through these new technological methods. The interview and survey results can be interpreted to show some level of change in thinking, but changes in behavior in real life should be studied further. There is not much knowledge on how to evaluate learning outcomes when playing with MLEs in training activities (Radianti et al., 2020). Cognitive skills acquisition by training for performing successfully in professional real-life environments can be seen as a "tick the box" training or exercise with no real value for real-world application. While MLEs are expected to promote educational goals, they have also claim to support attitudinal and behavioral change. The big question remains of how to continue conducting a proper measurement and evaluation of such changes in attitude and behavior, especially since it is anticipated that learning will naturally occur with the use of MLEs or other digital environments (Aaltola, 2020; Aaltola, 2021; Aaltola & Ruoslahti, 2020; Henriksson, Ruoslahti, & Aaltola, 2018).

The benefits of technology can be used to enhance skills acquisition and expertise development in new ways as part of the selection of methods in training and education. MLEs can provide a variety of opportunities for new methods and practices. A perceptual learning experience can occur in the interaction between humans and learning technology. However, the value of technological innovation should not be overestimated when it comes to the acquisition of skills using MLEs; rather, the potential to integrate MLEs into relevant matters in education and training practices should be understood. For example, classroom-based lectures as a pedagogical method encourage passive learning, whereas active learning, participation, and practicing are far more desirable ways to acquire knowledge and skills.

The empirical data established some level of evidence for the potential of MLEs' effects on skills acquisition. The MLEs' main effect on skills acquisition was through providing experiences and helping users retain the learning content longer. It must be acknowledged that the experts' experiences of playing in MLEs were captured immediately after the MLE play. In terms of skills acquisition and expertise performance in real life, this study contributes only to the discussion on the change in thinking before and after the use of technology for learning.

Based on the data results, the emphasis on the value of technology use for skills acquisition and learning applies especially to the audio-visual experience, which affects thinking and the awareness of skills in a real-life environment. There is a place for MLEs in skills acquisition, but practice in real life cannot be forgotten especially in relation to skills acquisition and expert performance. Moreover, the additional benefits of using learning technologies, such as social interactions and distance opportunities, can create greater knowledge and enhance professional communities in other ways.

RQ2: How can MLEs be designed to ensure the acquisition of skills, and how can they be integrated meaningfully into training and education?

The design and development challenges are to meet actual needs or achieve overarching goals through the use of MLEs and immersive content in training and education. The purposes of MLEs vary from providing better access to knowledge and creating professional online communities to enhancing skills acquisition and expertise development. Training plays a crucial role in both domains, cybersecurity and peacebuilding (Aaltola, 2020; Aaltola & Taitto, 2019; Hyttinen et al., 2017b). All the MLEs studied during this dissertation process were seen as having potential and being important in domain-specific training and higher education. More experienced experts felt that the learning game was very relevant as training content for immersion in actual life in the peacebuilding mission environment. The findings show that there is interest in and motivation to engage with immersive learning content in professional training sessions and higher education. Nevertheless, the MLEs were seen more as additional components or methods in current practices and curricula than as replacements for face-to-face practices.

The complexity of real life, such as the peacebuilding and cybersecurity contexts in this study, requires the analysis of experiences and expert performances to model, mimic, and augment the virtual content for learning. The knowledge, skills, and expertise needed in complex, multifaceted crisis environments are mutually constructed across experiences in actual work. Digital technologies enable new ways of narrating content (Hyttinen, 2017) and provide opportunities for users to be actively involved in building content through the use of different digital tools and channels (Katz, 2013).

Within the field of security, MLEs are relevant for replicating challenging situations like shootings and ethnic profiling in the form of immersive content (Greitemeyer, 2020). The replication of the actual environment through expert interviews and human-centered design practices provided the baseline for visual design, storytelling, narrating, and gamified features of the MLEs studied in this dissertation. The audiovisual and perceptual contents of studied MLEs were created by replicating reality through immersive content in MLEs. The MLEs designed during this dissertation process provide an individual journey of activities based on the selection of the players. Decision-making and problem-solving options for the player were designed based on the predefined skills in the expert interviews and the ratings of different options by the groups of domain professionals.

In general, there has been a growing interest in mimicking real-life content in other realities, and MLEs focus on facilitating learning in scenarios or simulations to increase our skills acquisition and performance in real life (Aaltola, 2020; Aaltola, 2021; Aaltola & Taitto, 2019). The complexity of reality requires a great deal from training professionals and designers in their selection of methods to mimic, augment, and narrate real life in MLEs. Beyond the system design selection, the processes of maintaining and developing the content within the necessary timeframe would quickly evolve into the requirement that teachers and trainers gain design expertise. The design cases are often domain specific and may require tailoring content for customers. The findings of this dissertation address the importance of updating real-life scenarios and content to be used in the design. The conflict scenarios are constructed from serious issues and are linked, for example, to human suffering, and the content is thus often sensitive. Tailoring and updating raises additional challenges for designers, providers, and practitioners in keeping content relevant and engaging.

The mimicking of real experiences with easy-to-access immersive tools can serve as a new type of learning resource (Aaltola, 2020). The translation and transformation of human knowledge from real-life to MLE contexts have become crucial in design. To mimic reality, actions, simulations, storytelling, and role-playing aim to create immersive and affective experiences in a virtual environment. While professionals and designers try to replicate a particular actual scenario with storytelling and roleplaying methods in MLEs, a lack of empirical studies remains an obstacle to a systematic evaluation (Aaltola, 2020). Tailor-made MLE solution is time consuming. A need for domain-specific knowledge and the lack of skills and effective abilities to create new immersive content in MLEs on the part of practitioners, training designers, and even teachers or trainers will increase the difficulties in designing, maintaining, and integrating technologies in training and education (Aaltola 2020; Hyttinen, 2017).

Tailor-made needs and large group of designers in design process raise potential barriers to effectively putting meaningful MLEs and technologies in use. An understanding of the benefits and limitations of MLE integration will help us utilize technologies more realistically in training sessions and education (Aaltola, 2020). The design and development of MLEs involve design phases that address user needs and requirements. For example, the peacebuilding training community experts said that the peacebuilding community especially should mostly look for technological solutions that are easy to use without any further guidance needed. The most desirable technical functions of the studied learning tool, according to the learners, were its multibrowser compatibility, smart phone friendliness, and gamified learning. The experts interviewed in the studies of this dissertation also strongly asserted that learning objectives should be in line with training and education content and provided clearly and early in the interface with the MLEs.

A comprehensive understanding of human learning, skills, and expertise acquisition principles can provide valuable insights into technology design, including their creation processes. The alignment of pedagogical approaches,

research into skills acquisition, and identified changes in cognitive processes challenges MLE design to include the important factors of human information processing, problem-solving, emotions, and usability. For example, understanding emotions and their relation to memory in perception and HTI is essential in the design processes. Understanding the user's emotions is a fundamental part of future HTI (Saariluoma, 2020). Emotions play a crucial role in human thinking (Kahneman et al., 2011), but often designs focus on intuition instead of objective scientific research into user emotion (Saariluoma & Jokinen, 2014; Saariluoma & Maarttola, 2003). In technology design for adult education and training, the principles of expertise development and skill acquisition can set new requirements for MLE design. The expertise development happens in different layers. The role of pedagogical theory as a basis for the design and integration approach has been addressed in several articles of this dissertation.

In this dissertation, the experiential learning was built by aligning the theoretical model with the experiences analyzed in playing with MLEs. This model posits that the learning content of MLEs is part of a comprehensive learning cycle. The alignment of theories and empirical findings supports the relevance of experience and reflection in technology design and integration as well. Experience in MLEs involving audio-visual and immersive content can be combined with effective pedagogical methods such as reflection or practicing and that can provide new features to the previous integration of immersive content into training sessions and education. New technologies can lend support as complementary tools, but there is still a need for traditional learning methods in skills acquisition, such as actual-life practice, reflection, and replay in expertise development.

This dissertation highlights the importance of pedagogical underpinnings and the role of integration between technology and training practices. Also, the trainers and pedagogical professionals addressed the need to align pedagogical methods with the desired learning outcomes and quality requirements. Pedagogical practitioners frequently apply different methods in training and exercise settings. One potential main shortfall in the further commitment to using MLEs in training and education focuses on the interest among educational professionals, such as teachers and trainers, in sticking with traditional methods. Rather than seeing technology as simply used to deliver material or carry out administrative tasks, we should see it as deployed to engage students in active learning that allows them to construct knowledge. At the strategic and policy levels, background organizations' procedures and policies play a crucial role in the peacebuilding and cybersecurity training framework and in terms of knowledge, skills, and competence development guidance. This means a strong reflection of technology integration for training and education and discussion with policymakers.

The psychological concepts of skills acquisition, expertise performance, and findings of HTI cannot be underestimated in peacebuilding or cybersecurity training and education. These aspects are and will be needed in the design and development of successful MLEs to increase skills acquisition and improve

human performance in actual cases. HTI in cognitive skills acquisition and expertise performance research should be further examined and also applied in design. Moreover, research findings in domain expertise, such as medicine and surgery (Norman et al., 2018) and in expert performance (e.g., Ericsson 2018), can benefit the design practices, as well as the simulation of the high performance of experts. These can benefit the skills acquisition of novices and intermediates and support the application of learning experiences of human performance and its practice in real life. It is difficult to find complete evidence of the successful transfer of skills and knowledge from MLEs to real life. Valid and reliable experimental research settings are hard to facilitate and organize. Skills acquisition and expertise development principles could be used as pedagogical requirements for the design of MLEs' content and training material. They could determine a specific design aspect for the development of digital learning technologies.

The integration of research, work life, and higher education supports the perspectives of lifelong learning in Europe and ensures effective information sharing among knowledge networks. We must definitely include technology integration in this paradigm. The effective implementation of MLEs for training programs requires a meaningful integration process between technologies and practice. The findings support the need to enhance the integration of learning technologies through blended training methods, consisting of feedback and interaction with a trainer, teacher, or mentor to deepen the learner's reflection about the interaction with technology and content. User commitment and engagement were seen as relevant to the successful integration of technologies into education and training. The integration of technology into training and education may require the application of new methods and strategies to teaching methods and competence building. The findings of this dissertation show that there is growing pressure to redefine and develop higher education teachers' and trainers' competences due to the emerging use of immersive, online, and digital content in learning environments. This can be time-consuming, although the enhancement of training practices can significantly increase human performance in work life. A study by Hyttinen et al. (2017) established that integration practices may include the enhancement of technology-supported content, teachers' and trainers' competences, and a smarter alignment of learning outcomes to design practices.

Learning outcome needs in curriculum planning help by directing learning toward a common goal and measuring it. Learning outcomes capture the preceding training needs analysis and should contain an indicator to assess learning. (Aaltola & Taitto, 2019). MLEs can also have other values, such as enhancing the communication of complex ideas in an accessible way to audiences (Sou, 2018) or increasing the learning process performance and student motivation and engagement (Bacca et al., 2014). During the studies conducted as part of this dissertation, it was established that MLEs can also be used for network purposes among a larger audience of stakeholders and other communities of interest and for dissemination purposes.

Based on the above results, learning objectives and skills acquisition utilization can also be analyzed from the perspective of integrating it into the human-centered design process. In the design process, the step of gathering empirical data from experts produces valuable context-specific knowledge that can be transcribed as narratives, scenarios, or vignettes. The next step—transferring explicit knowledge with specific artistic design features into animated digital content—is taken by multiprofessional groups. The design and technical professionals collaborating with higher education and their institutional professionals must further improve the cocreation processes to ensure knowledge sharing regarding requirements, learning outcomes, or objectives. It seems that new forms of technology should be effectively developed for all professional training and educational fields, which could reach diverse audiences and potentially reduce the costs of large training settings. Even though there has been an absolute explosion of digital games for industry sectors, the gaming industry could provide more meaningful ways of incorporating training and complex environments into the design of MLEs.

The principles of skills acquisition, expert performance, and the pedagogical underpinnings of design support designers in developing MLEs that ensure skills acquisition when users engage in the MLEs. Studying and modeling expert performances with the use of technology can also increase a domain-specific understanding of expertise performance. Unfortunately, the ultimate goals of enhancing expert performance or skills acquisition by the use of technology are not always at the core of MLEs or immersive content. The proper features and design from a skills-acquisition point of view do not themselves guarantee the successful integration and implementation of the developed technologies' part in training and learning. Attractive features or capabilities to ensure simplicity of use have the relevant role of committing humans to work with technology. In terms of engaging learners in using the designed learning tool and game, several important aspects were identified during the research. Finally, only time will show whether the extensive research and commitment of experienced practitioners in the design and development phase will support users' engagement with and continued use of them.

5.2 Recommendations for practice

Based on the empirical findings of past years, this dissertation contributes by clarifying domain-specific knowledge on the effects and roles of MLEs regarding knowledge and skills acquisition in expertise development and models integration practices for meaningful technology-enhanced education and training. To improve human performance through skill acquisition, the interview descriptions provide valuable insights about current methods, viewpoints, and challenges within security education and training.

The use of technologies in the field of training and education continues to focus on the distance-based management of learning with traditional features

and practices. Particularly during Covid-19, different training communities were forced to adapt new learning practices, including technologies such as AR and VR. In practice, technological simulation is one option for creating and integrating a meaningful learning environment as part of the skills acquisition process, where a combination of cognitive and experiential learning may occur. Current digital technologies are a means for creating and facilitating a meaningful learning experience, where the learner can have audio-perceptual experience and further learn through reflection and abstraction.

The benefits of visual immersive content should not be underestimated for learning purposes, for VR patterns, features, and devices can include almost the entire person (Aaltola, 2020). Technology should not be used as a substitute for real-life collaboration, experiences, or interpersonal exchanges (Laszlo & Castro, 1995). Immersive learning content provides the opportunity for learners to engage in augmented scenarios, while the storytelling journey with role-playing increases the feeling of belonging and commitment and initiates thinking. To perform skills in real life, practice, including, for example, movements of different body parts to acquire a basic level of the skill, is the new basis for competence. Comprehensive experiential learning theories (e.g., Kolb & Kolb), expertise research (e.g., Ericsson), and findings of skills acquisition (e.g., Anderson) as academic theoretical frameworks are presented in this dissertation as advantages for gaining skills in MLEs.

Skills acquisition and the utilization of learning principles in training design or higher education programs with embedded digital tools and technology are highlighted in this dissertation. MLEs with immersive content can facilitate the experiential part of skills acquisition, as already found in previous studies, such as those by Laszlo and Castro (1995). This dissertation also highlights the relevance of applying cognitive and constructive learning principles by selecting the methods as well as the design. A development of technological solutions to support efficient learning should not only focus on technology design from a human perspective in the interaction, but also include human cognitive research and processes in the design. Cognitive research can support interaction design to help with knowledge and skills acquisition when human is a target for the technological content.

The time for playing with the designed MLEs, learning applications, and games was limited, and there was not enough time for reflection. It is recommended that teachers ensure enough time for feedback and reflection after learners play with technology and that the learners practice the acquired skills in real life. Appropriate actions as part of the education or training program can be executed by instructors and training providers. Often, the focus is on the guidelines and perceptions afforded by playing with technology, and the reflective aspect is missing due to time considerations.

Beyond providing the experiential opportunity to engage with learning content in MLEs, the facilitator plays a critical role in reflection and abstraction as parts of the learning process. As the study findings of this dissertation show, the cognitive load, such as massive amounts of reading materials, in MLEs

should be carefully analyzed. Learning principles, such as those presented in the earlier chapters, can be utilized throughout training design or higher education programs. The value of constructive and cognitive methods is addressed in the competence acquisition of the adult learner. The importance of cognitive processes in skills and knowledge acquisition is highlighted through learners' processes of inputting, storing, and retrieving information from memory. Findings about age-related differences in performance should be considered in technology design for adult training. People construct new knowledge and understandings based on what they already know, and learning is shaped by previous experiences in collaboration with others. Smart phones and mobile devices are already suitable for immersion and visualization because of their developed capacities. In terms of acceptance and user satisfaction when these devices are used, ease of use and adoption are also relevant elements of MLEs' content.

Key features of learning approaches focus on subjective experiences and perceptions of the world, but training and education practices have commonly taken place in facilities such as classrooms and meeting rooms. These kinds of limitations in training and education settings are discussed extensively, and ways for more effective teaching practices are created. Meaningful practice with feedback in social environments is seen as effective in improving skills and metacognitive capabilities. The models created in this dissertation are in line with the experiential learning cycle and aim to enhance expertise development. MLEs not only shape learning, skills, and expertise acquisition, but also demand competences in designing and integrating the use of technologies in training and education successfully.

Nevertheless, the use of technologies in the field of training and education persists in focusing on the distance-based management of learning with traditional features and facilitation practices. The challenges for the integration of technology into training practices consist of gaps in teachers' competence, an inadequate demonstration of good practices, a lack of resources, the requirements of highly context-specific content, and the high costs of developing technologies. In research article V, the integration practices between work life, research, and education were identified. By identifying current practices, we can find relevant ways to integrate MLEs in a meaningful way into training and education. Ultimately, using technological solutions in training and education is about understanding their role in the pedagogical process and integrating them in a meaningful way. Technological solutions can be seen as an additional feature for these current integration practices for training and education, beyond work life needs, research findings, or projects. The purpose is not to replace classroom learning but rather to create opportunities for a blended-methods toolbox. For example, blended learning activities are not always easy or reasonable to implement for pedagogical professionals. In practice, the selection of learning methods in the learning process affects whether set learning goals are met (Buendía-García et al., 2013).

The successful integration of technological content or MLEs may require the application of new methods and strategies. The studies in this dissertation reveal new empirical findings about knowledge and skills acquisition in order to design learning technologies to better meet human needs in education and training contexts, as well as to design and model their successful integration into education and training. Experiences with MLEs empower professionals to engage with them. There are benefits of a human-centered approach in design. The implementation of new practices may also be time consuming, and the teachers and trainers also need learning. It was established in articles I and V that teachers, trainers, and educators have important roles as guides and facilitators to find and even design knowledge in the form of visual and immersive content.

The principles of human-centered design (see, e.g., Hyttinen, 2017; Saariluoma et al., 2016) are essential considerations in the development of novel technologies (Aaltola, 2020). The proposed model for integration (article I) recommends practical solutions for instructors and teachers for integrating immersive technology-based tools more successfully into training or education courses. The meaning of success lies in ensuring comprehensiveness, engagement, and commitment in learning processes. The commitment of key actors who establish training policies, guidelines, and instructions is crucial in the integration processes. The benefits of earlier research findings from psychological and educational fields on emotions, memory, and skills acquisition could further benefit the design of MLEs and help with the choosing of meaningful pedagogical methods. Therefore, the alignment of these methods with the design and integration practices of MLEs would not only ensure success, but also save time.

In design work with training, education, and companies, it is rare to have many years to conduct background research. More agile ways to build actual life scenarios and visualize learning content and augmented realities need to be investigated by future research. Moreover, the potential value of psychological concepts as part of the pedagogical competences of teaching, training, and facilitating learning with the use of MLEs should be investigated to narrow the gap. As authors (Saariluoma, 2016; Leikas, 2009) have previously established, considerations of usage are relevant. Simple learning technologies may work more effectively in training and education practices. Article 4 argues that applying a human-centered model to the design supports efficiency, effectiveness, and evaluation. One could argue that it is important to apply technologies that increase the motivation of learners to achieve their goals.

Moreover, considerations about analyzing impacts or effects, for example, in the form of societal impact assessment, should not be underestimated among practitioners, and academic practices and studies can provide critical insights into this topic. Societal impact assessment indicators (development of behaviors and attitudes, acquisition of skills and knowledge, community norms and values, and dissemination quality systematic documentation) were identified in article 5 for a network project. In terms of assessment and evaluation, model to assess impacts can contribute to any activity as a logical toolkit and could be utilized for

any innovation and network project or organization that wishes to understand how its actions and solutions influence society.

5.3 Future research

The use of technical tools has been common in humans throughout evolution (Osiurak et al., 2018). The digital revolution has influenced both the ways professional communities operate in cooperation with each other and the ways in which they facilitate learning in training and education environments. Nowadays, learning experiences take place in different realities—in real life and in extended realities with augmented and virtual features (Aaltola, 2020). Indeed, a major advantage of digital learning opportunities is the uniformity and consistency offered globally.

While this dissertation specifically focuses on the domain-specific skills of peacebuilding and cybersecurity, interest in more common basic skills, such as problem-solving and situational awareness, should be further studied in different domain contexts. To inspire researchers, practitioners, and designers who analyze and conduct practices with skills, skills acquisition, and the use of MLEs for skills acquisition, the dissertation proposes new ways to incorporate skills acquisition, expert performance, and pedagogical practices into the learning technology design processes. Beyond domain-specific skills, it is recommended that more skills in the educational field be studied to enhance domain-specific training sessions and exercises.

This dissertation posits that the technological solution is best utilized as a complementary resource for tailored needs but is not adequate and sufficiently nuanced to act as a stand-alone training tool or as a replacement for real-life experiential learning, such as reflection or sensorimotor exercise. In this dissertation, the recommendations based on the study findings highlight practical solutions to better meet or be prepared for the potential effects of using MLEs in skills acquisition. However, to increase the validity of these recommendations, scientific research, cases in different domains, and design work will be needed in the future.

The findings of this dissertation address concern about properly facilitating the use of MLEs and reserving time for reflection as part of the pedagogical process when using technologies. The survey before and after playing the learning game provided some data to analyze knowledge and skills acquisition. Nevertheless, more comprehensive, and longer-term research is needed to understand the role and value of MLEs and their content for expert performance. Further research is also needed on the appropriate methods for performance evaluation. Because of the ethical and security aspects of MLEs, their capabilities are interesting for future research from the perspectives of different academic disciplines. However, that role of MLEs should not be overstated, and this study demonstrates that, given the fluid, dynamic nature of professionals' work in

peacebuilding and cyber security environments, the nuances and sector-specific challenges cannot always be exactly replicable in MLE platforms.

In this dissertation, the initial recommendations were modeled to ensure a scientific background of skills acquisition, pedagogy, and learning in the emerging usage of learning technologies in the future. There is an inherent danger that overreliance on behaviorist learning at the expense of traditional learning approaches and scientific evidence of skills acquisition might leave individuals ill prepared, underinformed, and under-skilled for their actual professional roles and work environments. The continuum of AR/VR from a learning and performance viewpoint should be further studied. It is recommended that the research community carry out further study, in close cooperation with practitioners and user communities, of the skills acquisition and expertise performance aspects and their influences on the design and knowledge transfer of intelligent cognitive behavior.

6 CONCLUSION

In this dissertation, the theoretical framework was built on expertise development and learning technology design to contribute comprehensively to the research agenda of both skills acquisition in and the design of MLEs. A certain scrutiny of learning technologies has emerged in recent years, particularly as the fields have diversified. Although both domains studied highlight the relevance of training among personnel to enhance their performance in daily work, the use of MLEs is a relatively new technological innovation for potential training for peacebuilding and cybersecurity. In terms of skills acquisition, this dissertation focused on analyzing the effects and role of MLEs in skills acquisition, training, and education to improve experts' performance in actual life. Academic research and studies have analyzed, evaluated, and assessed MLEs and methods with regard to skills training and learning. Much of this assessment has thrown down the gauntlet regarding the merits of skills training with the use of modern technologies. While there is potential, there are also many obstacles and limitations.

One key research focus of this dissertation was to analyze domain-specific skills acquisition in MLEs to improve performance in actual life. Earlier studies and the literature review show that there is a relationship between higher processes of sensorimotor skill learning and experiential learning approaches in adult learners' skills acquisition and expertise development. In addition, previous studies on skills acquisition and expertise development highlighted the skills common to humans, such as problem-solving, adaption, and situational awareness, which are common in different domains. The findings of this dissertation on peacebuilding experts' experiences of playing with MLEs focused on how to gain skills to perform successfully in a real-life environment.

Interestingly, there are few empirical findings on learning's impacts on performance and thinking after the use of MLEs for learning and skills acquisition purposes (Aaltola, 2021). The findings of this dissertation showed that the general effects, from the users' perspective immediately after playing in the MLEs, focused on enjoyment and motivation. Individuals with real-life experience in comparable settings portrayed in interactions with MLEs

considered them to be useful additional training tools. Research participants felt that instead of written texts, the immersive learning content in a digital format should include visual solutions, such as videos, animations, storytelling, scenarios, maps, and other visual and structured material. The qualitative analyses pointed out that experts experienced the rich media content positively, especially visualizations and video animations. Both positive and negative implications were addressed in the mimicking narratives of the challenging and culturally sensitive topic of peacebuilding. They established that these visual contents helped to adapt new information more precisely and quickly. There are multiple previous scientific findings on the role of emotions in information processing, memory, and human behavior (e.g., Myllylä & Saariluoma, 2022; Saariluoma, 2020). However, this dissertation's conclusions about digital learning content effects were tentative and focused on the immediate perceptual experience.

Consequently, it is posited that the content of MLEs is best utilized as a complementary tool, but it is not sufficiently and adequately nuanced to act as a stand-alone training tool or as a replacement for pedagogical methods of experiential learning (Aaltola, 2020; Aaltola, 2021). Empirical difficulties persist, and one of the most significant questions relates to expectations for and relevance of digital content, as well as the estimation of its potential uses. The critical conclusion to be drawn from this dissertation is that there is room for improvement in the design and use of MLEs within peacebuilding and cybersecurity training and higher education. However, the role of technologies should not be overstated, and the findings demonstrated that, given the fluid, dynamic nature of professionals' work in complex environments, the nuances and contexts of those environments cannot always be an exact replicable of modern environments and realities. There is an inherent danger that overreliance on active learning through digital learning content in the MLEs at the expense of traditional learning approaches could leave individuals underinformed and under-skilled for their professional roles and actual working environments. The effects of using MLEs focused on shaped pedagogical methods and the transmission of a large amount of cognitive knowledge and information within a short timeframe. The time used for using the learning tool or playing the game was experienced as too short by the players. This kind of cognitive load challenges HTI, and its influence on learning should be further studied.

MLEs access the people of global communities and provide learning opportunities through the use of technology in a potentially cost-effective way. While MLEs are expected to promote educational and competence-improvement goals, they have also claimed to support attitudinal and behavioral change. When it is anticipated that learning, skills acquisition, or expertise development will occur through the use of MLEs, new challenges for an accurate assessment of them immediately after use may arise in the future (Aaltola, 2021). The subjectivity of learning and expertise development theories also afflicts AR/VR simulation and scenario methods (Aaltola, 2021). Aaltola and Taitto (2019), as well as Radianti et al. (2020), argued that regardless of educational learning

theory, MLE design and development should be especially firmly guided by learning and cognitive theories since they provide guidance based on scientific evidence to reach the desired outcomes. Ensuring the link between learning theories and MLE design and development will improve their consistency with learning goals or objectives.

Technologies designed for learning and training often aim to support humans in gaining the competences and skills to work in new contexts or environments. Modern digital tools enable new ways of narrating content (Hyttinen, 2017) and creating stories (Alexander, 2017), and developers attempt to augment the illusion of a virtual reality or world for the players or users by immersive experience (Zyda, 2005). Nevertheless, the design and development of MLEs is a time-consuming and difficult process that includes developing efforts, interactive experiences, interactions, details, quality graphics, and journey content (Knapp, 2012). Consequently, this dissertation recommends that developers, in close cooperation with practitioners, researchers, and user communities, understand the purpose and context of usage from the point of view of skills acquisition, expert performance, and expertise development.

According to empirical data analysis from international security, peacebuilding, and cybersecurity domains, an understanding of the standards of behavior and an awareness of current practices in a real-life context are required for designing learning technologies. Otherwise, there might be even higher resistance among training and education providers to integrating the beneficial technologies into the curricula of education and training. The findings show that, even though learning technologies are seen as beneficial by users in evaluation, their integration into training is one of the key challenges in current practices. In the context of adult training for professionals and experienced personnel, skills acquisition and learning principles should be given high priority in both the integration and design of technology. Interviewees described how culture, history, religion, and gender aspects play important roles in conflict-area work. For example, learning content creation should encompass the role of emotions.

The inclusion of more human-centric design perspectives and psychological concepts of HTI could be suggested for the design of MLEs to increase skills acquisition and human performance in actual cases. In the study by Aaltola (2020), the experiential learning cycle was utilized as a foundation for a model to integrate immersive learning technologies into adult training. The proposed model presents solutions for instructors and teachers to integrate immersive technology-based tools more successfully into training or education courses. The meaning of success lies in commitment, engagement, and ensuring that learning processes are comprehensively supported by play and immersive learning content. The design and development of MLEs should consider ensuring the design phases of user needs and requirements, representation models, and methods include subconscious and tacit knowledge, as well as ensure embodied cognition opportunities with VR devices and immersive content creation. These can benefit skills acquisition and the application of learning experiences to human competence in real life. Nevertheless, we must

better understand the roles of human information processing, memory, and emotions, and their influences on performance.

MLEs with immersive and affective learning content can complement the acquisition of human skills and competences in the development of expertise. To conclude, it can be suggested that the design and development of MLEs for experts deployed in complex real-life settings should comprehensively understand learning theories and follow the principles of human-centered design and research findings on HTI. There is the potential for learning technologies to be integrated in a more effective and engaged way into training and education as part of a means or method to improve immersive experiences and experiential opportunities for skills acquisition and successful performance in real life.

YHTEENVETO (SUMMARY IN FINNISH)

Nykyaikaiset oppimisympäristöt taitojen hankinnassa

Tämä väitöskirja keskittyy taidon hankkimiseen ja asiantuntijuuteen moderneissa oppimisalustoissa. Tavoitteena on selvittää modernien oppimisympäristöjen vaikutuksia ihmisten oppimiseen ja taitojen hyödyntämiseen todellisessa työympäristössä. Informaatioteknologian viimeaikaisten suurten muutosten mukaisesti tutkimuskysymykset ovat valittu niiden merkityksellisyyden ja ajankohtaisuuden vuoksi. Pedagogiset teoriat ja menetelmät, kuten käyttäytymistieteellinen, sosiaalinen konstruktionismi, kognitivismi ja konnektiivisuus, ovat ohjanneet taidon hankkimista kohti asiantuntijuutta todellisessa työelämäkontekstissa.

Digitaalisten teknologioiden nopea muutos ja kehitys on vaikuttanut myös pedagogisten teorioiden ja menetelmien tarkasteluun. Kehitys on muuttanut ainakin osittain perinteisiä oppimisympäristöjä. Teknologinen siirtymä on nostanut uudenlaisia tarpeita oppimiskokemusten järjestämisen kannalta sekä oppimistavoitteiden saavuttamisen osalta. Koulutuksen uudenlaiset digitaaliset käytännöt ovat lisänneet myös monitieteellisen tutkimuksen merkitystä, jotta ymmärrämme paremmin tiedon ja taidon hankkimista uusissa oppimisympäristöissä sekä ihmisen ja teknologian välistä vuorovaikutusta vaikutuksineen. Tarvitsemme uusia tutkimukseen perustuvia malleja ja lähestymistapoja modernien oppimisympäristöjen suunnitteluun ja kehittämiseen, jotta ne ovat niin pedagogisesti hyväksyttäviä, motivoivia kuin sitouttavia.

Väitöskirjan teoreettinen tietopohja perustuu aikuiskasvatustieteellisille lähestymistavoille, asiantuntijuuden kehittymiseen ja teknologiseen suunnitteluun. Aiemmat kognitiivisen psykologian ja kasvatustieteiden empiiriset tutkimukset ovat osoittaneet laajasti tuloksia oppimisesta, taidon kehittymisestä ja asiantuntijuuden kehittymisestä. Viimeaikaiset muutokset toimintaympäristöissä kohti digitaalisuutta ovat lisänneet tarvetta tutkia myös modernien oppimisympäristöjen vaikutuksia kontekstisidonnaisten taitojen oppimiselle. Lisäksi meidän tulee paremmin ymmärtää kuinka digitaaliset käytännöt tulisi järjestää koulutuksessa, jotta mahdollistamme todellisten työelämätaitojen parantamisen koulutusympäristöissä. Tutkimustulokset tukevat digitaalisten oppimissisältöjen suunnittelua ja järjestämistä.

Kuinka asiantuntijat hankkivat taitoja ja asiantuntijuus kehittyy? Kuinka modernit oppimisympäristöt muokkaavat asiantuntijoiden oppimista ja tietotaidon siirtämistä todellisiin työelämäkonteksteihin? Millaisia ovat asiantuntijoiden käyttökokemukset moderneista oppimisympäristöistä koulutuksessa? Tämän väitöskirjan artikkelit I, II, III ja VIII tarkastelevat modernien oppimisympäristöjen vaikutuksia oppimiseen ja tietotaidon siirtämiseen todelliseen työelämäkontekstiin

Mitkä ovat tietotaidon ja tiedon siirtämisen tapoja moderneissa oppimisympäristöissä? Kuinka voimme kehittää modernien oppimisalustojen suunnittelua, hyödyntämistä ja integraatiota koulutuksessa? Tämän väitöskirjan artikkelit

IV, V, VI ja VII tarkastelevat tiedon siirtämistä ja teknologiaintegroinnin mahdollisia haasteita ja menetelmiä. Tutkimustuloksiin perustuen tässä väitöskirjassa ehdotan

1. alustavia lähestymistapoja kestävien, motivoivien ja sitouttavien ratkaisuiden suunnitteluun ja käytännön toteutukseen,
2. immersiivisen oppimissisällön integrointimallia aikuiskoulutuksessa,
3. ihmiskeskeistä suunnittelumallia verkko-oppimistyökalujen kehittämiselle,
4. motivaatiopainotteista systemaattista lähestymistapaa teknologian integroimiseen korkeakoulutuksessa,
5. yhteiskunnallisen vaikuttavuuden työkalu- ja arviointikehikkoa verkostoyhteistyölle ja tiedon siirtämiselle.

Tämän väitöskirjan tutkimustuloksia voi hyödyntää koulutuksissa ja asiantuntijuuden kehittämisessä, jossa oppiminen keskittyy tiedon ja taidon hankkimiseen moderneilla oppimisalustoilla. Tämän väitöskirjan osatutkimukset ovat toteutettu rauhanrakentamisen ja kyberturvallisuuden asiantuntijakonteksteissa. Ihmiskeskeinen teknologiasuunnittelu ja digitaalisten teknologioiden tarkoituksenmukainen hyödyntäminen koulutuksissa voi parantaa sekä oppimista että asiantuntijoiden suoriutumista haastavissa turvallisuuden työelämäkonteksteissa. Hyvän taidon hankkiminen koulutuksessa voi vaikuttaa suorasti tai epäsuorasti operatiiviseen asiantuntijatoimintaan riski- ja turvallisuustilanteissa. Kognitiotieteisiin perustuva taidon hankkiminen ja asiantuntijuuden kehittyminen moderneilla oppimisalustoilla voi avata yhä uusia metodeja ja käytäntöjä tehokkaalle ja vaikuttavalle oppimiselle ja kouluttamiselle eri todellisuuksissa ja työelämäkonteksteissa.

REFERENCES

Aaltola K. (2021) Empirical Study on Cyber Range Capabilities, Interactions and Learning Features. In: Tagarev T., Atanassov K.T., Kharchenko V., Kacprzyk J. (eds) *Digital Transformation, Cyber Security and Resilience of Modern Societies*. Studies in Big Data, vol 84. Springer, Cham. https://doi.org/10.1007/978-3-030-65722-2_26

Aaltola, K. M. (2020). New Technologies Shaping Learning?: AR Learning Experiences and Integration Model. In Zheng, R. (2020) *Cognitive and Affective Perspectives on Immersive Technology in Education* (pp. 195-214). IGI Global.

Aaltola, K. (2020b). Empirical study on Cyber Range (CR) capabilities, interactions and learning features. In Tagarev, T. Atanassov, K., Kharchenko, V., Kacprzyk, J. (Eds.) *Digital Transformation, Cyber Security and Resilience of Modern Societies*. Springer. Accepted.

Aaltola, K. & Ruoslahti, H. (2020). Societal Impact Assessment of a Cyber Security Network Project. *Information & Security: An International Journal 46, no. 1 (2020): 53-64*. https://doi.org/10.11610/isij.4604

Aaltola, K., Taitto, P. (2019). Utilising experiential and organizational learning theories to improve human performance in cyber training. *Inf. Secur. Int. J. 43*(2), 123–133 (2019). https://doi.org/10.11610/isij.4311

Aaltola, M. (2020). The Chinese Recruitment Web as a Contrast Point. In *Democratic Vulnerability and Autocratic Meddling* (pp. 159-171). Palgrave Macmillan, Cham.

Abyshev, O. A., Yablochnikov, E. I., Mäkiö, J. (2020). Industrial Cyber-Physical Systems Engineering: The Educational Aspect. *International Conference Modern Engineering: Science and Education*, 9-12. 2020.

Agasisti, T., & Soncin, M. (2021). Higher education in troubled times: on the impact of Covid-19 in Italy. *Studies in Higher Education*, *46*(1), 86-95.

Aivatoglou, G., Anastasiadis, M., Spanos, G., Voulgaridis, A., Votis, K., Tzovaras, D., & Angelis, L. (2021). A RAkEL-based methodology to estimate software vulnerability characteristics & score-an application to EU project ECHO. *Multimedia Tools and Applications*, 1-21.

Alexander, B. (2017). *The New Digital Storytelling: Creating Narratives with New Media--Revised and Updated Edition*. Abc-clio.

All, A., Castellar, E. P. N., & Van Looy, J. (2016). Assessing the effectiveness of digital game-based learning: Best practices. *Computers & Education*, 92, 90-103.

Allan, J., & Clarke, K. (2007). Nurturing Supportive Learning Environments in Higher Education through the Teaching of Study Skills: To Embed or Not to Embed? *International Journal of Teaching and Learning in Higher Education, 19*(1), 64-76.

Allen, I. E., & Seaman, J. (2010). Class differences: Online education in the United States, 2010. *Sloan Consortium (NJ1)*. Babson Park, MA: Babson Survey Research Group.

Abyshev, O. Yablochnikov, E. & Mäkiö, J. (2020). Industrial Cyber-Physical Systems Engineering: The Educational Aspect. In: Evgrafov A.N. (eds) Advances in Mechanical Engineering. MMESE 2020. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-62062-2_2.

Anderson, J., Betts, S., Bothell, D., Hope, R. M., & Lebiere, C. (2018). Three Aspects of Skill Acquisition. PsyArXiv. https://doi.org/10.31234/osf.io/rh6zt

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological review*, *89*(4), 369. Copyright 1982 by the American Psychological Association, Inc. doi.org/10.1037/0033-295X.89.4.369

Ansari, J. A. N., & Khan, N. A. (2020). Exploring the role of social media in collaborative learning the new domain of learning. *Smart Learning Environments*, *7*(1), 1-16

Aspin, D. N., & Chapman, J. D. (2007). Lifelong learning: Concepts and conceptions. In *Philosophical perspectives on lifelong learning* (pp. 19-38). Springer, Dordrecht.

Argyris, C. (1993). *Knowledge for Action. A Guide to Overcoming Barriers to Organizational Change*. San Francisco Jossey-Bass Publishers.

Argyris, C., & Schon, D. A. (1974). *Theory in practice: Increasing professional effectiveness*. Jossey-bass.

Argyris, C., & Schon, D. (1978). *Organizational learning: A theory of action perspective*. Addison-Wesley Publishing Company, 1978 - 344 pages.

Attig C., Wessel D., Franke T. (2017). Assessing Personality Differences in Human-Technology Interaction: An Overview of Key Self-report Scales to Predict Successful Interaction. In: Stephanidis C. (eds) *HCI International 2017 – Posters' Extended Abstracts. HCI 2017. Communications in Computer and Information Science,* vol 713. Springer, Cham. DOI: 10.1007/978-3-319-58750-9_3

Bacca, J., Baldiris, S., Fabregat, R., & Graf, S. (2014). Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *Journal of Educational Technology & Society, 17*(4), 133-149. Retrieved November 11, 2020, from http://www.jstor.org/stable/jeductechsoci.17.4.133

Bandura, A. (1971). Vicarious and self-reinforcement processes. *The nature of reinforcement*, *228278*. Academic Press, Inc., New York and London.

Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1992). Theory into practice: How do we link. In Duffy, T. M. & Jonassen, D. H. *Constructivism and the technology of instruction: A conversation*, *8*(1), 17-34. Lawrence Erlbaum.

Bennett, S. (2009). Libraries and learning: A history of paradigm change. *portal: Libraries and the Academy*, *9*(2), 181-197.

Benner, T., Binder, A., & Rotmann, P. (2007). Learning to Build Peace? United Nations Peacebuilding and Organizational Learning: Developing a Research Framework.

Berki, E., Valtanen, J., Chaudhary, S., & Li, L. (2018). The Need for Multi-Disciplinary Approaches and Multi-Level Knowledge for Cybersecurity

Professionals. In *Multidisciplinary Perspectives on Human Capital and Information Technology Professionals* (pp. 72-94). IGI Global.
Bétrancourt, M. (2005). The animation and interactivity principles in multimedia learning. In Mayer, R. (Eds.) *The Cambridge handbook of multimedia learning*, 287-296. University of California, Santa Barbara.
Bidell, T. & Fischer, K. (1992). Cognitive development in educational contexts - Implications of skill theory. In Demetriou, A., Shayer, M. & Efklides, A. (Eds) *Neo-Piagetian Theories of Cognitive Development. Implications and applications for education*. Routledge, New York.
Blažič, B. J. (2021). Changing the landscape of cybersecurity education in the EU: Will the new approach produce the required cybersecurity skills?. *Education and Information Technologies*, 1-26.
Boeker, M., Andel, P., Vach, W., & Frankenschmidt, A. (2013). Game-based e-learning is more effective than a conventional instructional method: A randomized controlled trial with third-year medical students. *PLoS One, 8*, e82328.10.1371/journal.pone.0082328
Bonk, C. J., & Cunningham, D. J. (1998). Searching for learner-centered, constructivist, and sociocultural components of collaborative educational learning tools. *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse*, *25*, 25-50.
Boutsiouki, S. (2010). Dynamics and potentiality of postgraduate students regarding lifelong learning: A Greek case. *International Education Studies*, *3*(1), 3-16.
Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribero, C. & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, *94*, 178-192.
Boyd, R., & Richerson, P. J. (1996, January). Why culture is common, but cultural evolution is rare. In *Proceedings-British Academy* (Vol. 88, pp. 77-94). OXFORD UNIVERSITY PRESS INC.
Bozkurt, A., Akgun-Ozbek, E., Yilmazel, S., Erdogdu, E., Ucar, H., Guler, E., ... & Aydin, C. H. (2015). Trends in distance education research: A content analysis of journals 2009-2013. *International Review of Research in Open and Distributed Learning*, *16*(1), 330-363.
Blockmans, S. (2007). Tough love: the European Union's relations with the Western Balkans. The Hague: T.M.C. Asser Press.
Bimber, O., & Raskar, R. (2005). *Spatial augmented reality: merging real and virtual worlds*. CRC press.
Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational researcher*, *18*(1), 32-42.
Brown, S. W., Lawless, K. A., Boyer, M. A. (2013). Promoting Positive Academic Dispositions Using a Web-based PBL Environment: The GlobalEd 2 Project. *Interdisciplinary Journal of Problem-Based Learning,* 7(1). Available at: https://doi.org/10.7771/1541-5015.1389.

Brown, C. (2018). The Use of ICTs in Conflict and Peacebuilding: A Feminist Analysis. *Australian Feminist Law Journal*, *44*(1), 137-153.
Bruder, I. (1989). Distance Learning: What's Holding Back This Boundless Delivery System?. *Electronic learning*, *8*(6), 30-35.
Bruner, J. S. (1993). *Acts of Meaning: Four Lectures on Mind and Culture*. Harvard University Press.
Bruner, J. S. (1973). Organization of early skilled action. *Child development,* 1-11.
Bruner, J. S. (2009). *Actual minds, possible worlds*. Harvard University Press.
Brynen, R., & Milante, G. (2013). Peacebuilding with games and simulations. *Simulation & Gaming*, *44*(1), 27-35.
Buendía García, F., García-Martínez, S., Navarrete-Ibañez, E. M., & Cervelló-Donderis, M. (2013). Designing Serious Games for getting transferable skills in training settings. *Interaction Design and Architecture (s)*, (19), 47-62.
Burnard, P., Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Analysing and presenting qualitative data. *British dental journal, 204*(8), 429-432.
Campfield, M. (2021). Mind the gap: the cloud security skills shortage. *Computer Fraud & Security*, *2021*(8), 6-10.
Casey, D. M. (2008). The historical development of distance education through technology. *TechTrends*, *52*(2), 45-51.
Carrera, C. C., Perez, J. L. S., & Cantero, J. D. L. T. (2018). Teaching with AR as a tool for relief visualization: Usability and motivation study. *International Research in Geographical and Environmental Education*, *27*(1), 69-84.
Carey, S. (1986). Cognitive science and science education. *American psychologist*, *41*(10), 1123. https://doi.org/10.1037/0003-066X.41.10.1123
Cedefop. (2015). *Skill shortages and gaps in European enterprises: striking a balance between vocational education and training and the labour market*. Luxembourg: Publications Office. Cedefop reference series; No 102. http://dx.doi.org/10.2801/042499
Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4*(1), 55–81. https://doi.org/10.1016/0010-0285(73)90004-2
Chatham, R. E. (2009). The 20th century revolution in military training. In K.A. Ericsson (Eds.) *Development of professional expertise. Toward measurement of expert performance and design of optimal learning environments*, 27-60. Cambridge University Press.
Cheng, M. T., She, H. C., & Annetta, L. A. (2015). Game immersion experience: its hierarchical structure and impact on game‐based science learning. *Journal of Computer Assisted Learning*, 31(3), 232-253. 10.1111/jcal.2015.31.issue-3
Chen, S. W., Yang, C. H., Huang, K. S., & Fu, S. L. (2019). Digital games for learning energy conservation: A study of impacts on motivation, attention, and learning outcomes. *Innovations in Education and Teaching International*, 56(1), 66-76.DOI: 10.1080/14703297.2017.1348960
Chieffi, S., Messina, G., Villano, I., Messina, A., Valenzano, A., Moscatelli, F., ... & Cibelli, G. (2017). Neuroprotective effects of physical activity: evidence

from human and animal studies. *Frontiers in neurology*, 8, 188. 10.3389/fneur.2017.00188
Choi, J. I., & Hannafin, M. (1995). Situated cognition and learning environments: Roles, structures, and implications for design. *Educational technology research and development, 43*(2), 53-69.
Chomsky, N. (1986). *Knowledge of language: Its nature, origin, and use*. Greenwood Publishing Group.
Clark, A. (1999). An embodied cognitive science?. *Trends in cognitive sciences, 3(9), 345-351*. September 1999. 1999 Elsevier Science.
Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. John Wiley & Sons. ISBN 1119158664.
Charalambos, V., Michalinos, Z., & Chamberlain, R. (2004). The design of online learning communities: Critical issues. *Educational Media International*, *41*(2), 135-143. International Council for Educational Media.
Cianciolo, A. T., & Sternberg, R. J. (2018). Practical intelligence and tacit knowledge: An ecological view of expertise. In K.A. Ericsson, N. Charness, P. Feltovich & R.R. Hoffman (Eds.) *The Cambridge Handbook of Expertise and expert performance*. Second Edition. Cambridge, Cambridge University Press.
Clement, A. (1994). Computing at Work: Empowering Action by 'Low-level Users'. *Communications of the ACM (37)1 (Jan):* 52-65.
Cobb, M. J. (2018). Plugging the skills gap: The vital role that women should play in cyber-security. *Computer Fraud & Security*, *2018*(1), 5-8.
Cohen-Cole, J. (2007). Instituting the science of mind: intellectual economies and disciplinary exchange at Harvard's Center of Cognitive Studies. *British Society for the History of Science 40*(4): 567-597. doi:10.1017/S0007087407000283
Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychological science*, *14*(2), 125-130. 10.1111/1467-9280.t01-1-01430
Coleman, J.S. (1990) *Foundations of Social Theory.* Cambridge, MA: Harvard University Press.
Colt, H. G., Crawford, S. W., & Galbraith III, O. (2001). Virtual reality bronchoscopy simulation: a revolution in procedural training. *Chest*, 120(4), 1333-1339.
Conole, G., & Alevizou, P. (2010). A literature review of the use of Web 2.0 tools in Higher Education. *A report commissioned by the Higher Education Academy*. The Open University, Walton Hall, Milton Keynes, UK.
Conrad, D. 2002. Deep in the hearts of learners: Insights into the nature of online community. *Journal of Distance Education*, 17(1), 1−19.
Cook, D. A., Levinson, A. J., Garside, S., Dupras, D. M., Erwin, P. J., & Montori, V. M. (2008). Internet-based learning in the health professions: A meta-analysis. *Journal of the American Medical Association, 300(10), pp.1181–1196*.

Crookall, D. 2010. Serious Games, Debriefing, and Simulation/Gaming as a Discipline. *Simulation & Gaming. Vol. 41. No 6 pp.898–920.*
Costley, K. (2014). The Positive Effects of Technology on Teaching and Student Learning. *Online Submission* ED554557.
Cuhadar, Esra and Ronit Kampf. 2014. Learning about Conflict and Negotiation through computer simulations: The Case of PeaceMaker. *International Studies Perspectives, Vol. 15. pp. 509-524.*
Curran, D. (2013). Training for peacekeeping: Towards increased understanding of conflict resolution?. *International peacekeeping*, *20*(1), 80-97.
Crebert, G., Bates, M., Bell, B., Patrick, C. J., & Cragnolini, V. (2004). Developing generic skills at university, during work placement and in employment: graduates' perceptions. *Higher Education Research & Development, 23*(2), 147-165.
Dalsgaard, C. (2006). Social software: E-learning beyond learning management systems. European Journal of Open, Distance and e-learning, 9(2). Institute of Information and Media Studies, University of Aarhus, Helsingforsgade.
Dankbaar, M. E., Richters, O., Kalkman, C. J., Prins, G., Ten Cate, O. T., van Merrienboer, J. J., & Schuit, S. C. (2017). Comparative effectiveness of a serious game and an e-module to support patient safety knowledge and awareness. *BMC medical education*, *17*(1), 30.
Daiute, C. (2013). *Narrative inquiry: A dynamic approach*. Sage Publications. https://doi.org/10.4135/9781544365442
Davis, J., Magrath, S. (2013). A Survey of Cyber Ranges and Testbeds. Cyber Electronic Warfare Division. Commonwealth of Australia 2013.
Dawson, C. & Rakes, G. (2003). The Influence of Principals' Technology Training on the Integration Of Technology into Schools, *Journal of Research on Technology in Education*, 36:1, 29-49, DOI: 10.1080/15391523.2003.10782401
Delvin, C., Trochowska, K., Hyttinen, K., Clarke, J., McCready, P., Smith, R., Curristan, S., Singleton, S. (2017). Deliverable 3.1 Regional Stakeholder Reports. GAP -project (H2020). Available at: https://gap-project.eu/wp-content/uploads/2019/03/D3.1-Regional-Stakeholder-Reports-2.pdf
De Coning, C. (2020). Adaptive Peace Operations: Navigating the Complexity of Influencing Societal Change Without Causing Harm. *International Peacekeeping*, *27*(5), 836-858. 10.1080/13533312.2020.1797500
De Freitas, S. (2014). *Education in Computer Generated Environments*. Routledge: New York and London
De Freitas, S. and Routledge, H. (2013). Designing leadership and soft skills in educational games: The e-leadership and soft skills educational games design model (ELESS). *British Journal of Educational Technology, Volume 44 (6): 951-968.*
De Freitas, S and J Jameson. (2012). *The E-Learning Reader*. Continuum Books: London and New York.
De Freitas, S. (2006). Using games and simulations for supporting learning. *Learning, media and technology, 31*(4), 343-358. DOI: 10.1080/17439880601021967

Dewey, J. (1938). Experience and Education. London: Collier MacMillan.
Devlin, C., Trochowska, K., Hyttinen, K., Clarke, J., McCready, P., Smith, R., Curristan, S., Singleton, S. (2017). *Deliverable 3.1 Regional Stakeholder Reports*. GAP Gaming for Peace. This project has received funding from the EU Framework Programme for Research and Innovation HORIZON 2020 under the agreement 700670.
DiCicco-Bloom B., & Crabtree B. F. (2006). The qualitative research interview. Med Educ. 40(314–21).
Di Serio, Á., Ibáñez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education, 68*, 586–596. doi:10.1016/j.compedu.2012.03.002
Doane, S. M., Sohn, Y. W., & Jodlowski, M. T. (2004). Pilot ability to anticipate the consequences of flight actions as a function of expertise. *Human factors*, *46*(1), 92-103.
Drožđek, B., Rodenburg, J., Moyene-Jansen, A. (2020). "Hidden" and diverse long-term impacts of exposure to war and violence. *Frontiers in Psychiatry, 10*, Article 975. https://doi.org/10.3389/fpsyt.2019.00975
Dunleavy, M., Dede, C., Mitchel, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. J Sci Educ Technol 18(1):7–22.
Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., ... & Williams, M. D. (2019). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, 101994.
Dworschak, B., & Zaiser, H. (2014). Competences for cyber-physical systems in manufacturing–first findings and scenarios. In *Procedia CIRP* Vol. 25, No. C, pp. 345-350. Elsevier.
Ejdus, F., & Juncos, A. E. (2018). Reclaiming the local in EU peacebuilding: Effectiveness, ownership, and resistance. *Contemporary Security Policy, 39*(1), 4-27.
Edmondson, A. & Moingeon, B. (1998). From Organizational Learning to the Learning Organization. *Management learning 29*.1: 5-20.
Ellis, R. (2009). Implicit and explicit learning, knowledge and instruction. In R. Ellis, S. Loewen, C. Elder, R. Erlam, J. Philp, & H. Reinders (Eds.), *Implicit and explicit knowledge in second language learning, testing, and teaching* (pp. 3-26). Clevedon: Multilingual Matters.
Elliott, S. (2017). *Computers and the Future of Skill Demand*. Educational Research and Innovation. OECD Publishing, Paris, https://doi.org/10.1787/9789264284395-en.
Evans, K., Guile, D., Harris, J., & Allan, H. (2010). Putting knowledge to work: A new approach. *Nurse Education Today, 30*(3), 245–251. doi:10.1016/j.nedt.2009.10.014
European Commission (2020a). The EU's Cybersecurity Strategy for the Digital Decade. JOIN(2020) 18 final.

European Commission (2020b). Descriptors defining levels in the European Qualifications Framework (EQF). https://ec.europa.eu/ploteus/content/descriptors-page

European Commission (2001). Communication from the Commission - Making a European Area of Lifelong Learning a Reality - "When planning for a year, plant corn. When planning for a decade, plant trees. When planning for life, train and educate people." COM/2001/0678 final.

Earnshaw, Y., Tawfik, A., & Schmidt, M. (2017). User experience design. In R. E. West (Ed.), Foundations of learning and instructional design technology (1st ed.). EdTech Books

Ericsson, K. A. (2018). The Differential Influence of Experience, Practice and Deliberate Practice on the Development of Superior Individual Performance of Experts. In K.A. Ericsson, N. Charness, P. Feltovich & R.R. Hoffman (Eds.) *The Cambridge Handbook of Expertise and expert performance. Second Edition*. Cambridge, Cambridge University Press.

Ericsson, K. (2006a). The influence of experience and deliberate practice on the development of superior expert performance. In K.A. Ericsson, N. Charness, P. Feltovich & R.R. Hoffman (Eds.) *The Cambridge Handbook of expertise and expert performance* (p. 685-706). Cambridge, Cambridge University Press.

Ericsson, K. (2006b). Protocol Analysis and expert thought: Concurrent verbalizations of thinking during experts' performance on representative task. In K.A. Ericsson, N. Charness, P. Feltovich & R.R. Hoffman (Eds.) *The Cambridge Handbook of expertise and expert performance* (p. 223-242). Cambridge, Cambridge University Press.

Ericsson, K.A (2003). How the expert-performance approach differs from traditional approaches to expertise in sports: In search of a shared theoretical framework for studying expert performance. In J. Starkes & K. A. Ericsson (Eds.) Expert performance in sport: Recent advances in research on sport expertise (pp.371–401). Champaign, IL: Human Kinetics.

Ericsson, K. A., Krampe, R. Th., & Tesch-R¨omer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100,* 363–406.

Ericsson, K. A., & Smith, J. (1991). *Toward a general theory of expertise: Prospects and limits*. Cambridge University Press.

Ericsson, K. A., & Polson, P. G. (1988). A cognitive analysis of exceptional memory for restaurant orders. *The nature of expertise, 1*, 23-70.

Ertmer, P. & Newby, T. (1993). Behaviorism, Cognitivism, Constructivism: Comparing Critical Features From an Instructional Design Perspective. *Performance Improvement Quarterly 6*(4), 1993. pp. 50-72. doi: 10.1111/j.1937-8327.1993.tb00605.x

European Parliament, (2012). CSDP Missions and Operations: Lessons Learned Processes. *European Union, 2012. Directorate-General for External Policies, Policy Department*. ISBN: 978-92-823-3756-1. Accessed September 21, 2017.

Farrell, C. (2005). Perceived Effectiveness of Simulation in International Business Pedagogy: An Exploratory Analysis. *Journal of Teaching in International Business, 16(3), 71-88*.

Felix, U. (2005). E-learning pedagogy in the third millennium: The need for combining social and cognitive constructivist approaches. *ReCALL, 17*(1), 85-100.

Feltovich, P.J., Prietula, M. J., & Ericsson, K.A (2006). Studies of Expertise from Psychological Perspectives. In Ericsson, K.A., Charness, N., Feltovich, P.J, & Hoffmann, R.R. (2006). *The Cambridge Handbook of Expertise and Expert Performance. Cambridge University Press.* Published in the United States of America by Cambridge University Press, New York.

Ferguson, B., Tall, A., & Olsen, D. (2014). National Cyber Range Overview. 2014 IEEE Military Communications Conference, pp. 123–128.

Fernandes J., Arida R., Gomez-Pinilla, F. (2017). Physical exercise as an epigenetic modulator of brain plasticity and cognition. *Neurosci. Biobehav. Rev. 80, 443–456*. 10.1016/j.neubiorev.2017.06.012

Ferrel, M. and Ryan, J. (2020). The Impact of Covid-19 on Medical Education. *Cureus, 2020 Mar: 12*(3): e7492. DOI: 10.7759/cureus.7492

Firth, J., Torous, J., Stubbs, B., Firth, J. A., Steiner, G. Z., Smith, L., Alvarez-Jimenez, M., Gleeson, J., Vancampfort, D., Armitage, C. J., & Sarris, J. (2019). The "online brain": how the Internet may be changing our cognition. *World psychiatry: official journal of the World Psychiatric Association (WPA), 18*(2), 119–129. doi:10.1002/wps.20617

Fischer, K. (1980). A Theory of Cognitive Development: The Control and Construction of Hierarchies of Skills. *Psychological Review*. Volume 87, No 6, 477-531. November 1980.

Field, J. (2006). *Lifelong Learning and the New Educational Order (2nd edition)*. Stoke-on-Trent. Trentham Books.

Firth, J., Torous, J., Stubbs, B., Firth, J. A., Steiner, G. Z., Smith, L., Alvarez-Jimenez, M., Gleeson, J., Vancampfort, D., Armitage, C., & Sarris, J. (2019). The "online brain": how the Internet may be changing our cognition. *World Psychiatry, 18*(2), 119-129.

Fitts, P.M. (1964). Perceptual-Motor Skill Learning. *Categories of Human Learning, 47*, 381-391.

Flavián, C., Ibáñez-Sánchez, S., Orús, C. (2019). The impact of virtual, augmented and mixed reality technologies on the customer experience, *Journal of Business Research*, Volume 100, 2019, Pages 547-560, ISSN 0148-2963, https://doi.org/10.1016/j.jbusres.2018.10.050.

Fovino, I., Neisse, R., Lazari, A., Ruzzante, G-L., Polemi, N., Figwer, M., (2018) European Cybersecurity Centres of Expertise Map - Definitions and Taxonomy. *EUR 29332 EN. Luxembourg: Publications Office of the European Union, 2018.* p. 5, https://doi.org/10.2760/622400, JRC111441.

Friedrich, P. (2013). Web-based co-design. Social media tools to enhance user-centered design and innovation process, *University of Tampere, 2013*.

Fritsch, D. (2019). Cognitive Aspects of Human-Computer Interaction for GIS. *ISPRS International Journal of Geo-Information (ISSN 2220-9964).* MDBI Switzerland.

Furnell, S., & Bishop, M. (2020). Addressing cyber security skills: the spectrum, not the silo. *Computer Fraud & Security*, *2020*(2), 6-11.

Furnell, S. (2021). The cybersecurity workforce and skills. *Computers & Security*, *100*, 102080.

Futter, A. (2016). Cyber Threats and Nuclear Weapons – New Questions for Command and Control, Security and Strategy. *RUSI Occasional Paper*, July 2016. London: Royal United Services Institute for Defence and Security Studies.

Gardner, H. (1983). *Frames of Mind: The Theory of Multiple Intelligences*. New York: Basic Books.

Gaebel, M., Kupriyanova, V. & Rita, C., Colucci, E. (2014). *E-learning in European higher education institutions. Results of a mapping survey conducted in October-December 2013*. European University Association.

Garrison, D. R. (2003). Cognitive presence for effective asynchronous online learning: The role of reflective inquiry, self-direction and metacognition. In J. Bourne, & J. C. Moore (Eds.), *Elements of quality online education: Practice and direction*. Needham, MA: The Sloan Consortium.

Giacomin, J. (2014). What Is Human Centred Design?. *The Design Journal, 17*:4, 606-623

Giegerich, B. (2017). *Europe and Global Security. The International Institute for Strategic Studies*. Routledge. ISBN-13: 978-1138414488

Goleman, D. (1998). What Makes a Leader? IQ And Technical Skills Are Important, But Emotional Intelligence Is The Sine Qua Non Of Leadership. *Harvard Business Review, Nov-Dec 1998 pp. 93-102.*

Gowing, J. R., Walker, K. N., Elmer, S. L., & Cummings, E. A. (2017). Disaster preparedness among health professionals and support staff: what is effective? An integrative literature review. *Prehospital and disaster medicine*, 32(3), 321.

Gullickson, T. (1997). Review of Thinking About Answers: The Application of Cognitive Processes to Survey Methodology. *PsycCRITIQUES v. 42*, n. 7 (Jul 1997): 652-652. DOI: 10.1037/000266

Glover, I. (2013). Play as you learn: Gamification as a technique for motivating learners. In J. Herrington, A. Couros, & V. Irvine (Eds.), *Proceedings of world Conference on educational multimedia, hypermedia and telecommunications (pp. 1999–e2008)*. Chesapeake, VA: AACE.

Grego F., Vallier J., Collardeau M., Rousseu C., Cremieux J., Brisswalter J. (2005). Influence of exercise duration and hydration status on cognitive function during prolonged cycling exercise. *Int. J. Sports Med. 26, 27–33*. 10.1055/s-2004-817915

Greene, O. (2006). Conflict Prevention, Management and Reduction in Africa. In Buxton, J., Greene, O. & Salonius-Palsternak, C. (Eds.), *Conflict Prevention, Management and Reduction in Africa.* ISBN-13: 978-951-724-577-7. Hakapaino Oy. Helsinki 2006

Greitemeyer, T. (2020). The police officer's dilemma: The relationship between violent video game play and response in a first-person shooter task. *Journal of Media Psychology: Theories, Methods and Applications, 32(2), 82*-88. doi.org/10.1027/1864-1105/a000260

Habermas, J. (1981) *Theory of Communicative Action, Volume Two: Lifeworld and System: A Critique of Functionalist Reason*. Translated by Thomas A. McCarthy. Boston, Mass.: Beacon Press. ISBN 0-8070-1401-X.CS1

Habermas, J. (1979). What is universal pragmatics. *Communication and the Evolution of Society, 1*, 2-4.

Hallward MC, Tarkhani H. (2019). Training and Capacity Building for Peacebuilding and Development. *Journal of Peacebuilding & Development. 2019; 14*(3): 237-241. doi:10.1177/1542316619876121

Happa, J., Glencross, M., Steed, A. (2019). Cyber security threats and challenges in collaborative mixed-reality. *Front. ICT 6*, 5 (2019). https://doi.org/10.3389/fict.2019.00005

Henriksson, K. Ruoslahti, H., Hyttinen, K. (2018). Opportunities for Strategic Public Relations - Evaluation of International Research and Innovation Project Dissemination. *Public Relations and the Power of Creativity.,* Emerald Publishing Limited. doi:10.1108/S2398-391420180000003012

Herrmann, E., Call, J., Hernàndez-Lloreda, M., Hare, B., Tomasello, M. (2007). Humans Have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis. *Science 07 Sep 2007: Vol. 317, Issue 5843*, pp. 1360-1366 DOI: 10.1126/science.1146282.

Hevner, A., March, S. T. Park, J. (2004). Design Science in Information Systems Research. *MIS Quarterly 28*:1, 2004, pp. 75-105.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational technology research and development*, *55*(3), 223-252.

Hirschmann, G. (2012). Organizational learning in United Nations' peacekeeping exit strategies. *Cooperation and Conflict*, *47*(3), 368-385.

Holohan, A. (2019) Transformative Training in Soft Skills for Peacekeepers: Gaming for Peace. *International Peacekeeping, 26*:5, 556-578, DOI: 10.1080/13533312.2019.1623677

Hussler, E. (1997). Thing and Space: Lectures of 1907. *Husserliana: Edmund Husserl – Collected Works*. Springer. ISBN 978-0-7923-4749-1

Hyttinen, K. & Hario, P. (2020). Lessons from IECEU case study. In Hyttinen, K., Hario, P., & Österlund, P. (Eds.). Improving the Effectiveness of Capabilities (IEC) in EU conflict prevention. *Laurea Julkaisut 86*.

Hyttinen, K. & Smith, R. (2019). Navigating the Experiential Learning Landscape: Alternative Approaches in the Acquisition of Soft Skills. In Juvonen, Marjanen & Meristö (Eds.) *Learning by Developing 2.0. Case Studies in Theory and Practice*. Laurea Julkaisut 101.

Hyttinen, K., Hario, P., & Österlund, P. (2017). Improving the Effectiveness of Capabilities (IEC) in EU conflict prevention. *Laurea Julkaisut 86*.

Hyttinen, K. (2017). Human-centered Design Model in the Development of Online Learning Tools for International Security Training - CASE IECEU New Media based Learning Application (NMLA). *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Volume 3*: ISE, 275 - 282. doi: 10.5220/0006559902750282.

Hyttinen, K. Ruoslahti, H., Jokela, J. (2017). Model for Effective Integration Research, Worklife and Higher Education in International Security Studies. *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Volume 3*: ISE, 299-306. doi: 10.5220/0006588102990306.

Horton, W. (2006). *E-Learning By Design*. San Francisco: Pfeiffer.

Huda, M., Maseleno, A., Shukri Mat Teh, K., Ghafar Don, A., et al., (2018). Understanding Modern Learning Environment in Big Data Era. International Journal of Emerging Technologies in Learning Vol. 13, No. 05, 2018.

Ignatov, G. (2007). Theories of Embodied Knowledge: New Directions for Cultural and Cognitive Sociology? *Journal for the Theory of Social Behaviour 37:2*, 0021–8308. Published by Blackwell Publishing, 9600 Garsington Road, Oxford, OX4 2DQ UK and 350 Main Street, Malden, MA 02148, USA.

IECEU –project, (2016a). D1.2 Analysis of the current preventive activities. Accessed in April 2016. http://www.ieceu-project.com. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 653371.

IECEU -project, (2016b). D5.2 Design and Development Processes of the NMLA. Accessed March 2017. www.ieceu-project.com. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 653371.

Illeris, K. (2009). A comprehensive understanding of human learning. In Illeris, K. (Eds). *Comtemporary Theories of Learning - Learning theorists… in their own words.* Routledge Taylor & Francis Group. London and New York.

ISO (1999). 10015:1999. Quality Management- Guidelines for Training.

Jarvis, P. (2009). Learning to be a person in society - learning to be me. In Illeris, K. (2009). *Contemporary Theories of Learning - Learning Theorists… in their own words*. Routledge Taylor & Francis Group. London and New York.

Jarvis, P. (2006). Towards Comprehensive Theory of Human Learning. *Lifelong Learning and the Learning Society Volume 1*. Routledge Taylor & Francis. London and New York.

Jarvis, P. (2004). *Adult Education and Lifelong Learning: Theory and Practice (3rd Edition).* London. RoutledgeFalmer.

Jarvis, P. (1998). Paradoxes of the learning society. In J. Holford, P. Jarvis, & C. Griffing (Eds.). *International Perspectives on Lifelong Learning* (pp. 56-68). London.

Jokinen, J. Sarcar, S., Oulasvirta, A., Silpasuwanchai, C., Wang, Z., and Ren, X. (2017). Modelling Learning of New Keyboard Layouts. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems.* Association for Computing Machinery, New York, NY, USA, 4203–4215. DOI: 10.1145/3025453.3025580

Jonassen, D. (1991). Objectivism vs constructivism: Do we need a new philosophical paradigm. *Educational Technology Research and Development*, 39(3), 5-14.

Jongbloed, B., Enders, J. & Salerno, C. (2008). Higher education and its communities: Interconnections, interdependencies and a research agenda. *High Educ* **56,** 303–324 (2008). https://doi.org/10.1007/s10734-008-9128-2

Jounghyun, G. (2015). *Human–Computer Interaction Fundamentals and Practice*. Taylor and Francis Group. ISBN 978-1-4822-3389-6

Juncos, A. & Blockmans, S. (2017). The EU's role in conflict prevention and peacebuilding: four key challenges. *Global Affairs, 4:2-3, 131-140,* DOI: 10.1080/23340460.2018.1502619

Kahneman, D., Lovallo, D., & Sibony, O. (2011). Before you make that big decision. Harvard business review, 89(6), 50-60.

Kane, G. (2019). The Technology Fallacy - People Are the Real Key to Digital Transformation. *Research-Technology Management*, 62:6, 44-49, DOI: 10.1080/08956308.2019.1661079

Kanselaar, G. (2002). Constructivism and socio-constructivism. *Constructivism and socio-constructivism* (2002): 1-7.

Kasarskis, P., Stehwien, J., Hickox, J., Aretz, A., & Wickens, C. (2001). Comparison of expert and novice scan behaviors during VFR flight. *Paper presented at the11th International Symposium on Aviation Psychology*. Columbus OH: The Ohio State University.

Katz, J. (2013). Mobile gazing two-ways: Visual layering as an emerging mobile communication service. *Mobile Media and Communication, 1, 129-133*.

Katz, E. & Lazarsfeld, P. (2006). *Personal Influence: The Part Played by People in the Flow of Mass Communications*. Transaction Publishers.

Kaplan, F. (2016). *Dark Territory: The Secret History of Cyber War*. London: Simon & Schuster.

Kara, N. & Sevim, N. (2013). Adaptive Learning Systems: Beyond Teaching Machines. *Contemporary Educational Technology 4*, no. 2 (2013): 108-120.

Karaca, F., Can, G., & Yildirim, S. (2013). A path model for technology integration into elementary school settings in Turkey. *Computers & Education*, *68*, 353-365.

Khan, B. (2015). Introduction to E-Learning. In B.H. Khan and Ally, M. (Eds.) *International Handbook of E-Learning, Volume 1: Theoretical Perspectives and Research*. New York: Routledge.

Kirjalainen, E. (2010). *Viisi vuotta valmistumisesta – ammattikorkeakoulusta valmistuneiden urakehitys. Uraseuranta vuonna 2003 valmistuneille. Selvitys seitsemän ammattikorkeakoulun yhteisistä tuloksista*. Jyväskylän ammattikorkeakoulu.

Kirk, J. (2007). Education and fragile states. *Globalisation, Societies and Education. Vol. 5, No. 2, July 2007*, pp. 197

Kirriemuir, J., & Mcfarlane, A. (2004). *Report 8: Literature Review in Games and Learning*. NESTA Futurelab Series.

Klein, C. (2009). *What Do We Know About Interpersonal Skills? A Meta-analytic Examination Of Antecedents, Outcomes, And The Efficacy Of Training*. Electronic Theses and Dissertations, 2004-2019. 3950.

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education*, *49*(3), 740-762.

Kolb, D. (2015). *Experiential Learning - Experience as The Source of Learning and Development*. 2nd edition. Pearson Education: Upper Saddle River, NJ, USA, 2015.

Kolb, A. & Kolb, D. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning and Education. 4*(2): 193-212.

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development.* 1st Edition. Englewood Cliffs, NJ: Prentice-Hall.

Korte, M. (2020). The impact of the digital recolution on human brain and behavior: where do we stand? Dialogues Clin Neurosci. 2020 June; 22(2): 101-111- DOI 10.31887/DCNS.2020.22.2/mkorte

Kujala, T. & Saariluoma, P. (2018). Cognitive Mimetics for Designing Intelligent Technologies. *Advances in Human-Computer Interaction*. Volume 2018, 10.1155/2018/9215863

Kuijpers, D. (2014). Reducing Political Risk in EU pooling and sharing. *European Liberal Forum* (2014), 5.

Knapp, K. (2012). *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education*. Pfeiffer and Company Publishers.

Kramer A., Hahn S., Cohen N., Banich M., McAuley E., Harrison C. (1999). Ageing, fitness and neurocognitive function. *Nature 400*, 418–419. 10.1038/22682

Kraiger, K., Ford, K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology, 78(2), 311–328*.

Kraiger, K., Passmore, J., Rebelo dos Santos, N., Malvezzi, S. (2014). *The Wiley Blackwell Handbook of the Psychology of Training, Development, and Performance Improvement*. John Wiley & Sons.

Kraemer, S., Carayon, P., and Clem, J. (2009). Human and Organizational Factors in Computer and Information Security: Pathways to Vulnerabilities. *Computers and Security 28* (2009): 509-520, https://doi.org/10.1016/j.cose.2009.04.006.

Könings, K. D., Brand-Gruwel, S., & Van Merriënboer, J. J. (2005). Towards more powerful learning environments through combining the perspectives of designers, teachers, and students. *British Journal of Educational Psychology, 75*(4), 645-660.

Laouris, Y. & Eteokleous, N. (2005). We need an educationally relevant definition of mobile learning. *Proceedings of mLearn*. Vol. 2005. 2005.
Larkin, J. & Simon, H. (1987). Why a Diagmm is (Sometimes) Worth Ten Thousand Words. *Cognitive science*, 65-99 (1987).
Laszlo, A., & Castro, K. (1995). Technology and values: Interactive learning environments for future generations. *Educational Technology*, 7-13.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.
Lavoie, R., Main, K., King, C. (2021) Virtual experience, real consequences: the potential negative emotional consequences of virtual reality gameplay. *Virtual Reality 25, 69–81* (2021). DOI: doi.org/10.1007/s10055-020-00440-y
Law, B., Atkins, M. S., Kirkpatrick, A. E., Lomax, A. J., & Mackenzie, C. L. (2004). Eye gaze patterns differentiate novice and experts in a virtual laparoscopic surgery training environment. *Proceedings of the eye tracking research &applications symposium on eye tracking research & applications (pp. 41–48)*. New York: ACM Press.
Lawlor, B. (2012). Smart Goals: How the Application of Smart Goals Can Contribute to Achievement of Student Learning Outcomes. *Developments in Business Simulation and Experiential Learning 39* (2012).
Lee, E. (2008). Cyber Physical Systems: Design Challenges. Electrical Engineering and Computer Sciences University of California at Berkeley. Technical Report No. UCB/EECS-2008-8.
Lehto, M. & Limnéll, J. (2020). Strategic leadership in cyber security, case Finland. *Information Security Journal: A Global Perspective*. doi: 10.1080/19393555.2020.1813851. Springer, Cham.
Leinonen, T. (2010). *Designing Learning Tools. Methodological Insights*, Aalto University, 2010.
Leikas, (2009). Life-Based Design – A holistic approach to designing human-technology interaction. *VTT Publications 726*. ISBN 978-951-38-7375-2.
Leikas, J., Koivisto, R., & Gotcheva, N. (2019). Ethical framework for designing autonomous intelligent systems. *Journal of Open Innovation: Technology, Market, and Complexity, 5(*1), 18.
Levy, F. (2010). How Technology Changes Demands for Human Skills. *OECD Education Working Papers No. 45.* ISSN: 19939019 (online) https://doi.org/10.1787/19939019
Lewin, K. (1997). Behavior and development as a function of the total situation. In D. Cartwright (Ed.), *Field theory in social science: Selected theoretical papers* (pp. 337-381). Washington, DC: American Psychological Association.
Lewin, K., & Grabbe, P. (1945). Conduct, knowledge, and the acceptance of new values. *Journal of Social Issues, 1*, 3, 53–64. https://doi.org/10.1111/j.1540-4560.1945.tb02694.x
Lewis, C., and Rieman, J. (1993). Task-Centered User Interface Design. A Practical Introduction.
Linton, M. (1982). Transformations of memory in everyday life. In U. Neisser (Ed.), *Memory observed: Remembering in natural contexts* (pp. 77-81). San Francisco: Freeman.

Liu, T., & Chu, Y. (2010). Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation. *Computers & Education, 55(2), 630–643*. doi:10.1016/j.compedu.2010.02.023

Lista I. & Sorrentino, G. (2010). Biological mechanisms of physical activity in preventing cognitive decline. *Cell. Mol. Neurobiol. 30, 493–503*. 10.1007/s10571-009-9488-x

Lowyck, J., & Pöysä, J. (2001). Design of collaborative learning environments. *Computers in human behavior*, *17*(5-6), 507-516.

Ma, H. I., Trombly, C. A., & Robinson-Podolski, C. (1999). The effect of context on skill acquisition and transfer. *American Journal of Occupational Therapy*, *53*(2), 138-144.

Mandl, H., Gräsel, C., & Fischer, F. (2000). Problem-oriented learning: Facilitating the use of domain-specific and control strategies through modeling by an expert. *Control of Human Behavior, Mental Processes, and Consciousness: Essays in Honor of the 60th Birthday of August Flammer*, 151.

Mandl, H., & Krause, U. M. (2003). Learning competence for the knowledge society. *Toward the virtual university: International online perspectives*, 65-86.

Mantovani, F. & Castelnuovo, G. (2003). The Sense of Presence in Virtual Training: Enhancing Skills Acquisition and Transfer of Knowledge through Learning Experience in Virtual Environments. In Riva G., D. F. (eds.). *Being There: Concepts, Effects and Measurement of User Presence in Synthetic Environments*. IOS Press, Amsterdam 2003: 167- 182.

Mangina, E. (2017). 3D learning objects for augmented/virtual reality educational ecosystems. *23rd International Conference on Virtual System & Multimedia (VSMM)*, Dublin, 2017, pp. 1-6, doi: 10.1109/VSMM.2017.8346266.

Matthews, W. (2003). Constructivism in the Classroom: Epistemology, History, and Empirical Evidence. In *Teacher Education Quarterly*, Vol. 30, No. 3, The Summer Collection (Summer 2003), pp. 51-64 (14 pages)

Marsick, V., and Watkins, K. (2001). *Informal and Incidental Learning*. Jossey-Bass, A Publishing Unit of John Wiley and Sons, Inc

Martín-Gutiérrez J., Mora C.E., Añorbe Díaz B., González-Marrero A. (2017). Virtual technologies trends in education. *EURASIA Journal of Mathematics Science and Technology Education*, 13 (2) (2017), pp. 469-486.

Mason J. London, Routledge: 1994. Linking qualitative and quantitative data analysis. Analysing qualitative data; pp. 89–110.

McClain, J, Silva, A., Emmanuel, A., Anderson, B., Nauer, K., Abbott, R. & Forsythe, C. (2015). Human Performance Factors in Cyber Security Forensic Analysis. *Procedia Manufacturing 3* (2015): 5301-5307.

McCready, P. Smith, R., Timms, R., Trochowska, K., Barrett, R., Holohan, A., Wade, V. (2017). *D3.2 Learning Outcomes, Skills/Competencies Definitions, Methods & Metrics of Assessment*. GAP Gaming for Peace. This project has received funding from the EU Framework Programme for Research and Innovation HORIZON 2020 under the agreement 700670.

McGonigal, J. (2011). *Reality is Broken: How games make us better and how they can change the world*. Penguin Press. USA.
McNamara, C. (1999). General Guidelines for Conducting Interviews, PhD. University of Minnesota.
Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. Project Report. Centre for Learning Technology.
Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning. A review of the literature*. Learning and Skills Development Agency.
Moon, J. (2013). *Reflection in Learning and Professional Development: Theory and Practice*. Routledge, Tayloris & Francis Group. London and New York.
Moore, J. Dickson-Deane, C. & Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same? *Internet and Higher Education 14* (2011) 129–135. 2010 Elsevier Inc.
Moore, M. (1990). Background and overview of contemporary American distance education. *Contemporary issues in American distance education* (pp. xii−xxvi). New York: Pergamon Press.
Morley, D., Bettles, S., Cerham, C. (2018). The exploration of students' learning gain following immersive simulation – the impact of feedback. *Higher Education Pedagogies,* Volume 4, 2019 - Issue 1. Pages 368-384. https://doi.org/10.1080/23752696.2019.1642123
Mishra, P. & Koehler, M.J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*. 108 (6), pp. 1017-1054.
Moore, M. G. (1990). Background and overview of contemporary American distance education. *Contemporary issues in American distance education* (pp. xii−xxvi). New York: Pergamon Press.
Moore, J. Dickson-Deane, C. Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same? *Internet and Higher Education 14* (2011) 129–135. 2010 Elsevier Inc.
Mostakhdemin-Hosseini, A. and Tuimala, J. (2005). Mobile Learning Framework. *Proceedings IADIS International Conference Mobile Learning 2005, Malta*, pp 203-207.
Myllylä, M. T., & Saariluoma, P. (2022). Expertise and becoming conscious of something. *New Ideas in Psychology, 64* (2022) 100916. https://doi.org/10.1016/j.newideapsych.2021.100916
Nadkarni, S., & Prügl, R. (2021). Digital transformation: a review, synthesis and opportunities for future research. *Management Review Quarterly 71*, 233-341 (2021). https://doi.org/10.10077s11301-020-00185-7.
Nelson, M. J., & Hawk, N. A. (2020). The impact of field experiences on prospective preservice teachers' technology integration beliefs and intentions. *Teaching and Teacher Education*, *89*, 103006.
Newell, B. & Börder, A. (2008). Cognitive processes, models and metaphors in decision research. *Judgment and Decision Making*, Vol. 3, No. 3, March 2008, pp. 195–204.

Newell, A. & Simon, H. (1956). The logic theory machine - A complex information processing system. *IRE Transactions on information theory*, *2*(3), 61-79.

Newell, A., & Rosenbloom, P. S. (1981). Mechanisms of skill acquisition and the law of practice. In Anderson, J (Eds.) *Cognitive skills and their acquisition*, 1(1981), 1-55. Lawrence Erlbaum Associates, Publishers. Hillsdale, New Jersey.

Nitecki, D. & Simpson, K. (2016). Communicating the Library as a Learning Environment. *Journal of Learning Spaces*, 5(2), 39-52.

North, K. & Kumta, G. (2018). *Knowledge Management - Value Creation Through Organizational Learning*. Second edition. Springer Nature. https://doi.org/10.1007/978-3-319-59978-6.

OECD. (2012). Evaluating peacebuilding activities in settings of conflict and fragility: Improving learning for results, DAC guidelines and references series. Paris: OECD Publishing.

OECD. (2007). Encouraging Effective Evaluation of Conflict Prevention and Peacebuilding Activities, Towards DAC Guidance. Off-Print of the *OECD Journal on Development 2007*, Volume 8. No. 3. Development Assistance Committee. Organisation for Economic Co-operation and Development.

Oikonomou, N., Mengidis, N., Spanopoulos-Karalexidis, M., Voulgaridis, A., Merialdo, M., Raisr, I., ... & Votis, K. (2021, July). ECHO Federated Cyber Range: Towards Next-Generation Scalable Cyber Ranges. In *2021 IEEE International Conference on Cyber Security and Resilience (CSR)* (pp. 403-408). IEEE

O'Shea, P., Mitchell, R., Johnston, C., Dede, C. (2009). Lessons learned about designing augmented realities. Int J Gaming Comput Mediat Simul 1(1):1–15.

Osiurak, F., Navarro, J., & Reynaud, E. (2018). How Our Cognition Shapes and Is Shaped by Technology: A Common Framework for Understanding Human Tool-Use Interactions in the Past, Present, and Future. *Frontiers in psychology*, *9*, 293. doi:10.3389/fpsyg.2018.00293

Papadopoulou, P., Chui, K. T., Daniela, L., & Lytras, M. D. (2019). Virtual and Augmented Reality in Medical Education and Training: Innovative Ways for Transforming Medical Education in the 21st Century. In *Cognitive Computing in Technology-Enhanced Learning* (pp. 109-150). IGI Global.

Pappalardo, S., Niemiec, M., Bozhilova, M., Stoianov, N., Dziech, A. & Stiller, B. (2020). Multi-sector Assessment Framework – a New Approach to Analyse Cybersecurity Challenges and Opportunities. In: Dziech A., Mees W., Czyżewski A. (eds) Multimedia Communications, Services and Security. MCSS 2020. Communications in Computer and Information Science, vol 1284. Springer, Cham. https://doi.org/10.1007/978-3-030-59000-0_1

Parziale, J., & Fischer, K. (2009). The practical use of skill theory in classrooms. In R. J. Sternberg & W. M. Williams (Eds.), *Intelligence, instruction, and assessment: Theory into practice* (pp. 95-110). New Jersey: Taylor & Francis eLibrary.

Pedley, D., Borges, T., Bollen, A., Shah, J. N., Donaldson, S., Furnell, S., & Crozier, D. (2020). Cyber security skills in the UK labour market 2020.
Philips, A., Walz, A., Bergner, A., Graeff, T., Heistermann, M., Kienzler, S., Korup, O., Lipp, T., Schwanghart, W., Zeilinger, G. (2015). Immersive 3D geovisualization in higher education. *Journal of Geography in Higher Education*.
Piaget, J. (2005). *The Psychology of Intelligence*; Taylor & Francis: London, UK, 2005; ISBN 0-203-98152-9
Piaget, J. (1973). *To understand is to invent: The future of education*. New York: Grossman.
Piaget, J. (1950). *The Psychology of Intelligence*. London: Routledge.
Piaget, J. (1936). *Origins of intelligence in the child*. London: Routledge & Kegan Paul.
Pinkwart, N., Hoppe, H., Milrad, M. & Perez, J. (2003) Educational scenarios for the cooperative use of Personal Digital Assistants. *Journal of Computer Assisted Learning, 19*, 3, 383-391.
Pirinen, R. (2013). *Towards realisation of research and development in a university of applied sciences*. Doctoral dissertation, University of Eastern Finland)
Pirinen, R. (2008). Integrative action process in the perspective of globalization. *International Journal of Emerging Technologies in Learning* (iJET), 3(2008).
Pirinen, R. (2015). Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers. *Creative Education*, 2015, 6, 3, 315-330.
Pirozzi, N., Venturi, B., & Marrone, A. (2018). EU member states' capabilities in conflict prevention and peacebuilding: Personnel and technology. *Global Affairs*.
Pivec, M. & Dziabenko, O. (2004). Game-Based Learning in Universities and Lifelong Learning: 'UniGame: Social Skills and Knowledge Training', Game Concept. *Journal of Universal Computer Science*, (1) 14-26.
Penprase, B. E. (2018). The fourth industrial revolution and higher education. *Higher education in the era of the fourth industrial revolution*, *10*, 978-981.
Pereira A., Huddleston D., Brickman A., Sosunov A., Hen R., McKhann G. (2007). An in vivo correlate of exercise-induced neurogenesis in the adult dentate gyrus. *Proc. Natl. Acad. Sci. U.S.A. 104, 5638–5643*. 10.1073/pnas.0611721104
Prenzel M., Mandl H. (1993) Transfer of Learning from a Constructivist Perspective. In: Duffy T.M., Lowyck J., Jonassen D.H., Welsh T.M. (eds) Designing Environments for Constructive Learning. NATO ASI Series (Series F: Computer and Systems Sciences), vol 105. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-78069-1_16
Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, 103778.

Raij K. (2014). Learning by Developing Action Model. *Laurea Julkaisut 36*., Laurea-ammattikorkeakoulu. URN:NBN:fi:amk-2016070613570
Rauste-von Wright, M. & von Wright, J. (1994). *Oppiminen ja koulutus*. WSOY, Juva, Finland. ISBN: 951-0-20024-7.
Ravyse, W. S., Blignaut, A. S., Leendertz, V., & Woolner, A. (2017). Success factors for serious games to enhance learning: a systematic review. *Virtual Reality, 21*(1), 31-58.
Reinmann-Rothmeier, G., & Mandl, H. (1998). Wissensmanagement. Eine Delphi-Studie. Forschungsbericht Nr. 90. LMU München: *Lehrstuhl für Empirische Pädagogik und Pädagogische Psychologie,* Internet, ISSN 1614-6336
Renkl, A. & Atkinson, R. (2002). Learning From Examples: Fostering Self-Explanations. *Computer-Based Learning Environments, Interactive Learning Environments, 10:2, 105-119,* DOI: 10.1076/ilee.10.2.105.7441
Resnick, L. B. (1989). Introduction. In L. B. Resnick (ed.) *Knowing, learning, and instruction*. Hillsdale, NJ: Lawrence Erlbaum Associates.
Reynolds, C. (2020). The Advantages of Using Technology in Human Resource Training and Development. *Annual Research Journal of Symbiosis Centre for Management Studies, Pune 46 Vol. 8*, March 2020.
Rosenberg, M. (2006). *Beyond E-Learning: Approaches and Technologies to Enhance Organizational Knowledge, Learning and Performance.* John Wiley & Sons, Inc.
Roszkowski, M. & Snelbecker, G. (1983). The One-Month Temporal Stability of Children's Self-Reported Hand Preferences. *Journal of Psychoeducational Assessment*. 1983; 1(2):143-148. doi:10.1177/073428298300100204
Royer, J., Cisero, C., Carlo, M. (1993). Techniques and procedures for assessing cognitive skills. *Review of Educational Research*; Summer 1993; 63, 2; Research Library Core. pg. 201
Roztocki, N., Soja, P. & Weistroffer, H. (2019) The role of information and communication technologies in socioeconomic development: towards a multi-dimensional framework. *Information Technology for Development, 25:2, 171-183*, DOI: 10.1080/02681102.2019.1596654
Ryan, T. & Bagley, G. (2015). Nurturing the integration of technology in education. *Journal of Theory & Practice in Education (JTPE). 2015, Vol. 11 Issue 1, p33-50. 18p.*
Saariluoma, P. (2020). User Psychology of Emotional Interaction—Usability, User Experience and Technology Ethics. In *Emotions in Technology Design: From Experience to Ethics* (pp. 15-26). Springer, Cham.
Saariluoma, P., Kujala, T., Karvonen, A., & Ahonen, M. (2018). Cognitive mimetics: Main ideas. In H. R. Arabnia, D. d. l. Fuente, E. B. Kozerenko, J. A. Olivas, & F. G. Tinetti (Eds.), ICAI'18: *Proceedings of the 2018 International Conference on Artificial Intelligence* (pp. 202-206). CSREA Press.
Saariluoma, P., Cañas, J., Leikas, J. (2016). *Designing for Life - A Human Perspective on Technology Development.* Macmillan Publishers Ltd. London. ISBN 978-1-137-53047-9 (eBook)
Saariluoma, P., & Jokinen, J. (2014). Emotional Dimensions of User Experience? A User Psychological Analysis. *International Journal of Human-Computer Interaction, 30* (4), 303-320. doi:10.1080/10447318.2013.858460

Saariluoma, P. (2004). Explanatory frameworks in interaction design. In A. Pirhonen, H. Isomäki, H., C. Roast, & P. Saariluoma (Eds.), *Future interaction design* (pp. 67–83). London: Springer.
Saariluoma, P., & Maarttola, I. (2003). Stumbling blocks in novice building design. *Journal of Architectural and Planning Research*, 20(4), 344–354.
Sánchez, J. & Mitchell, R. (2017). Conceptualizing Impact Assessment as a Learning Process. *Environmental Impact Assessment Review 62* (2017), 195-204, https://doi.org/10.1016/j.eiar.2016.06.001.
Šašinka, Č., Stachoň, Z., Sedlák, M., Chmelík, J., Herman, L., Kubíček, P., & Svatoňová, H. (2019). Collaborative immersive virtual environments for education in geography. *ISPRS International Journal of Geo-Information, 8*(1), 3.
Schugurensky, D. (2000). The forms of informal learning. Towards a conceptualization of the field. Working Paper 19-2000. Presented at the *New Approaches for Lifelong Learning (NALL) Fourth Annual Conference*, October 6-8.
Schrader, P. G., & McCreery, M. (2008). The acquisition of skill and expertise in massively multiplayer online games. *Educational Technology Research and Development, 56*(5-6), 557-574.
Sein, M., Henfridsson, O. Purao, S., Rossi, M. and Lindgren, R. (2011). Action Design Research. *MIS Quarterly,* (35: 1), pp. 37-56.
Senge, P. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York: Doubleday.
Sevillano-Garcia, M. L., & Vázquez-Cano, E. (2015). The impact of digital mobile devices in higher education. *Journal of Educational Technology & Society*, 18(1), 106-118.
Schunk, D. (1991). *Learning theories: an educational perspective*. New York: Macmillan.
Schneider, W., & Fisk, A. D. (1983). Attention theory and mechanisms for skilled performance. In *Advances in psychology* (Vol. 12, pp. 119-143). North-Holland.
Schneier, B. (2019). Semantic Attacks: The Third Wave of Network Attacks. *Crypto-Gram*, October 15, 2000
Schrader, D. (2015). Constructivism and Learning in the Age of Social Media: Changing Minds and Learning Communities. *New Directions for Teaching and Learning*. No. 144. Wiley Periodicals, Inc. DOI: 10.1002/tl.20160
Shuell, T. (1986). Cognitive conceptions of learning. *Review of Educational Research, 56*, 411-436.
Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *The Journal of High Technology Management Research*, *14*(1), 111-133.
Siemens G. (2005). Connectivism: a learning theory for the digital age. *Instructional Technology and Distance Learning*, 2(1).

Siller, H., Waibel, E. M. (2018). "Not pure harmony, but less of a power struggle": What do teachers and pedagogues think about using existential pedagogy? *The Teacher Educator, 53*(1), 44-66. https://doi.org/10.1080/08878730.2017.1386252

Simon, H. (1996). Computational theories of cognition. *The philosophy of psychology*, 160-172.

Simon, H. (1980). Problem Solving and Education. In D.T. Tuma, & F. Reif, (Eds.) *Problem solving and education: Issues in Teaching and Research*. Hillsdale, NJ: Lawrence Erlbaum Associates, 1980.

Singh, H. (2021). Building effective blended learning programs. In *Challenges and Opportunities for the Global Implementation of E-Learning Frameworks*, pp. 15-23. IGI Global.

Skinner, B. (1954). The science of learning and the art of teaching. *Harvard Educ Rev 1954*; 24: 86–97.

Stevenson, W. B., & Greenberg, D. (2000). Agency and social networks: Strategies of action in a social structure of position, opposition, and opportunity. *Administrative science quarterly*, *45*(4), 651-678.

Sloboda, J. (1991). Musical expertise. In K. A. Ericsson and J. Smith. (eds.) *Toward a General Theory of Expertise: Prospects and Limits.* pp. 153–171, Cambridge University Press, 1991.

Snelbecker, G. (1983). *Learning theory, instructional theory, and psychoeducational design*. New York: McGraw-Hill.

Sohime, F. H., Ramli, R., Rahim, F. A., & Bakar, A. A. (2020, August). Exploration study of skillsets needed in cyber security field. In *2020 8th International Conference on Information Technology and Multimedia (ICIMU)* (pp. 68-72). IEEE.

Sofat, R. & Sharma, R. (2020). A study on perception of academicians towards online education courses. İşman, A. et al. (eds.) *The Online Journal of Distance Education and e-Learning*, Volume 8, Issue 1. Turkey.

Solak, E., & Cakir, R. (2015). Exploring the Effect of Materials Designed with Augmented Reality on Language Learners' Vocabulary Learning. *Journal of Educators Online*, *12*(2), 50-72.

Sou, G. (2018). Trivial pursuits? Serious (video) games and the media representation of refugees. *Third World Quarterly*, 39:3, pp. 510-526

Stage, M. (2020) The Negotiation of Expertise by the United Nations Peacebuilding Architecture in Reaction to the Ebola Outbreak in West Africa, *Journal of Intervention and Statebuilding*, 14:5, 615-633, DOI: 10.1080/17502977.2020.1812963

Stainton-Rogers, W. & Willig, C. (2017). *The Sage Handbook of Qualitative Research in Psychology*. 2nd Edition.

Staszewski, J., & Davison, A. (2000). Mine detection training based on expert skill. In A. C. Dubey, J. F. Harvey, J. T. Broach, & R. E. Dugan (Eds.) *Detection and remediation technologies formines and mine-like targets V*. Proceedings of Society of Photo-Optical Instrumentation Engineers 14th Annual Meeting, SPIE Vol. 4038, 90–101.

Stone, J. & Clements, A. (1990). Research and Innovation: Let the buyer be aware. In R. Spillane & P. Regnier (Eds.) *The superintendent of the future*, 59-97. Gaithersburg, MD: Aspen.

Sutherland, I. E. (1968). A head-mounted three dimensional display. In *Proceedings of the December 9-11, 1968, fall joint computer conference, part I* (pp. 757-764).

Szilárd, S., Benedek, A., Ionel-Cioca, L. (2018). Soft Skills Development Needs and Methods in Micro-Companies of ICT Sector. *Social and Behavioral Sciences 238* (2018) 94 – 103. Elsevier.

Säljö, R. (1999). Concepts, cognition and discourse: From mental structures to discursive tools. *New perspectives on conceptual change*, *81*, 90.

Tabansky, L. (2011). Basic Concepts in Cyber Warfare. *Military and Strategic Studies 3* (1): 75–92.

Tagarev T., Davis B.Á. (2020) Towards the Design of a Cybersecurity Competence Network: Findings from the Analysis of Existing Network Organisations. In: Dziech A., Mees W., Czyżewski A. (eds) Multimedia Communications, Services and Security. MCSS 2020. Communications in Computer and Information Science, vol 1284. Springer, Cham. https://doi.org/10.1007/978-3-030-59000-0_4

Tam, K., Moara-Nkwe, K., & Jones, K. D. (2020). The use of cyber ranges in the maritime context: Assessing maritime-cyber risks, raising awareness, and providing training. *Maritime Technology and Research*, *3*(1), 16-30. https://doi.org/10.33175/mtr.2021.241410

Taitto, P. (2017). "When Diversity is the only Unity": How to Train for a Comprehensive Approach in EU Crisis Management. In E. Norvanto & H. Dumur-Laanila (Eds.) *Contemporary Peace Operations - from theory to practice, 93 - 99.*

Taylor-Jackson, J., McAlaney, J., Foster, J. L., Bello, A., Maurushat, A., & Dale, J. (2020, February). Incorporating psychology into cyber security education: a pedagogical approach. In *International Conference on Financial Cryptography and Data Security* (pp. 207-217). Springer, Cham.

Teichler, U. (1998). *Higher education and the world of work: Changing conditions and challenges*. Paris: UNESCO.

Teschner, J. (2016). Serious Games in Medical Education: As Learning Tools. University of Twente.

Tissot, P. (2004). *Terminology of vocational training policy: a multilingual glossary for an enlarged Europe*. European Centre for the Development of Vocational Training (Cedefop), Luxembourg; Office for Official Publications of the European Communities.

Topcu, M. K., & Sigri, U. (2018). Leadership training for peacebuilding operations. Journal of Defense Resources Management, 9(2).

Turunen, H., Syvänen, A. & Ahonen, M. (2003). Supporting observation tasks in a primary school with the help of mobile devices. In Nyvri, K. (eds.) *Mobile learning: essays on philosophy, psychology and education*. Communications in the 21st Century. Vienna: Passagen Verlag, 209–221.

Tussyadiah, I, Jung, T., tom Dieck, M. (2017). Embodiment of wearable augmented reality technology in tourism experiences. *Journal of Travel Research, 57* (5) (2017), pp. 597-611

Traxler, J. (2005). Defining Mobile Learning. *Proceedings IADIS International Conference Mobile Learning 2005*, Malta, pp 261-266.

Treaty of Lisbon (2007). *Amending the Treaty on European Union and the Treaty establishing the European Community* (OJ C 306, 17.12.2007); entry into force on 1 December 2009.

Ukwandu, E., Farah, M. A. B., Hindy, H., Brosset, D., Kavallieros, D., Atkinson, R., Tachtatzis, C., Bures, M., Andonovic, I., & Bellekens, X. (2020). A review of cyber-ranges and test-beds: Current and future trends. *Sensors, 20*(24), 7148; https://doi.org/10.3390/s20247148

Ulicsak, M. & Wright, M. (2010). *Games in Education. Serious Games*. A FutureLab Literature Review.

UNESCO International Institute for Capacity-Building in Africa (2015). *Transformative pedagogy for peace-building: a guide for teachers*. UNESCO IIC/2018/ED/WS/1 REV 2.

UNESCO (2014). *Teaching and Learning – Achieving Quality for All*. ISBN 978-92-3-104255-3

United Nations. (2010). *UN Peacebuilding: an Orientation*. Peacebuilding Support Office, September 2010. Copyright United Nations, 2010.

United Nations (2000). *Report of the panel on United Nations peace operations*. A/55/305–S/2000/80. New York.

US Department of Education. (2017). Reimagining the role of technology in education: 2017 national education technology plan update. *US Department of Education*.

Van der Lijn, J. (2009). If only there were a blueprint! Factors for Success and Failure of UN Peace-Building Operations. *Journal of International Peacekeeping, 13* (1-2), 45-71.

Van Hedel, H. J. A., & Dietz, V. (2004). The influence of age on learning a locomotor task. *Clinical Neurophysiology*, *115*(9), 2134-2143.

Van Eimeren, B., & Frees, B. (2012). 76 Prozent der Deutschen online—neue Nutzungssituationen durch mobile Endgeräte. Media Perspektiven, 7–8, 362–379.

Vargas, G., Juan C., Fabregat, R., Carrillo-Ramos, A., Jové, T. (2020). "Survey: Using Augmented Reality to Improve Learning Motivation in Cultural Heritage Studies" *Appl. Sci.* 10, no. 3: 897. https://doi.org/10.3390/app10030897

Veksler V. D., Buchler N., Hoffman B.E., Cassenti D.N., Sample C., & Sugrim S. (2018). Simulations in Cyber-Security: A Review of Cognitive Modeling of Network Attackers, Defenders, and Users. *Frontiers in Psychology Vol 9*, 2018. DOI=10.3389/fpsyg.2018.00691. ISSN=1664-1078

Vlachopoulos, D. & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. *International Journal of*

Educational Technology in Higher Education volume 14, Article number: 22 (2017).
Von Solms, R. and van Niekerk, J. (2013). From Information Security to Cyber Security. *Computers & Security 38* (2013): 97-102, https://doi.org/10.1016/j.cose. 2013.04.004.
Voelcker-Rehage, C. (2008). Motor-skill learning in older adults—a review of studies on age-related differences. *European Review of Aging and Physical Activity volume 5*, pages 5–16 (2008). ISSN: 1861-6909
Vygotsky, L. (1978). *Mind in Society: The Development of Higher Psychological Processes.* Harvard University Press, Cambridge, MA, 1978.
Vygotsky, L. (1986). *Thought and Language*. Translation newly revised and edited by A. Kozulin. Cambridge, MA: The MIT Press. (Originally published in Russian in 1934.)
Välimaa, J. (2004). Kolmas tehtävä korkeakoulutuksessa: tavoitteena joustavuus ja yhteistyö. In K. Kankaala, E. Kaukonen, P. Kutinlahti, T. Lemola, M. Nieminen, & J. Välimaa (Eds.), *Yliopistojen kolmas tehtävä?* (pp. 43–68). Sitran julkaisusarja 264. Helsinki: Edita.
Xu, D., & Jaggars, S. S. (2013). The impact of online learning on students' course outcomes: Evidence from a large community and technical college system. *Economics of Education Review*, *37*, 46-57.
Wafta, M. & Audi, D. (2015). New learning methodologies using modern technologies. International Journal of Innovation and Learning, 17(3). pp. 275-297.
Ward, P., Williams, A. M., & Hancock, P. A. (2006). Simulation for Performance and Training. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), The Cambridge handbook of expertise and expert performance (pp. 243–262). Cambridge University Press. https://doi.org/10.1017/CBO9780511816796.014
Watson, W., & Watson, S. L. (2007). An argument for clarity: What are learning management systems, what are they not, and what should they become. *TechTrends volume 51*, pages 28–34.
Weimer, M. (2013). *Learner-centered teaching: Five key changes to practice*. John Wiley and Sons.
Weisberg, R. (2006). Modes of Expertise in Creative Thinking: Evidence from Case Studies. In Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (eds.) *Cambridge Handbook of Expertise and Expert Performance*. New York: Cambridge University Press.
Widmer, M., Ziegler, N., Held, J., Luft, A., & Lutz, K. (2016). Rewarding feedback promotes motor skill consolidation via striatal activity. In B. Studer, S. Knecht (Eds.) *Progress in Brain Research*. Vol. 229, pp. 303-323. Elsevier. doi.org/10.1016/bs.pbr.2016.05.006
Wiener, N. (1948). *Cybernetics or Control and Communication in the Animal and the Machine*. Cambridge, MA: The MIT Press

Williams, A. M., Ward, P., & Chapman C. (2003). Training perceptual skill in field hockey: Is there transfer from the laboratory to the field? *Research Quarterly for Exercise and Sport, 74,* 98–103.

Wilkinson, P. (2016) A Brief history of Serious Games. In Dörner, R., Göbel, S., Kickmeier-Rust, M., Masuch, M., Zweig, K.A. (Eds.) *Entertainment Computing and Serious Games*. International GI-Dagstuhl Seminar 15283, Dagstuhl Castle, Germany, July 5-10, 2015, Revised Selected Papers.

Winter B., Breitenstein C., Mooren F., Voelker K., Fobker M., Lechtermann A. (2007). High impact running improves learning. *Neurobiol. Learn. Mem. 87, 597–609*. 10.1016/j.nlm.2006.11.003

Zhang, D., Zhao, J. L., Zhou, L., and Nunamaker Jr., J. F. (2004). Can e-learning replace classroom learning? *Communications of the ACM , 45* (5), 75-79.

Zheng, B., Niiyab, M. and Warschauerb, M. (2014). Wikis and collaborative learning in higher education. *Technology, Pedagogy and Education*, 2015. Vol. 24, No. 3, 357–374.

Zyda, M. (2005). From Visual Simulation to Virtual Reality to Games. *Computer 38*(9), 25–32.

Zupančič, R., & Pejič, N. (2018). *Limits to the European Union's normative power in a post-conflict society: EULEX and peacebuilding in Kosovo*. Springer Nature.

Zupančič, R., Pejič, N., Grilj, B., & Peen Rodt, A. (2018). The European Union rule of law mission in Kosovo: An effective conflict prevention and peace-building mission?. *Journal of Balkan and Near Eastern Studies, 20*(6), 599-617

Zwart, D., Van Luit, J., Noroozi, O. & Lin Goel, S. (2017). The effects of digital learning material on students' mathematics learning in vocational education. *Cogent Education, 4:1* DOI: 10.1080/2331186X.2017.1313581.

ORIGINAL PAPERS

I

NEW TECHNOLOGIES SHAPING LEARNING? AR LEARNING EXPERIENCES AND INTEGRATION MODEL

by

Aaltola, Kirsi, 2020

Cognitive and Affective Perspectives on Immersive Technology in Education, IGI Global, pages 195–214

https://doi.org/10.4018/978-1-7998-3250-8.ch010

NEW TECHNOLOGIES SHAPING LEARNING? AR LEARNING EXPERIENCES AND INTEGRATION MODEL

by Aaltola, Kirsi Maria 2020 (VTT Technical Research Centre of Finland, Finland & University of Jyväskylä, Finland)
Book Chapter in Cognitive and Affective Perspectives on Immersive Technology in Education, edited by Robert Z. Zheng, IGI Global, 2020, pp. 195-214. DOI: 10.4018/978-1-7998-3250-8.ch010

KEYWORDS: Augmented Reality (AR), Immersive Technologies, Experiential Learning, Constructivism, Cognitivism, Adult Learning, Embodied Cognition, Simulation

Abstract: Jean Piaget described that intelligence is shaped by experience. In augmented reality (AR) learning environments, the learner may have an immersive experience, from a sensor-motoric opportunity as a person to 3D experience. Few studies in the academic literature directly evaluate and analyze learning technology with regard to immersive experience in training. This chapter seeks to examine learning experiences when playing with AR learning technologies and suggests an alternative implementation model for the integration of immersive learning content to adult training. Specifically, this study examines a learning tool and a game targeted for the professionals working in security and peacebuilding context. This study points out a relevance of cognitive and constructive learning processes with a special attention to experience and reflection, and those technological immersive tools can positively support training when designed properly. Moreover, case study findings led to proposing an implementation model to integrate immersive content, AR tools, and games into adult training.

Introduction

Specific case studies have shown potentiality of virtual technologies to be integrated to training and education in order to enhance motivation and commitment (Harris & Reid, 2005; Kerawalla et al., 2006; Martin-Gutierrez et al., 2010; Di Serio et al., 2013). Already in 2008, the online enrollments were growing significantly faster than the higher education enrollments in general (Allen & Seaman, 2008). In 2010 onwards, it was recognized that there will be a rapid shift in education from traditional classrooms to online and virtual environments (Allen & Seaman, 2010; Lindgren & Johnson-Glenberg, 2013). Emerging technologies make education and training more accessible, and students with disabilities can join to virtual environments (Lange, et al. 2010) as well as communities with access to Internet. Use of exploratory learning technologies, such as Augmented Reality (AR) as well as Virtual Reality (VR), is raised in training and education field. Simulation of a real-life scenario transfers knowledge from reality setting to simulation targeted for communities. VR and AR systems create a feeling of exploring virtual world with use of features and tools

(e.g. projection screens, virtual glasses, gloves with sensors, trackers, keyboards etc.). Nevertheless, the level of features used is completely lower in the field of education compared to the commercial game industry. In addition, the use of full potential of AR and VR in training and education is limited, even immersive and visual experiences has become a new trend in several fields. Practical challenges have been noticed especially from the learning point of view and when integrating solutions to training curricula.

Benefits of technologies are recognized in different fields. In addition, humanitarian, security, and justice actors working in conflict response or peacebuilding have also recognized that the changing global digital landscape and the rapidly evolving role of Information and Communication Technology (ICT). Digitalization represents new and important opportunities in terms of preventing and responding to international disasters and conflicts (Brown, 2018, p. 137) through training of competent experts and professionals. Training plays a crucial role in learning and expertise development before entering to different work environment or landscape. This chapter reviews learning approaches, presents particular case study findings about experiences in two AR technologies and provides a model to integrate of technologies to training more efficiently in practice.

When empiricism focuses on a relevance of experiences, constructivism addresses a knowledge as compilation of human constructions. Cognitive learning perspectives consider important the knowledge acquisition and learners' process to input, store and retrieve information in memory. In constructive learning approaches, people construct knowledge and understandings based on what they already know, shaped by previous experiences and in collaboration with others. One emergent theory of learning, connectivism, argues that knowledge is a network of connections and learning consist construction and exploring of these networks (Kop & Hill, 2008; Downes, 2007; Siemens, 2005). Nevertheless, the role of immersive and affective learning contents and use of technological features in learning still remains underestimated and studied. Moreover, there are challenges in translation of knowledge and mimic reality to AR context, such as to simulations or storytelling and role-played games. Beyond the overall learning and use of technological tools and immersive contents part of training, this chapter highlights a specific case study to touch dilemmas of learning in AR/VR. The key questions for this case study were; How did the learners experience AR games in training? How can acquisition of skills in AR environment enhance expertise performance in real contexts and situations? What are the lessons when integrating immersive technological solutions into adult training, which aims to improve human performance in reality?

There are enormous prospects and challenges when it comes to appropriate and effective technological methods for training personnel to work in new and complex environments. Often learning outcomes are described as a skill or a competence orientated, which leads to discussion about sensorimotor learning and expertise development. It is essential to investigate perspectives of kinetic, sensorimotor experiences in AR/VR learning and study the role of embodied cognition to drive the learning and expertise development. In practice, adult training can aim to improve performance through enhancement of skills, such as intercommunication competences, project management skills, technological skills or decision-making skills. Educational learning foundations aim to ensure that relevant steps of learning are taken into the consideration. This case study revealed potentials as well as challenges when practically integrating technologies into training setting. General findings of case study addressed rather low and poor level integration of new technologies to adult

training. To match with learning foundations and integration challenges, the constructive experiential learning cycle is taken as a baseline to model integration and present it in line with learning principles.

BACKGROUND

New technologies emerge new types of instructional and design opportunities for training. Training is a systematic process designed to impart, attitudes, concepts, knowledge, rules or skills in trainees, and result in improved performance or other organizational outcomes of value (Kraiger et al. 2014). Mimic knowledge and reality for learning experiences in AR and immersive content therefore contribute to entire cognitive and constructive learning processes of the learners. Games engage with augmented or virtual information via wireless devices. Most conventional AR or VR games use headsets and haptic bodysuits to mimic and amplify sensory feedback to match the visual scene of the game. Interaction and bodily presence represent body movement and responses to game events on external devices. Embodied self-representations in AR/VR provide an anchor for visuomotor tasks and can have behaviour implications (Borrego et al., 2019).

Augmentation aims to mimic real experiences and interactions in easy-to-access immersive tools and therefore provide new types of learning resources. There are numerous perspectives and studies about AR and VR as well as human cognitive processes among different disciplines, authors and practitioners. Technically VR solutions are more developed and simulate a physical presence of the user in a virtual environment, and includes sensory-motoric and cognitive features and can provide emotional experiences (Björk & Holopainen, 2004). The understandings from philosophical, psychological and educational foundations can bring added value to the discussions of immersive and affective learning. Studies, on cognitive processes in learning and differences of these processes in AR/VR contexts, have increased. Even patterns, features and devices can include almost entire person to virtual reality, there are also findings of benefits on basic level AR patterns like visual immersive contents. There are claims that perception functions in AR games to plan for action constitute a kind of action in virtue of sharing a representational code (Shapiro, 2014). Accordingly, the analyses of embodied aspects and cognition show that kinesthetic patterns more generally are activated in correlation with visual perception (Gallagher, 2014). Simple sensor-motor skill development enhances the performance also in more challenging tasks.

In the context of this case study, pedagogical and methodological challenges for adult training were not only around methods or integrating technological tools into training, but also that professionals should possess an awareness of multiple actors, capacities to cope with complexity and uncertainty in conflict-affected settings (OECD 2012: 33) and learn large set of skills. Training practitioners have noticed the importance of common standards and procedures in terms of necessary skillset to be trained through training architecture globally for mission personnel (Cutillo 2013: 5-7). Complexity of reality provides lot of requirements for training designers and selections of methods. Background organizations and their procedures play crucial role in training framework and in terms of knowledge, skills and competence development guidance. It means strong reflection of policymakers as well as causality with training methods matching with needs and requirements of quality.

Adult training delivery and professional expertise development struggle with how to comply with complexity and technological innovations at the same time. Complex reality

requires people who are committed both at organizational and individual levels to be prepared and trained with knowledge, skills and competences before entering to area. Since security and humanitarian work in conflict context has grown into a multidimensional and complex phenomenon, enhancing the training delivery for the personnel globally is paramount (Hyttinen et al., 2017, p. 72). Norheim-Martinsen (2010) concludes in his analysis, recent operational experience has shown that effective peacebuilding requires a quick response from flexible teams of people with various professional backgrounds who can address different types of challenges, i.e. filling immediate security gaps, while, at the same time, starting to build local capacity. European Union's growth as a security actor since 2003 has affected as a development of various learning mechanisms to improve its performance (Smith, 2018) in humanitarian and conflict areas. As a professional working context, activities include a broad awareness of multiple actors and capacities to cope with complexity and uncertainty in fragile and conflict-affected settings (OECD, 2012. p. 33). It is evident, that both political and field approaches are challenging training providers towards effectiveness and efficiency. Since, the target personnel of training possess different educational and professional backgrounds there has been a specified need for a joint training (Taitto, 2017). These context-specific communities and cultures are important to study and discuss. Especially how to proceed with the integration of technological solutions to training among instructors and teachers who have used to work with traditional pedagogical methods.

The acquisition of knowledge and skills

This part reviews the background theoretical principles and relevant insights of learning approaches and cognitive processes in adult training. Traditional empiric, constructive and rational learning approaches (Rauste-von Wright & von Wright, 1994, p. 105) have influenced to teaching, instructional design and learning methods. Role of learning styles and methods becomes critical and valid when training aims to transfer learning outcomes to preferred performance in another context. This happens almost in every case of formal learning that learning takes place in different context than preferred performance, also in simulations.

Theory of cognitive development (Piaget, 1936), theory of experience (e.g. Dewey, 1938) and social constructivism (e.g. Miller) were the key constructivist viewpoints, which led to commonly used experiential learning tradition in adult education and training. Jean Piaget (1950) described that intelligence is shaped by experience. His theories highlighted the role of experiment as validation part of constructive processes. Adult learners taught using constructive learning methods have displayed competences and skills in doing. Piaget built the basis for constructive way of thinking (Rauste-von Wright & von Wright, 1991, p. 118). Constructivist learning theories believe in the role of social environmental context and interactions with others in individual development (Dewey, 1938) and assert learning socially situated (Lave & Wenger, 1991). Dewey (1938) addressed that human is active learner and the nature of learning is based on problem solving.

Polanyi (1958) discussed about tacit knowledge and his assumption was that some knowledge is difficult to articulate with language and may exists in a form of experiences. His understanding of tacit knowledge is in a relation with society and to our personal interests and commitments. According to Nonaka & Takeuchi (1995, p. 57-58) knowledge is defined in relation to action and with commitment and beliefs on messages. They described

information as a flow of meaningful messages. Later on, Stenmark (2001) argued that fact knowledge includes both forms of knowledge, tacit and explicit. Knowledge creation and learning theories strongly argue about the relevance of understanding knowledge as socially constructed process. Also experiential learning approaches and skill development highlight experience high when aim is to improve knowledge, skills and competences. In training setting, experiences may often take place outside of the classroom in daily real-life setting and informal form. Humans developing their skills and knowledge in a training with a purpose to work in new environment require comprehensive learning setting and awareness of learning methods, not only among facilitators, trainers, teachers or mentors but also by the learners. The range of instructional and methodological design opportunities is quite broad, and the effective learning techniques support adaption of new competences in different contexts in a form of informal learning (Marsick & Watkins, 2001). Cognitive skills can be transferred with almost same logical principles than knowledge (Rauste-von Wright & von-Wright, 1991, p. 130).

Acquisition of knowledge and skills includes processes from holistic experiential and sensorimotor learning to tacit knowledge creation. Moreover, the acquisition of competence combines the relationship between experience transformation, knowledge creation and social constructions. Learning of new skill or movement enhancement is a complex phenomenon of human (Coker, 2017). Simple motor skill learning influences to motor and movement abilities, such as posture or presenting. The relation between movement skill learning and experiential learning approach is strong. Successful skills learning require practice, experiences, starting from the simple versions of the task and increasing the level of complexity (Charter & Christiansen, 2018). Previous acquisition mechanisms affect to next processes of skills acquisition throughout the lifespan. Transformation of experiential visual perceptions into knowledge and performance of movements require cognitive mental process. Movements of different body parts must be coordinated to produce a movement skill that can be basis of new competence. In movement skill, inputs from human sensory and cognition are important in order to choose correctly, organizing and adjusting movement. Task requirements, environmental conditions and personal characteristics inflict to constraints to determine what person must do. Most of the motor skills schemes are based on experiences and descriptive and distinguished with regard to skill complexity, structure and the level of difficulty and familiarity (Voelcker-Rehage, 2008). In addition, considerations of reflection and abstraction and their cognitive mental processes are relevant in learning. Often reflection and abstraction require reflective thinking and explicit knowledge creation in social construction.

Embodied, environmentally embedded approaches have a lot to offer to cognitive science as well as to other disciplinary. It is increasingly clear that, in a wide variety of cases, an individual brain should not be the sole locus of cognitive scientific interest. Cognition is a phenomenon that can be successfully studied when including the roles of body, world and action. The facts about embodiment influence our ideas about low-level sensorimotor processes (Clark, 1999). The most evident way to analyze embodied cognition is to find out changes in motor system in correlation with changes in perception. Sensor-motor approaches have addressed the importance of perceptual experiences (such as vision) with the integration of environment where those normally arise in (Myin & Degenaar, 2014). The most evident way to define embodied cognition is to analyze the correlation between changes in perceptions and changes in motor system. Perceptual mechanisms and

representations on immersive learning content for action need to take into account constraints of action and goals of action.

Auditory perception like listening music when playing often effects to a raise of emotions. Even deeper immersive feeling requires external sensors to capture user's movements to virtual environment (Gutiérrez et al. p. 476-477), but also embodied cognitive processes especially when learning a skill require dependencies with perception, emotions and movements. Theory of the perception of sensory outcome (Prinz, 1997) is important to address through associative learning processes. Perception leads to activation of the patterns, which involves sensory and motor-cortical areas. Music perception implies an involvement of emotional and motor systems, affecting to mood regulation and motivation to move. A growing awareness of the embodied viewpoints gathering different perceptions, like effects of music, has capacities to influence to next level ranges what cognitive approaches can achieve.

Experiential Learning Cycle

"Learning is a holistic process of adaptation to the world. Not just the result of cognition, learning involves the integrated functioning of the total person— thinking, feeling, perceiving, and behaving" (Kolb & Kolb 2005: 194). Several other authors and experiments consider the role of experience as one of the most relevant in adult learning processes. Kolb's (1984) dichotomy between doing and reflection has strongly influenced to adult education and training (Wang & Newton, 2012, p. 191). Kolb's (1984) experiential learning style theory is a four-stage learning cycle;

1. Concrete Experience - a new experience or situation is encountered, or a reinterpretation of existing experience (i.e. feeling).
2. Reflective Observation of the New Experience - of particular importance are any inconsistencies between experience and understanding (i.e. watching).
3. Abstract Conceptualization - reflection gives rise to a new idea, or a modification of existing abstract concepts (i.e. thinking)
4. Active Experimentation - the learner applies the idea(s) to the world around them to see what happens (i.e. doing).

This comprehensive learning style builds the theoretical model when analyzing experiences in AR setting and when understanding cognitive processes in relation to skills development and learning. Experiential learning cycle is one of the most dynamic approaches in training and education domain (Kolb & Kolb, 2011). Academic studies and findings from past twenty years have influenced to improve an understanding about the role of instructor or teacher in learning processes. Experiential learning encourages to systematically taking the learners through each step, and knowledge is created through the transformation of experience. The value of experiential educational theories lays in a more holistic approach including cognition, environmental factors (context), and emotions. They provide opportunities to apply experiential instructional practices in due time. Other scientific approaches, like cognitive sciences, neuroscience or other psychological theories, offer multiple several options to choose but author of this chapter chose to stay in the holistic experience oriented educational basis.

Learning principles can be utilized throughout training design or higher education programs. Key features of learning approaches are experiences and adoptions of the world, but training and education practices have commonly situated in facilities such as in

classrooms or meeting rooms. These kind of limitations in training and education settings are discussed and new ways are already created. Reflection of the experiences can be facilitated through social constructive instructors and methods (such as group discussions or tasks) in a classroom and innovate in knowledge creation and abstractive processes. Rose & Church (1998) found that practicing with performance and feedback stronger effects in learning teaching behaviors and skills. Findings from use of high-quality constructivist curricula have showed increased performance in problem solving, high commitment and metacognitive outcomes. Mentoring, advising or practice with feedback in social environments are seen effective in improving skills and metacognitive capabilities. Experiential learning cycle and social constructivism ensure competence development and learning.

Learning Technologies

When technological solutions aim to improve human performance, the knowledge and skill development as well as competence transfer from context to another set some requirements for learning. The purpose of playing with technology such as games, tools, simulations or Learning Management Systems (LMSs) can target to better access to knowledge, enhancing human performance or learning new competences. The emerging digital possibilities enabled the raise of e-learning and information distribution around the globe (Zhang et al., 2004, p. 75-79). With its potential for providing flexible access to content anywhere and anytime, digital learning opportunities have become popular worldwide (IECEU, 2016). In 2008, online enrollments were growing significantly faster than the higher education enrollments in general (Allen & Seaman 2008). Technological solutions have developed, but still LMSs and eLearning stay the most used solutions in education and training.

Technological simulation, such as game, connects scenario, immersive and affective contents and learning methodologies in a meaningful way to the learning process. A simulation has been defined as an artificial or augmented scenario or environment that is designed to represent or simulate some aspects of reality. Generally, we aim to understand imitated system in a variety of simulated environments. The relation of program to environment opened up the role of computer simulation as a tool to understand human behavior. (Herbert, 1996, p. 13-23). Simulations can incorporate different degrees and types of fidelity, or realism, namely, physical, functional and psychological. Learning games or gamified learning tools are or include parts of Augmented Reality (AR) simulations. Milgram´s reality-virtuality continuum (Milgram & Kishino, 1994) provides the understanding that the frontier between AR and VR is continuous scale with totally real and virtual environment. In practice, technological simulation is one mean to create meaningful learning environment, where learner can experience and learn through reflection, abstraction and constructivism. In learning processes, also with use of AR and VR, the learners are not often able to present explicitly their learning immediately after the process. In addition, playing AR learning game does not yet guarantee applying and transferring skills to other context physically. The discussion among scholars related to observational and physical experience (see for example Cross et al. 2009) in learning is becoming even more relevant to further study when digital environments are developed.

AR/VR games are suitable training tools also various levels and positions in organizations, because they provide immersive and affective content for perceptions and visual experiences of reality. Games engage individuals in real-life experiences that result to interaction between humans and their environments observed seeing, feeling, and doing. The perceptions may take place in reality as well as in AR forms of games, tools, simulations or scenarios. AR game and tool provide often, also in this case, only immersive and affective learning content perceived visually or sense of hearing. AR game simulations immerse the player in the game and immersion in the decision-making process of the game requires the player to learn the consequences of their decisions, and thus being part of an active learning process. (Kraiger, 2014). Simulation can enable achievement of assessable and measurable learning objectives, when learner navigates in a learning space, where he/she receives feedback constantly and is facing new challenges in an evolving and dynamic environment. Surrounding the user with virtual or augmented technologies or devices is often used to create immersion (Wu, Lui, Wang & Zhao, 2015). To be credible, perception with virtual environment requires real-time interaction and feedback (Riva, 2006).

Nowadays, smart phones and other mobile devices are more suitable to visualization and immersion because of their developed capacities. In terms of acceptance and user satisfaction also ease to use and ease to adopt are relevant elements. Moreover, findings from the age-related performance differences must be taken into account in design of technology for adult training. For example, researchers have showed that older adults rely more on visual control when acquiring and performing a precision locomotor tasks (e.g. Hedel & Dietz, 2004). In addition, cognitive studies have shown the effect of perceptual speed the performance level. There are instructional design practices for the integration of basic immersive learning contents considered in line with adult educational principles (see for example Keillor & Littlefield, 2012). Tutorial quizzes, audiovisual contents, surveys and forms provides easy to use tools for the teachers and instructors to ensure perceptional experiences for the learners.

The principles of human-technology design (see i.e. Saariluoma et al., 2016, Hyttinen, 2017) is essential consider in the development of new products. Development of technology supported efficient training should be user centric and development curve faster in games and online tools since both tacit and explicit knowledge changes. Nevertheless, the process of human-centered design does not yet guarantee the successful implementation of developed technologies into training curriculums and practices. Individual instructors or teachers may teach in ways that reflect their own learning styles, and therefore teachers should be encouraged learners to Kolb's learning stages (Healey & Jenkins, 2000). There are potentials for learning technologies to be integrated more effectively to training as part of a mean or method to improve immersion and experiential opportunities. Moreover, shifting the focus from technology-centered to human-centered design approach creates systems relevant to the learning objectives (Persson, 2017) and this may also support enhanced integration. As McGonigal points out, "game design isn't just a technological craft. It's a twenty-first century way of thinking…It's a twenty-first century way of working together to accomplish real change." (McGonigal, 2011, p.13). Design and development of AR games to ensure user needs, embodied cognition and experiential learning would benefit skills learning and transformation of competence to reality.

CASE STUDY

The findings of this case study are drawn from in-depth expert interviews (n=15) and two technology evaluation workshops conducted during the Improving the Effectiveness of Capabilities in EU conflict prevention (IECEU) and Gaming for Peace (GAP) projects in years 2015-2019. IECEU developed an immersive learning tool to get familiar with peacebuilding context, legislation and practices. Selected empirical approach in data collection (interviews and observations) and analysis aims to contribute as a case study and provide knowledge through researcher's senses and interviewees' experiences. Qualitative research methods are often inductive (Kaplan & Maxwell, 2005) and in this study the hypothesis were developed in conducting the study and while learning about the setting and people in it.

Semi-structured interview is a method to collect in-depth information about people's experiences and opinions. This methods was seen as the most appropriate within this context. Learner's experiences when playing the game and the tool were collected by observations and interviews. Observations of the evaluation sessions provided valuable information about the setting to describe strengths and weaknesses when playing with AR technologies. Triangulation of two different project data (interviews, observations and documents) was selected as analyzing method to interpret the phenomena comprehensively. Patton (1999) identified that the convergence of data from different sources and methods is a qualitative research strategy to test validity.

Part of IECEU- project, a learning tool was developed based on the research findings from EU operations in eight different conflict areas. GAP –project designed an online role-playing game in soft skills development for professionals working in the conflict field. Both case study technologies offered immersive and affective contents in digital forms for the learners. Both technological learning solutions, the learning tool and the learning game, are accumulated multicultural and multi-professional design innovation and development collaboration. Methods, to collect the information for the transcriptions, vignettes and scenarios, were interviews and workshops among professionals with long-term experience from the conflict or crisis zones. Learning tool comprehended immersive multimedia content of written documents, augmented storytelling animations based on reality scenarios as well as affective and gamified features to raise motivation. Gamified elements implied grading throughout the tool was played and question sets answered. Learning tool motivated the learners with certification. Certification was a concrete production for the learner to show completion of eLearning part. Learning tool enclosed augmented animated scenarios and storylines for visual observations to mimic multicultural reality conflict zone. Learning game consisted features to engage player's senses of audition (sense of hearing) and vision in a form of animation, music and storytelling. Gamified features were roleplaying options and question sets for learning reflection. Question sets were followed into next situation in game scenario. Animated scenario and storyline with audio provided important features for game playing experiences. The player was able to read and hear the storytelling and then complete decision to click text boxes to proceed in a game. Game playing mode allows the player to explore a scene in the game. The player must pan the scene to discover all its elements within a scene. The decisions taken by the player give scoring results during the game play.

FINDINGS

Experiences in use of AR Technologies

Viewpoint in this study focused on analyzing learners' experiences when playing game and tool. Described experiences, such as feelings, provided meanings to analyze achievement of the learning outcomes. They also revealed the level of awareness about the desired human performance. Learners perceived mainly visually and with a sense of hearing. Both the game and the tool provided perceptions of immersive and affective content in AR. Experiences were categorized to five themes, which are further elaborated below; first impressions, experiential methods of AR tool and game, perceptions and embodiment, and human-technology interaction.

When asking about first impressions, the learning tool players valued the first impression high even the learning tool included only written material, immersive animations and gamified quizzes. Learners described the first impression as the most relevant in order to continue the use of learning tool. Learners felt higher motivation and excitement when using or playing the online tool or game when they were asked to compared it to traditional methods; reading or listening a lecture. The game players addressed the game as "very interesting option" as a learning method. Motivation, not only to use of technological solutions, but also in human learning processes, plays very important role. Research participants felt that instead of written texts, the learning content in online format should include visual solutions such as videos, animations, storytelling, scenarios, maps and other visual and structured material. They addressed that visual contents help to adapt new information more precisely and faster.

It was observed that the tool provided a possibility for learners to observe visually augmented conflict scenarios. Game offered option to join with a specific role in augmented conflict scenario and follow the storytelling journey as "role playing". Tool gamified quizzes after observing animations and therefore provided an immediate reflection opportunity based on visual perception. Few players described roleplaying as "eyes-opening", when the player needed to consider his/her thoughts in a specific role including nationality, profession, gender and age. Both, gamified animations (tool) and storytelling role-play (game), provided experience flows for the learners. In comparison to traditional visual learning methods, such as videos or pictures, learners described that they felt deeper belonging to the context. One respondents described that she did not feel to do other things at the same time, like normally she would do when following lectures or while reading. This can be interpreted as deeper commitment while playing in AR environment. The negative aspects focused in both data analysis on personal capabilities and possibilities to adapt so extensive amount of knowledge and information in so short timeframe. The time used for using the learning tool or playing the game was experienced too short by the players. Often the time for reflection is minimal even in real-life exercises and training. The training content may also influence to persons' attitudes, emotions and values, and therefore the time for reflection through discussions or other methods should be consider to ensure appropriate learning curve as well as several learning methods and techniques. Beyond providing the experiential opportunity, the reflection and abstraction are essential to facilitate among the learners. Instructors and training providers can easily execute these appropriate actions part of adult training based on technical instructional practices.

Several interviewees described that they earlier heard real-life stories from colleagues in conflict zones, but with the learning game, they were able to get a visual and audio perceptions in augmented environment. In evaluation workshops, a sense of hearing was addressed important additional feature and music influenced to "get in to right mood". Music may raise emotions when playing. Perceptions of immersive and affective content in learning game and tool led learners to describe cognitive processes and their individual emotions. Theoretical discussions of the meaning between perception and action may differ from perception for action even to perception as action. In this case study, players mainly used same position during and after playing. Immersive learning content perceptions, mainly visual and hearing, and there was no bodily movement observed in AR or real life situations. It was recognized that even learners of case studies felt excitement and value of learning tool and game; they were not able to analyze the learning outcomes immediately after the playing. Most of learners felt that they did not precisely learn anything new, but they felt that the new learning technologies very much needed and valuable. Nevertheless, as a comparison the professionals who already had real-life experiences from fragile areas and conflict settings were able to describe their learning experiences better after playing the game or tool.

When observing human and technology interaction during case study AR tool and game playing, there was a clear lack of movement or physical activities during playing. This is a critical limitation of AR from the learning point of view, especially when considering individual skill and competence development. From the technical feature point of view, the learners addressed the most desired functions of the tool as options for gamified learning, mobile friendly and multi-browser compatible. In terms of technological sensory design, tool and game did not include sensors, headsets, glasses, joysticks or opportunities for different sensing than hearing, watching, observing and touching. The interaction between human and technology occurred with visual and audio perceptions with content via screen and audio of smart phone, laptop or pad. When learning tool included only animated videos, learning game offered roleplaying option. Roleplaying is more attractive method for the player and it can help to produce the feeling "to be inside the game". On PC and Mac, the player uses their mouse to drag the scene or highlighted element in order to interact with them. On iPad, the player swipes the scene left and right to pan, and they can tap on the highlighted elements to interact. This scoring result were visible either for the learner (learning tool) or for the trainer or teacher (learning game).

Integration Model

Triangulation of data revealed that current training practices focused on traditional pedagogical methods than blended learning methods supported with technologies, i.e. AR or immersive technological solutions. Pedagogical methods of the training were mainly face-to-face courses with lectures, workshops and exercises and mainly organized nationally, not always internationally. Practices of trainings mainly laid on classroom teaching and mentoring, even studies of adult learning and emerging technologies provide extensive range of methods and solutions to be facilitated. Data analyses addressed an integration of technological solutions to training as one of the key challenges in current practices. In the context of adult training for the professional and experienced personnel, the adult education principles in training should be considered with high priority in the integration and designing of technology. Interviewees described that culture, history,

religious as well as gender aspects play important roles in conflict area work. Therefore, also training should possess the roles of emotions and attitudes, as well as learning principles in the exercises. According to empirical data analyses, the understanding of the standards in behaving and awareness of current practices in real life context are required when designing technological tools, exercises, games or simulations. Otherwise, there might be even higher resistance among training providers accepting beneficial immersive learning contents to curriculums of training.

Experiential learning cycle was utilized as a foundation to a model to integrate immersive learning technologies to adult training. In addition, this chapter builds on the educational approaches and learning theories. The proposed model presents solutions for instructors and teachers to more successfully integrate immersive technology-based tools for training or education courses. The meaning of successful rest on commitment, engagement and ensuring learning processes comprehensively in playing. The model combines triangulation of empirical data and learning perspectives. It aims to enhance integration of technologies in order to reach set learning outcomes and improve human performance in reality setting. Model to integrate immersive learning content to adult training presented below aims to follow the experiential learning cycle and base on educational underpinnings.

Perceptual experience can be facilitated through integration of AR (e.g. tools or games), including immersive content, to training curricula as a task or pre-course task. Experience can happen as individually by the learner. Immersive learning content can provide the experiential basis for the adult learners before training. Even perceptions that AR solutions offer are rather simple and lack variations of senses beyond hearing and seeing, they help to start cognitive processes towards next phases of the learning.

Action and Reflection in reality, AR or VR should be followed after perceptual experience. This can take place individually by the learner, but also among peers. A special attention to embodied cognition in action should be encouraged. Reflective discussions with experienced mentors or teachers enhance learning from perceptual experience and action towards desired performance and finally achievement of learning objectives.

Experience and Abstraction increase the understanding of new experiences and ideas in the abstraction level. The bridge between experiences and theoretical abstractive level raises learning potential based on individual experience. Summarizing reflected experiences with frameworks and explicit concepts benefits in human performance and competence development. Also at this stage, a deliberation of immersive and affective contents in abstraction can support representations and especially visual learners.

Organizational knowledge creation concludes the learning process with aim to improve human performance in a community or group level. Constructivist activities add on information sharing and knowledge creation in the organizations or communities. Individual experiences in reality, AR or VR can build the basis for knowledge creation and face-to-face classroom-based training is valuable way to facilitate it with use of constructivist teaching methods. Sharing individual experiences and discussions enhance new knowledge creation and learning together.

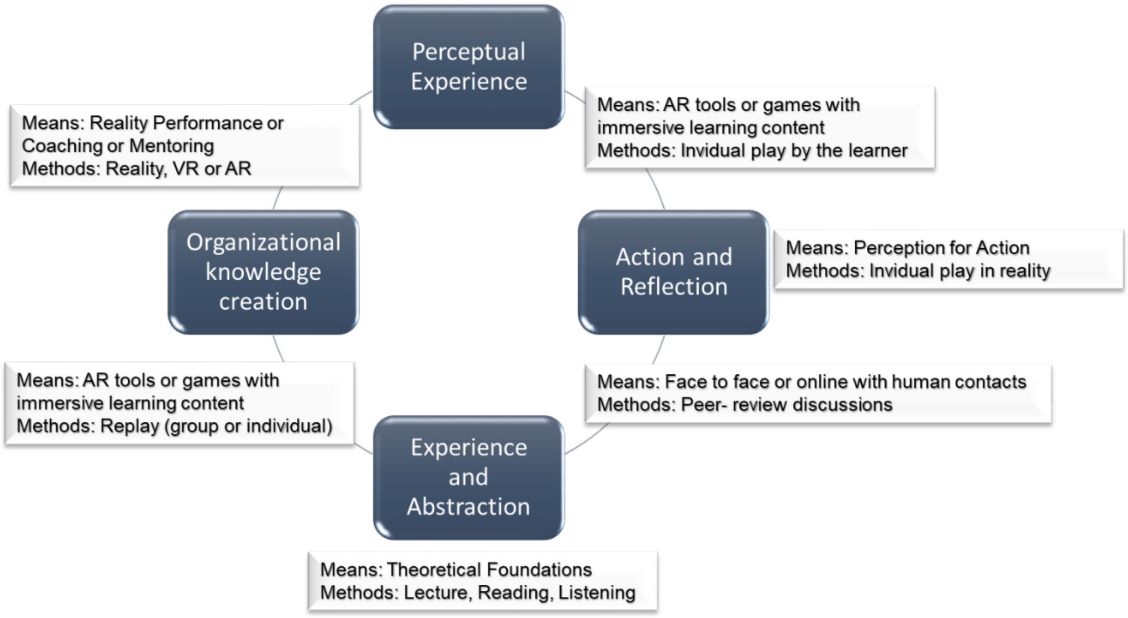

Figure 1: A proposed implementation model to integrate immersive content, AR environments into adult training.

Learning is a comprehensive process including cognition, feelings, kinetics, and individual experiences. AR and VR technologies can provide new type of experiences online, located close to learners. As case studies have shown, a special attention should be paid on the integration of AR and VR in a meaningful way to training and education. This integration model helps the trainers, teachers and learners to understand the entire process and select the use of technological parts meaningfully to reach learning outcomes.

DISCUSSION

Lately, the swift from traditional classroom training to more technological training seems to progress and there is an interest to integrate smarter learning solutions to training and education. In addition, high costs of technological developments, such as AR and VR tools or games, have maybe negatively affected to use and integrate them in the educational courses and adult training. Unfortunately, the current formats of learning technologies are still low level in comparison with trends and commercial industry.

This chapter addressed that the role of immersive perceptions supplying experiences and experiential learning cycle provide visions and positions for integrating technologies more comprehend. In skill and competence development, a lack of movement and sensorimotor activities influence to learning and embodied cognition as well as low adaptive capabilities to perform skills and competences in reality context. The understanding of the benefits and limitations to human performance in reality when playing AR or VR game helps to utilize technologies realistically in practice. It was recognized that the content of multi-cultural and novel augmented realities raise different emotions and thoughts by the learner.

In this case, a lack of embodied cognition when playing the tool or the game was recognized. It raised several limitations in terms of learning skills and competences in AR. There was not dependencies between perception, action movement and emotions as part of

playing experience of immersive learning content. Therefore, this kind of approach highlighting the importance of embodied cognitive processes in learning strongly pushes integration of immersive learning content, such as AR technologies, with use of other learning methods. It is also identified earlier "digital tools do not substitute face-to-face methods, but complement them by enabling more constant interaction with users and lowering certain users' participation thresholds" (Friedrich 2013). Blended learning techniques and methods are seen relevant. Another opportunity to consider would be rather easily applied in AR simulations and games. Tasking and directing player to movements during game playing would include opportunities of embodied cognition to entire learning process. Tasking and skill movement in real life can be facilitate without technical features like sensors. In line with previous findings of motor skill and competence development and learning, the exercises of activity and movements in real context are crucial beyond experience, reflection and abstraction of knowledge.

AR technologies do not usually guarantee the embodied cognition itself. In order to decrease the level of costs or instructional challenges in using AR technology, simple solutions without sensors, joysticks or glasses are often more suitable for adult training purposes. If the learning goal is around skills or competences, applying a perception for action in physical reality with use of methods like exercising or playing allows improved performance and successful reach of the learning outcomes. Experiential learning studies showed the contextual relevance of the experience in learning process. Therefore, the potential to apply the learned knowledge, skill or competence in demand context grows if training ensures applying or exercising the competence in reality together with AR.

This is suggested especially in the cases where the reality environment is challenging to face to provide experience for the learner (e.g. location). As this case study showed, AR can provide individual perceptual experience for the learner through simulations or scenarios for example in visually supported games or animations. Because AR context provides different environment than reality, the immersive learning experience should not focus towards total absolute in terms of matching with reality. In the end, the aim of perfection may influence negatively to adaption of immersive contents by the adult training community. This case study showed that more complex the AR is, more challenging it is to integrate to training because of its time efforts. Therefore, considerations on use of simple AR tools may work more effectively in practice. One could argue it is important to apply tools or games that potentially raises the motivation (with use of immersion, affective content, goals etc.) towards learning goal by the learners.

The models from movement-based game design or interphases provides simple baseline for training and education field. Another key finding of this study was that AR technologies are not often successfully integrated to training and curricula. The commitment of key actors who establish training policies, guidelines and instructions is crucial in the integration processes. Case study found out that integration of technological solutions often failed to facilitate reflective and abstractive parts of experiential learning cycle in training sessions among adult learners. In practice, the instructors and teachers focused on introducing guidelines to use and play the tool or the game and followed the playing in the classroom. Individual playing afforded perceptions, experiences and cognitions to process them throughout playing, but reflective parts are missing.

This raised an intention to introduce key influences of empiric and constructivism theoretical underpinnings multidisciplinary. Successful applying experiential learning

model in the integration of AR tools and games to adult training gives opportunities for learning and instructors. Before immersive technologies, learning methods such as case studies, board games, role-plays, observations, reading and listening were the most commonly used to provide substitutional experiences. Exploitation of these traditions and practices cure the technological learning methods. These kind of learning features could enhance the integration of learning technologies more effectively to training setting for instructions who have not used these or similar tools in their own learning.

FUTURE RESEARCH

The findings of earlier studies have showed the relations between perceptions and actions. The perceptions of immersive learning contents for action or performance in the environment, reality or augmented, should effect on ways of designing and producing learning tools and games. The large setting of multiple experiments shows a relation between different bodies of people and thinking, in a predictable way (Casasanto, 2014). These kinds of implications could be further studied in the field of immersive and affective capacities of learning technologies to improve their training potential to performance and actions. During this research, a use of AR technologies raised number of questions from efficiency and learning perspectives. Does AR learning games and tools provide dynamic opportunities for learning? How can immersive content provide kinetic experiences such as feelings compared in reality? How can we ensure embodied cognition (body, world and action), learning and sensorimotor experiences in adult expertise development with use of AR technologies?

Findings revealed number of potentials as well as challenges during integration processes of AR games to adult training. Case study showed that the technologies with affective content and positive player feedback was not successfully integrated afterwards to training curricula. Therefore, the considerations around integration of AR and VR technologies to adult professional training call for further studies, discussions and good practices.

CONCLUSIONS

This case study showed that beyond the traditional LMSs, immersive learning contents provide valuable experiences for the learners. Experiences in Augmented or Virtual Reality (AR/VR) are perceived often visually and with sense of hearing. AR/VR games and tools mimic real scenarios and are rather new phenomena in adult training. Moreover, the value of using multiple learning techniques and methods, such as reading, observations, problem solving, decision-making and quizzes in AR, is around the wide range of opportunities to reach individual learning characteristics. How can we benefit from the immersive learning experiences? How does these experiences shape our learning processes compared to reality experiences?

Case study findings described first impressions, experiential methods of AR tool and game, perceptions and embodiment, and human-technology interaction. When observing the users of AR tool or game, it was evident that embodied cognition was lacking. When learning content aims to improve skills and competences and to apply them in the real-life setting as performance, we encounter complexity of cognitive processes and learning perspectives. Moreover, there were challenges with facilitating reflection and abstraction stages when playing with AR technologies.

Even the acceptance of digital training solutions is rather positive among learners and practitioners, the use of AR/VR as part of training has stayed low. Complex hardware is not the most appropriate when aiming at popularizing use of VR or AR. The costs of AR or VR solutions can easily reach too high even with one AR scenario. Use of AR technologies in training still requires research and validation of good practices. Reality is often complex and changing, how can we develop easy to use and implemented technologies for traditional adult training setting? However, can we then raise the efficiency using AR? In addition, should we or how should we complete the translation of complex realities into AR and training setting? Moreover, how to engage instructors and training providers to integrate technologies into training if they have no previous experience?

Comprehensive research already exists and suggestions focuses on how to apply interactive multimedia instructions to teaching and learning especially in the educational practices (see for example Zheng, 2008). Existence of professional training mechanisms is the first step, but in order to learn skills to improve performance there is emerging need to study learning and use of technological solutions part of training more critically. In order to enhance the learning potential, human-centered design of the content in line with learning outcomes support learner to succeed and raise the engagement of instructors to use AR/VR. Nevertheless, the techniques to translate situated knowledge, experiences or scenarios from real-life setting to AR are developed, the multi-professional collaboration is needed. The translation or transfer require effective multi-professional collaboration among IT specialists, researchers, practitioners and educators.

REFERENCES

Allen, E. & Seaman, J. (2010). Class differences: Online education in the United States, 2010. Babson Park, MA: Babson Survey Research Group.

Allen, E. & Seaman, J. (2008). Staying the Course: Online Education in the United States. Sloan Consortium. United States of America.

Benford, S., Greenhalgh, C., Hopkins, G., Brown, C. & Koleva, B. (1998). Understanding and Constructing Shared Spaces with Mixed-Reality Boundaries. ACM Transactions on Computer-Human Interaction 5(3): 185-223. DOI: 10.1145/292834.292836.

Borrego, A., Latorre, J., Alcaniz, M., Llorens, R. (2019). Embodiment and Presence in Virtual Reality After Stroke. A Comparative Study With Health Subjects. Front. Neurol. 10:1061. DOI:10.3389/fneur.2019.01061

Björk, S. & Holopainen, J. (2004). Patterns in Game Design. Charles River Media, Boston, MA.

Charter, N. & Christiansen, M. (2018). Language acquisition as skill learning. Current Opinion in Behavioral Sciences 2018, 21:205-208. Elsevier.

Clark, A. (1999). An embodied cognitive science? Trends in Cognitive Sciences – Vol. 3, No. 9, September 1999. 1999 Elsevier Science.

Coker, C. (2017). Motor learning and control for practitioners. 4th Edition. Routledge. DOI: 10.4324/9781315185613.

Cutillo, A. (2013). Deploying the Best: Enhancing Training for United Nations Peacekeepers. Providing for Peacekeeping No. 5, New York: International Peace Institute, August 2013.

Cross, E., Kraemer, D., Hamilton, A., Kelley, W, and Grafton, S. (2009). Sensitivity of the action observation network to physical and observational learning. Cerebral Cortex, 19(2), 315–26.
Dewey, J. (1938). Experience and Education. London: Collier MacMillan.
Di Serio, Á., Ibáñez, M., & Kloos, C. (2013). Impact of an augmented reality system on students' motivation for a visual art course. Computers & Education, 68, 586-596.
Gallagher, S. (2014). Phenomenology and embodied cognition. In L. Shapiro (Eds.), The Handbook of Embodied Cognition. Routledge, New York (2014).
Gutiérrez, J. M., Domínguez, M. G., & González, C. R. (2015). Using 3D Virtual Technologies to Train Spatial Skills in Engineering. International Journal of Engineering Education 31(1), 323-334.
Friedrich, P. (2013). Web-based co-design. Social media tools to enhance user-centered design and innovation process, University of Tampere, 2013. VTT Science 34. http://www.vtt.fi/publications/index.jsp
Harris, K., & Reid, D. (2005). The Influence of Virtual Reality Play on Children's Motivation. Canadian Journal of Occupational Therapy Vol: 72, Issue: 1, page(s): 21-29. DOI: 10.1177/000841740507200107.
Healey, M. & Jenkins, A. (2000). Kolb's Experiential Learning Theory and Its Application in Geography in Higher Education. Journal of Geography, 99:5, 185-195. DOI: 10.1080/00221340008978967.
Herbert, S. A. (1996). The Sciences of the Artificial. 3rd Edition. Massachusetts Institute of Technology. The MIT Press.
Hyttinen, K. (2017). Human-centered Design Model in the Development of Online Learning Tools for International Security Training: CASE IECEU New Media based Learning Application (NMLA). Science and Technology Publications. DOI: 10.5220/0006559902750282.
Hyttinen, K. Smith, R. & Timms, R. (2017). Soft Skills for Peacekeeping and Crisis Management Experts. In E. Norvanto & H. Dumur-Laanila (Eds.), Seminar Publication on Contemporary Peace Operations – From theory to practice. Finnish Defence Forces International Centre. Helsinki 2017. http://urn.fi/URN:ISBN:978-951-25-2945-2
IECEU –project. (2016). D5.2 Design and Development Process of the NMLA. Laurea University of Applied Sciences, October 2016.
Kaplan, B. & Maxwell, J. A. (2005). Qualitative research methods for evaluating computer information systems. Anderson, J. & Carolyn, E. (Eds.) Evaluating the Organizational Impact of Healthcare Information Systems, 30-55, 2005. Springer.
Keillor & Littlefield (2012). Engaging Adult Learners with Technology. Digital Commons. Saint Mary's University.
Kerawalla, L., Luckin, R., Seljeflot, S., & Woolard, A. (2006). Making it real: Exploring the potential of augmented reality for teaching primary school science. Virtual Reality (Waltham Cross), 10(3-4), 163–174. doi:10.1007/s10055-006-0036-4.
Kolb, D. (1984) Experiential learning: Experience as the source of learning and development (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.
Kolb, A. Y., and Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. Academy of Management Learning and Education. 4(2): 193-212. H. Hedel & V. Dietz (Eds). The influence of age on learning a locomotor task. Clin. Neurophysiol. 115:2134–2143.

Kolb, A. & Kolb, D. (2011). Experiential Learning Theory: A Dynamic, Holistic Approach to Management Learning, Education and Development. S. Armstrong & C. Fukami (Eds.) Handbook of management learning, education and development. DOI: 10.4135/9780857021038.
Kraiger, K., Passmore, J., Rebelo dos Santos, N., Malvezzi, S. (Eds). (2014). The Wiley Blackwell Handbook of the Psychology of Training, Development, and Performance Improvement. Publishers.
Lange, B., Requejo, P., Flynn, S., Rizzo, A., Valero-Cuevas, F., Baker, L., & Winstein, C. (2010). The potential of virtual reality and gaming to assist successful aging with disability. Physical medicine and rehabilitation clinics of North America, 21(2), 339-356
Lave, J. & Wenger, E. (1991). Situated Learning: Legitimate peripheral participation. Cambridge university press, 1991.
Leman, M. & Maes, P-J. (2014). Music Perception and Embodied Music Cognition. In Shapiro, L. (eds.). (2014). The Handbook of Embodied Cognition. Routledge, New York (2014) p.81-89.
Lewer, N. (1999). International Non-Governmental Organisations and Peacebuilding - Perspectives from Peace Studies and Conflict Resolution. Bradford, Centre for Conflict Resolution, Department of Peace Studies. University of Bradford. CCR Working Papers: No. 3.
Marsick, V., & Watkins, K. (2001). Informal and Incidental Learning. New Directions for Adult And Continuing Education. no. 89, Spring 2001 © Jossey-Bass, A Publishing Unit of John Wiley & Sons, Inc.
Martín-Gutiérrez, J., Saorín, J., Contero, M., Alcaniz, M., Pérez-López, D., & Ortega, M. (2010). Design and validation of an augmented book for spatial abilities development in engineering students. Computers & Graphics, 34(1), 77–91. doi:10.1016/j.cag.2009.11.003.
McGonigal, J. (2011). Reality is Broken: How games make us better and how they can change the world. Penguin Press. USA.
Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS on Information and Systems, 77(12), 1321-1329.
Nonaka, I. and Takeuchi, H. (1995). The Knowledge - creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, New York, NY.
Norheim-Martinsen, P. (2010). Managing the Civil-Military Interface in the EU: Creating an Organisation Fit for Purpose, In: Vanhoonacker, S., Dijkstra, H. and Maurer, H. (eds). Understanding the Role of Bureaucracy in the European Security and Defence Policy, European Integration. online Papers (EIoP), Special Issue 1, Vol. 14, http://eiop.or.at/eiop/texte/2010-010a.htm
OECD. (2012). Evaluating Peacebuilding Activities in Settings of Conflict and Fragility: Improving Learning for Results. DAC Guidelines and References Series. OECD Publishing. http://dx.doi.org/10.1787/9789264106802-
Patton, M. Q. (1990). Qualitative evaluation and research methods. Newbury Park: Sage.
Persson, J. (2017). A review of the design and development processes of simulation for training in healthcare – A technology-centered versus a human-centered perspective. Applied Ergonomics Vol 58, p. 314-326. doi.org/10-1016/j.apergo.2016.07.007
Piaget, J. (1950). The Psychology of Intelligence. London: Routledge.
Polanyi, M. (1966). The Tacit Dimension. Anchor Day Books, New York, NY.

Prinz, W. (1997). Perception and action planning. European Journal of Cognitive Psychology, 9(2), 129–54.
Rauste-von Wright, M. & von Wright, J. (1994). Oppiminen ja koulutus. WSOY, Juva, Finland. ISBN: 951-0-20024-7.
Riva, G. (2006). Virtual reality. Encyclopedia of Biomedical Engineering. London: John Wiley & Sons.
Rose, D. & Church, J. (1998). Learning to teach: the acquisition and maintenance of teaching skills. Journal of Behavioral Education 8 (1), 5-35. 1998. Springer.
Saariluoma, P., Cañas, J., Leikas, J. 2016. Designing for Life - A Human Perspective on Technology Development. Macmillan Publishers Ltd. London. ISBN 978-1-137-53047-9 (eBook).
Shapiro, L. (2014). The Handbook of Embodied Cognition. Routledge, New York (2014).
Smith, R. (2018). Learning in European Union peacebuilding: rhetoric and reality. Global Affairs. DOI: 10.1080/23340460.2018.1500427
Stenmark, D. (2001). The Relationship between Information and Knowledge, in Proceedings of IRIS 24, Ulvik, Norway, August 11-14.
Voelcker-Rehage, C. (2008). Motor-skill learning in older adults—a review of studies on age-related differences. European Review of Aging and Physical Activity volume 5, pages 5–16 (2008). ISSN: 1861-6909
Wang, R. & Newton, S. (2012). A review of Kolb's learning styles in the context of emerging interactive learning environments. In AUBEA 2012: Proceedings of the 37th International Conference of the Australasian Universities Building Educators Association, University of New South Wales, Sydney, N.S.W., pp. 191-199.
Wu, F., Liu, Z., Wang, J., & Zhao, Y. (2015). Establishment virtual maintenance environment based on VIRTOOLS to effectively enhance the sense of immersion of teaching equipment. In Proceedings of the 2015 International Conference on Education Technology, Management and Humanities Science (ETMHS 2015). Atlantis Press. doi:10.2991/etmhs-15.2015.93.
Zhang, D. Zhao, L. Zhou, Li. & Nunamaker, J. (2004). Can e-learning replace classroom learning? Communications of the ACM 47, 5 (May 2004), 75-79. DOI: https://doi.org/10.1145/986213.986216
Zheng R. (2007). Cognitive functionality of multimedia in problem solving. In T. Kidd & H. Song (Eds.) Handbook of Research on Instructional Systems and Technology, pp. 230 – 246. IGI Global, Hershey, PA.
Taitto, P. (2017). "When Diversity is the only Unity": How to Train for a Comprehensive Approach in EU Crisis Management. In E. Norvanto & H. Dumur-Laanila (Eds.), Seminar Publications on Contemporary Peace Operations - From Theory to Practice. Based on EAPTC Seminar, 2-4 May 2017, Helsinki, p. 93-99, Puolustusvoimat. URN: NBN:fi:amk-2017113018994

Additional Reading

1. Appelman, R. (2005). Designing Experiential Modes: A Key Focus for Immersive Learning Environments. TechTrends: Linking Research & Practice to Improve Learning. May/Jun2005, Vol. 49 Issue 3, p. 64-74. 10.1007/BF02763648
2. Barsom, E.Z., Graafland, M. & Schijven, M.P. Surg Endosc (2016). Systematic review on the effectiveness of augmented reality applications in medical training. Surgical Endoscopy,

October 2016, Volume 30, Issue 10, pp 4174–418330: 4174. Springer US. DOI: 10.1007/s00464-016-4800-6
3. Bhattacharjee, D. Paul, A., Kim, J., Karthigaikumar, P. (2018). An immersive learning model using evolutionary learning. Computers & Electrical Engineering, Volume 65, 2018, Pages 236-249, ISSN 0045-7906, https://doi.org/10.1016/j.compeleceng.2017.08.023. © 2017 Elsevier Ltd.
4. de Freitas, S. (2018). Are Games Effective Learning Tools? A Review of Educational Games. Educational Technology & Society, 21 (2), 74–84.
5. Fischer, F., Hmelo-Silver, C., Goldman, S., Reimann, P. (2018). International Handbook of the Learning Sciences. Routledge. New York. https://doi.org/10.4324/9781315617572
6. Hwang G-J., Wu, P-H., Chen, C-C. & Tu, N-T. (2016) Effects of an augmented reality-based educational game on students' learning achievements and attitudes in real-world observations. Interactive Learning Environments, 24:8, 1895-1906, Taylor & Francis Online. DOI: 10.1080/10494820.2015.1057747
7. Jean, S., Medema, W., Adamowski, J., Chew, C. Delaney, P. Wals, A. (2018). Interaction analysis data of simulation gaming events using the serious game Aqua Republica. Journal of Environmental Management, Volume 223, 1 October 2018, Pages 1010-1022. Elsevier. https://doi.org/10.1016/j.jenvman.2018.05.021.
8. Kujala, T. & Saariluoma, P. (2018). Cognitive Mimetics for Designing Intelligent Technologies. Advances in Human-Computer Interaction, Volume 2018, Article ID 9215863, 9 pages. https://doi.org/10.1155/2018/9215863
9. Kolb, D. 2014. Experiential Learning – Experience as a source of Learning and Development. Second Edition. Pearson Education, Inc. New Jersey. USA.
10. Lave, J., & Wenger, E. (1998). Communities of practice: Learning, meaning and identity. Cambridge: Cambridge University Press.
11. Li, N. & Duh, H. (2013) Cognitive Issues in Mobile Augmented Reality: An Embodied Perspective. W, Huang., L, Alem & M, Livingston. (Eds.) Human Factors in Augmented Reality Environments. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-4205-9_5
12. Saariluoma, P., & Rousi, R. (2015). Symbolic Interactions: Towards a Cognitive Scientific Theory of Meaning in Human Technology Interaction. Journal of Advances in Humanities, 3 (3), 310-324. Retrieved from http://cirworld.org/journals/index.php/JAH/article/view/100na
13. Stieler-Hunt, C. & Jones, C. (2018). A professional development model to facilitate teacher adoption of interactive, immersive digital games for classroom learning. British Journal of Educational Technology. 11 September 2018 https://doi.org/10.1111/bjet.12679.
14. Wang, M., Callaghan, V., Bernhardt, J. et al. (2018). Augmented reality in education and training: pedagogical approaches and illustrative case studies. Journal of Ambient Intelligence and Humanized Computing, October 2018, Volume 9, Issue 5, pp 1391–1402. Springer Link. https://doi.org/10.1007/s12652-017-0547-8
15. Zheng, R. & Gardner, M. (2014). Handbook of Research on Serious Games for Educational Applications. IGI Global.

Key Terms and Definitions

Adult Learning = Adult learning is a process of adults gaining knowledge, skills and competences. It is defined as the practice of teaching and educating adults, theory and study of adults learning or pedagogical process. Adults learn are differently experienced, motivated, oriented, and in need to learn, than children.
Immersive Learning Technology = Immersive Learning Technology is an integration of augmented or virtual content of physical environment for user or player to experience and engage with. Technologies for immersive experiences are Augmented Reality (AR), Virtual Reality (VR) or other recognition and sensing tools.

Experiential Learning = Experiential Learning is a learning process through doing (experience) and reflecting. Person has a concrete experience following by the reflection of the experience. Effective experiential learning includes also abstraction analysis with generalization.

Constructivism = Constructivism is a philosophical learning theory of education. Learners' knowledge and experiences are determined by learners' social and cultural environment. Learning occurs by learners constructing knowledge out of experiences. Therefore learning is an active and constructive process.

Augmented Reality = AR is a system which combines a real or virtual world, interaction with objects and include perceptional information. Sometimes it also includes multiple sensory modalities, such as visual or auditory.

Cognition = Cognitive mental actions or processes of acquiring knowledge and understanding through senses and experiences.

Perception = Perception is an ability to be aware of something through senses. From psychological viewpoint, it includes processes, including memory, of sensory information in order to represent and understand the presented information. It involves signals that go through nervous system.

Embodied Cognition = Embodied cognition is the theory that understands that features of cognition are shaped by aspects of the entire body of the organism. The body aspects include the motor system, the perceptual system, interactions and assumptions about the world. This theory addresses the importance of body for thinking and problem solving.

Knowledge Creation = Knowledge creation means continuous combination, transfer and conversion of different knowledge. It is a formation of new ideas, occurs through interactions, and includes tacit and explicit forms of knowledge.
Peacebuilding = Peacebuilding is an activity to resolve conflicts and "action to identify and support structures, which will tend to strengthen and solidify peace in order to avoid a relapse into conflict" (UN).

Simulation = Simulation of technology for training, education and games is an imitation of a situation or process. Simulation show the real eventual effects of conditions and courses

of action. Simulation is often used in cases when the real system or environment cannot be engaged because, for example, it is not accessible or it may be dangerous.

Scenario = Scenario is often a written outline or synopsis of a novel or stage of work giving details of specific scenes. It includes a description of possible actions and events of future, and provides a written plan giving particulars as to the scenes, characters, or situations.

II

EMPIRICAL STUDY ON CYBER RANGE (CR) CAPABILITIES, INTERACTIONS AND LEARNING FEATURES

by

Aaltola, Kirsi, 2021

Digital Transformation, Cyber Security and Resilience of Modern Societies, Studies in Big Data, 84, Springer, Cham, pages 413–428

https://doi.org/10.1007/978-3-030-65722-2_26

Empirical study on Cyber Range (CR) capabilities, interactions and learning features

Aaltola, Kirsi

VTT Technical Research Centre of Finland & University of Jyväskylä, Finland

Abstract

Emerging technologies and the globalization require constant investment in people and their performance in actual and virtual environments. New technologies such as autonomous systems, machine learning and artificial intelligence (AI) radically re-contextualize the human dimension of the organization. Technological developments are changing the ways people experience the physical and the virtual environments. Strategic changes have revealed new critical vulnerabilities such as social media-based disinformation campaigning with impact on the human aspects at state, societal, organizational and individual levels. Scenarios of gathering information, committing fraud or getting access to critical systems are often used for follow-up actions. Cybersecurity education and training aim to raise the level of expertise, skills and competences and ensure better performance in complex situations in cyber space. Researchers have addressed assumptions, models, concepts and cognitive aspects of humans performing in the cyber domain. However, the human cognitive learning and human performance approaches in Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (XM) and Cyber Range (CR) learning platform design are only partly touched. CRs are becoming crucial means in acquisition of skills and knowledge but also to augment and mimic human cognitive behaviour for cognitive agents. Empirical studies and evaluations of the capabilities, tools and techniques for enhancing organizational cyber resilience by the human performance to better face cyber-attacks are needed. The purpose of this paper is to provide a literature review, suggest viewpoints on cybersecurity training and education and to study the current capabilities of CRs. This paper includes a literature review to support human performance and provides empirical findings on CR capabilities, interactions and learning features. The results of this study can be used as a baseline for future initiatives towards the development of CRs in accordance with human cognitive learning and future improvements in design. Furthermore, the intention is to constructively promote discussion on current issues about humans in cyber physical systems and cybersecurity domain and thus boost multidisciplinary studies to enhance cyber awareness in different sectors.

1 Introduction

Emerging technologies promise benefits for humanity and reality environment. Market growth for personal technological equipment and computing technologies adds to unforeseen security challenges of network technologies (Couretas, 2019, p.3). The

consequences of deploying certain applications presents uncertain risks, untested mechanisms and involve challenging issues of values and ethics (Linkov et al. 2018). The lack of experience in dealing with technological issues and the recent increase in adoption of digital equipment and personal devices opens to several vulnerabilities in different sectors. As an example, it is still quite common to have general human errors such as passwords written on top of devices or down on paper close to PC the password should protect. Every-body can easily peek a password stored this way with high effectiveness beyond sophisticated phishing campaigns or malware attacks. There are several suggestions to improve human performance more secure in cyber domain. For example social engineering could lead to the compromise of sensitive and financial in-formation. Nevertheless, training and education still play key role in improvement of human performance and also cybersecurity industry and business have recognized the need of sector-specific learning opportunities.

Recently, there has been indicated an interest to augment and facilitate reality in virtual learning platform focusing on facilitating cyber threat scenarios to in-crease human performance and preparedness. The use of cyber virtual environments raises the situational awareness (Kabil et al., 2018) and VR simulations can simulate and augment decision-makers' understanding of cyber-physical situational awareness (Piskozub et al., 2017). This kind of work focuses on enhance security and cyber security capabilities, where cyber ranges are acting a crucial role. At the same time, even this study does not focus on it, this raises the interests to discuss and research the security of devices and environments or plat-forms themselves. When writing this article, there was not a comprehensive systematic literature review found by the author on the topic of Cyber Ranges (CR). Nevertheless, several articles was identified with focus on cyber physical systems, computer network operations (CNO) and cyber security training. Several reviews might been completed under the classified domain since CR work has been covered and funded strongly by the US military (e.g. Davis & Magrath, 2013, p.1). Moreover, there are several pilots and development initiatives on cyber ranges, such as European Commission funded projects, launched during year 2019. An example project is called ECHO (European Network of Cybersecurity Centres for Innovation and Operations) consists of 30 partners from different fields and sectors including health, transport, manufacturing, ICT, education, research, telecom, energy, space, healthcare, defence & civil protection. It aims to further develop cyber range infrastructures to boost European cybersecurity industry.

Cyber range is a system to be used or it can include learning platform to be integrated in the training and education around cyber, information technology or security topics. Using technology as a training mechanism and learning skills with the support of technology can have positive and beneficial experiences. Due to a gap of conceptual background of the definition "cyber range" among academic practice, this study points out the literature of cybersecurity learning plat-forms and AR or immersive learning as well as studies the current capabilities of cyber ranges. Moreover, this study contributes to examine the role of cybersecurity learning platforms as reality-virtuality technologies and their applications during learning experience. Firstly, this research reviews previous literature and clarifies some terminological conceptions in an attempt to establish limits and standardize the use of the terms describing cyber range capabilities in the different realities. With this goal in mind, this study extend the "Reality-Virtuality continuum" (Milgram & Kishino, 1994) and Human-Technology Interaction (HTI) to development and design of

cyber ranges as training technologies. Secondly, this article presents the findings of qualitative survey responses on cyber range learning platform capabilities. Thirdly, this article integrates different disciplines related to learning experience (technological, cognitive and behavioral) in cyber ranges to propose recommendations. The overall aim of the study is to improve the understanding of cyber range learning platform capabilities from the learning and human performance perspective and enhance the design and impact of these technologies on the human experience.

2 Literature Review

Originally or traditionally, the word or definition "cyber" can be traced back to Ancient Greece and Kybernetes, when it meant "the art of steering" (Tabansky 2011, p. 76). Nobert Wiener (1948) published Cybernetics as a study of the im-portance of systems in both, living and artificial machines. In the 1980s there was at the same time, a cyberpunk movement and a spread of sophisticated com-puters for military operations by U.S. In the 1995, the investigation revealed some vulnerabilities in U.S. critical national infrastructure, and a phrase "cyber" was chosen to capture the challenges posed by computer vulnerabilities. (Kaplan 2016, p. 45–46). The definition cyberwar grow from Information Warfare (IW), Information Operations (IO) and revolution in military (Collins & Futter, 2015). The language of IW and IO begun to disappear from academic debate in early 2000s.

The definition "cyber" had replaced these, as an overall concept to discuss and analyse security related challenges in the information age. "Cyber" also often refers to real-time context, digital information as well as to virtual domains. It also includes both people and machines, which lead to concepts of interfaces and interactions between human, computers and machines. Cybersecurity has emerged from precise langue and the concept already has and will have even more complexity, activities, phenomena and dynamics to label. In the context of cybersecurity, "cyber" connotes with a strong relationship with information technology and relates to characteristics of security and virtual reality culture in different sectors and contexts. The definition varies naturally from narrow conceptions to broader framework.

The conceptualization to physical/mechanical, logical, informational and human/cognitive (e.g. Futter, 2016), is not enough. Beyond them, there is a need to analyse more in details physical infrastructure and hardware, command of control, collection/store/generate/rely of system data or information, and human beings and their interactions with computers, machines and technology. The semantics of cybersecurity relate with rather challenging topics and activities, such as threat, crime, and attack, variety of physical sectoral scenarios and specific contexts, and there is an ambition to find and define transversal and inter-sectoral requirements and needs. In order to specify how comprehensive the concepts are, the definition cyber-attack is commonly used in tactical, operational, academic and political discourses. Often, the original purpose of the defined cyber-attack in practice can be to indirectly mislead or spark to crisis rather than aiming to damage computers, technology or machine. The semantics of phrases "cyber" and "cybersecurity", reveal the complexity and comprehensiveness of the vocabulary and taxonomy used. The challenges are only increasing when the aim is to conceptualize them in several sectors and link their inter-connectedness. The very original purposes of these meanings are based on leadership and importance of both, physical and virtual technology

domains. “Resilience” provides means for communicating about system performance, organizational operational risks, organize the challenges, measure and quantify organizational cyberattack surface (Couretas, 2019).

2.1 Cyber Range (CR) Capabilities

Cybersecurity and assessment frameworks offer to look more comprehensively at the reality of cybersecurity concept and practices that are highly nuanced. The taxonomy and vocabulary provide reality based definitions for strategical and political levels of responsibilities. Semantics, taxonomies and vocabularies offer better and more precise language for entire domain and frameworks. Lumping all terms under the framework draws the direction. The pace of technological change will only continue faster development, and the understanding of differences (through analysing activities, means, methods, capabilities, threats and responsibilities) is required especially from academic and political actors to pro-vide more precisely and clarity. The definition “range” implies an environment for offensive target practice, much like a shooting range for soldiers (Davis & Magrath, 2013).

A Cyber Range (CR) would therefore be an environment where staff can practice their skills and competences towards the challenges posed by computer vulnerabilities. While cyber range tries to replicate a particular scenario, the lack of empirical studies on cyber ranges remains a critical drawback to a systematic evaluation. CR is a technological system or tool, which includes often scenarios and simulations, and it is used an exercise learning platform. Davis & Magrath (2013) defined that “*a CR provides an environment to practice CNO skills such as penetration testing, defending networks, hardening critical infrastructure and responding to attacks*”.

CR, which includes a learning platform to learn cyber skills and improve performance in different scenarios and potential simulated exercises, can be under-stood and defined as technological VR/AR immersive learning platform. The cyber range proof of concept can address learning objectives, exercises in e.g. network forensics, reverse engineering, social engineering, or penetration testing and learning is facilitated problem-based and self-directed (Raybourn et al., 2018). Simulations and game theories are acknowledged as methods of CRs (e.g. Wang 2010). Game theory models the interaction between to acting teams (often called red and blue teams). Cyber-attack simulations actually implement hackers to attack to network to define potential vulnerabilities with the aim to increase cyber defense preparedness. Agent-based simulation platforms on simulating the effects of attacks and analyse the impacts (Grunewald et al. 2011). Even the simulations are seen beneficial at providing insights, the impracticality has been raised to the technological and policy changes. (Moskal et al. 2018).

Depending of CR purposes (national level virtual facility for testing, running network simulation, respond to incidents, configure virtual machines, gaming, training, practice skills, promote education) the capabilities varies largely. The purposes of CRs can aim to providing so called cyber warriors, develop cyber experts’ competences, developing and practicing skills as well as testing organisations’ environments, running threat scenarios and identifying critical processes. The CR capabilities include simulations of real world network environment, data traffic generation and capture, penetration testing, incident response, thread injection, patch levels and network services to testing, evaluation, interoperability

assessment of devices and applications, operations based models to respond to threat scenarios, platform based security tools, simulations for real applications, continuous updating and upgradation and a cloud hosted environment. CR can also implement electronic warfare, test and rehearsal, mission refinement capabilities with use of tools, techniques and procedures. (Priyadarshini, 2018, p. 1-28).

CR setting provides opportunities review and analyse the benefits of cyber range capabilities for human improvement. It also raises the importance of human learning research and principles in design and use of cyber ranges in training and education. A simulation has been defined as an artificial or augmented scenario or environment that is designed to represent or simulate some aspects of reality. Simulations can incorporate different degrees and types of fidelity, or realism, namely, physical, functional and psychological. AR game simulations immerse the player in the game and immersion in the decision-making process of the game requires the player to learn the consequences of their decisions, and thus being part of an active learning process. (Kraiger, 2014).

2.2 Interactions and Reality-Virtuality Continuum

As a starting point, commonly known theory of research, Human-Computer Interaction (HCI), possess the importance to study and understand interaction be-tween human and technology. Dix (2017) stated the extended concept of HCI to Human-Technology Interaction (HTI). The presented boundaries of realities raise the interest towards the knowledge area on the processes between human and technologies, actions and interactions. Recent technological developments integrate technology to human body. This raises the users' experiences and extend the processes to sensory, cognitive and motor functions (Idhe, 1990). When this kind of technological embodiment increases, the technology becomes part of human actions which changes also the HTI processes.

Among all revised taxonomies, for researchers to classify the wide variety of realities has been "Reality-Virtuality Continuum" by Milgram and Kishino (1994). Real Environments (RE) encompass the reality, and it also includes di-rect or indirect views of real scene such as video display. Virtual Environments (VE) are entirely computer-generated, the real objects do not exist, and users interact through technological interface in real time. Virtual Reality (VR) is also computer-generated environment and user can navigate and interact in real-time simulation with own senses (Guttentag, 2010). VR provides a sensory immersive experience. Augmented Reality (AR)"modifies the user's actual physical surroundings by overlaying virtual elements", such as images, videos, virtual and other immersive items. In addition to this approach of reality-virtuality continuum, the extended approach of realities has been defined, with the independent dimension called "Pure Mixed Reality" (PMR). In PMR the "*users can interact with both virtual and reality objects in real-time and, simultaneously, these objects can interact with each other*". (Flavián et al., 2019).

The different realities of the continuum provide the factors for human to interact in physical and virtual worlds. Online games, VR and AR, in particular, are addressed under various different names and definitions, e.g. immersive learning simulation, digital game-based learning, gaming simulations, and cyber range. The merits of incorporating VR and AR design not only into education and training but should be used for solving real world

challenges, from societal problems to specific issues of conflict or climate change (McGonigal, 2011).

2.3 Learning with use of AR/VR technologies

"After behaviourism, constructivism, the "connectivism" is a new concept of learning for the digital era. Learning is no longer an individual process. When talking about online learning groups, for example, there are different and changing tools used: formal (dedicated e-learning platforms) and informal (through chat platforms)" (Szilárd et al., 2018, p. 97). When digitalization started to strongly influence to education and training sector, practitioners pointed out that traditional methods should move beyond LMS (Learning Management Systems) (Dalsgaard, 2006), and that online learning components are often combined or blended, such as hybrid methods which include face-to-face instruction, in order to provide more learning outcomes (Means et al, 2009). In practice, face-to-face learning still represents the standard in education (de Freitas, 2014: 16), and we have to consider how new tools and emerging technologies allow us to utilise and improve methods for enhancing human improvement. Siemens (2014) posits that the digitization of training and learning methods should be aligned to the connectivism of the training subjects, and Friedrich (2013) stresses that digital tools complement traditional methods enabling more constant interaction with users and lowering users' participation.

CRs provide platforms for learning with immersive simulations and scenario-oriented capacities in specified sectors. The use of reality-virtuality technologies in learning allows to have a more dynamic and autonomous role in experiences (Ostrom et al., 2015) leading to higher perceptions of value (Patrício et al. 2011). It has been recognized by the empirical studies that AR and gamification have raising potentials to model and teach complex cognitive competences in an engaging way (Dankbaar et al, 2017) and they are practical and functional methods to train and educate. Beyond technological embodiment raises the immersive experiences, extends the human perception and enhances the motor and sense perceptual skills. (Flavián et al., 2019; Tussyadiah et al., 2017).

Interestingly, there are not too many empirical findings on learning impacts with performance change immediate after playing the immersive simulation in AR/VR reality emerged. The AR/VR platforms and systems raise excitement and motivation with providing visual expressions different from traditional training settings, the extent of actual learning and human performance, in particular, is more difficult to decipher. A meta-analysis study conducted by the University of Colorado Denver Business School in 2010 reported that workers gained a greater skill level and higher retention of relevant information with online simulation versus formal classroom or web-based tutorials. The studies also show that the level of interactivity within a learning environment is driving the learning through higher motivation level. The more the learner interacts and collaborates with other learners, the content, and the instructor, the more likely it is that learning with occur (Knapp, 2012 p.21). According to de Freitas (2014), "*learning in the immersive worlds presents us with the ability to remember learning experiences for longer, engaging and motivating us as learners*". VR solutions simulate the physical presence of the user in a virtual environment, which is categorized as sensory-motoric, cognitive, and emotional experiences (Björk & Holopainen, 2004). Integrating human body and including human personal spaces to improve their experiences can extend to sensory, cognitive and motor functions (Ihde, 1990).

The philosophical and psychological foundations in cognition can bring the foundations to the discussions and practical solutions of immersive learning in cybersecurity learning platforms. Experiential learning approaches and motor skill development are relevant when target is to improve knowledge, skills and competences. More critical the role of learning styles and methods becomes if the training aims to augmenting (virtual) reality with desired learning outcome to human performance in reality context. Cyber domain itself is taking place in virtual reality and therefore the competence development learning with reflection in reality is even more complex. Dewey, Lewin and Piaget were the founders of experiential learning approach, which led to commonly used conceptual tradition to adult education and training. Kolb's (1984) dichotomy between real or actual doing and reflection has strongly influenced to adult education and training (Wang & Newton, 2012, p. 191). The acquisition of knowledge about the relationship between performance and AR immersive contents is related to sensorimotor learning. In movement skill, inputs from sensory and cognitive processes are important in order to choose correctly and organizing and adjusting movement. Task requirements, environmental conditions and personal characteristics inflict to constraints to determine what person must do. Most of the motor skill schemes are based on experiences and descriptive and distinguished with regard to skill complexity, structure and the level of difficulty and familiarity. (Voelcker-Rehage, 2008). This possess that the relation between movement skill learning and experiential learning approach is strong.

"*Learning is a holistic process of adaptation to the world. Not just the result of cognition, learning involves the integrated functioning of the total person — thinking, feeling, perceiving, and behaving*" (Kolb & Kolb 2005: 194). Kolb's (1984) experiential learning style theory is a four-stage learning cycle of 1) Concrete experience (new experience or situation is encountered, or a reinterpretation of existing experience (feeling)), 2) Reflective observation of the new experience - of particular importance are any inconsistencies between experience and understanding (watching), 3) Abstract conceptualization - reflection gives rise to a new idea, or a modification of existing abstract concepts (thinking), 4) Active experimentation - the learner applies the idea(s) to the world around them to see what happens (doing). The experiences and adoptions may take place in daily re-al-life setting and informal form. Persons developing their performance in a training with a purpose to work with the performance in different environment or reality require comprehensive learning setting and awareness of learning methods, not only among facilitators, trainers, teachers or mentors but also by the learners.

3 Findings/Results

To understand current CR interactions, capabilities and learning features, qualitative research methods were implemented to collect empirical data part of ECHO (European Network of Cybersecurity Centres and Competence Hub for Innovation and Operations) – project funded by the European Commission. Sur-vey questions were prepared for both, the cyber-range providers and potential users or customers. The questions were framed based on cyber range capacities and capabilities, and with combinations of open-ended and multiple-choice questions. Multiple choices questions were framed to potential responses or with open ended "something else" opportunity. The survey questionnaire respondents were selected and questionnaire was sent to specified organizational group to ensure CR expertise and experience of the respondents. The pre-selection was decided to ensure proper

responses from the organizational representatives who either use the cyber ranges or provide cyber range services.

The survey was conducted among the sample of respondents (n=49). Data validation ensured that the questionnaire was fully completed and presented the consistent data. This study focuses on presenting the analysis and findings of qualitative responses which focused on understanding CR capabilities by the providers. Quantitative questions of the survey addressed mainly cybersecurity competences by the personnel in the organisations and budgetary constraints. The background data included organization related information and position in the organization. The data was analysed with use of qualitative method content analysis. This empirical research identified the current CR interactions, capabilities and learning based on the survey findings and observations by the researcher during study process. In terms of learning practices (scenarios, simulations, tasks, outcomes), the observation of open access CR descriptions were studied.

3.1 CR capabilities

Respondents identified that their CR is deployed on the premises. One de-scribed the cyber-range in cloud, and another in both, cloud and on the premises. When asking about the technology used for managing and orchestrating the virtualized system, the respondents identified these; Custom-made tools and automations, virtualization platform vendor's tools, VirtualBox - vagrant – ansible, Vmware, OpenStack, Ansible Packer, COTS hypervisor technology. In terms of predefined scenarios, the maximum was up to 50 and one answered they didn't have predefined scenarios. Respondents identified they had SCADA, IoT and Mobile devices as specific scenarios in their cyber-range. Respondents detailed scenarios of different business sectors for financial, critical infrastructure, ISP, Cloud Service Provider, Supply Chain, Software development and Healthcare. When analysing the technical capabilities within cyber-range scenarios, all respondents answered they had attack simulations. Beyond that defence simulation and learning platform were commonly found by different providers. When asking about "How training debriefing/performance evaluation is performed in your cyber-range?", the majority of the respondents addressed that they have evaluation activities such as hot wash up as debriefing, provide of feedback based on collected data during training, or debriefing by company personnel. Only half of the respondents identified the possibility to include physical devices part of CRs.

Deployed	Technicalities	Scenarios	Capabilities	Evaluation
Premises Cloud Premises and Cloud	Custom-made tools and automations, virtualization platform vendor's tools, VirtualBox - vagrant – ansible, Vmware, OpenStack, Ansible Packer, COTS hypervisor technology	SCADA, IoT and Mobile devices, Sectors: financial, critical infrastructure, ISP, cloud service provider, supply chain, software development and Healthcare	Attack simulation, defence simulation, learning platform, performance evaluation, real-time monitoring of the running, traffic simulations	hot wash up as debriefing, provide of feedback based on collected data during training, debriefing by company personnel

Figure 1. Summary of Results: CR capabilities

From the development point of view, respondents would like to further develop their sector specific capabilities (e.g. healthcare, space, transportation, energy), provide better automation for quicker development and deployment and add automatic performance evaluation. The domain specific approach was seen necessity and one respondent described *"we always draw domain-specific expertise when create a cyber exercise"*. SCADA capabilities were seen the most relevant by the respondents.

3.2 CR interactions and AR/VR continuum

CR raises the new level to AR/VR continuum with modelling cognitive and behavioural interact successfully with the task-environment. Cognitive models of network users, defenders, and attackers that can interact with the same software that humans interact with generate offline predictions and adding simulated participants in training sessions. Cognitive modelling aims to integrate with memory dynamics and explaining human awareness to predict system on cyber-attack. Modeling efforts involve scenario building and predict of human behaviour.

CR simulations and game exercises implement several levels of interactions in system or platform; red and blue teams' interaction (defined as attackers and defense), human-network interactions (defined as exploitation) and network-human interactions (defined as defense). Scenarios include specific models of behaviours and interactions. Cyber-attack perform and actions are often modelled from real world descriptions and use cases. CR platforms embed the interactions of human cognition and behaviour in the context of network and computer systems.

3.3 Learning features

All CR studied provided training and education services for capacity building for any public or private organisation and their personnel. Therefore, the users of cyber-ranges also were mainly teachers, students, and teams of companies, SMEs and big enterprises. The number or participants attending to single training session varied from five to fifty participants. The red and blue team exercise format was commonly used and the learners play a role of members in security teams under the scenario or simulation. Scenarios commonly followed phases of reconnaissance, exploitation, escalation and completion of the mission (e.g. "shut-down" or "kill"). Tasks included securing network and services as well as collaboration with different actors.

Observations of five different CRs revealed the general lifecycle of cyber exercises or simulations. In general, the exercise lifecycle could outlined as follows; a set of learning outcomes or objectives, included scenario tasks or injects, scoring design (gamified features), repetition of the exercise with scenario and simulation tweaks, familiarisation by the learners, execution of the exercise, hot wash up and possible internal lessons learned processes. The survey respondents addressed the performance evaluation as the most important to be further developed, even some of the CRs in the survey already implemented hot wash up or debriefing after the exercise or simulation. From the learning and human performance view point, the evaluation and reflection in real world among other professionals enhances to achieve the learning outcomes.

4 Discussion

The lack of experience in dealing with cybersecurity issues and the recent in-crease in adoption of digital equipment have raised the interest to empower cybersecurity training and education in different sectors. Due to the large turnover and the number of different employees involved in organisations, the comprehensiveness of cybersecurity often stays limited and several vulnerabilities may occur. CR can be defined as a safe environment for cyber-attack scenario simulation and test. It offers the capabilities to create realistic cyber simulations useful for cyber training and exercise, to equip cyber analysts and operators with advanced cyber skills, cyber research and development, to prototype development in realistic cyber scenarios, test and evaluate, adapt test framework for certification testing. CR capabilities include strategies, skills and competences of red and blue team, tools and techniques selected in CR and vulnerabilities. Competences of attackers of defenders are set in a form of nodes in the network to exploit the capabilities to finally perform on the target. The iteration of logics of CR game theories or simulations sets possible actions towards achieving the goals. Simulations are often run for multiple network configurations and demonstrating different behaviours on a network.

Knapp (2012, 20) argued that gamification is a time-consuming and difficult process which requires development efforts for interactive learning experiences, multiple interactions and a careful melding of content. Emerging development of CR capabilities (techniques, tools procedures) shows the difference of reality to traditional e-Learning, AR, VR, and gamification discussions. CR capabilities are emerging fast and provides several opportunities for different organizational purposes. The upsurge interest in learning platforms and serious games has not led to convincing evidence when it comes to learning and human improvement. In general, the interest towards games and AR/VR techniques has been speculative, discussing mainly of the potential of games to provide new methods for supporting learning (Boyle et al, 2016).

While AR, learning platforms and games are expected to promote educational and competence improvement goals, they also have further claims of supporting attitudinal and behavioral change by virtue of playing between reality and virtuality. This can pose additional questions and challenges as to the accurate measurement and evaluation of such changes in attitude, behavior or competences, especially since it is anticipated that some kind of learning will naturally occur by participating. The subjectivity of all learning approaches also afflicts AR/VR simulation and scenario methods. CR exercises and simulations following rather traditional exercise life-cycle could be improved with human performance and experiential learning features allowing AR/VR continuum. The link with CR activities with their relevance to human performance and learning perspectives enhances the cybersecurity resilience in the organisations. Practicing hands-on practical cyber reality skills in AR/VR platform is not only enough to improve human performance with critical thinking and problem solving competences in real cyber-attacks.

Studies argue that there is an emerging need for cognitive-level synthetic cyber offense and defense in order to ensure realistic cyber simulation and training. The purpose to analyse human cognitive behavior (which is already seen rich, subtle, and combines autonomous and deliberative information processing) often focuses to capture the dynamic and cognitive-level characteristics of cyber warfare. (Randolph, J. 2015). While the potential for cybersecurity learning plat-forms in cyber ranges must be acknowledged, over-

emphasizing the results in cases where substantial and consistent research is lacking and purposes of human performance and cognitive processes varies.

5 Conclusions

The organizational representatives value the cybersecurity learning platforms in CRs high and there is emerging need to expand the use of CRs among entire personnel. Currently, the cyber ranges are lacking evaluation and wash-up capacities. Consequently, it is posited that the cyber range or learning platform is best utilised as a complementary training and education resource but not adequate and sufficiently nuanced to act as a stand-alone training tool, nor as a replacement for real-life experiential learning. Often, cyber range learning platforms aim to provide experiences with the combination of virtual-physical touchpoints in learning environment and improvement of human performance. The perceptions may take place in AR forms, tools, simulations or scenarios. Cognitive learning processes may finally lead to competence development and learning. In practice, simulation is one mean to create meaningful learning environment, where learner can apply experience based constructivist-learning approach.

This study revealed that number of cyber range learning capabilities mainly lack the use of evaluation tools for reflection. Humans have a unique capacity to adapt their skills and competences to different natural and cultural environment and this adaptation requires the building of suitable mental representations, which help in learning and creating new concepts, skills, preferences, motivations, and emotional tendencies on the individual, social and cultural levels. Variety of factors must be considered in the effective design of cyber range learning platforms in use of training and education purposes. Empirical difficulties continue to persist and one of the most significant questions relates to cyber range learning platform expectations and overestimation of potential uses.

The conclusion to be drawn from this study is that there is a role for CR learning platforms within AR/VR and gamification discussion. The CR capabilities are reaching high level variety and is interesting are for future research from different academic disciplines. However, that role should not be over-stated, and this study demonstrated that given the fluid, dynamic nature of professionals working in cyber environments, the nuances and sector-specified challenges can-not be always an exact replicable in AR or VR platforms. There is an inherent danger that over-reliance on behaviorist learning through CRs at the expense of traditional learning approaches could leave individuals ill-prepared, under-informed and under-skilled for their professional roles and work environments. The continuum of AR/VR from learning and performance view point should be further studied in use of CRs.

References

Boyle, E., et al. (2016). An update to the systematic literature review of em-pirical evi-dence of the impacts and outcomes of computer games and serious games. Computers & Education. Vol. 94. pp.178-192

Collins, J., and Futter, A. (2015) Reassessing the Revolution in Military Af-fairs: Transformation, Evolution and Lessons Learnt. London: Palgrave.

Couretas, J. (2018). An Introduction to Cyber Modeling and Simulation. John Wiley and Sons, Inc. Published 2019.

Dankbaar, M et al (2017). Comparative effectiveness of a serious game and an e-module to support patient safety knowledge and awareness. BMC Medical Education.

Davis, J. & Magrath, S. (2013). A Survey of Cyber Ranges and Testbeds. Cyber Electronic Warfare Division. Commonwealth of Australia 2013. October 2013.

De Freitas, S. (2014). Education in Computer Generated Environments. Routledge: New York and London

De Freitas, S and J Jameson. (2012). The E-Learning Reader. Continuum Books: Lon-don and New York.

De Freitas, S. and Routledge, H. (2013). Designing leadership and soft skills in educational games: The e-leadership and soft skills educational games design model (ELESS). British Journal of Educational Technology, Volume 44 (6): 951-968. European Qualification Framework (1-8 levels): https://ec.europa.eu/ploteus/content/descriptors-page

Dix, A. (2017) Human–computer interaction, foundations and new paradigms. Journal of Visual Languages and Computing, 42 (2017), pp. 122-134

Flavián, C., Ibáñez-Sánchez, S., Orús, C. (2019). The impact of virtual, aug-mented and mixed reality technologies on the customer experience. Journal of Business Research. Volume 100, July 2019, Pages 547-560.

Futter, A. (2016) Cyber Threats and Nuclear Weapons – New Questions for Command and Control, Security and Strategy. London: RUSI.

Grunewald, D, Lützenberger, M, Chinnow, J. (2011). Agent-based network security simulation. In: proceedings of the 10th international conference on autonomous agents and multiagent systems. Taipei, Taiwan, 2–6 May 2011, pp.1325–1326. Richland, SC: International Foundation for Autonomous Agents and Multi-agent Systems.

Happa J, Glencross M and Steed A. (2019) Cyber Security Threats and Chal-lenges in Collaborative Mixed-Reality. Front. ICT 6:5. doi: 10.3389/fict.2019.00005

Ihde, D. (1990). Technology and the Lifeworld: From Garden to Earth. Bloomington: Indiana University Press.

Jones, R., O'Crady, R., Nicholson, D., Hoffman, R., Brunch, L., Bradshaw, J., Bolton, A. (2015). Modeling and Integrating Cognitive Agents Within the Emerging Cyber Domain. Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2015 Paper No. #15232.

Kabil, A., Duval, T., Cuppens, N., Le Comte, G., Halgand, Y., and Ponchel, C. (2018). "Why sh. ould we use 3d collaborative virtual environments for cyber security?" in IEEE Fourth VR International Workshop on Collaborative Virtual Environments (IEEEVR 2018) (Reutlingen: IEEE), 1–8.

Kaplan, F. (2016). Dark Territory: The Secret History of Cyber War. London: Simon & Schuster.

Knapp, Karl. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. Pfeiffer and Company Publishers

Linkov, I. et al. (2018). Comparative, collaborative, and integrative risk gov-ernance for emerging technologies. Environment Systems and Decisions. Spring-er. 4 May 2018. https://doi.org/10.1007/s10669-018-9686-5

McGonigal, J. (2011) Reality is Broken: How games make us better and how they can change the world. Penguin Press. USA.

Milgram, P., and Kishino, F. (1994). A taxonomy of mixed reality visual dis-plays. IEICE Trans. Inform. Syst. E77-D, 1321–1329.

Moskal, S., Yang, S., & Kuhl, M. (2018). Cyber threat assessment via attack scenario simulation using an integrated adversary and network modeling ap-proach. The Journal of Defense Modeling and Simulation, 15(1), 13–29. https://doi.org/10.1177/1548512917725408

Ostrom, A., Parasuraman, A., Bowen, D., Patricio, L., Voss, A. (2015). Ser-vice research priorities in a rapidly changing context. Journal of Service Re-search, 18 (2) (2015), pp. 127-159

Patrício, L., Fisk, R. Falcão e Cunha, J. Constantine, L. (2011). Designing multi-interface service experiences: The service experience blueprint. Journal of Service Research, 10 (4) (2008), pp. 318-334

Piskozub, M., Creese, S., and Happa, J. (2017). "Dynamic re-planning for cy-berphysical situational aFwareness," in CPS Conference on Computational Sci-ence and Computational Intelligence (Las Vegas, NV), 1–6.

Priyadarshini, I. (2018). Features and Architecture of the Modern Cyber Range: A qualitative analysis and survey. University of Delaware. http://udspace.udel.edu/handle/19716/23789 © 2018 Ishaani Priyadarshini

Raybourn E., Kunz M., Fritz D., Urias V. (2018) A Zero-Entry Cyber Range Environment for Future Learning Ecosystems. In: Koç Ç. (eds) Cyber-Physical Systems Security. Springer, Cham. https://doi.org/10.1007/978-3-319-98935-8_5

Tabansky, L. (2011). Basic Concepts in Cyber Warfare. Military and Strategic Studies 3 (1): 75–92.

Vlachopoulos, D & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. International Journal of Educa-tional Technology in Higher Education. 14. 10.1186/s41239-017-0062-1.

Tussyadiah, I, Jung, T., tom Dieck, M. (2017) Embodiment of wearable aug-mented reality technology in tourism experiences. Journal of Travel Research, 57 (5) (2017), pp. 597-611

Wang, B, Cai, J, Zhang, S. (2019). A network security assessment model based on attackdefense game theory. In: proceedings of the IEEE 2010 interna-tional conference on computer application and system modeling (ICCASM), Tai-yuan, China, 22–24 October 2010, pp.V3–639. Piscataway, NJ: IEEE.

Wiener, N. (1948). Cybernetics or Control and Communication in the Animal and the Machine. Cambridge, MA: The MIT Press.

III

UTILISING EXPERIENTIAL AND ORGANIZATIONAL LEARNING THEORIES TO IMPROVE HUMAN PERFORMANCE IN CYBER TRAINING

by

Aaltola Kirsi & Taitto Petteri, 2019

Information & Security, 43(2), 123–133

https://doi.org/10.11610/isij.4311

Information & Security

K. Aaltola & P. Taitto
vol. 43, no. 2 (2019): 123-133
https://doi.org/10.11610/isij.4311

Published since 1998

ISSN 0861-5160 (print), ISSN 1314-2119 (online)

Research Article

Utilising Experiential and Organizational Learning Theories to Improve Human Performance in Cyber Training

Kirsi Aaltola [a] (✉), ***Petteri Taitto*** [b]

[a] *Laurea University of Applied Sciences, Finland, https://www.laurea.fi/en*

[b] *Savo Consortium for Education, Finland, https://www.sakky.fi/kuntayhtyma/english*

ABSTRACT:

Development of information technology and the globalization require constant investment in people. New and emerging technologies such as autonomous systems, machine learning and AI radically re-contextualize the human dimension of the organization. Strategic changes have revealed new critical vulnerabilities such as social media-based election meddling and disinformation campaigning with impact on the human aspects at state, societal, organizational and individual levels. Education and training raise the level of expertise, skills and competences and ensure better performance in complex cyber situations. Researchers have addressed assumptions, models, concepts and cognitive aspects of human performance in the cyber domain. However, the theories and approaches of human learning in training and exercises are only partly touched. New techniques for enhancing organizational cyber resilience to cyber-attacks are needed and they still lack sound theoretical foundations.

This article aims to advance the discussion suggesting viewpoints on training and exercises in the cyber domain, taking into consideration specifics of skills in cyber security. It provides overview of theories of learning to better support human performance. Our critical interpretation enhances the comprehensive understanding of decision-making, learning theories, and design of cyber security training and exercises. Furthermore, our intention is to constructively promote discussion on current issues about human learning in cyber training and education and thus boost multidisciplinary studies to enhance cyber awareness.

ARTICLE INFO:

RECEIVED: 10 MAY 2019
REVISED: 12 SEP 2019
ONLINE: 18 SEP 2019

KEYWORDS:

cybersecurity, human factors, organizational learning, education and training, exercises

✉ Corresponding Authors: kirsi.hyttinen@laurea.fi; taittopetteri@gmail.com

Introduction

Information technologies are incorporated everywhere in our everyday life and they have shaped our thinking and decision-making processes. Inventing and maintaining technological products and processes will have impact on the world in which people live. Beck claims that reflection is the self-confrontation of unintended consequences of human actions.[1] It has been described, for example, what happens when technology develops faster than societal institutions monitoring technology. Scientific and academic studies have also seen rather challenging evolving threats, digital changes and innovations.[2] The foundations for this positioning employ different scientific disciplines (Information Technology (IT), organizational and management, adult education, cognitive science and psychology of learning). Traditional information security mainly focuses on protection of information sources and the roles of humans in the security processes, when cyber security also sees humans as potential targets of cyber-attacks or participants in a cyberattack.[3] Researchers have considered already a need for multidisciplinary research, with focus on multilevel adult education directions in cyber security education.[4]

Cyberattacks normally use codes to change computer code, data or logic with the aim to result in disruptive consequences that lead to cybercrime.[5] The consequences of cyberattacks vary from identity theft, spoofing, stolen hardware, breach of access, and system infiltration to instant message abuse. Beyond *physical* (e.g. physical outage of power) and *syntactic* (e.g. attack against logic of computer systems) cyberattacks, *semantic* (e.g. targeting the way human perceive or interpret) cyberattacks are seen more serious threats since they target human interface.[6] Therefore, human performance is pertinent issue within cyber security,[7] where human and organizational factors play a significant role in the computer and information security (CIS) vulnerabilities.[8]

Instead of only focusing human in cyber context, considerations to improve capabilities and human competences cyber domain has found the relevance of learning, education and training at the societal level. Improving cyber security competencies boost skills of citizens and professionals in threat preparedness and in managing vulnerabilities and disruptions.[9] Raising interest of researchers as well as practitioners is to analyse human performance already during cyber trainings and exercises that can be considered more proactive learning than experiences during actual cyberattacks. Nevertheless, the considerations mainly screen on education and trainings as information sharing mechanisms and leave out pedagogical models, organizational and learning theories when understanding learning part of expertise and competence development. Approaches like experiential learning or organizational learning theories from concrete experience and reflection towards transformed action broader humans' experiences (to become richer and deeper) [10] could further enrich managing better human performance in cyberattacks.

Purpose and methods

This position paper aims to provide position of current practices and *rethink* considerations of human performance in cyber security trainings and exercises. We focus on consider research and practical *implications* and *construct* beyond current concepts in cyber security trainings and exercises and evaluating human performance.

We analysed collected information from different sources with use of qualitative analysing methods. Qualitative research methods are seen valuable especially when analysing social or cultural phenomena from the participants' point of view.[11] Especially in complex cyber domain the understanding of shared taxonomy and language together with shared meanings are crucial as social constructions. Our analysis is based on reality assumptions of written concepts, and therefore philosophical base is in phenomenology.[12]

Cyber Training and Exercises

Education approaches recognize the transitioning from novice expert through mentoring and participation into community of practice.[13] In 2010 onwards, it was recognized that there would be a rapid shift in education from traditional classrooms to online and virtual environments.[14, 15] The learning spaces extend beyond traditional thinking of a teacher and a classroom. The learning spaces include participation and socialization into a wider community of practice with an involvement as a member, identity formation and experience in the activities of the practice.

The terms *cyber education* and *cyber training* are some of the key terminology. Cyber education is more focused on the acquisition of knowledge and understanding, through which skills are developed. Whereas, training tends to be targeted at the acquisition of skills to a demonstrable level of competence. There is a strong case for engaging in both education and training as part of career development in cyber security and therefore assessing and evaluating competence needs.[16] The term *cyber exercise* is used for a planned event during which an organization simulates a cyber-disruption to develop or test capabilities such as preventing, detecting, mitigating, responding to or recovering from the disruption.[17] Cyber exercises train personnel across different organization levels in a simulated learning environment of large-scale cybersecurity incidents that escalate to become cyber crises. The exercises offer opportunities to analyse, train and rehearse advanced technical cybersecurity incidents but also to deal with complex business continuity and crisis management situations. Cyber exercises are based on real-life events, which are further developed to evolving scenarios. The term *cyber exercise methodology* refers to the model of the exercises. Exercises can be both Discussion based (like workshops, tabletop or games) and Operations based (like drills, functional or full-scale exercises).[18]

Humans performing in cyber domain deal with multi-faced disasters and crisis. Simulation exercises are proven beneficial by preparing people to sudden onset hazards. Cyber safety and security exercise platforms provide an opportunity to

analyse human-machine or human-computer interactions or transactions. Analysing tools can measure human performance during the cyber exercises on their cognition or decision-making based on eye tracking or use of mouse or keyboards. Such analyses are normally provided with use of quantitative methods and measures (e.g. number of transitions between software tools).[19] Cyber exercises involve competitive events with teams, including problem solving, decision-making, analysis skills and situational aware- ness. Situational awareness (SA) in cyber security is seen relevant in describing, measuring and predicting human performance. It includes *situation recognition* (e.g. perception of the type of cyberattack, target of the attack, source of the attack), *situation comprehension* (e.g. understanding why and how the situation is caused, and its impacts), and *situation projection* (the expectations of the future, locations and impacts).[20, 21] To more comprehensively consider learning, including knowledge creation, skills, competences and expertise, we could adapt experiential learning and relevance of tacit knowledge in to the discussion of cyber security training and education.

Experiential and organizational learning

Beyond research and studies to be conducted in cyber security, education and training play crucial role in promoting the knowledge we need to develop.[22] We reviewed two key approaches of learning, experiential learning and organizational learning theories, to be introduced more in this chapter. Our viewpoints are elaborated in line with these theoretical considerations.

Experiential learning is broadly defined as “learning from experience” or “learning by doing.” Active learning like ‘learning by doing’ promotes understanding of the experience by involving the participants directly in the experience in relevant context. For instance, experiential education first permits learners with an experience and then facilitates reflection about experiences in order to develop skills, attitudes, or new ways of thinking and competences.[23] The well-known David Kolb’s theory of experiential learning has expanded philosophy of experiential education.[24] A foundation of inter-disciplinary and constructivist learning and constructivist approaches are the basis of experiential learning. In cyber domain and cyber security, cognitive approaches are mainstreamed to emphasis the assumptions and building new forms of understanding through activity. This understanding is gained within learning field as well.[25] Experiential Learning Theory (ELT) is a dynamic perspective to learning. It includes dual dialects of action with reflection and experience with abstraction.[26] Active process and understanding create together deeper levels of learning.

Already in 1966 Polanyi concluded that “tacit knowing is such elusive and subjective “awareness” of individual that cannot be articulated in words.”[27] Nonaka and Takeuchi continued this dichotomy of knowledge towards organizational learning activities in social interactions.[28] Social interactions among professionals can create knowledge and enhance knowledge environment. According to cyber phenomena, it could be considered that cyber professionals and experts have lot of tacit knowledge they know but they do not tell or explain. More complex cybersecurity field increases within its sectors and their dependencies or

applications and technologies, more complicated it will be for humans and professionals to communicate among people in different level of knowledge.

Our focus on decision-making of cybersecurity professionals is seen dynamic process where analysts interact with task environment with limited information and uncertainty.[29] Taitto et al. argue that the decision-making processes are pivotal in order to prevent further damages and creating necessary protective measures in the cyber related incidents.[30] Exercising these decision-making processes, is often times crucial for the organization's resilience, and require innovative techniques for an increased engagement and more effective results. Helliar and co-authors have explored the risk and decision making of the financial managers, and found that the decision makers have number of systematic biases that that dominates decision-making.[31] Such are over-confidence, representativeness and conservatism, narrow framing, and ambiguity aversion. Over-confidence arises partly from self-attribution bias. This is a tendency on the part of investors to regard successes as arising from their expertise while failures are due to bad luck or the actions of others. This leads to excessive confidence in one's own powers of forecasting.

Decision-making is not always rational, and either the linear decision-making process is not always optimal. Decision making processes have been discussed and studied for example by Leonard and Biberman in several dimensions.[32] They present additional dimensions to classical decision-making theory. Such are for instance tacit knowledge decision models and intuitive decision models. Tacit models encourage managers to draw on their latent cumulative experience in order to improve decision-making. Intuitive decision models draw on the brain's ability to make unconscious correlations that are beyond the conscious mind's capability.

Education, training and exercises should simulate the reality to ensure experiential learning. A good cyber drill encourages decision maker to challenge traditional processes and test intuitive and tacit models. The optimal cyber exercise includes not only exercising on individual level, but also as collective. Those possessing managerial position in the organization should experience the consequences of their decisions in a safe learning environment providing opportunity for action and reflection. To provide opportunity to wider and deeper learning, organizational learning theories could be tested and adapted among professionals working in cyber domain.

Consequently, when considering learning in education and training, we automatically face training planning aspects. Outcome needs in curriculum planning helps directing the learning towards common goal and measuring it. Back in the days, already Greek philosophies, like Aristotele and Plato, final causality suggested that "purpose can incite action."[33, 34] The learning outcome captures the preceding training needs analysis and should contain a metric to assess learning. Therefore, the outcome needs to be SMART (specific, measurable, achievable, realistic and time-based) and thus the outcomes are defined in a constructive alignment process, where learning outcomes are defined using measurable terminology.

Training and exercise design

The diversity of threats and their reach compel states to build a strong cyber security strategy including education and training aspects. Training design should therefore acknowledge that the evolving nature of cyber space as itself creates new requirements. In every training and exercise design, setting the learning objectives is in the nucleus of the process. Simulation based exercises are means to transfer outcomes defined in the curriculum in to the practice. In some cases the online education is following a trend of using teaching technology, or teaching machines, dating back to the 1950s.[35] Moreover, the educational institutes still lack proven design approaches for complex learning that involves integration of skills, knowledge, attitudes and adapting them to real life context.[36] Cyber training and exercises will raise even more complex design challenges.

To enhance and raise the effectiveness of learning in cyber training, there are research findings around narrative-based and tool-based trainings, personalities in team performance and cognitive aptitude.[37] Like in any field, also within cyber domain, people should know how to use the products, services or systems.[38] Designing intelligent training and exercise systems like cyber ranges require simulation of human cognitive processes and for example decision-making processes. That is why methods for designing are important. Specialists of human technology interaction will need to meet with this challenge on designing technologies with intelligent capacities.[39] Purpose of human-centred design is to create technological solutions easy to use and commit community of practices can support design in cyber training.

The innovative and cost-effective technological solutions like cyber ranges in cyber education architectures can illustrate the strength of experiential learning of skills and competencies through simulated scenarios, role-playing, problem-solving and visual observations in cyber training contexts. Simulation based exercises connect learning, simulation and gaming aspects in an innovative way imitating reality by using virtual environments or virtual programs in a way where computer-assisted games are integral part of learning environment.

Conclusions

Responding to crisis, preparedness and building resilience requires multidisciplinary approaches. Cyber domain is one of the disciplines, not only as one among the others, but crosscutting issue in every function in every organization and society. As human behaviour and decision-making in particular, play a crucial role in the cyber security, the training and exercising should simulate this reality as well as possible.

First, we found that considering cyber education and training in respect to experiential learning principles deepens the level of learning. Developing human skills and competence in cyber domain should be seen as a constructive process, where learner's previously adapted competences are recognized and utilized. Learning process begins always by screening what competences participants have and these competences can be utilized to enhance others' learning process. Experiential learning approach can create framework and theoretical basis for holistic

approach training and exercise system. Knowledge, competences and expertise needed in complex multifaceted crisis environment is therefore mutually built and constructed across organization members. To infuse learning and ensure competitiveness for organizations utilizing explicit and tacit knowledge together later on become powerful engine.[40, 41, 42] The approaches of learning could be further utilized and conceptualised in cyber security training, education and exercises to better prepare human performance especially on skills like decision-making.

The traditional assumption of the optimality of rational decision-making may be improved by including other dimensions of decision-making. It is posited that organizations that encourage and support multi-dimensional decision making, which utilizes the rational, intuitional, emotional and spiritual aspects of the whole person, develop better management–employee relations, more creative problem solving, and better market place performance.[43] Leonard and Biberman argue against the classical decision theories that are based on the assumption that decision makers are rational, and make reasoned choices based on their analysis of the risks and rewards of the situation.[44] Instead of making decision consciously there are number of bias in every decision making process, and therefore exercises can be seen as important factor shaping the models of decision-making. It is important to improve such practices that best improve decision-making, taking into the consideration the characteristics of the decision maker. Knowing yourself, the self-reflection is the key for improvement of any decision maker. Intuitive and tacit decision-making theories can be aligned through training and exercising, thus making the models more systematic.

Consequently, we suggest research community in close cooperation with practitioners and user communities to study more human performance and human aspects in cyber training from learning perspective with transfer of intelligent cognitive behaviour. It could be suggested to include more design perspectives of human-technology interaction also to cyber training and exercises to improve human performance in actual cases.

Acknowledgement

This work was supported by the ECHO project which has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement no. 830943. European Commission funded cyber pilot projects like European network of Cybersecurity centres and competence Hub for innovation and Operations (ECHO) bring opportunities for researchers to conduct experiments and gather empirical data to study these aspects from different perspectives.

References

1 Ulrich Beck, *Risk Society. Towards a New Modernisation* (London: SAGE, 1992); and Ulrich Beck, "Cosmopolitical Realism: On the Distinction Between Cosmopolitanism in Philosophy and the Social Sciences," *Global Networks* 4, no. 2 (2004): 131-156.

[2] Igor Nai Fovino, Ricardo Neisse, Alessandro Lazari, Gian-Luigi Ruzzante, Nineta Polemi, and Malgorzata Figwer, "European Cybersecurity Centres of Expertise Map - Definitions and Taxonomy," EUR 29332 EN (Luxembourg: Publications Office of the European Union, 2018), p. 5, https://doi.org/10.2760/622400, JRC111441.

[3] Rossouw von Solms and Johan van Niekerk, "From Information Security to Cyber Security," *Computers & Security* 38 (2013): 97-102, https://doi.org/10.1016/j.cose.2013.04.004.

[4] Eleni Berki, Juri Valtanen, Sunil Chaudhary, and Linfeng Li, "The Need for Multi-Disciplinary Approaches and Multi-Level Knowledge for Cybersecurity Professionals," in *Multi-disciplinary Perspectives on Human Capital and Information Technology Professionals* (IGI Global, 2018), p. 72, https://doi.org/10.4018/978-1-5225-5297-0.ch005.

[5] Berki et al.,"The Need for Multi-Disciplinary Approaches and Multi-Level Knowledge for Cybersecurity Professionals."

[6] Bruce Schneier, "Semantic Attacks: The Third Wave of Network Attacks," *Crypto-Gram*, October 15, 2000, accessed September 2, 2019, https://www.schneier.com/crypto-gram/archives/2000/1015.html#1.

[7] Jonathan McClain, Austin Silva, Glory Emmanuel, Benjamin Anderson, Kevin Nauer, Robert Abbott, and Chris Forsythe, "Human Performance Factors in Cyber Security Forensic Analysis," *Procedia Manufacturing* 3 (2015): 5301-5307.

[8] Sara Kraemer, Pascale Carayon, and John Clem, "Human and Organizational Factors in Computer and Information Security: Pathways to Vulnerabilities," *Computers and Security* 28 (2009): 509-520, https://doi.org/10.1016/j.cose.2009.04.006.

[9] Martti Lehto, "Cyber Security Competencies: Cyber Security Education and Research in Finnish Universities," *Proceedings of the 14th European Conference on Cyber Warfare & Security*, Hatfield, UK, University of Hertfordshire, July 2-3, 2015, pp. 179-188, quote on p. 179, http://ti- nyurl.com/ECCWS2015.

[10] Alice Y. Kolb and David A. Kolb, "Experiential Learning Theory: A Dynamic, Holistic Approach to Management Learning, Education and Development," in *The SAGE Handbook of Management Learning, Education and Development*, edited by Armstrong and Fukami (SAGE Publications, 2009), p. 13.

[11] Bonnie Kaplan and Joseph Alex Maxwell, "Qualitative Research Methods for Evaluating Computer Information Systems," *in Evaluating Health Care Information Systems: Methods and Applications*, edited by J.G. Anderson, C.E. Aydin and S.J. Jay (Thousand Oaks, CA: Sage, 1994), 45-68.

[12] See, for example, R. Boland, "Phenomenology: A Preferred Approach to Research in Information Systems in Research Methods," in *Information Systems*, edited by E. Mumford, R.A. Hirschheim, G. Fitzgerald, and T. WoodHarper (Amsterdam: North Holland, 1985), 193-201.

[13] Alice Y. Kolb and David A. Kolb, "Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education," *Academy of Management Learning & Education* 4, no. 2 (2005): 193–212, quote on pp. 199-200.

[14] Elaine Allen and Jeff Seaman, *Class differences: Online education in the United States, 2010* (Babson Park, MA: Babson Survey Research Group, 2010).

[15] Robb Lindgren and Mina Johnson-Glenberg, "Emboldened by Embodiment: Six Precepts for Research on Embodied Learning and Mixed Reality," *Educational Researcher* 42 (2013): 445–452.

[16] K. Blaine Lawlor and Martin J. Hornyak, "Smart Goals: How the Application of Smart Goals Can Contribute to Achievement of Student Learning Outcomes," *Developments in Business Simulation and Experiential Learning* 39 (2012).

[17] See the definition for "cyber exercise" in Joaquin Jay Gonzalez III and Roger L. Kemp, eds., *Cybersecurity: Current Writings on Threats and Protection* (Jefferson, NC: McFarland, 2019), p. 239.

[18] Spanish National Cybersecurity Institute, "Cyber Exercises Taxonomy," 2015.

[19] McClain, et al.,"Human Performance Factors in Cyber Security Forensic Analysis."

[20] George Tadda, John J. Salerno, Douglas Boulware, Michael Hinman, and Samuel Gorton, "Realizing Situation Awareness within a Cyber Environment," in *Proceedings of Defense and Security Symposium*, Orlando (Kissimmee), Florida, United States, vol. 6242 (2006), https://doi.org/10.1117/12.665763.

[21] Sushil Jajodia, Peng Liu, Vipin Swarup, and Cliff Wang, *Cyber Situational Awareness* (New York: Springer, 2010).

[22] UNESCO, "Rethinking Education – Towards Common Goal?" p. 66.

[23] Linda H. Lewis and Sarol J. Williams, "Experiential Learning: Past and Present," *New Directions for Adult and Continuing Education* 62 (1994): 5-16.

[24] Farooq Mughal and Aneesa Zafar, "Experiential Learning from a Constructivist Perspective: Reconceptualizing the Kolbian Cycle," *International Journal of Learning & Development* 1, no. 2 (2011): 27-37.

[25] Sara de Freitas and Jill Jameson, *The E-Learning Reader* (London and New York, Continuum Books, 2012).

[26] Kolb and Kolb, "Experiential Learning Theory: A Dynamic, Holistic Approach to Management Learning, Education and Development," p. 43.

[27] Michael Polanyi, *The Tacit Dimension* (New York: Anchor Day Books, 1966).

[28] Ikujirō Nonaka and Hirotaka Takeuchi, *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation* (New York, NY: Oxford University Press, 1995).

[29] Ian A. Cooker, Alexander Scott, Kasia Sliwinska, Novia Wong, Soham V. Shah, Jihun Liu, and David Schuster, "Towards Robust Models of Cyber Situation Awareness," in *Advances in Human Factors in Cybersecurity,* edited by Tareq Z. Ahram and Denise Nicholson, Proceedings of the AHFE 2018 International Conference on Human Factors in Cybersecurity, July 21-25, 2018, Orlando, Florida, USA, in *Advances in Intelligent Systems and Computing*, vol. 782 (Cham: Springer, 2018), 127-137.

[30] Petteri Taitto, Julia Nevmerzhiskaya, and Csaba Virag, "Using Holistic Approach to Developing Cybersecurity Simulation Environments," *eLearning & Software for Education* 4 (2018): 77-84, https://doi.org/10.12753/2066-026X-18-226.

[31] Christine Helliar, Alasdair Lonie, David Power, and Donald Sinclair, *Attitudes of UK Managers to Risk and Uncertainty* (Edinburgh: The Institute of Chartered Accountants of Scotland, 2001).

[32] Barbara Leonard and Jerry Biberman, "Utilizing Multi-dimensionality in the Workplace: A Meta-study," *Managerial Finance* 33, no. 12 (2007): pp. 935-946.

[33] Claude S. George, *The History of Management Thought* (Englewood Cliffs, NJ, Prentice-Hall, Inc. 1972).

[34] K. Blaine Lawlor and Martin J. Hornyak, "Smart Goals: How the Application of Smart Goals Can Contribute to Achievement of Student Learning Outcomes," *Developments in Business Simulation and Experiential Learning* 39 (2012): 259-267.

[35] Nuri Kara and Nese Sevim, "Adaptive Learning Systems: Beyond Teaching Machines," *Contemporary Educational Technology* 4, no. 2 (2013): 108-120.

[36] Jeroen J. G. van Merrienboer and Paul Kirschner, *Ten Steps to Complex Learning: A Systematic Approach to Four-Component Instructional Design*, Third Edition (New York, Routledge, 2018), p. 2.

[37] See for example Susan Stevens-Adams, Armida Carbajal, Austin Silva, Kevin Nauer, Benjamin Anderson, Theodore Reed, and Chris Forsythe, "Enhanced Training for Cyber Situational Awareness," in *Foundations of Augmented Cognition*, edited by Dylan D. Schmorrow and Cali M. Fidopiastis, *Lecture Notes in Computer Science*, vol. 8027 (Berlin, Heidelberg: Springer, 2013), 90-99, https://doi.org/10.1007/978-3-642-39454-6_10.

[38] Jaana Leikas and Pertti Saariluoma, "'Worth' and Mental Contents in Designing for Ageing Citizens' Form of Life," *Gerontechnology* 7, no. 3 (2008): 305-318.

[39] Pertti Saariluoma, Antero Karvonen, Mikael Wahlstrom,Kai Happonen, Ronny Puustinen, and Tuomo Kujala, "Challenge of Tacit Knowledge in Acquiring Information in Cognitive Mimetics," in *Proceedings of the 2nd International Conference on Intelligent Human Systems Integration (IHSI 2019): Integrating People and Intelligent Systems*, February 7-10, 2019, San Diego, California, USA, edited by Waldemar Karwowski and Tareq Ahram, 228-233.

[40] Meng Li and Fei Gao, "Why Nonaka Highlights Tacit Knowledge: A Critical Review," *Journal of Knowledge Management* 7, no. 4 (2003): 6-14, https://doi.org/10.1108/13673270310492903.

[41] Polanyi, *The Tacit Dimension*.

[42] Nonaka and Takeuchi, *The Knowledge Creating Company.*

[43] Barbara Leonard, *Multidimensional Decision Making*, Ebook (Bradford: Emerald Publishing, 2007).

[44] Leonard and Biberman, "Utilizing Multi-dimensionality in the Workplace: A Meta-study."

About the Authors

Kirsi **Aaltola** (MA, PhD Candidate) is currently acting as a Senior Manager for Research at Laurea UAS. She has a strong experience with coordination of wide networks through various international projects (funded by "Horizon 2020," the Seventh Framework Programme, by EC general directorates or regionally funded) and design and implementation of different training and higher education training programs in the field of security. She is a PhD candidate in the University of Jyväskylä, finalising her doctoral thesis related to the human-centred approach in the design of technologies and analysing human-technology interaction. Her research interests include information management technologies and their design with theoretical HCI understanding in the safety and security fields. In 2009-2014 she has run international crisis management courses such as EU Concept Core Courses, Pre-Deployment Trainings (also under ENTRi framework), Hostile Environment Awareness Training (HEAT) and UN/NATO/IHP led humanitarian/civil protection large scale exercises.

Petteri **Taitto** (MA, General Staff Officer) is currently holding the position of Head of Development at the Savo Consortium for Education in Kuopio, Finland. Petteri has previously held positions of Principal Scientist in Laurea UAS and in the European External Action Service as an operations planner and training coordinator for EU CSDP Mission related training programmes at the European Security and Defence College. He has also developed and implemented training programmes for civilian crisis management when working as CMC Finland's Head of Training. His other earlier appointments include Principal Lecturer and education programme leader at the Emergency Services College, and various assignments in Finnish Defence Forces, including teacher at the National Defence University. His research interests have focused on EU integrated approach for security and educational implications in professional crisis management training.

IV

HUMAN-CENTERED DESIGN MODEL IN THE DEVELOPMENT OF ONLINE LEARNING TOOLS FOR INTERNATIONAL SECURITY TRAINING: CASE IECEU NEW MEDIA BASED LEARNING APPLICATION (NMLA)

by

Hyttinen, Kirsi, 2017

Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - ISE, pages 275–282

https://doi.org/10.5220/0006559902750282

Human-centered Design Model in the Development of Online Learning Tools for International Security Training

CASE IECEU New Media based Learning Application (NMLA)

Kirsi Hyttinen

Research and Development Unit, Laurea University of Applied Sciences, Vanha maantie 9, Espoo, Finland
Department of Information Technology, Cognitive Science, University of Jyväskylä, Finland
kirsi.hyttinen@laurea.fi

Keywords: Human-centered Design, Human-technology Interaction, Technology Solutions, Learning Environments, Online Learning, e-Learning, Peacebuilding, Crisis Management, Security Training, International Security.

Abstract: A need to enhance online training solutions among peacebuilding and conflict prevention actors in the field of international security has been addressed in order to raise the collaboration, information sharing and provide more effective training. The implementation of educational technologies is inherently difficult especially if it is technology driven. This paper presents the idea of human-centered design approach in line with the principles of human-technology interaction in order to tackle the possible training challenges that may occur in the development and implementation of online and Elearning environments for adult students. As part of research and development project, the design case for peacebuilding and crisis management online-based training was conducted and studied. The case study showed that before providing the technological solutions there is a need in dept analysis on the requirements as well as iteration of algorithms. Moreover, functionality and completeness of the instantiations, such as services, raised the motivation among the user community. The created human-centred design model for the learning environment development processes supports to meet not only with current training needs in security but also in identifying which parts of education and training can be facilitated by technology.

1 INTRODUCTION

Department for International Development (2005) listed 46 countries considered fragile states, in which 870 million people, or 14% of the world's population live and 250 million children worldwide has no access to education (UNESCO, 2014). The new threats from weak states, asymmetric conflicts, organised crime, and terrorism, traditional peacekeeping has frequently given way to complex peacebuilding in protracted conflicts. These kinds of global challenges and threats have led to the complexity of crisis and conflicts. It has been argued that international community needs to focus more on strengthening the emerging fragile or unstable state with preventive activities in early stage (IECEU-project, 2016. D1.2). The Lisbon Treaty highlights conflict prevention as key objective for EU's foreign policy and external relations (Treaty of Lisbon, 2009). The conflict prevention has been part of EU's Common Foreign and Security Policy (CFSP) and the development of European Security and Defence Policy (since 2009 the Common Security and Defence Policy, CSDP) with the aim of the EU to take action through its capacities in conflict prevention and crisis management. The complexity of EU engagement and current conflict and crisis areas requires continuously assessment on the effectiveness of different conflict prevention and crisis management activities (see for example European Parliament, 2012) also training and technology. The development of the international community's perception has changed towards international security, shifting from robust peacekeeping towards the stabilization of fragile states via conflict prevention and peacebuilding. (Morton and O'Hagan, 2009).

At the same time, around 80% of the world's population will have mobile connectivity and 60% will enjoy broadband access. Like any use of technology in the classroom, there is a need to unify content, technology and pedagogy (Mishra and Koehler, 2006). The digital possibilities enable the

Hyttinen, K.
Human-centered Design Model in the Development of Online Learning Tools for International Security Training - CASE IECEU New Media based Learning Application (NMLA).
In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2017) - Volume 3: KMIS*, pages 275-282
ISBN: 978-989-758-273-8

learning distribution around the globe online (Zhang et al, 2004, p. 75-79) and already in the beginning of 21st century the online learning as a field has been described as complex, diverse, and rapidly evolving (Anderson and Elloumi, 2004). Technology has a significant influence on teaching and learning processes and the technology has re-organized the human life, communication and learning (Siemens, 2004). Due to current trends, Information Technology (IT) tools and resources have significant influence on teaching and learning processes (Sevillano-García and Vázquez-Cano, 2015. p. 106-118). With its potential for providing flexible access to content anywhere and anytime, it has become popular worldwide (IECEU –project, 2016. D5.2) and can benefit local counterparts as well as peacebuilding organisations. Information and Communication Technology (ICT) can provide the access to education and enhance the ability of minor and vulnerable groups to attend to education and training (Gulati, 2008).

Even with the opportunities that technology can provide, the researchers have seen the implementation of technology-supported collaborative learning environments as a challenge (Zheng, 2014. p.357). In addition, there is a need for academic practice-based design research when developing learning tools (Leinonen, 2010). Like any use of technology in the classroom, there seems to always be a need to unify content, technology and pedagogy (Mishra and Koehler, 2006). The Web 2.0 offers features, which are not always considered with human learning processes. Moreover, the flexible media options of digital environments are not currently fully benefitted in e-learning contexts (Clark and Mayer, 2016). It has been argued that the online learning should move beyond from traditional Learning Management Systems (LMS). Sevillano-García and Vázquez-Cano (2015) argue that "*institutions need to orientate methodologies toward the use of new mobile devices, from the possibilities offered primarily through open educational resources (OERs) distributed on wikis, blogs, mash-ups, podcasts, social software, virtual worlds, personal learning environments (PLEs), massive open online courses (MOOCs), and other emerging online practices*".

These identified needs, challenges and recommendations provide the basis for this research and online learning application case study. Human-Technology Interaction (HTI) with its broadest sense covers forms of interaction between technical and human interfacts and includes all roles in to the design process (Saariluoma et al., 2016, p.2). This approach could be benefitted in the online training of peacebuilding and conflict prevention.

1.1 Objective and Purpose

Overall purpose of this paper is to analyse the learning technology that could be utilized for the peacebuilding and international security training. In order to tackle the challenges with learning technology, this study aims to provide the understanding between human and learning technology interaction. This study provides the analysis of the findings in the design and development of New Media based Learning Application (NMLA) during Improving the Effectiveness of the Capabilities in EU conflict prevention (IECEU) –project in years 2015-2017. Finally, this study provides a human-centered design model for the development of Elearning solutions and information sharing especially for adult education purposes in the field of international security, peacebuilding and conflict prevention. Ideally this will finally lead to research on successful implementation of online training initiatives in the field of international security and peacebuilding. The research purpose is to support the educational capacity building that concentrates to the societal education structures and enhancing the protection and successful delivery of education in online basis according to the principles of effective human technology interaction.

2 HUMAN-TECHNOLOGY INTERACTION IN CHANGING LANDSCAPE OF TRAINING

The technology has re-organized the human life, communication and learning (Siemens, 2004). In practice, the learning takes place partially or entirely over the Internet. With its potential for providing flexible access to content anywhere, it has become popular worldwide. The computers made the delivery of education possible and the material were able to deliver both print and electronical media. (Moore, 1990). The online learning includes different sets of learning applications, web resources, web-based applications and new collaboration technologies. Moreover, new type of hybrid approaches regarding online learning activities are increasing. (Means et al, 2009). The term distance learning evolved towards online learning, virtual learning, e-Learning, mediated

learning, web-based learning etc. (Conrad, 2002, p. 1-19). In the European countries especially tablets and smartphones are considered as an important development on the field of education (Eimeren and Frees, 2012). From the pedagogical point of view, the higher education institutes benefits of e-learning e.g. by revision of teaching methods, monitoring study progress and student learning, interactive collaboration among students and by enhancing learning and teaching in foreign languages (Gaebel, M. and al. 2014). In 21 century, the theoretical insights have raised the collaborative practices in online learning (Siemens, 2004). Dalsgaard (2006) argues that social software tools can support a social constructivist approach to e-learning by providing students with personal tools and by engaging them in social networks, thus allowing learners to direct their own problem-solving process. He points out that e-learning should move beyond from Learning Management Systems (LMSs).

The technologies in digital context enable new ways of narrating contents. The users are actively involved to building the content to different media and channels. (Katz, 2013. p. 129-133). It has been also argued that collaborative learning tools can be used from both a cognitive constructivist and social constructivist perspective (Bonk and Cunningham, 1998, p.35). It has been issued that the design of learning environments can be based on the learning objective, target audience, access (physical, virtual and/or both), and type of content (Moore and Dickson-Deane, 2011. p. 129). Different technology applications are used to support different models of online learning. Ideally, the online learning components are combined or blended with face-to-face instruction, in order to provide more learning outcomes. (Means et al, 2009). The engagement in Web 2.0 environments provides more avenues for self-representation, expression or reflection and more organized forms of collaboration and knowledge building. Web 2.0 tools can support associative pedagogies and be used effectively in terms of providing structured guidance through tasks and through provision of effective and timely feedback. (Conole and Alevizou, 2010). New media and technology resources are based on principles of mobility, collaboration and active participation. Ubiquity and mobility become recurrent principles for educational performance in this century. (Sevillano-García and Vázquez-Cano, 2015).

The overall purpose of human-centered design is on making systems or applications easy to use (ISO, 1999). Jounghyun (2015) defines the goals of Human–Computer Interaction (HCI): (a) functional completeness, (b) high usability, (c) aesthetic appeal and (d) compelling user experience. Firstly, the research interest can focus on technology-driven design with emphasis on products, systems or interphases. Secondly, the human-center or human-driven approach is seen as important as technology-driven. Further, the Human-Technology Interaction (HTI) research aims to support the design and develop usable technology for humans. The most emphasied aspect of HTI has been that difficult-to-use technology is easily rejected and weather people find it easy to use the systems and products (Saariluoma et al, 2016) and people should know how to use the products, services or systems. (Leikas 2008). Despite the early focus of HTI has been how to design interaction and implement interfaces for high usability, it has been used for specific user community. The critical components of successful integration of technology innovations within education and training settings and influences the adoption rate of such technologies are transparency in user interface design (Charalambos et al, 2004).

3 METHODOLOGY

In the research and development program of IECEU (H2020) –project, the methodology concept and quality assurance system for technology systems were created by co-created methods in early stage of the project, in the year 2015. The group of developers, IT specialists and researchers worked together during years 2016 and 2017 and design process included the engagement of end users.

This particular study followed the principles of Design Science Research (DSR) approach and focused on the HTI during the design and development of online learning solution for EU conflict prevention and international security training. DSR approach has been used for develop and evaluate IT artifacts in order to understand, explain and improve them. Artifacts within DSR are constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (systems and services). (Hevner et al., 2004). This paper analyses the design and development process of IECEU New Media based Learning Application (NMLA) and findings from the data collection by end users. The overall framework of NMLA included the selection of pedagogical approach, technology in design of NMLA, understanding of new media interactive solutions and intercultural competences.

The selected user community representatives participated to participatory learning application testing and provided the self-assessment on the learning and evalauted the application interface. The test groups consisted of both men and women of different age. The majority presented experienced academic researchers from different disciplines. The participants were divided into three groups: group of educators, professors and trainers (n=5), a group of end user experts (n=14) and higher education students (n=43). Firstly, each participant tested the NMLA with use of device (mobile, iPad or laptop) and answered to the survey. The survey included multi-choise and open questions and the results were analysed through quantitative and qualitative methods. Secondly, the discussions around user experiences were facilitated. The survey gathered the first impressions and user experiences. The discussions focused on analysing the learning objectives and relevance of the NMLA with end user needs in peacebuilding training.

The researchers analysed the interaction between users and the different devices (PC, laptop, mobile devices) based on research findings and observations. The findings were further tested (triangulation) in the discussions with the selected key representatives in order to further improve the learning application. The collected information was then assessed and fed into development process

3.1 Design Case: IECEU Learning Application

The purpose in the NMLA was to transfer the original IECEU (Improving the Effectiveness of capabilities in EU conflict prevention, H2020) – project research findings and identified good practices in the online format. In order to the learn of key competences needed in the field of crisis management and peacebuilding, the NMLA was developed. The objective of the tool was primary to exhibit the selected eight IECEU case studies and further disseminate the findings of the comparative analysis. Secondly, the development aimed at creating an interactive training tool which could be used in various crisis management training or as a basis to introduce the new Common Security and Defence Policy (CSDP) personnel to the roots and dynamics of different conflicts either in their future deployment areas or in general. During the development process it was identified that the tool can also be used among the larger audience of stakeholders and other communities of interest (civil servants, trainers, higher education, students etc.) The IECEU NMLA offers a complimentary tool to enhance the knowledge of a broad end-user audience on themes related to selected crisis case studies and crisis management decision making and planning. The term new media was used to differentiate between old media (print press, TV, radio) and the new information technology based media. The learning content is also supported by the social media and rich digital contents as selected algorithms. These algorithms often include interactive elements and possibility to communicate and provide feedback. Examples of new media include websites, games, augmented reality, multimedia and various learning platforms. (IECEU, 2017, D5.2). This also because in spite of the presented benefits Eearning can provide to various training, “digital tools do not substitute face-to-face methods, but complement them by enabling more constant interaction with users and lowering certain users’ participation thresholds.” (Friedrich, 2013).

Figure 1: The framework of IECEU NMLA (IECEU, 2017, D5.2)

3.1.1 Instantiation: The Context for Service

The selection of service as part of instantiation process was clarified after the analyses on the context of use in early stage of design and development. The project reseachers and developers interviewed, made observations of the context and participated to project workshops in order to build comperehensive picture of the context. The special attention was addressed to functional completeness in this solution design process. Moreover, the criteria for the solution selection was that the

platform needed to based on open source code featuring desired functions: options for gamified learning, mobile friendly (meaning a website or web application that displays correctly in mobile devices), multi-browser compatible (meaning that it must be displayed correctly in multiple browsers). The platform can be easily gamified with artifacts such as badges, user scoring, certification awards and H5P module integration, all of which are pre-installed in the package or obtainable via the free app store. H5P is an extension developed for WordPress, Moodle and Drupal from a separate organization that is used to gamify Elearning with ease, all done in HTML5, including video quizzes. The NMLA, which can also be downloaded to laptop, tablet or mobile phone, could be utilized as a part of the training conducted in fragile and crisis areas. The IT instantiations were identified by the developers. The service as instantiation was selected with in depth understanding of the context, end users and other requirements.

3.1.2 Construct Framework: Vocabulary and Symbols

After instantiation, the key end users and stakeholders of NMLA were analysed by the project expert group. The IECEU Advisory Board provided further guidance and support to understand key training and education providers that may benefit with the use of learning application in the future. IECEU NMLA focused on European security and defence network training initiatives as well as higher education institutes and university. The research of IECEU built the overall constrcuts for the NMLA in line with end users' vocabulary and symbols. The learning objectives and outcomes were set according to the needs and gaps identified during the IECEU – project research. The end users group discussions supported the identification of current training needs that technologies could support. Learning objectives are regognised among the training and education community and they provided the contruct framework for NMLA.

3.1.3 Quality Assurance Requirements

The requirements for the NMLA were also set in IECEU Quality Assurance plan according to technology development. At this phase, the designer analysed wheather the instantiation, constructs and representations were in line with quality assurance requirements.

3.1.4 Iteration of Methods (Algorithms and Practices)

There is a possibility to organize the technology supported learning and training in decentralized or centralized way (IECEU -project, 2016. D5.2). The methods were agreed by the designers with understand of algorithms and practices. It was decided to use cartoon like visualisations from one hand to keep the developing and programming time manageable and on the other hand rather flexible to accommodate any possible changes. Also the field of international security and peacebuilding support the use of animations rather than authentic pictures or videos. Although the serious topic of crisis management is linked to human suffering, the visualisations were preferred to keep light. Finally, perhaps most importantly, peacebuilding and crisis management topics are often sensitive.

3.1.5 Models: Transfer of the Content

The research studies and analysis (content) were transferred to rich digital online learning content. Instead of written texts, the learning content finally included more visual solutions such as videos, animations, gamified quizes, and other more visual material. These representations of information provided the key models for NMLA design.

3.1.6 Evaluation and Assessment

In order to guarantee a systematic and comprehensive assessment of the NMLA and its impact, IECEU Consortium representatives conducted different types of evaluation that correspond to the four levels: NMLA evaluation by the producers, NMLA evaluations by the users, In- and Out-Tests for the users and possibly a NMLA Impact Evaluation Mission (IEM). The evaluation of NMLA against the requirements (needs, gaps, curriculas) included the analysis based on the end users and quality assurance review. The end user groups finalised the testing, completed the individual survey and attended to group discussions. The data collection led to analysis to further improve the NMLA. The most important step from the pedagogical point of view in the development process of NMLA was to test and assess the learning outcomes when using the tool in trainings and education. Before and after the use of NMLA, their knowledge and skills were tested to identify the first learning and development. The final learning outcomes will be further identified in the real life context.

4 FINDINGS

Firstly, the findings of the case study interviews of experts working currently in the conflict setting (IECEU Case Studies) corroborated the assumption that up until now eLearning and learning applications have been not been broadly and systematically utilized in the peacebuilding training. The main shortfalls in the EU conflict prevention and peacebuilding training focus on information sharing and the content of Elearning modules. The general findings of the NMLA design elaborated experiences of NMLA use by end users. Especially the evaluation and assessment phases gave valuable feedback for the NMLA design process and its further development. The survey findings identified the benefits and shortfalls of initial version of NMLA by end users. The introduction of the NMLA (landing page) paid crucial role in motivation of the users. The higher motivation raised the level of continuing the use of service. The users described the functionality and completed interface of NMLA to support their active use of service. For the master level higher education students the content was seen rather advanced and hard to understand. It was identified that higher education students were not identified as key end users in construct framework. The qualitative analyses pointed out that experts experienced positively the rich media contents, especially visualisations and video animations. The positive implications were addressed on succesful descriptions of the challenging and culturally sensitive topics of peacebuilding. The methods and algorithms used were seen easy to understand.

In the group discussions it was observed that the content of peacebuilding training material must be updated and changes must be completed to the application in line with the global situation. It was addressed that research could contribute to online training with providing new knowledge and updated content. NMLA enabled learning taking place by adapting knowledge via different methods such as reading, watching, and hearing. There was also a possibility to use learners' earlier experiences and knowledge and combine them with NMLA content. Opposite than teacher-centered pedagogy, the learner-centered pedagogy acknowledges students' needs, ability and learning styles (Weimer, 2013). The digital rich media contents were identified motivating compared to traditional learning contents. The survey findings described how video scenarios described well the conflict setting (24 mentions) and enabled the possibility of problem-based learning. The gamification features (stages, certification) raised the learners' motivation when the objective was clearly mentioned. The shortfalls of NMLA were discussed in both end user groups. Massive reading materials (such as research articles or research reports) were analysed challenging to adapt by the learner during learning process. Moreover, the necessity of the possibility for feedback and reflection was underlined in order to ensure learning. The researcher observed that the learning tool must be easy to use in order to ensure positive learning experience through technology. Most of the users (17 out of 19) felt the NMLA easy to use. The clear navigation and structure help to ensure humans interacting with learning tools. The end users using only mobile devices paid attention to scaling of the learning content such as videos. As an additional key finding, the user group that did not receive the information on how to use the learning application, mainly produced feedback on clarity of navigation in the platform. From the HTI point of view, it can be discussed that human aims to receive the guidance on how to use the technology solutions before the actual use. The clear navigation helps the learner to focus on learning rather than guidance. The relevance of guidance to be available for online learning tool users would be beneficial to further study. According to the interviews, the practitioners of peacebuilding and conflict prevention mainly look for technical instatiantions for training that are ease to use without any further guidance needed.

During the NMLA design, the The Human-Centered Model for Online Learning Tool Design was created. The case study of IECEU NMLA design and development provided an overall model for successful online learning tool development, which follows the principles of DSR, human-centered design and successful human-technology interaction. The online based and new media supported educational tools aim to reach well the end user needs and ensure several learning methods. It was identified that if different communities of practice are engaged through test, review and feedback during the design, it will provide motivation and possibility to better integrate online tools for training. Figure 2 presents the Human-Centered Model for Online Learning Tool Design.

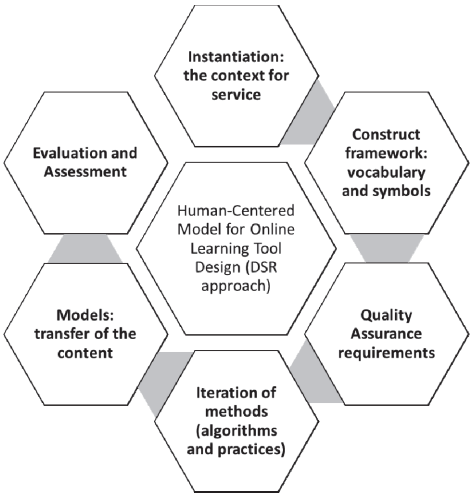

Figure 2: The Human-Centered Model for Online Learning Tool Design (Hyttinen, 2017).

5 CONCLUSIONS

The education technology accesses the people to the larger community and provides learning opportunities via online solutions for people in a cost effective way. As a conclusion of this study, it can be suggested that the development of online learning and education tools for peacebuilding should follow the principles and theories of adult learning and human-technology interaction. This study argues that human-centered approach supports with better interaction between human and technology. This study shows the benefits of considering Human-Technology Interaction (HTI) in the development of learning solutions for international security, conflict prevention and peacebuilding. The importance of the interaction was observed high especially when the motivation to use technology in learning is in low level. The commitment of end users may support the engagement of human to continue the use of services. Saariluoma et al (2016, p.148) discuss the motivation beign rather relevant in explaining the use of technologies by human. This study showed, the functional and completed user interface was seen important to raise the motivation. A relation of the motivation to use of learning tools could be further assessed among different communities.

Before development of the online solutions it is suggested to conduct in dept analysis on the current needs and requirements, context as well as end users. Therefore, I argue that implementation of educational online technology should focus more on user centric approach and Data Science Research. The created model for development process of learning tools support to meet with current training needs and to identify which parts of education and training can be organised in an online learning basis the most effectively. Moreover, the model supports when seeking the services for online learning. The emphasis must also focus on transfering the learning content to rich online format (videos, animations, gamified solutions). Also, blended training possibly consisting feedback and interaction with a trainer, teacher or mentor deepen the understanding of the learner and/or users of the content. It would also provide a fast way to collect feedback to improve the content or functionalities of the platform further. Instant hot-wash-up with a trainer/mentor could be considered beneficial in order to deepen users' understanding and learning as well as to identify possible knowledge gaps to be covered better in various training activities. Based on this paper analyses and desk study, there is still need for deeper analysis regarding online education possibilities in conflict prevention and crisis management training and education, such as:

1) How can the online learning solutions more effectively be implemented in current training and education practices?
2) How will the artificial intelligence and machine learning affect to the training and information sharing in international security?

REFERENCES

Adebahr, C. 2011. *The Comprehensive Approach to Crisis Management in Concerted Weimar Effort*. Stiftung Genshagen, 2011.

Bonk, C. J. and Cunningham, D. J. 1998. *Searching for Learner-Centered, Constructivist, and Sociocultural Components of Collaborative Educational Learning Tools*.

Buckland, P. 2004. *Reshaping the Future: Education and Post-Conflict Reconstruction.* World Bank Publications. ISBN 9780821359594

Burbules, N. 2000. *Does the Internet constitute a global educational community*? In Burbules, N and Torres, CA (eds) Globalization and Education: Critical Perspectives, New York, Routledge, pp. 323–355.

Bruner, Jerome. 1990. *Acts of Meaning*, Harvard University Press, 1990

Carlson, S. and JBS International. 2013. *Using technology to deliver educational services to children and youth in environments affected by crisis and/or conflicts*. United States Agency for International Development

Charalambos, V., Michalinos, Z. Chamberlain, R. 2004. *The Design of Online Learning Communities: Critical*

Issues. Educational Media International. ISSN 1469-5790 online © 2004 International Council for Educational Media.

Clark, R. and Mayer, R. 2016. *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*. John Wiley and Sons, 2016. ISBN 1119158664.

Conole, G. and Alevizou, P. 2010. *A literature review of the use of Web 2.0 tools in Higher Education. A report commissioned by the Higher Education Academy.* August 2010, The Open University, Walton Hall, Milton Keynes, UK.

Conrad, D. 2002. *Deep in the hearts of learners: Insights into the nature of online community.* Journal of Distance Education, 17(1), 1−19.

Department for International Development (DfID). 2005. *Why we need to work more effectively on Fragile States* (London, DfID).

European Union External Action, 2016. *Strategic Assessment of 2016 EU Global Strategy on Foreign and Security Policy*. Accessed in February 2016.

European Parliament, 2012. *CSDP Missions and Operations: Lessons Learned Processes*. European Union, 2012. Directorate-General for External Policies, Policy Department. ISBN: 978-92-823-3756-1. Accessed September 21, 2017.

Friedrich, Pirjo. 2013. *Web-based co-design. Social media tools to enhance user-centered design and innovation process,* University of Tampere, 2013.

Gaebel, M. and al. 2014. *E-learning in European higher education institutions.* Results of a mapping survey conducted in October-December 2013.

Gulati, S. 2008. *Technology-Enhanced Learning in Developing Nations: A review*.

Hevner, A., March, S. T. Park, J. 2004. *Design Science in Information Systems Research*. MIS Quarterly (28:1) 2004, pp. 75-105.

IECEU –project. 2016. *D1.2 Analysis of the current preventive activities*. Accessed in April 2016. http://www.ieceu-project.com

IECEU -project, 2016. D5.2 *Design and Development Processes of the NMLA*. Accessed March 2017. www.ieceu-project.com

ISO, 10015:1999. *Quality Management- Guidelines for Training.*

Jounghyun, G. K. 2015 *Human–Computer Interaction Fundamentals and Practice*. Taylor and Francis Group. ISBN 978-1-4822-3389-6

Katz, J. 2013. *Mobile gazing two-ways: Visual layering as an emerging mobile communication service*. Mobile Media and Communication, 1, 129-133.

Kirk, J. 2007. *Education and fragile states*. Globalisation, Societies and Education. Vol. 5, No. 2, July 2007, pp. 197

Leinonen, T. 2010. *Designing Learning Tools. Methodological Insights*, Aalto University, 2010.

Leikas, 2009. *Life-Based Design – A holistic approach to designing human-technology interaction*. VTT Publications 726. ISBN 978-951-38-7375-2.

Marsick, V., and Watkins, K. 2001. *Informal and Incidental Learning. New Directions for Adult and Continuing Education*, no. 89. Spring 2001 © Jossey-Bass, A Publishing Unit of John Wiley and Sons, Inc

Means, et al. 2009. *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*.

Mishra, P., and Koehler, M. 2006. *Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge.*

Moore, J. Dickson-Deane, C. Galyen, K. 2011. *e-Learning, online learning, and distance learning environments: Are they the same?* Internet and Higher Education 14 (2011) 129–135. 2010 Elsevier Inc.

Moore, M. G. 1990. *Background and overview of contemporary American distance education.* Contemporary issues in American distance education (pp. xii−xxvi). New York: Pergamon Press.

Morton, K. and O'Hagan, J. 2009. *Humanitarianism then and now: Exploring the boundaries of civil–military relations in a post-9/11 world* in Humanitarianism and civil– military relations in a post-9/11 world, ed. Jacinta O'Hagan and Katherine Morton, (Canberra: The Australian National University, 2009), 1-7.

Rutkowski, 1982. *New Soft Computing Techniques for System Modelling, Pattern Classification and Imafe Processing.* Springer.

Roto, V. Kaasinen, E. Heimonen, T. Karvonen, H. Jokinen, J. Mannonen, P. Nousu, H. Hakulinen, J. Lu, Y. Saariluoma, P. Kymäläinen, T. Keskinen, T. Turunen, M. Koskinen, H. 2017. *Utilizing Experience Goals in Design of Industrial Systems.* Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. ACM, 2017.

Saariluoma, P., Cañas, J., Leikas, J. 2016. *Designing for Life - A Human Perspective on Technology Development.* Macmillan Publishers Ltd. London. ISBN 978-1-137-53047-9 (eBook)

Sein, M., Henfridsson, O. Purao, S., Rossi, M. and Lindgren, R. 2011. *Action Design Research*. MIS Quarterly, (35: 1), pp. 37-56.

Sevillano-García, M. L., and Vázquez-Cano, E. 2015. *The Impact of Digital Mobile Devices in Higher Education*. Educational Technology and Society, 18 (1), p. 114.

Siemens, G. 2014. *Connectivism: A learning theory for Digital Age.*

Smith, J., 1998. *The book*, The publishing company. London, 2nd edition.

The Treaty of Lisbon, entered into force on 1 December 2009. Accessed September 25, 2017.

UNESCO, 2014. *Teaching and Learning – Achieving Quality for All*. ISBN 978-92-3-104255-3,

Weimer, M. 2013. *Learner-centered teaching: Five key changes to practice*. John Wiley and Sons.

Zhang, D., Zhao, J. L., Zhou, L., and Nunamaker Jr., J. F. 2004. *Can e-learning replace classroom learning?* Communications of the ACM , 45 (5), 75-79.

Zheng, B., Niiyab, M. and Warschauerb, M. 2014. *Wikis and collaborative learning in higher education.* Technology, Pedagogy and Education, 2015. Vol. 24, No. 3, 357–374.

V

MODEL FOR EFFECTIVE INTEGRATION BETWEEN RESEARCH, WORK LIFE AND HIGHER EDUCATION IN INTERNATIONAL SECURITY STUDIES

by

Hyttinen, Kirsi, Ruoslahti, Harri & Jokela, Jorma, 2017

Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - ISE, pages 299–306

https://doi.org/10.5220/0006588102990306

Model for Effective Integration between Research, Work Life and Higher Education in International Security Studies

Kirsi Hyttinen[1,2], Harri Ruoslahti[2,3] and Jorma Jokela[1]
[1]*Research, Development and Innovation Unit, Laurea University of Applied Sciences, Vanha maantie 9, 02650, Espoo, Finland*
[2]*Information Technology (Cognitive Science), University of Jyväskylä, Jyväskylä, Finland*
[3]*Security Management, Laurea University of Applied Sciences, Vanha maantie 9, 02650 Espoo, Finland*
{kirsi.hyttinen, harri.ruoslahti, jorma.jokela}@laurea.fi

Keywords: International Security Studies, Innovative Learning Environment, Systematic Integration Approaches, Higher Education, Research, Learning, Work Life, Knowledge Co-creation, Collaboration.

Abstract: This is an introduction about building an innovative learning environment for the integration of research, work life and higher education. The current international security education facilitates higher education studies through innovative, research integration and collaborative learning activities. Similarly, the education and training faces challenges and new technology trends in learning delivery. It has been recognised that an integration between research, work life and education studies may benefit each other in knowledge creation. The research group completed a desk research and studied four different cases where the integration between research, work life and higher education was implemented during years 2016 and 2017. According to the findings of the desk research and case studies, the researchers build a model of innovative learning environment in order to ensure successful integration processes in the international security management studies.

1 INTRODUCTION

This paper introduces the understanding of building systematic and competence-based integration between research, work life and education to meet with current global challenges in learning and education delivery. We must ensure that future experts will gain high level of education in the real life setting in order to successfully be employed.

This paper is based on four different cases during three years where systematic tools for integration of research and projects were facilitated in course implementation with the view of lifelong learning and Learning by Developing (LbD) -concepts (Raij, 2014) in higher education security management studies. The overall goals of the courses were to ensure the learning according to set objectives for the courses.

Earlier research has mainly focused on how to integrate the higher education to research and development activities (Ojasalo et al; Pirinen 2008, 2013). Our approach is to focus on studying how to successfully integrate research and projects to higher education programs or independent courses. Beyond the systematic tools for integration, our focus was mainly on how the integration of research and projects can benefit the course implementation and learning in higher education. Before doing so, we aim to review the current state of art on integration between higher education and research. Moreover we provide analysis of different learning approaches to support the integration process.

2 THE HIGHER EDUCATION SETTING

2.1 Integration of Research and Work Life with Higher Education

Higher education aims to meet with the work life needs and is tasked to have a societal role nationally and internationally. Universities are expected to interact with the surrounding society so that their research findings better impact society (Raij, 2014). A systemic and competence-based approach to integrate the work life and EU –projects is highly

Hyttinen, K., Ruoslahti, H. and Jokela, J.
Model for Effective Integration between Research, Work Life and Higher Education in International Security Studies.
In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2017) - Volume 3: KMIS*, pages 299-306
ISBN: 978-989-758-273-8

needed to ensure successful transfer of knowledge and research findings in large collaboration research projects.

Earlier research identifies the term "integrative" as a perspective within research and development and education strategies that are recognized collectively. The focus of integrative education has been in the participation of students in projects and in achieving advanced results and impact for the research and development projects. (Pirinen, 2013, 8-26). Pirinen (2008) announced the importance of learning activities producing a sustainable drive for the integration of research and development with higher education. Beyond the research and development, the meaning of well-structured work life connections are seen crucial in order for students be successfully employed after higher education studies in the universities of applied sciences (Kirjalainen, 2010, 2). Work life-oriented education includes a set of definitions that clarify the competences needed in today's work life. The definitions are comprehensiveness, internationality, research touch, communication competences, change management and entrepreneurship. (Salonen, 2010, 3). Also Tynjälä & Virtanen (2013) address how higher education students hope more work life competences during their master level studies in universities.

Universities of Applied Sciences and current higher education institutes aim to provide learning possibilities for humans throughout their life-cycle. Lifelong learning is considered an important part of the Lisbon strategy of the European Union, whereas the European Union aims to be the most competitive and dynamic knowledge-based area as well as a more cohesive and inclusive society (Eurostat, 2009). The concept of lifelong learning is developed into a broader concept from the everyday life learning of people with its aim of improving knowledge, skills and competences (Tissot, 2004, 102) in knowledge societies (Boutsiouki, 2010). Learning is related to politics, ideologies, knowledge employment, and different creative and interactive ways of living (Aspin & Chapman, 2007; Jarvis, 1998). Today the lifelong learning is described as high-individualized way of learning which is guided by the changes and new ways of life (Field, 2006, 77).

2.2 Technology in a Higher Education Setting

Technology has re-organized human life, communication and learning. (Siemens, 2004), and 21st century theoretical insights have raised the collaborative practices in online learning. Thus education is in a changing position and technology brings new opportunities and challenges for teaching and learning. Based on earlier theories, learning can happen through one's own experiences (see Kolb, 1984), through critical reflection (see Mezirow, 1981) and as problem based solving (see Poikela & Poikela 1991). The theoretical background for online learning has concentrated on behaviourism, cognitive and constructivism learning theories. Furthermore, most of the current online education tools and environments are developed based on these theories. Behaviourism answers to the question "what", cognitive to the question "how" and constructivism to the question "why". Researchers have raised criticism regarding the theoretical background of online learning technology.

E-learning can be implemented as distance learning, where learners and teachers do not see each other, and learners may be geographically distant from one another. Moreover, e-learning is highly appreciated worldwide because of its cost-effective possibilities. An online training environment provides a variety of opportunities: teaching can be organized and the online learning environment can be utilized in many different ways. Online teaching can be divided into guided e-learning, self-study online learning and multiform learning, in which classroom training and e-learning are combined.

The new terminology of multiform teaching has begun to use the term "blended learning". When the classroom based learning is more structured and formal, informal learning is not typically classroom based or structured and the learning is in the hands of the learner (Marsick & Watkins, 2001). Furthermore, the learning experiences provided by education technology and applied in appropriate ways have been show to enable positive learning experiences and improve learning outcomes. (Carlson, 2013). The challenges in learning in online setting and technology supported may be raise when the constructivist pedagogy is aimed to be implemented.

2.3 Learning by Developing and Co-creative Approaches in Higher Education

From philosophical stance, it has found out that students learn by working collaboratively with social impacts and influence and as a definition we discuss about constructivist pedagogy (Vygotsky, 1978). Moreover, the social constructivism is not seen as method but as a view of learning which leds to decision making about pedagogy and curriculum (Oldfather & West 1999, p.91). Ruoslahti (2017)

finds that there are cyclical connections between value co-creation networks: cooperation platforms and active facilitation are needed for co-creative innovation and knowledge sharing. Active stakeholder participation stems from common aims that promise benefits for all collaborators, resulting in an active drive for co-creation of knowledge and change.

Innovation environments and collaboration technology are widely discussed in literature as ways to facilitate active and open collaboration, which in turn is the key to successful co-creation. First there should be a need for collaboration, all collaborators must feel that they benefit from the co-creation process and its outcomes, and that the collaboration becomes jointly constructed and lead. Any one organization cannot be in charge alone. A common problem and goals guide the co-creation process, and just identifying these common problems may be a co-creation process. These processes take time and are not without challenges.

These principles also apply to the co-creative processes of higher education. Ruoslahti, et. al. (2011) note that, when learning becomes integrated to projects, it becomes important to also actively manage networks. First, on a teaching level the teacher follows student learning and personal curricula, as well as student specific project advancement and competences. Second, on a project management level a teacher may manage projects and project resources. Third, on a network management level a teacher manages partners and possible partner registers. "To be able to genuinely and individually follow and manage the learning of each student is no easy task" (p. 12). A forth level for teachers to manage, may be considered being the level of co-creation. Ruoslahti (2017) notes that a value network that aims at the co-creation of knowledge and its cooperation platforms, which may be electronic or traditional, require facilitation by the teacher, in order to achieve the active stakeholder participation, which is needed to co-create knowledge and innovation. "Active and open collaboration is the key to successful co-creation." (p. 14).

Cost-effective highly interactive higher education level learning can be achieved, when partners collaborate to first define a problem worth their combined efforts, and then they develop dialogues with their strategic partners to improve knowledge sharing and develop collaborative processes. The search for opportunities for the mutual benefit of the partners serves to unlock the talents of the diverse groups working together in co-creation (Powell, 2012).

Doyle (2010) identifies that awareness is needed to clarify meanings between partners, when universities' engage with the regions that they are in. Complex and pervasive cooperation can promote economic and social inclusion, and community development. But there is a need to facilitate this development of mutual understanding, which calls for both mutual expectations and a common language, so that universities may become drivers of creative change.

Ruoslahti & Hyttinen (2017) promote the creation of education programs that provide learning possibilities, which are not tied to time or place. Flexible approaches enable students across these collaborative networks to choose a learning curriculum matching its content to one's individual interest. They suggest that a co-created network community could award higher levels of post post-graduate and post-doctoral education, with a specifically defined scope and focus on security, and safety. "This should provide an opportunity to experience a multi-disciplinary approach toward security and safety of activities" (p. 10).

Raij (2014) finds that research and development projects, which are directly based on real working life, form a learning environment that motivate students to develop new ways of action as competences. The ability and preparedness for both students and teachers to engage and interact with the ever changing surrounding society becomes crucial in building new knowledge and competences. The impact of changes on the character of learning in projects was first recognized. This in turn "led to the recognition of the characteristics and stages of the Learning by Developing action model" (Raij, 2014, p. 13)

3 CASES OF INTEGRATION IN INTERNATIONAL SECURITY MANAGEMENT EDUCATION

3.1 Case 1: An International Approach to Leadership in Crisis, Conflicts and Disasters

The master level higher education "International Approach to leadership in crisis, conflicts and disasters" – course (5 credits) at Laurea University of Applied Sciences was implemented with a strong integration to European Commission Horizon 2020 funded project IECEU (Improving the Effectiveness of Capabilities in EU conflict prevention) in the

Autumn 2016. In total, 32 students, a principal lecturer, a group of lecturers, and three external experts attended to the implementation process of this course. The process included planning, execution and evaluation phases. Most of the learners were adults with bachelor level knowledge, competences and own work life experiences. The approaches of adult education, especially lifelong learning, and Learning by Developing were used as basis of course implementation.

Hybrid learning methods were applied in the course implementation. Different influences such as reading (the background material of project deliverables), watching (video material from the conflict, crisis and fragile areas), peer discussions (working groups), self-reflection (learning diaries), writing (theory together with experiences) in and exit tests (evaluation) and online learning tools (LMS and social media) were used as teaching and learning methods. Finally the grades were given as a combination of different learning outputs.

The feedback of the students addressed that the possibility to attend H2020 IECEU –project network community, and be involved in latest research, raised their motivation towards the external security and international approach of conflict prevention and peacebuilding. The external experts working with crisis management and peacebuilding were seen as very important figures in receiving the latest information from the field and future work employment possibilities.

3.2 Case 2: Humanitarian Aid and Crisis Management

The master level higher education "Humanitarian Aid and Crisis Management" course (5 credits) by Laurea University of Applied Sciences was implemented in a strong integration with different humanitarian programs and experiences. Experts have shared their experiences and discussed with students how to lead humanitarian work in crisis areas, such as in the International Committee for Red Cross (ICRC), the European Union Monitoring Mission (EUMM) in Georgia, the Organisation for Security, Co-operation in Europe (OSCE) Special Monitoring Mission (SMM) to Ukraine and in Kosovo, and The Finnish Defence Forces International Centre (FINCENT) peace keeping missions.

Training and deployment of Finnish experts to humanitarian leadership and management missions and humanitarian aid was the basis of the study unit. The process included planning, execution and evaluation phases. The majority of the learners were adults with bachelor level knowledge or competences and strong work life experiences of their own. Approaches of adult education, such as lifelong learning, and Learning by Developing (LbD) the basis of the course implementation. The hybrid learning methods were applied in the course implementation.

Assignments of the master level course were to (1) raise the awareness in terms of international agencies and organisations (students picked a national, regional or international humanitarian aid agency that they studied further); (2) practical methods giving a guidance on “packing your “go-pack”; (3) plan an international humanitarian architecture based on response need.

The general course feedback of students included several feedback on motivating learning content and getting familiar on interesting topic through external speakers and professionals. This was also identified as one of the key factor in an individual learning process. Several earlier adult education research supports the approach where the motivation of the learner can be very crucial role in learning process.

3.3 Case 3: Student Integration and Co-creation of a Guide of Practices for Greater Social Responsibility toward Immigrants

Project Antura was a co-creative project, funded by the Finnish ministry of justice, which involved active members of an independent citizens’ forum, area neighbourhood associations, and active student integration, based on the learning method Learning by Developing at the Laurea University of Applied Sciences (Raij, 2014). The project promoted active cooperation between area actors, neighbourhood and immigrant associations, researchers, and students of both higher education and secondary level institutions. This was realized in the spirit of open co-creation.

The aim of project Antura was to evaluate the effects of immigration themed citizens’ forums, coordinated by the Greater Leppävaara Citizens’ Forum, a voluntarily coordinated arena for citizens’ participation in Espoo, Finland. Antura’s network partners co-created forms to smoothen the integration of immigrants by more open interaction, where all actors are encouraged to ‘be on the same side’” (Ruoslahti & Meristö, 2017).

The project was integrated to the Laurea University of Applied Sciences bachelor level study unit “Research and Development Methods (5 credit points) in the fall of 2016. 17 students took the class.

The study unit was in Finnish, so all students were Finns. The students formed three teams and each team was responsible, under a student project manager and senior lecturer supervision, of completing task 2, 3 or 4: student research team observation of the immigration themed citizens' forum discussion event, observation of Finnish language discussion groups at the local Library, or interviews of local neighbourhood association representatives, respectively. The aim of project Antura was to pave the way to finding best practices, and development suggestions for a better future with shared vision towards greater social responsibility and better integration between people, be they immigrants or born in Finland. This was also the focus of the student work completed.

The studies conducted as student integration promote, on a very practical level, understanding of the factors that facilitate immigration challenges, and identify examples of positive co-existence and social responsibility, while at the same time promoting higher education level learning. But also the study unit addressed the main learning objectives of the study unit, where students are able to choose the proper methods for development project and give reasons for these choices, collect empirical data and analyse it, interpret empirical results, make conclusions based on empirical results, recognize the ethical point of view of the research and development work, and evaluate the reliability and validity of research. They did all these on a very practical level.

3.4 Case 4: An Integration between IECEU –Project and "Organisational Management and Leadeship"-Course

An integration process between IECEU –project conceptual framework and security management programme's "Organisational management and leadership" –course (5 credits) was implemented in Laurea UAS from September to December 2016. In total, a group of 31 students, 3 IECEU –project researchers and 2 course lecturers participated to integration process.

The IECEU –project (funded by the European Commission H2020 programme) published multidisciplinary methodological framework for analysing the effectiveness of the capabilities of EU crisis management and peacebuilding with use of comparative methods. The process of collaborative creation of the conceptual framework included a workshop of researchers in June 2015. Organisational theories identifies capabilities as resources and competences and in the context of IECEU –project research, the researchers apply the six different capabilities in total. The capabilities were planning capacity, organisational capacities, interoperability, competences (skills and knowledge), comprehensiveness and technologies. The conceptual framework allows the use in a variety of contexts and situations because of modularity. (IECEU –project, 2016).

In terms of piloting the methodology in different contexts, the conceptual framework of IECEU was tested by the students in the research studies in analysing the effectiveness of the capabilities in private sector organisations. The implementation of the student research part of integration process included several steps; (1) Firstly, the IECEU researcher and lecturers of the course produced in collaboration a tailored model for bachelor students with specific research methodology to meet with course objectives and timespan. (2) Secondly, the IECEU project researcher participated to teaching seminar in the early phase of course implementation in order to understand the course setting and objectives in practice as well as to build the trust among the students, lecturers and project. (3) Thirdly, the students applied the IECEU conceptual framework (incl. mixed methods such as interviews and surveys in selected organisation) in their specific course study in analysing the effectiveness of capabilities in selected private sector organisation. (4) Fourthly, the guidance was given twice a month in small student group workshops by lecturers and IECEU project researchers. These collaborative workshops implemented the co-creation between students (=peers), lecturers and researchers (=were seen in a role of mentors). (5) Finally, the students introduced their findings of their research studies in seminar in order to ensure knowledge sharing, raising the presenting skills as well as receiving the feedback.

The students gained competences how to apply a research concept and different research methods (interviews, surveys, desk research) practically. Finally, the use of IECEU conceptual framework in student research task ensured the possibility to compare the findings. From the learning perspective, the students gained especially professional research skills and competences. An integration of higher education with work life is seen crucial especially for polytechnic and applied sciences. Therefore, the connections and activities between students and work life representatives can bring added value for learning and reaching the set goals. The implementation of IECEU Conceptual Framework in student task enabled real life contacts with work life

representatives in different private sector organisations. The research competences of the students were seen rather limited in bachelor level studies. Therefore the implementation of research concepts from H2020 projects was required a tailor-made guidance for the course participants.

In order to ensure systematic approaches in the integration, the students, lectures and researchers identified challenges in piloting the IECEU conceptual framework in student research. The guidance by researchers and lecturers was seen crucial to ensure the progress of research process. Students identified challenges in finding joint time among each other, whereas the project management skills were seen crucial in the implementation of the task. Students also felt collaborative practices with researcher raising their motivation and involvement to larger research communication. As a conclusion, the integration process was time consuming and the tailoring of IECEU framework to meet with bachelor student course objectives required several collaborative interaction cycles among researchers and lecturers. The process reached the set goals and student work reports gained valuable findings also for the H2020 research project. The IECEU –project also met one of its dissemination goals to integrate key research findings to higher education.

4 RESULTS

The successful integration of research and projects to higher education programs and courses is seen to raise the motivation of students towards the learning topics and themes. A good motivation can help reach the set learning objectives as well as increases the knowledge creation within the topic. Group and community level learning can raise the socio-constructivism in life-long learning. Integration should be embedded with a systematic approach where the research will primarily benefit the learning objectives and later, if needed, can influence towards the process of development of courses and programs in higher education. The integration of international research projects to higher education may benefit the level of knowledge when the external experts are giving lectures and provide current research results for bachelor and master level students. A research project can be a very useful platform for knowledge creation and the students get opportunities to access larger expert communities. Integrating project tasks with studies serves both project and curriculum goals very well. The co-creative approach involves students, teachers, citizens, and outside experts creating shared excitement and commitment. This in turn facilitates reaching these shared goals.

At the same time, there have been challenges in the integration of research projects and work life to higher education studies in the context of international security. The integration does not often follow systematic processes and it often requires time-consuming collaborative practices among lecturers, researchers, work life representatives and students. Moreover, the integration may need to apply of new methods and strategies for the teaching in collaborative activities. These activities may be time-consuming although they may serve better in problem-based and constructivist learning processes. It was also identified that online tools are only used as one method during course implementation. The online implementation still happens mainly in information sharing between lecturer and students and social media tools were not actively used part of learning practices by the institution.

The implementation of integration of work-life and research requires that the educator has competences to facilitate blended learning activities. The role of networking in projects is much greater than in the traditional teaching paradigm, where the teacher mainly shares one's knowledge with the students. The implementation of integration of work-life and research requires that the educator becomes a guide and facilitator to ways of finding and creating knowledge.

The case studies identified that the integration practices may include both, content and competence related, learning taxonomies. The case studies showed that the awareness of professional knowledge finally led to analysing and producing professional knowledge in constructive frames as required EQF7-8 levels. Overall, the integration between research, work life and education requires new systematic collaboration skills and competences among personnel in higher education. As a final result, based on the literature review (Ruoslahti, 2017) and the findings of the case studies presented in this paper, the model of innovative learning environment in order to facilitate integration between research, work and higher education studies in the international security studies with actors and practices was created. The purpose of the model is also to meet with European Qualification Framework (EQF) standards and lifelong learning practices in the integration processes.

The model identifies the key actors, practices and sets requirements to key competences to facilitate the innovative learning environment in integration between research, work life and higher education.

The key actors identified are 1) Educators, teachers and lecturers, 2) Researchers and project professionals, 3) Work life representatives and professionals, 4) International higher education students which are already enrolled for Higher Education Institute (HEI). The systematic practices in integration were found out as 1) traditional face-to-face lecturing, seminars and workshops, 2) knowledge creation through collaborative expert groups among students as peers, mentors and professionals, 3) guidance and mentoring, 4) documented inputs and outputs (e.g. assignments), 5) professional knowledge and information sharing in online setting, 6) professional knowledge analysing and co-creation by students in online setting. The innovative learning environment requires competences for facilitating the collaboration among actors and practices successfully. This study supports the findings by Ruoslahti, et. al., 2011, who identified teacher competences needed in project and networking based learning. A teacher should be able to understand and manage both learning and the required collaborative process, but also understand project management in order to manage the co-creation process, when integrating teaching into project work.

5 CONCLUSIONS

The role of higher education is in changing position and a need for new methods is identified. The research and development projects may benefit also with these future needs in co-creation of knowledge in innovative environments. The integration between research, work life and higher education supports the perspectives of lifelong learning in Europe. The social collaborative practices between higher education students, researchers, lecturers and work life representatives ensure constructivism and effective information sharing among different communities of interests. The innovative learning environment may facilitate the experience possibilities for social constructivism. Jarvis (1998, p.199) addresses the experience as necessity in learning process.

It is important to make sure that primarily the learning objectives of the course or study unit in question are met. But this not enough, also the work done on the course or study unit must benefit the project in some way. This can be reached through selection of actors and practices in an innovative learning environment. At the same time, the effective integration practices have been time-consuming and require more resources. To support the integration, the implementation can address systematic process in an innovative environment but especially it may bring benefits for different groups and professionals. There is a growing pressure to higher education teachers' competences. This shift in teaching and learning paradigm adds further pressure towards the management if projects, networks, and co-creation activities. Furthermore, the professionals collaborating with higher education and their institutional professionals must further improve their knowledge regarding degree and programme requirements and EQF objectives.

The teaching profession is changing. Teaching professionals need a more varied set of skills and competences to manage network-based co-creative integration. Students need teachers to guide them to discover learning. Projects provide an excellent basis for learning. The teacher is required to have the skills to make this connection between benefitting both the students learning and the accumulation of knowledge for the project. The teacher needs competences to identify what are the best ways to apply this in practice. One way of making sure that the learning objectives and project aims meet can be achieved by setting a specific set of macro learning objectives for the integration tasks. One possible direction to further enhance students' learning could be to encourage them to publish as part of professional knowledge creation. As it is now students produce a variety of different level research papers, such thesis. Institutions could develop paths, where these papers could be further developed into both professional and academic articles. Teachers can provide the needed support and if needed be co-authors. Since the higher education setting requires better practices in online basis, the use of technology in collaborative information creation and knowledge sharing must be addressed. The technology may benefit different groups and brings new tools for social activities. The use of social media and open source tools should be better piloted and studied especially among international security professionals and other communities of interest. Universities should follow and foster closely at the networks that they have. Just as one example, Laurea University of Applied Sciences is implementing a Partner Relationship Management (PRM) System as online tool for network management. With PRM students and teachers will have a better access to the university contacts and the university can better follow and quantify the network contacts made and facilitate their online connections.

REFERENCES

Aspin, D. N. & Chapman, J. D. 2007. *Lifelong learning: Concepts and conceptions.* In D. N. Aspin (Ed.), Philosophical perspectives on Lifelong learning (PP. 19-38). The Netherlands: Springer.

Boutsiouki, S. 2010. *In search of wellbeign – aspirational and functional purposes of learning of Greek post-graduates.* In Lifelong Learning in Europe, 2010.

Building a Better Response. Available online at http://www.buildingabetterresponse.org/

Doyle, L. 2010. *The Role of Universities in the 'Cultural Health' of their Regions: universities' and regions' understandings of cultural engagement*. European Journal of Education, vol. 45, no. 3, pp. 466.

Carlson, S. 2013. *Using Technology to deliver educational services to children and youth in environments affected by crisis and/or conflict.* Final Report. JBS International. p. 30.

Eurostat, 2009. *The European Union Labour Force Survey: Annual Results 2006*. Eurostat data in focus. 10/2007.

Field, J. 2006. *Lifelong learning and the new educational order (2nd ed.)* Stoke on Trent, UK: Trentham Books and USA: Sterling.

IECEU –project, 2016. *D1.5 Conceptual Framework.* Public deliverable available at European Commission CONRIS.

Jarvis, P. 1998. *Paradoxes of the learning society*. in J. Holford, P. Jarvis, & C. Griffing (Eds.). International Perspectives on Lifelong Learning (pp. 56-68). London.

Kirjalainen, E. 2010. *Viisi vuotta valmistumisesta – ammattikorkeakoulusta valmistuneiden urakehitys. Uraseuranta vuonna 2003 valmistuneille. Selvitys seitsemän ammattikorkeakoulun yhteisistä tuloksista.* Jyväskylän ammattikorkeakoulu.

Kolb, D. 1984. *Experiential Learning: experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice Hall.

Marsick, V., & Watkins, K. 2001. *Informal and Incidental Learning. New Directions for Adult And Continuing Education.* no. 89, Spring 2001 © Jossey-Bass, A Publishing Unit of John Wiley & Sons, Inc.

Mezirow, J. 1981. *A Critical Theory of Adult Learning and Education.* Journal of Adult Education 32 (1), 3-24.

Oldfather, P., West, J., White, J. & Wilmarth, J. 1999, *Learning through Children's Eyes: Social Constructivism and the Desire to Learn.* American Psychological Association, Washington, DC.

Ojasalo, K., Juvonen, S., Kaartti, V. & Haapaniemi, H. 2017. *New Approach and Tools for Systematic Integration of Higher Education with Research and Development Projects*. INTED2017 Proceedings, pp. 1839-1846. DOI: 10.21125/inted.2017.0563

Pirinen, R. 2010. *Towards Realization of Research and Development in a University of Applied Sciences.* Publications of the University of Eastern Finland Dissertations in Forestry and Natural Sciences No 108. ISBN: 978-952-61-1149-0 (Print)

Pirinen, R. 2008. *Integrative action process in the perspective of globalization*. International Journal of Emerging Technologies in Learning (iJET), 3(1), 61–68.

Poikela, E. & Poikela, S. 1999. *Kriittisyys ja ongelmaperustainen oppiminen*. Teoksessa Järvinen-Taubert, Johanna & Valtonen, Päivi (ed.). Kriittisyyteen kasvu korkeakouluopetuksessa. Tampere: TAJU.

Powell, J. 2012. *The university role in the innovative leadership of small to medium sized enterprises*. International Journal of Entrepreneurial Behaviour & Research, vol. 18, no. 4, pp. 396-416.

Ruoslahti, H. 2017. *Co-creation of Knowledge for Innovation and Multi-Stakeholder Participation of End Users: A Structured Literature Review*, unpublished paper, submitted to EUPRERA 2017, 12th – 14th October 2017.

Ruoslahti, H. & Meristö, T. 2017. *Project ANTURA: Creating Better Immigrant Integration and Greater Social Responsibility*. unpublished paper, submitted to BledCom 2017 Proceedings, presented at BledCom 2017, June 30th – July 1st.

Ruoslahti, H., & Hyttinen, K., 2017. *A Co-created network Community for Knowledge and Innovations – Promoting Safety and Security in the Arctic.* Proceedings of BledCom 2016, Engaging people in a disengaged world, BledCom 2016 23rd International Public Relations Research Symposium, 1st – 2nd July 2016, Bled, Slovenia, www.bledcom.com/knowledge.

Siemens, G. 2004. *Connectivism: A learning theory for Digital Age.*

Tissot, P. 2004. *Terminology of vocational training policy. A multilingual glossary of an enlarged Europe, Cedefop.* Luxembourg: Officer for Official Publications of the European Communities.

Virtanen, A. & Tynjälä, P. 2013. *Kohti työelämätaitoja kehittävää yliopistopedagogiikkaa – opiskelijoiden näkökulma.* Yliopisto pedagogiikka.

Vygotsky, L. S. 1978. *Tool and symbol in child development.* In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.). Mind in Society: The development of higher psychological processes. Cambridge, Mass: Harvard University Press

VI

SOCIETAL IMPACT ASSESSMENT OF A CYBER SECURITY NETWORK PROJECT

by

Aaltola, Kirsi & Ruoslahti, Harri, 2020

Information & Security, 46(1), 53–64

https://doi.org/10.11610/isij.4604

Information & Security

K. Aaltola & H. Ruoslahti
vol. 46, no. 1 (2020): 53-64
https://doi.org/10.11610/isij.4604

Published since 1998

ISSN 0861-5160 (print), ISSN 1314-2119 (online)

Research Article

Societal Impact Assessment of a Cyber Security Network Project

Kirsi Aaltola [a] (✉), *Harri Ruoslahti* [b]

[a] *VTT Technical Research Centre of Finland, https://www.vttresearch.com/en*

[b] *Laurea University of Applied Sciences, Finland, https://www.laurea.fi/en/*

ABSTRACT:

The European Union promotes innovation through its funding programmes for research and innovation. To support the innovation process, one of these projects, ECHO, aims to deliver a Societal Impact Assessment (SIA) toolkit to assess the impact of establishing a European network of cybersecurity competence centres. This article provides an overview of the theoretical foundations on network co-creation and inter-organizational knowledge transfer as learning outcomes, and discusses these approaches in performing impact assessment at the societal level. Literature review on evaluation and assessment, co-creative innovation, and learning approaches are examined, summarized and combined into a learning and SIA-outcomes Matrix. Measurement of impacts through a digital Societal Impact Assessment toolkit can improve the quality of the value creation. Towards that purpose, we offer an approach that combines traditional evaluation and assessment, co-creative innovation, learning and SIA-outcomes in a practical Matrix to provide an applicable element towards a more comprehensive SIA-toolkit for the ECHO network.

ARTICLE INFO:

RECEIVED: 08 JUNE 2020
REVISED: 01 SEP 2020
ONLINE: 16 SEP 2020

KEYWORDS:

societal impact assessment, network co-creation, innovation, organisational learning, skills acquisition, competence development, cybersecurity

✉ E-mail: Kirsi.Aaltola@vtt.fi

Introduction

The European Union (EU) promotes innovation through its funding programmes for research and innovation. These offer opportunities for the creation of knowledge by engaging diverse organizations of academics, businesses and public organizations to form project consortia. Innovation projects have a strong focus in sharing insights and experiences, though participants may simultaneously have conflicting interests for participation. Project ECHO aims at organizing a net-worked approach through effective and efficient multi-sector collabo-ration that aims at strengthening proactive cyber security in the Euro-pean Union. Project ECHO (European Network of Cybersecurity Centres and Competence Hub for Innovation and Operations) started in 2019. This position paper in part explains the nature of the body of knowledge that the project will cumulate in regards to assessment of societal impacts.

Research and innovation network projects, increasingly face the challenge of mobilizing knowledge towards value creation in a manner that takes into account assessing its impact and effectiveness.[27] Societal expectations increasingly demand projects to review the criteria of the community and a comprehensive impact assessment processes that is capable of delivering outcomes, which ad-dress learning and sharing of knowledge.[36]

One part of the purpose of the ECHO project is to deliver a Societal Impact Assessment (SIA) toolkit. The aim is to measure the effective-ness and impacts of network co-creation. The purpose of this article is to provide an overview of approaches on network co-creation and interorganizational knowledge transfer as learning outcomes, and to discuss the nature of these approaches in performing Societal Impact Assessment. The aim is to elaborate the path from the selection of relevant learning outcomes to means of impact assessment, which be-comes demonstrated in forms of learning outcomes. This paper builds on the dissemination evaluation framework for European research projects presented in Henriksson et al., "Opportunities for Strategic Public Relations – Evaluation of International Research and In-novation Project Dissemination." [13]

Literature

Evaluation and Assessment

Knowledge management has become complex in requiring, for example, comprehensive approaches to assessment. Some limitations of evaluation approaches that have can been recognized are their limited foci on degrees of influence, subjective satisfaction of results, or empowerment. Daniel Fiorino [10] and Frank Laird [19] used political theories in the development of normative evaluation criteria, and they evaluated a wide variety of participation models. The concept of *public participation* played a role in the impact assessment of public participation programs, and provided some added strength to earlier, more narrow, evaluation approaches. The model helped describe proper and improper conduct in public decision-making activities in democratic government.

Good practices of traditional research dissemination and exploitation are needed.[13] A traditional documentation in evaluating research impacts with quality dimensions (clarity, environment orientations, consistency, responsiveness and effectiveness) and systematic documentation activities (quarterly dissemination and progress evaluation, relevant exposures across targeted media sectors, successful two-way information transfer, committed project partners, and adoption of project processes).[13, 28]

Social learning can be treated purposefully as an outcome of impact assessment, which is facilitated through the organizational learning approach and linked with best practices of stakeholder engagement. Sánchez and Mitchell grouped learning outcomes into three different categories: "acquisition of knowledge and skills, developing new behaviours and developing sustainability-oriented norms and values". In order to achieve such outcomes, the means include education and/or training, experiential learning, learning through participation and social learning as well as a 'learning organization approach'." [36]

Vos et al. [39] see measurement processes may need "*strong commitment and an open culture of learning*" (p. 66). In sensitive matters outcomes may be difficult to compare, and it "*would be recommended to supplement self-assessment with other measures such as external assessment*" (p. 66). Interactions can be understood through cycles of input, throughput, and output communication, and in the context of innovation projects, communication activities follow the elements of complexity in cyclical ways. This can provide a framework to evaluate the workings and impacts of innovation projects.

Beyond relevant evaluation and assessment processes, complex network reality requires people who are committed on both organizational and individual levels to learn and adopt the knowledge, skills and competences required by the network co-creation and communities that there are involved in. Development of professional expertise comply with networks, complexity and technological innovations at the same time. Complexity of research and innovation projects, raise the need of positioning variety of relevant approaches to impact assessment and evaluations. Network co-creation and learning approaches provide new systematic ways to analyse the impacts on a societal level of network projects funded by the public funding.

Network co-creation

Innovation is based on new knowledge and it drives growth and success.[6, 7] Creating knowledge for innovation requires collaboration between research and business partners; co-creation is seen as a collaborative activity, and it involves objectives, arenas, collaborators, tools, processes, and contracts,[5] on different layers, such as co-creating futures or policies, and involving agents.[1] Partners, who work in collaboration in research and network projects, generate new knowledge and skills resulting to innovations.[13]

Ruoslahti finds that co-creation in projects call for: collaboration and a common problem, and innovation networks have three main challenges to manage to ensure open communication toward co-creation of knowledge: stakeholders

need to be actively engaged throughout the project, which takes time and effort.[34] Co-creation of knowledge can occur in physical spaces, digital environments or combining both.[5]

Vos, Schoemaker and Luoma-aho suggest that communication takes place in Issue Arenas, where actors meet in physical or digital spaces to address and discuss issues that are relevant to them.[41] Arenas can thus, be seen as competitive spaces, where actors may, besides having common agendas, have interests their own, use with problem solving and influencing strategies,[35, 39] and yet, deep engagement of the actors involved benefit all stages of an innovation process.[8] Ruoslahti [33] demonstrates that a process flow of elements of complexity [25] can be recognized in the context of innovation projects, and in relation to the input-throughput-output communication.[40]

Learning approaches

When people are involved in working towards mutual common objectives, or a purpose that affects their communities, they become more responsible. This in turn reaffirms democracy. On a societal level, this phenomenon can be described as social learning.[44] In addition, Webler, Kastenholz and Renn [44] provided a solid basis for evaluating public participation processes through fairness, competence and social learning. Theory of cognitive development,[30] theory of experience [9] and social constructivism [24, 42] were some of the key constructivist viewpoints, which have led to the experiential learning tradition, commonly used in adult education and training.

Studies have shown that individual learning processes are dependent of social interaction and external sources.[4, 22] It has been argued that Piaget strongly built the basis for the constructive way of thinking.[32] Constructivist learning theories believe in the role of social environmental contexts and interactions with others in moulding individual development [9] and assert that learning becomes socially situated.[20] Dewey addressed that humans are active learners and the nature of learning is based on problem solving. [9] Network research and innovation projects are envisioned in line with the conceptual understanding of public participation where “a community of people with diverse personal interests, but also common interests, who must come together to reach agreement on collective action to solve a mutual problem.” [44]

Beyond the pedagogical or psychological tradition, social learning has been studied in the organizational and management studies with the use of concept organizational learning.[2, 3] The German sociological critical theory by Habermas described social change as a process of social learning with cognitive and normative dimensions.[11] Polanyi’s assumption was that some knowledge is difficult to articulate with language and may exists in a form of experiences.[31] His understanding of tacit knowledge is in a relation with society and to our personal interests and commitments. According to Nonaka & Takeuchi [26] (pp. 57-58) knowledge is defined in relation to action and with commitment and beliefs on messages. Wenger’s contribution as knowledge management theory focused on communities of practice in the central of learning, meaning and identity.[45]

They described information as a flow of meaningful messages. Stenmark argued that fact knowledge includes both forms of knowledge, tacit and explicit,[37] while Weick argues that paying attention to forgotten and avoided facts through stories and examples is a way to "discipline imaginations around the topic of organisational learning."[46]

Knowledge creation and learning theories strongly argue the relevance of understanding knowledge as a socially constructed process. In addition, experiential learning approaches and skill development highlight the role of experience, when the aim is to improve knowledge, skills and competences. The range of instructional and methodological design opportunities is quite broad, and the effective learning techniques support adaption of new competences in different contexts in a form of informal learning.[23]

Summary of the Literature Review

The summary of literature review discusses in the above-mentioned academic literature, Table 1 (below) presents three main theoretical dimensions relevant in the toolkit of societal impact assessment of network project: foundations of evaluation and assessment, co-creative innovation, and learning approaches. These three dimensions are shown in relation to some key concepts and themes as relevant authors have presented them.

The above literature review findings of key theoretical foundations (Table 1) indicate that Societal Impact Assessment (SIA) can be based on the relevant evaluation and assessment theories, co-creative innovation and learning approaches. The findings show that the measurement indicators to assess societal impacts can be combined from the evaluation and assessment practices, innovation targets and learning outcomes. This approach is discussed and modelled to practical needs of societal impact assessment below in the Conclusions section.

Table 1. Summary of the literature review.

Evaluation and Assessment		
Approach	**Author(s)**	**Key concepts and themes**
Evaluation and Assessment	Fiorino [10] Laird [19]	- normative evaluation criteria of participation models
Research project dissemination evaluation framework	Palttala & Vos [28] Henriksson et al.[13]	- quality dimensions in evaluation - systematic documentation of dissemination
Organizational learning approach and stakeholder engagement in impact assessment	Sánchez and Mitchell [36]	- social learning as an outcome of impact assessment

Co-creative innovation		
Approach	**Author**	**Key concepts and themes**
Plan and manage project to co-create value	Bhalla [5]	- collaborative activity with: objectives, arenas, collaborators, tools, processes, contracts
Input, throughput, output	Vos & Schoemaker [40]	- communication management contributes to three phases - mutual agreements about communication
Co-creation in EU-funded innovation projects	Ruoslahti [33]	- collaboration - common problem - stakeholder engagement, time and effort
Learning approaches and knowledge creation		
Approach	**Author**	**Key concepts and themes**
Cognitive development and cognitive constructivism	Piaget [30] Piaget [29]	- learning is a process of accommodation, assimilation and equilibrium
Social constructivism	Dewey [9] Vygotsky 42	- humans are active learners - learning is based on problem solving - culture and context are highly important
Learning in social change	Habermas [11] Webler, Kastenholz & Renn [44]	- social learning has cognitive and normative dimensions
Socially situated learning	Lave & Wenger [20]	- social environmental contexts and interactions with others in molding individual development
Organisational learning	Argyris & Schön [2] Argyris [3])	- a single and double loop learning processes - organizational learning is highly context-dependent
Knowledge creation and transfer loop	Nonaka & Takeuchi [26]	- knowledge defined in relation to action and with commitment and beliefs on messages
Tacit knowledge	Polanyi [31] Stenmark [37]	- some knowledge is difficult to articulate with language and may exists in a form of experiences
Informal learning	Marsick & Watkins [23]	- learner-centre focus - focus on self-directed nature, networking, coaching, mentoring, and performance planning

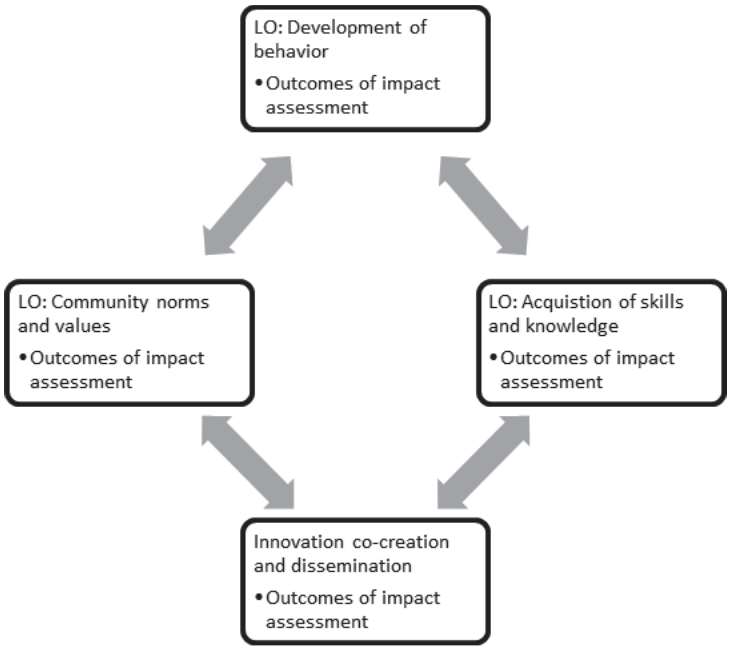

Figure 1: A flow of co-creation learning outcomes for SIA-toolkit.

Summary of the Findings

Positioning evaluation and assessment traditions, learning approaches and network co-creation can provide improvement for the design of Societal Impact Assessment. Combining these perspectives promote understanding of how structures foster knowledge sharing and interpretation, enhance organizational memory, provide sustainable innovation and finally improve the impact at the societal level. Learning outcomes have to go beyond instrumental learning to reach new behaviours, norms and values [36] to enable an increasingly practical approach to Societal Impact Assessment.

When Societal Impact Assessment becomes measured as both learning outcomes and as evaluation outcomes, a matrix of quality dimensions as noted by Palttala and Vos [28] and Henriksson et al.[13] can be developed (Table 2, below) to provide a way of evaluating societal impacts of network and innovation projects. The innovation co-creation and understanding of communication as issue arenas contribute to

The blue areas in Table 2 represent the linkages of learning approaches to SIA. The yellow areas represent linkages of co-creation for innovation activities to SIA. The grey areas represent linkages of project communication, dissemination and exploitation evaluation activities in SIA. Measurement of SIA-outcomes through a toolkit can improve the quality of the value creation at the societal level.

Table 2. SIA outcomes Matrix.

Level	Societal	Individual	Community	Dissemination	Communication
Learning out-come	**Outcome**	**Outcome**	**Outcome**	**Outcome**	**Outcome**
Description	Development of Behaviours and Attitudes	Acquisition of skills and knowledge	Community norms and values	Dissemination Quality	Systematic docu-mentation
Communication	*Input*	*Input*	*Throughput*	*Output*	*Output*
SIA-outcome	Action with commitment	Knowledge transfer loop	Collabora-tion objec-tives	Clarity	Dissemination progress
SIA-outcome	Stakeholder engagement	Social and in-formal learn-ing	Collabora-tion arenas	Environment linkages	Targeted media sectors
SIA-outcome	Experiential learning	Cognitive de-velopment	Collabora-tors	Consistency	Two-way infor-mation transfer
SIA-outcome	Meaningful messages	Joint problem solving	Collabora-tion tools	Responsiveness	Committed pro-ject partners
SIA-outcome	Social change	Interactions in joint envi-ronments	Collabora-tion pro-cesses, con-tracts	Efficiency	Project processes

Research and innovation projects have already been studied from the dissemination and exploitation evaluation point of view (e.g. [13]) but this approach goes beyond and positions relevant learning and co-creative innovation foundations as practical outcome indicators to analytical societal impact assessment in com-plex network innovation projects, such as ECHO -project. The practical Matrix (Table 2) can provide one applicable element towards a more comprehensive SIA-toolkit for the project ECHO network. A flow of co-creation learning outcomes for the SIA-toolkit are presented below in Figure 1.

Societal impact and its assessment have been lately discussed in both academic literature and in recent EU-funded research and innovation projects. This positioning aims to contribute to this research and practitioners' discussions to better understand the state-of-art, bring in the relevance of the theoretical foundations and to identify potential indicators to develop and provide more practical and accurate methodology for Societal Impact Assessment. Such a methodology contributes to digital creation of AI-assisted toolkit for data creation and could be utilized for any innovation and network project or organization that wishes to understand how its actions and solutions influence at the societal level.

Acknowledgement

This work was supported by the ECHO project, which has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement no. 830943. The European Commission funded cyber pilot projects, such as European net-work of Cybersecurity centres and competence Hub for in-novation and Operations (ECHO), bring opportunities for researchers to con-duct experiments and gather empirical data to study these aspects from different perspectives.

References

1. Franco Accordino, "The Futurium – a Foresight Platform for Evidence-Based and Participatory Policymaking," *Philosophy & Technology* 26, no. 3 (2013): 321-332.
2. Chris Argyris and David Schön, *Organizational Learning II: Theory, Method and Practice* (Reading, MA: Addison-Wesley, 1996).
3. Chris Argyris, "Education for Leading – Learning," *Organizational Dynamics* 21 no. 3, (1993): 5-17.
4. Albert Bandura, *Vicarious and self-reinforcement processes. The Nature of Reinforcement* (New York and London: Academic Press, 1971).
5. Gaurav Bhalla, "How to Plan and Manage a Project to Co-create Value with Stakeholders," *Strategy & Leadership* 42 no. 2 (2014): 19-25.
6. Stephen Burdon, Grant Richard Mooney, and Hiyam Al-Kilidar, "Navigating Service Sector Innovation using Co-creation Partnerships," *Journal of Service Theory and Practice* 25, no. 3 (2015): 285-303.
7. Patricia Dandonoli, "Open Innovation as a New Paradigm for Global Collaborations in Health," *Globalization and Health* 9, no. 1 (2013): 1-5.

8. Robert DeFillippi and Thorsten Rose, "Aligning the Co-creation Project Portfolio with Company Strategy," *Strategy & Leadership* 42, no. 1 (2014): 30-36.
9. John Dewey, *Experience and Education* (London: Collier MacMillan, 1938).
10. Daniel Fiorino, "Citizen Participation and Environmental Risk: A Survey of Institutional Mechanisms," *Science, Technology, & Human Values* 15, no. 2 (1990): 226-243.
11. Juergen Habermas, *Communication and the Evolution of Society* (Boston: Beacon Press, 1979).
12. Mick Healey and Alan Jenkins, "Kolb's Experiential Learning Theory and Its Application in Geography in Higher Education," *Journal of Geography* 99, no. 5 (2000): 185-195, DOI: 10.1080/00221340008978967.
13. Kristina Henriksson, Harri Ruoslahti, and Kirsi Hyttinen, "Opportunities for Strategic Public Relations - Evaluation of International Research and Innovation Project Dissemination," in *Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management*, edited by Sarah Bowman, Adrian Crookes, and Øyvind Ihlen, vol. 3 (Emerald Publishing Limited, 2018), 197 – 214, https://doi.org/10.1108/S2398-391420180000003012.
14. David Kolb, *Experiential Learning: Experience as the Source of Learning and Development*, Vol. 1 (Englewood Cliffs, NJ: Prentice-Hall, 1984).
15. Alice Kolb and David Kolb, "Learning styles and learning spaces: Enhancing experiential learning in higher education," *Academy of Management Learning and Education* 4, no. 2 (2005): 193-212.
16. Hubertus Hedel and V. Dietz (eds.), "The influence of age on learning a locomotor task," *Clin. Neurophysiol.* 115 (2004): 2134–2143.
17. Alice Kolb and David Kolb, "Experiential Learning Theory: A Dynamic, Holistic Approach to Management Learning, Education and Development," in *Handbook of management learning, education and development*, edited by S. Armstrong and C. Fukami (2011), https://doi.org/10.4135/9780857021038.
18. Kurt Kraiger, Jonathan Passmore, Nuno Rebelo dos Santos, and Sigmar Malvezzi (eds), *The Wiley Blackwell Handbook of the Psychology of Training, Development, and Performance Improvement* (Wiley Blackwell Publishers, 2014).
19. Frank Laird, "Participatory Analysis, Democracy, and Technological Decision Making," *Science, Technology, & Human Values* 18, no. 3 (1993): 341–361, https://doi.org/10.1177/016224399301800305.
20. Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge: Cambridge University Press, 1991).
21. Jean Lave, and Etienne Wenger, *Communities of Practice: Learning, Meaning and Identity* (Cambridge: Cambridge University Press, 1998).
22. Kurt Lewin, "Behavior and development as a function of the total situation," in *Field theory in social science: Selected theoretical papers*, edited by D. Cartwright (Washington, DC: American Psychological Association, 1997), 337-381.
23. Victoria Marsick and Karen Watkins, "Informal and Incidental Learning," in *New Directions for Adult and Continuing Education,* vol. 89 (Jossey-Bass, 2001).
24. Alan Miller, *Personality Types: A Modern Synthesis* (Calgary: University of Calgary Press, 1991).

25. Eve Mitleton-Kelly, "Ten Principles of Complexity and Enabling Infrastructures," in *Complex Systems and Evolutionary Perspectives on Organisations: The Application of Complexity Theory to Organisations*, edited by Eve Mitleton-Kelly (Amsterdam: Pergamon, 2003), 23-50.
26. Ikujiro Nonaka and Hirotaka Takeuchi, *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation* (New York, NY: Oxford University Press, 1995).
27. Klaus North and Gita Kumta, *Knowledge Management - Value Creation Through Organizational Learning*, second edition (Springer Nature, 2018), https://doi.org/10.1007/978-3-319-59978-6.
28. Pauliina Palttala and Marita Vos, "Quality Indicators for Crisis Communication to Support Emergency Management by Public Authorities," *Journal of Contingencies and Crisis Management* 20, no. 1 (2012): 39-51.
29. Jean Piaget, *The Development of Thought: Equilibrium of Cognitive Structures* (New York: Viking, 1977).
30. Jean Piaget, *The Psychology of Intelligence* (London: Routledge, 1950).
31. Michael Polanyi, *The Tacit Dimension* (New York, NY: Anchor Day Books, 1966).
32. Maijaliisa Rauste-von Wright and Johan von Wright, *Oppiminen ja koulutus* (Juva, Finland: WSOY, 1994).
33. Harri Ruoslahti, "Complexity in project co-creation of knowledge for innovation," *Journal of Innovation & Knowledge* (2020), In Press, Available on-line: https://www.sciencedirect.com/science/article/pii/S2444569X19300630.
34. Harri Ruoslahti, "Co-creation of Knowledge for Innovation Requires Multi-Stakeholder Public Relations," in *Public Relations and the Power of Creativity, Advances in Public Relations and Communication Management*, edited by Sarah Bowman, Adrian Crookes, and Øyvind Ihlen, vol. 3 (Emerald Publishing Limited, 2018), 115-133.
35. Lauri Saarinen, "Enhancing ICT Supported Distributed Learning through Action Design Research," Aalto University publication series, Doctoral Thesis 92 (Helsinki, 2012).
36. Luis Sánchez and Ross Mitchell, "Conceptualizing Impact Assessment as a Learning Process," *Environmental Impact Assessment Review* 62 (2017), 195-204, https://doi.org/10.1016/j.eiar.2016.06.001.
37. Dick Stenmark, "Information vs. knowledge: The role of intranets in knowledge management," In: *Proceedings of the Thirty-Fifth Annual Hawaii International Conference on System Sciences, January 7–10, 2002* (IEEE Computer Society Press, 2002), 1–10.
38. Marita Vos, "Issue Arenas," in: Heath, R. and Johansen, W. (eds.) *The International Encyclopedia of Strategic Communication (IESC)* (Malden MA: Whiley Blackwell, 2018).
39. Marita Vos, Petri Kekäle, A. Ruggiero, and Pauliina Palttala, "Measuring Crisis Communication Preparedness Across Different Branches of Government – Sharing Experiences Gained in Finland," *Online Journal of Communication and Media Technologies* 8, no. 1 (2018): 60-69.
40. Marita Vos and Henny Schoemaker, *Accountability of Communication Management: A Balanced Scorecard for Communication Quality* (Utrecht: Lemma, 2004).

41. Marita Vos, Henny Schoemaker, and Vilma Liisa Luoma-aho, "Setting the Agenda for Research on Issue Arenas," *Corporate Communications: An International Journal* 19 no. 2 (2014): 200-215.
42. Lev Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Cambridge, MA: Harvard University Press, 1978).
43. Rui Wang and Sidney Newton, "A review of Kolb's learning styles in the context of emerging interactive learning environments," In: *AUBEA 2012: Proceedings of the 37th International Conference of the Australasian Universities Building Educators Association, University of New South Wales, Sydney, N.S.W*. (2012), pp. 191-199.
44. Thomas Webler, Hans Kastenholz, and Ortwin Renn, "Public Participation in Impact Assessment: A Social Learning Perspective," *Environmental Impact Assessment Review* 15, no. 5 (September 1995): 443-463, https://doi.org/10.1016/0195-9255(95)00043-E.
45. Etienne Wenger, *Communities of practice: Learning, meaning, identity* (New York: Cambridge University Press, 1998).
46. Karl Weick, "Puzzles in Organizational Learning: An Exercise in Disciplined Imagination," *British Journal of Management, suppl*., Special Issue, London (13 September 2002): S7-S15, quote on p. 7.

About the Authors

Kirsi **Aaltola** is a Research Team Leader of Resilience of Society at VTT Technical Research Centre of Finland Ltd. She acted as Societal Impact Assessment work package lead during the year 2019 for project ECHO.
https://orcid.org/0000-0002-2048-5151

Harri **Ruoslahti**, PhD, is a Senior Lecturer of Security and Risk Management at Laurea University of Applied Sciences. He is Laurea's point of contact for project ECHO.

VII

OPPORTUNITIES FOR STRATEGIC PUBLIC RELATIONS – EVALUATION OF INTERNATIONAL RESEARCH AND INNOVATION PROJECT DISSEMINATION

by

Henriksson, Kristina & Ruoslahti, Harri & Hyttinen, Kirsi, 2018

Public Relations and the Power of Creativity: Strategic Opportunities, Innovation and Critical Challenges, Emerald Publishing, pages 197–214

https://doi.org/10.1108/S2398-391420180000003012

Henriksson, K., Ruoslahti, H., & Hyttinen, K.

in Sarah Bowman, Adrian Crookes, Stefania Romenti, Øyvind Ihlen (ed.) Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, pp.197 - 214.

Opportunities for Strategic Public Relations – Evaluation of International Research and Innovation Project Dissemination

Abstract

European industry, academia, and potential end users for future solutions are widely involved in applying for European Union (EU) funding of research and innovation and implementation of the projects. Funding instrument requirements emphasize the influence of skills and knowhow of these project consortia professionals. This chapter proposes a co-creative model for communication and dissemination, or project PR, based on the experiences of both planning and coordinating dissemination activities of three EU funded projects. Multidisciplinary international project PR offers strategic opportunities for PR professionals.

The model employs the co-creation methods based on the pedagogical model called Learning by Developing (Laurea, 2011). In addition to the pedagogical model, the proposed conceptualization of co-creation for public relations and dissemination utilizes a media evaluation framework, which is adapted from Vos & Schoemaker's model (2004), combining elements of both balanced scorecard and quality management.

The findings demonstrate that commitment and active participation of end user groups in the early stage of the project are needed for successful dissemination, which should be supported by each partner's PR actions and networks. The dissemination process should start when the project begins, be ongoing, even extending to beyond the project. Dissemination is an expanding process, and it requires facilitation that supports PR and the engagement of key stakeholders. The European Commission can gain from modernized PR and dissemination activities, and from as many end users as possible adopting new innovations, which generate more business possibilities for the industry, and further research projects for the academia.

Key words: Public relations, strategic communication, dissemination, communication, co-creation, Learning by Developing, evaluation

1. Introduction

European industry, academia, and potential end users for future solutions are widely involved in applying for EU funding for research and innovation projects. The requirements for efficient dissemination and exploitation set by the funding instruments, such as the European Commission's Horizon 2020, are increasing. Requirements emphasize the influence of the projects and the skills and knowhow of the project consortia, as Di Cagno et al. (2014, p. 853) write: "given the large and increasing amount of European resources devoted to promote scientific co-operations among countries, it is important trying to assess their actual technological and economic impact." One objective of funded projects is to expand the benefit of results in the European Union. The dissemination of Horizon 2020 projects is defined as public disclosure of results by all appropriate means (European IPR Helpdesk, 2014), and the overall purpose of dissemination includes achieving scientific excellence. Project dissemination can be looked upon as Public Relations (PR), and its actors as PR practitioners.

One example is the FP7 project topic SEC-2012.3.4-6 Enhancing the workflow and functionalities of Automated Border Control (ABC) gates - Integration Project (European Commission, 2011). This

project is expected to contribute towards a more harmonized common European approach in its field, automated border control. Funding instruments often require the active participation of end users in both research by project consortia and as targets for dissemination. In the case of the Automated Border Control (ABC) gates project, "Institutions of several Member States are expected to be involved in the case of large-scale pilot project involving different border crossing points and all types of borders" (European Commission, 2011, p. 43). Another example is the H2020 call BES-2014-12 on border and external security for improvement of conflict prevention and peacebuilding capabilities of the EU. This call looked for a project that can deliver enhanced activities of coordination and support with strong engagement of key stakeholders and end users. The resulting project, Improving the Effectiveness of Capabilities in EU Conflict Prevention (IECEU), was funded under this call and aimed to meet the requirements through active dissemination methodology and PR activities.

Funded projects are joint ventures built on trust and common goals. Basically, partners form a consortium with a joint interest for development and / or research which they carry out together. In light of this common interest, it is important to identify sufficient ways of communication and dissemination to satisfy the requirements of the funding instrument, and to meet the aims and agendas of the various stakeholders. The ways to plan and implement dissemination activities are many, so it is important that project consortia have clear plans, which are in line with the project objectives, carry them out actively, and react to any feedback that they receive.

There are clear duties set for partners regarding external communication and dissemination activities by the funding instruments. Project partner actors, who are not used to working with actual external communication and dissemination duties, can find these duties unnecessary or unfamiliar. Some partners outsource these PR activities, and some even end up avoiding the activities as much as possible.

Then there are partners who actively promote the project, disseminate and communicate externally to the general public, the academia, and various stakeholders. Projects, where every partner does not actively participate in PR activities throughout the whole project lifecycle, do not necessarily meet the criteria for funding. Although the projects are based on trust and partners' mutual agreement on joint ventures, the case of not participating in daily communication and dissemination makes the project and its results weaker than in those projects where there are shared ways of working.

This chapter proposes a modern co-creative model for PR activities and dissemination based on theoretical approaches on communication quality, and practical experiences gained in planning and coordinating communication and dissemination activities of three EU funded projects. The results section discusses some strategic opportunities for the creative use of Public Relations to mitigate critical challenges in innovation projects. The research question is: how can external communication and dissemination, i.e. project PR, be carried out to efficiently address the requirements of the funding instrument and benefit the project?

2. Project Communication and Dissemination

The European Commission (2014) outlines that communication about European research projects should aim at demonstrating the ways in, which "European collaboration has achieved more than have otherwise been possible" (p. 1) and how its outcomes are both relevant to the lives of us Europeans. Creative people best achieve desired outcomes, when objectives are clearly defined. For efficient strategic communication it is key to clarify messages and choose the appropriate media according to the target audience.

Henriksson, K., Ruoslahti, H., & Hyttinen, K.

in Sarah Bowman, Adrian Crookes, Stefania Romenti, Øyvind Ihlen (ed.) Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, pp.197 - 214.

Efficient and timely communication of project activities ensures the success of a project and is a core interest of projects (GAP D7.1, 2016), both during, and even beyond, the lifespan of the project. A dissemination plan will provide an overall framework to coordinate and manage communication during the implementation of a project. Dissemination in projects can be divided into two different key groups; dissemination material and dissemination activities. (Hyttinen, 2017). Different communication platforms and tools are developed to ensure a wide reach of various stakeholders and end users (IECEU, 2015). EU research and innovation funding and project dissemination should pay special attention to showing how collaboration has achieved more than would otherwise have been possible, showing how the outcomes are relevant, and making better use of the results among decision-makers, industry or academia (Hyttinen, 2017).

To make best use of project results, they should be taken up by the end users, policy-makers, industry, and the scientific community (European Commission, 2014). A project itself functions as an organization with an action plan, vision and mission, as well as a clear budget and time plan. The project's main actor organizations are partners by contract. Partners who work together in teams generate new knowledge and skills, resulting in innovations. In the action model Learning by Developing (LbD), projects function as a learning environment, while they also create new knowledge for innovations. LbD has five dimensions, which form the learning / working environment: authenticity, experiential nature, partnership, creativity, and research orientation (Laurea, 2011). A project is an authentic environment; the case is real. Partners operate in partnership with the stakeholders and end users, and they employ an experiential approach and are creative, while they carry out research and develop new joint products to meet their aims. The value that is created in a joint activity is generated by their shared experiences and the partnership with stakeholders, in an authentic manner.

In projects, partners co-create with stakeholders, and their shared experiences are vital for dissemination activities. With active co-creation, new competencies arise from social interaction and knowledge sharing, as shared competence of communities and organized groups of experts and professionals (Pirinen, 2015). The value of this shared competence is key to receiving funding for joint projects. Customers and users are active participants in value co-creation to design personalised experiences, services, and products (Allen et al., 2009). Pirinen (2015) concludes that building useful knowledge and innovation processes is "increasingly complex, multidisciplinary, trust-based, co-created, path-depended, and globalized" (p. 323). Frow et al. (2015) seek to provide an understanding on how co-creation can improve resource integration in complex settings and offer a framework for organizations to design and manage co-creation processes.

Project experts sometimes find themselves in uncomfortable positions when facing the need to communicate and disseminate in a professional way in projects. These experts might have a basic understanding of strategic communication. Wilson et al. (2010) find that the identified theoretical research dissemination frameworks are converging and still overly focus on "linear messenger-receiver models and do not draw upon other aspects of communication theory" (p. 14); they note that the key to successful dissemination is dependent on the need to interact with end users. Some traditional ways of sharing knowledge and interacting with end users have been press releases, seminars and conferences. At present, modern electronic platforms provide secure possibilities for co-creative knowledge sharing and learning online (Davis Cross, 2015).

Public relations is strategic communication, and different organizations use it to establish and maintain symbiotic relationships with relevant and increasingly culturally diverse publics (Sriramesh et al., 2017). Falkenheimer & Heide (2014) see PR as one of three fields under strategic communication, the other two being organizational communication, and marketing communication. They note that PR concentrates on activities and communication where stakeholders or publics can

be treated as segments. This also applies to innovation projects, as dissemination is described as the public disclosure of the results of the project in any medium.

According to the European Commission (2017), the key aim for dissemination is to make research results known to different stakeholder groups, such as academia, industry, professional end user organizations, and policymakers in a planned and targeted way. The Commission (European Commission, 2016) makes a clear difference between dissemination, exploitation, and communication, the concepts of which are defined as follows.

The Commission likens dissemination activities to a shopkeeper attracting customers. Therefore, one should always consider a funded project as a fixed-duration business with all the duties, aims, objectives and tasks. A process of promotion and awareness-raising from the beginning of a project can make its research results known to research peers, industrial and other commercial actors, and policymakers, in targeted ways, enabling them to exploit the results in their own work.

The Commission describes exploitation as "the use of the results during and after the project's implementation. It can be for commercial purposes but also for improving policies, and for tackling economic and societal problems" (European Commission, 2016). Exploitation, thus, spreads the findings and utilizes them for the benefit of a larger geographical area. Furthermore, if the benefits can be employed in a variety of fields of interest, in addition to the field of the project, it makes the results of exploitation activities more valuable.

Communication refers to the project

> taking strategic and targeted measures for promoting the action itself and its results to a multitude of audiences, including the media and the public, and possibly engaging in a two-way exchange. The aim is to reach out to society as a whole and in particular to some specific audiences while demonstrating how EU funding contributes to tackling societal challenges. European Commission, 2016

It is interesting to note that one-way communication still seems to be the main direction and scope for projects funded by the European Union. The option of engaging in a two-way exchange is voluntary. However, to make an impact, two-way communication has the potential of being more efficient than one-way. To ensure improved quality, research is needed to develop professionalism in the management of communication, and best practices should be actively shared (Vos & Schoemaker, 2004). This can be extended to external communication and dissemination in funded projects. Communication in a project will initially start when collaborators start working towards common goals, and information is input to serve as a basis for the project, and the development and innovation work within. A project can, for example, interview stakeholders and create scenarios that input information to the project and guide the co-creation of knowledge and innovation (Ruoslahti, 2017).

To guide the practical work of a project network, information is shared and communicated between project members, partners and other stakeholders. In many funded projects, work packages are distributed between partners, and solitude work by one partner at a time is carried out, making shared work activities sometimes difficult. Communication takes place all the time, whenever one acts or does something. If partners work as a team on different tasks and work packages, it would make all the duties of communication, dissemination and exploitation much easier for all. Vos (2015) notes that "communication can contribute to a company's economic and social goals by seeking to enhance its corporate reputation, positioning of products and services, and internal consistency" (p.64). Key processes in doing this include monitoring stakeholder perceptions, arranging interaction with them and facilitating network exchange within the organization (Vos and Schoemaker, 2011).

These same principles can be applied to projects as well as established organizations. Communication plays a role in a project's economic and social goals by seeking to enhance the reputation of the project in question, positioning of its outcomes and deliverables, and internal consistency. In their strategy map for communication, Vos & Schoemaker (2011) look at communication on four different levels: organizational goals, communication goals, key processes, and learning and growth.

On the first level, organizational goals, or in this case common goals for a project network, are added value and social acceptance. On the second level, communication goals, are reputation and being rooted in the social environment; project outcomes are positioned as products or services, and coherence as the organization of the project network. On the third level, key processes include monitoring stakeholder perception, examining communication via news, social media, etc., and facilitation of network exchange. These key processes are identifiable in the dissemination and communication plans for all three projects ABC4EU, IECEU, and GAP. On the fourth level, learning and growth, one can find communication planning and research, and knowledge management and training. The focus of this chapter is on this level.

Projects are required by the EU funding instruments to openly disseminate the results of the project for efficient exploitation. In past experiences this has been done towards the end of the project, which poses a serious problem both to the consortium and the funding instrument. Criteria for funding may not be met in those cases. This should change. One can keep in mind the Commission's simile of a shopkeeper and the need to attract the shop's customers. End users and other stakeholders should become involved in the dissemination process already from the start of the project. The dissemination process, and its evaluation, which are proposed in this chapter, are designed around this principle.

3. Three Projects Examined

This chapter explores the planning and evaluation of external communication and dissemination in three funded project cases. Project ABC4EU will have run its course during the year 2018, whereas IECEU and Gaming for Peace started their activities in the fall of 2015 and 2016, respectively. This chapter suggests that a framework with strengthened co-creation as a method can intensify external communication and dissemination in funded projects. The experiences of the three funded projects partially present the co-creation concept of this chapter; the authors have developed the idea further to conceptualize the planning, process, and evaluation of the activities. As an example, the dissemination process for ABC4EU is illustrated in Figure 1 (ABC4EU, 2012). The main aim of this process is to engage a community of potential users from the very start of the project to ensure not only efficient dissemination, but also the continuous and active input of end user experts. This model of co-creation can create opportunities to link stakeholder collaboration for creativity and innovation. PR skills and active facilitation become emphasized in this approach.

Henriksson, K., Ruoslahti, H., & Hyttinen, K.

in Sarah Bowman, Adrian Crookes, Stefania Romenti, Øyvind Ihlen (ed.) Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, pp.197 - 214.

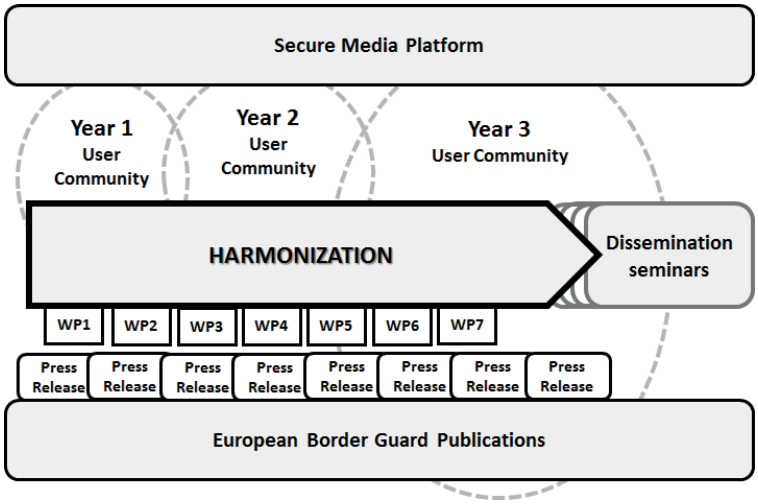

Figure 1: Communication and dissemination model for project ABC4EU

ABC Gates for Europe – ABC4EU is a project with 17 partners. The main objective of the project is to "focus in the need for harmonisation in the design and operational features of ABC Gates, considering specially the full exploitation of the EU second generation passports and other accepted travel documents" (ABC4EU, 2012, p.4). There are nine work packages, with WP7 Dissemination & Exploitation focusing on external communication and dissemination. In the Framework Programme FP7 project ABC4EU, dissemination, as seen in figure 1, was planned to begin from the very start of year one (Y1) of the project (ABC4EU, 2014). The aim has been to grow the User Community in number and keep end users, industry, and academia actively involved with interactive participation on a secure social media platform. The key to get end users involved in ongoing communication activities in a project where the end users receive no funding for their efforts is to find their ultimate benefit and smaller benefits during the project lifecycle. Interactive participation can enable the creation and growth of an end user community, and this community can in turn serve as a basis for two-way communication with end user organizations and professionals. In addition, press releases, publications and articles have been used.

The second examined project IECEU (Improving the Effectiveness of Capabilities in EU conflict prevention) was implemented from 2015 to 2018. The dissemination methodology was a combination of defined end user groups and the use of different dissemination tools and activities. The overall comprehensive dissemination methodology included the involvement of both EU and other international organizations, respective countries, universities, as well as other projects and partners, and the use of a secured internal website and external online tools for dissemination, discussion, and media-based learning (IECEU D8.1, 2015). The aim of the dissemination focused on making better use of the results among key stakeholders. (Hyttinen, 2017). The use of technology in dissemination and communication was strongly addressed in this project implementation.

The third funded project which this chapter discusses is the Horizon 2020 project Gaming for Peace, GAP, which is based on the notion that operationally critical soft skills, communication, cooperation, and negotiation, are often not emphasized enough. The Project GAP proposes to fill this training gap, by embedding, into a gaming environment, a "base curriculum of soft skills that facilitates coordination and relationship building in an environment of organisational, gender and cultural diversity" (GAP D7.2, 2016, p. 5). The project has fourteen partners. "The communication and dissemination activities are fundamental in order to create project visibility and to reach various target groups" (GAP D7.2, 2016, p. 3). Efficient communication is key to a successful GAP project.

Henriksson, K., Ruoslahti, H., & Hyttinen, K.

in Sarah Bowman, Adrian Crookes, Stefania Romenti, Øyvind Ihlen (ed.) Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, pp.197 - 214.

4. Adapted Methodology for Project PR

This chapter presents a model of co-creation based on the pedagogical model, Learning by Developing (Laurea, 2011). LbD is a way of learning and developing, created for university studies and utilized in project work. A project, in itself, is a learning environment, involving partners, stakeholders, possible clients and end users cooperating with each other in partnership, employing an experiential nature when researching and co-creating something new in an authentic project, all participants learning from each other at the same time. The LbD Guide (2011, p.12) also notes that

> A learning environment is also a psychological state. It enables encounters among different participants and interaction that leads to genuine cooperation. The atmosphere is open and respects equality. The working culture is inspiring, supporting creative and finding new ideas. Shortcomings and sidetracks are turned into positive learning experiences. The communication culture is open and respectful. Diversity is a resource for innovation. Partnership fosters responsible collaboration. Learning environments enable joint activities, evaluation and development of personal ways of action based on experiences.

The description above meets the ways of working in a multi-actor cross-border project. The criteria set by the funding instruments are crucial for the planning of external communication and dissemination of funded projects. The consortium needs to include a plan for communication and dissemination with their funding application. This emphasizes the importance of the role of PR, in this case communication and dissemination, for the project. Furthermore, in the planning stage of external communication and dissemination, one needs to look at the whole cycle of external communication and dissemination: plan, act, evaluate, re-plan, act, evaluate, etc. Projects should make sure that PR skills are developed, and that PR professionals jointly facilitate collaboration in co-creation activities. Communication and dissemination technologies require the competences of the people related to a project's knowledge and information sharing. The dissemination technologies which support project collaboration within a consortium as well as among key stakeholders and public audience are: the Web, secured access websites, video conferences, social media, document management and so forth. The selection of the dissemination technology depends on the target group (Juan, 2012. p. 220). The technology and information sharing increase additional competence and professional requirements for experts working with project dissemination.

The proposed framework employs the model of Vos and Schoemaker (2004) that combines elements of both balanced scorecard and quality management to evaluate communication. The evaluation of external communication and dissemination is done by measuring the effectiveness of its activities. The measurement process follows the quality cycle by Juholin, (2010). The first step is to define evaluation aims, the second step is the method and data sets, third, data is collected and analyzed, fourth, results reported, and the final step is re-evaluation and choosing the next steps, so that the cycle may start again. The main aim is to continuously improve the quality of the communication and its value for the organization (Vos, 2015). According to Verčič et al. (2015), finding internationally socialized people to "… work in a cross-cultural setting, and capable of taking international and global public relations practice to a new level …" (p. 791) is a major challenge. This is also demonstrated in the three projects examined.

4.1. Quality Dimensions

This section discusses the dimensions of communication quality by Palttala & Vos (2012, p. 39) and illustrates how these dimensions were linked to the externally funded project domain. These dimensions are A) clarity, B) environment orientation and linkages, C) consistency, D) responsiveness, and E) effectiveness and efficiency. They are summarized in Table 1 below.

Evaluation targets focus		
Dimensions of communication quality	A. Clarity	Clarity refers to communicating a clear profile and with messages that are distinctive, accessible, and in clear language
	A. Environment orientation and linkages	Taking into account the internal and external environment, networking and media contacts
	B. Consistency, effectiveness and efficiency	The communication is coherent, has a thread that connects the activities over time and fits the project
	C. Responsiveness	Detect changes through monitoring and use feedback for improvement
	D. Effectiveness and efficiency	A result- and goal-oriented communication effort, defining priorities by using planning, research and cost-efficient operations

Table 1: The dimensions of communication quality (adapted from Vos & Schoemaker, 2004; Vos 2009)

Palttala and Vos (2012) emphasize that these five dimensions are “the pillars of communication quality” (p. 39), and that they cannot be isolated from each other. They are all linked to and support each other.

4.2 Domains of Project Communication and Dissemination

The quality dimensions presented above are applied to various domains in evaluating dissemination activities. For this, the model of Vos and Schoemaker (2004) on organizational communication are adapted to meet the criteria of funded project dissemination. Figure 2 shows the different domains of project communication and dissemination, which are included in the evaluation framework proposed in this chapter. The five domains refer to the areas of project communication and dissemination.

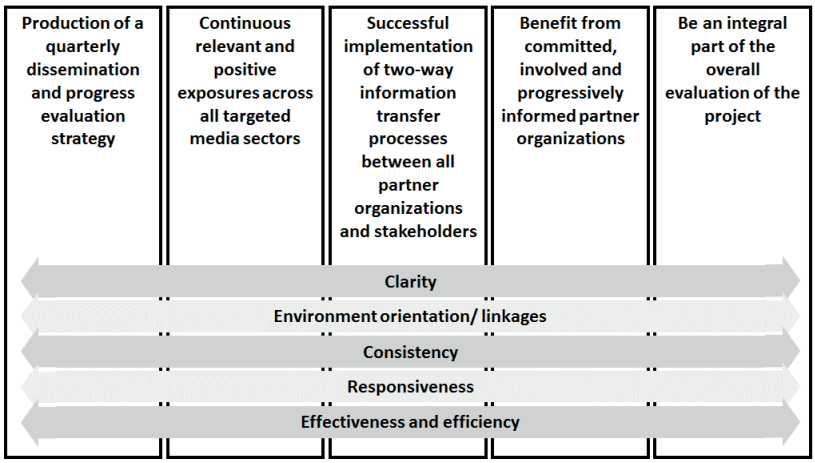

Figure 2: Communication and dissemination evaluation model (partly based on Vos & Schoemaker, 2004)

The domains are based on the grant agreement (unpublished document) for the project GAP and are thus expected to have a wider bearing. In the project GAP, they were used as a basis for the communications plan of the project (GAP D7.1, 2016). The grant agreements of EU funded projects specify important communication that, consequently, should be reported to the funder. In externally funded projects, dissemination and communication activities should be reported regularly both within the consortium, and to the funding agency. This is done as part of periodic technical reviews, as well as summarized for the duration of the project as part of the final report. Dissemination reporting is due between monthly and every four months' time, throughout the duration of the project implementation.

Some key features of reporting are the dissemination/communication action (e.g. event), date and place, target group, number of people/participants that dissemination was done towards, objective and description, and communication channels/tools used. Dissemination reporting is typically aided by templates, which are prepared based on these key features, and support the data collection from the various consortium partners.

If not paid close attention to, in the planning phase, these templates that gather information from dissemination activities may gather information that is dispersed into different tables, resulting in unlinked incoherent details. Also, it is advisable to remember to include an easy access system to attach written messages and texts to the report template as records of communication and dissemination activities carried out. All partners should report their external communication and dissemination activities regularly, even if there have not been any activities or only a few. Motivating each partner to do their reporting in a timely fashion and generating a routine to examine and document one's own dissemination activities are a way to develop one's own work and find common ground to cooperate with partners.

4.3 The Evaluation Framework

For evaluation of project communication and dissemination, the quality dimensions are applied to the communication dimensions. This provides a matrix with various indicators, as shown in Table 2.

Quality dimensions	Quarterly dissemination and progress evaluation	Relevant and positive exposures across all targeted media sectors	Successful two-way information transfer processes between project partners and stakeholders	Committed, involved and progressively informed partner organizations	Adoption of project processes across the EU
Clarity	Clear positioning of the project	Clear positioning across targeted media sectors	Information to stakeholders is clear	External communication vision is clearly defined	Clear positioning of project processes across the EU
Environment orientation/ linkages	Maintain networks for the project's reputation	Maintain networks across targeted media sectors	Communication reinforces commitment and supports two way information transfer between partner organizations and stakeholders	Internal and external communication function is well embedded in all project work	Communication supports two way information transfer of project processes across the EU
Consistency	Consistency with other communication	Consistency in message across targeted media sectors	Consistency with other communication	Common starting points for internal and external communication, with room for project partners	Consistency with other communication
Responsiveness	Monitoring and action based on managing issues	Monitoring and action based on feedback from targeted media sectors	Communication contributes to internal views on external changes and communication skills encourage internal responsiveness	Feedback is used to develop communication planning and activities	Monitoring and action based on feedback from professional sectors across the EU
Effectiveness and efficiency	Assessment of project reputation, cost efficient methods	Assessment of cost efficient methods	Internal communication audits, cost-efficient methods	Assessment of internal and external communication quality, time management	Assessment of project processes adoption across the EU, cost efficient methods

Table 2: GAP media evaluation tool; as an example of the proposed evaluation framework.

Measurement with the tool presented in Table 2 above is carried out as part of a quality cycle, the aim being to continuously improve the quality of the communication and its value for the organization (Vos, 2015; Juholin, 2010). Evaluation, according to Juholin (2010, p. 29), is an assessment of the value communication in its different forms produces, and how single actions benefit the organization. This chapter views projects as organizations created for a limited timeframe, and evaluation as a process, which aims at developing the activities of the project. Evaluation needs to be continuous and holistic, and based on the aims set for the project. Evaluations target planned activities, results achieved with these activities, objects for development, and needs for immediate action. The evaluation method and the measurements used must be defined, case-by-case, for the organization (Juholin, 2010, p. 30), or in this case, the project.

Section 5 discusses the experiences in the three projects ABC4EU, IECEU, and GAP, based on an analysis of the dissemination and communication plans of these three international projects. This chapter proposes an evaluation framework based on these experiences and illustrates the relevance of the framework by arguing that it fits the experiences gained in planning and coordinating dissemination activities in three EU funded projects.

5. Results from the Three Projects

The project ABC4EU Dissemination Plan (ABC4EU, 2014) stresses that all external communication and dissemination activities begin as soon as the project begins, and run throughout the project duration, with the aim of gaining project visibility. The plan outlines what will be communicated, who will do it, to whom, how, and why. Besides traditional methods for dissemination, such as press releases, newsletters, electronic publications, workshops, and conferences, the project aims at creating and growing its user network (end user community) in numbers, by using a secure online platform, an active end user community to disseminate relevant information of the project. "To ensure

continuation for the work done in the project" (p. 9), this end user community is urged to live on and continue its active existence and cooperation even after the project has ended. The means of dissemination in project ABC4EU are divided in: dissemination materials (the products created), and dissemination activities (the actions taken), and these are outlined in the ABC4EU Dissemination Plan (2014). Because the Framework Programme 7 did not have a requirement for media evaluation, the ABC4EU project did not evaluate its communication impacts in any other way than by listing and calculating its dissemination activities. For this purpose, there was a template and system of periodic reporting, and end user community reports.

The monitoring and evaluation indicators for IECEU were set early in the project, and later adapted, as the IECEU dissemination was evaluated to reach comprehensive visibility among its key stakeholders by use of different dissemination means, tools and activities (IECEU D8.1, 2015). The project was acknowledged by policymakers, academic and public audiences. The approach provided positive lessons for future projects in the external European safety and security domain. The engaging of key stakeholders in policy dialogues in various EU Member States was seen as a successful method of PR in terms of raising impact. The active use of technology selected in project dissemination activities by the partner organizations enhanced the information sharing towards end users and the general public. Moreover, social media polls and online meetings ensured the use of interactive methods when employing technology. In the final reporting phase, this was seen as key in terms of successful dissemination. IECEU engaged over 1,000 participants to actively follow only two social media channels, Twitter and Facebook.

The external communication and dissemination plan for GAP, Gaming for Peace (GAP D7.1, 2016) also looks for ways to "ensure efficient and sustainable information sharing in GAP even beyond the lifespan of the project" (p. 4). The GAP plan focuses on asking the questions: to whom to disseminate; where to disseminate? The plan is in line with the European Commission stressing the importance on clarifying messages based on the target audiences. These questions in the GAP plan guide all GAP dissemination actors to clearly focus their dissemination activities on the potential audiences for the results and products of the GAP project. Knowing how to identify these audiences can bring sustainability to the project. The Communications Plan for GAP lists key stakeholders for dissemination (GAP D7.1, 2016, pp.15-9).

GAP has a communication action matrix, which is built around milestones, work packages with partner responsibilities to communicate relevant actions, and deliverables that are related to each milestone. This is to ensure that all the partners of GAP are in a timely manner actively and fully carrying out the information sharing responsibilities that are expected of them. Building the relationships between the actors of the project's operational work packages and its external partners are based on these communication activities. It is important that all actors understand the values, which underline the communication practices of the GAP project. To create a GAP brand, the project partners need to share a clear vision. Thus, it is easier to form clear messages that communicate what GAP is, who its actors are, and why this project is important to society (GAP D7.2, 2016).

GAP's project documentation indicates that the division of work between internal and external communication is clear, with the coordinator being responsible for internal communication, and Laurea UAS for external communication, although external communication activities require approval by the coordinator before communication can take place. External communication and dissemination activities are also the responsibility of each beneficiary in addition to a work division table of responsibilities.

The media evaluation framework adapted for GAP takes the GAP Communications Plan, Grant Agreement and template for reporting of dissemination activities into consideration. The Communications Plan includes a table of both quantitative and qualitative questions to be used for

the scientific analysis of external communication and dissemination in the project. The required scientific analysis has so far not been possible to carry out because not all the partners have delivered their periodic reporting of external communication and dissemination activities.

The evaluation tool adapted for the media evaluation can, in the future, be utilized as a self-assessment tool, thus, including the qualitative approach to evaluation by the active actors and communicators themselves. This enables the emphasis of accountability and the generating of self-development of the communication and dissemination activities of each project partner (beneficiary). Accountability for communication refers to taking responsibility for the communication strategy and the choices that are made, and how these contribute to the objectives of the project (Vos, 2015). Accountability is examined here on the level of the communication work package and the communication performance of the project as a whole.

All three projects implemented their dissemination and communication activities with people who mainly had knowledge and competence of the substance areas of research and development (e.g. security). Only few communication and PR professionals participated in project dissemination. This result was unexpected, since the dissemination objectives in EU funded projects are strongly related to deep competences and experiences of management of dissemination and PR. It was, however, recognized that the co-creative collaboration between professionals, researchers and developers, as well as the feedback and learning provided by evaluation, supported the reach of dissemination objectives.

6. Tentative Conclusions and Implications

The experiences in the three projects suggest that it is important that partners agree to jointly cooperate on external communication and dissemination activities, and to understand how vital these activities are for the success of the project. These actions are PR for the project, and thus the project should include PR professionals to develop PR skills of its actors. Next, commitment and active participation of partners and end user groups in the early stage of the project implementation is key to increase the impact of the project results and finally, meet with the project's dissemination goals. Moreover, dissemination in international research and development projects should be an ongoing process. The process should start when the project begins, and last until the end of the project. Ideally, the dissemination process begins with the project proposal and extends to the sustainability of the project stakeholder community, even after the project has terminated or not received funding. The benefit of networks may bring added value for partners in the future.

Additionally, it can be noted that dissemination is an expanding process. Figure 1 shows this expansion of the User Community from year one (Y1) to year three (Y3), a growing number of stakeholders (end users, industry, NGOs, authorities, academia, etc.) participating in the communication within the community. A small nucleus in the beginning of the project leads to growing numbers of stakeholders actively being targeted and participating in the co-creation of the dissemination process. Also, key target audiences should be clarified, followed, and updated throughout the project lifespan. The selection of communication channels should be amended based on this clarification process. The target audience will most likely expand in not only number, but also to include a wider range of stakeholders by the end of the project, and after.

In the project IECEU, easily measurable indicators (IECEU D8.1, 2015) were set at an early stage to monitor the success of dissemination by IECEU. The monitoring process includes quantitative monitoring and evaluation indicators. Measuring the objectives throughout the project identified both gaps and trends to make sure that the project was going to a desired direction and provided valuable information to further improve the communication activities. Results from the first media evaluation

in GAP indicate that not all partners have yet realized the potential and benefits of actions promoting strategic communication of the project. Furthermore, there is little cooperation between partners as the cooperation is regulated by the contract and enacted by the project coordinator. However, as the project has only recently started, there are many options to develop the activities even together. The key to such co-creative work lies in the will to work as a team. Therefore, PR skills become more and more important for projects to meet requirements set by the EU for the external communication and dissemination of research and innovation projects. The use of selected technology for PR, dissemination and communication, presents a new type of competence challenges and opportunities for professionals and experts.

Instruments for public funding of research and innovation projects call for open dissemination of project results. However, the EU does not demand two-way communication in these activities, which clearly would be the way to generate better results and engage different audiences. Perhaps the EU could develop their visions of external communication and dissemination in the era of digital communication and community-based cooperation. When communication and dissemination activities begin early enough, for example right at the start of the project, and expand the stakeholder community, the project and its results become wider known. It is in the interest of the European Commission that as many end users as possible adopt new innovations, which in turn will generate more business possibilities for the industry, and further research projects for the academia.

Ideally the project's end user communities may find sustainability that outlasts the project. Project partners could engage end user communities in collaborative PR activities to engage the end users during the project. This creates opportunities for spontaneous cooperation and further the co-creation of innovations, products, and services, not to mention new development projects. PR professionals have a strategic opportunity in facilitating activities within the proposed model of co-creation in the EU funded projects context. The potentials in using technology in dissemination and communication of international research and innovation projects are highly recommended to be further studied while enhancing professionalism.

Acknowledgements:

The research leading to these results has received funding from the European Community's Framework 7 Programme for ABC4EU – ABC Gates for Europe, and the European Community's Horizon 2020 Programme for IECEU – Improving the Effectiveness of Capabilities in EU conflict prevention and GAP – Gaming for Peace.

References:

ABC4EU – ABC Gates for Europe (2012). ABC gates for Europe Proposal, SEC-2012.3.4-6 Enhancing the workflow and functionalities of Automated Border Control (ABC) gates –Integration Project

ABC4EU – ABC Gates for Europe (2014). Dissemination Plan, Project deliverable D 7.7 M3, 9.4.2014.

Allen, S., Bailetti, T., and Tanev, S. (2009). Components of Co-Creation, The Open Source Business Resource, November 2009.

Davis Cross, M.K., (2015). The Limits of Epistemic Communities: EU Security Agencies, Politics and Governance, Volume 3, Number 1.

Di Cagno, D., Fabrizi, A., and Meliciani, V. (2014). The impact of participation in European joint research projects on knowledge creation and economic growth, Journal of Technology Transfer, Vol. 39, 6, 836-858.

Falkheimer, J. & Heide, M. (2014). From Public Relations to Strategic Communication in Sweden: The Emergence of a Transboundary Field of Knowledge, Nordicom Review, 35(2), 123-138.

European Commission (2011). Cooperation, Work Programme 2012, Theme 10, Security, European Commission C(2011)5068, 19 July 2011.

European Commission (2014). Horizon 2020, Communicating EU research and innovation guidance for project participants, Version 1.0, 25 September 2014.

European Commission (2016). Webpage: What is the difference between dissemination, exploitation and communication? Research and Innovation. Participant Portal, available at: https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-933.html (accessed 25 May 2017).

European Commission (2017). Webpage: European Commission, Research & Innovation, Participant Portal, support, available at: https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-933.html (accessed 25 May 2017)

European IPR Fact Sheet (2014). The Plan for the Exploitation and Dissemination of Results in Horizon 2020, European IPR Helpdesk, available at: https://www.iprhelpdesk.eu/.

Falkheimer, J. & Heide, M. (2014). From Public Relations to Strategic Communication in Sweden: The Emergence of a Transboundary Field of Knowledge, Nordicom Review, 35(2), 123-138.

Frow, P., Nenonen, S., Payne, A., and Storbacka, K. (2015). Managing Co-creation Design: A Strategic Approach to Innovation, British Journal of Management, Vol. 26(3), 463.

GAP – Gaming for Peace (2016). D7.1 Communications Plan, available at: 1.9.2016. http://gap-project.eu/publications/deliverables/ (accessed 25 May 2017)

GAP – Gaming for Peace (2016). D7.2 Communications Package, available at: 1.9.2016. http://gap-project.eu/publications/deliverables/ (accessed 25 May 2017)

Hyttinen, K. (2017). Project Management Handbook. Laurea Publications 76, Laurea University of Applied Sciences. ISBN: 978-951-799-452-1.

IECEU – Improving the Effectiveness of Capabilities (IEC) in EU conflict prevention (2015). 8.1 Dissemination Plan PU IECEU CSA project: 653371 Start date: 01/05/2015, available at: http://www.ieceu-project.com/wp-content/uploads/2016/12/D8.1-Dissemination-Plan-PU.pdf (accessed 5 July 2017)

Juan, A et al. 2012. Collaborative and Distributed E-Research: Innovations in Technologies, Strategies and Applications: Innovations in Technologies, Strategies and Applications. IGI Global. ISBN13: 9781466601253.

Juholin, Elisa. Arvioi ja paranna. Viestinnän mittaamisen opas. Vantaa: Infor Oy, 2010.

Laurea University of Applied Sciences (2011). Learning by Developing. LbD Guide, available at: https://www.laurea.fi/en/document/Documents/LbD_Guide_04102011_ENG.pdf#search=lbd%20guide (accessed 5 July 2017).

Palttala, P., & Vos, M. (2012). Quality Indicators for Crisis Communication to Support Emergency Management by Public Authorities. Journal of Contingencies and Crisis Management, 20(1), 39–51.

Pirinen,R. (2015). Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers, Creative Education, 2015, 6, 3, 315-330.

Ruoslahti, H. (2017). Co-creation of Knowledge for Innovation and Multi-Stakeholder Participation of End Users: A Structured Literature Review, paper submitted to EUPRERA 2017, London, October 12 – 14.2017.

Sriramesh, K. Štumberger, N. (2017). Globalization and Public Relations, In: Global Encyclopedia of Public Administration, Public Policy, and Governance, A. Farazmand (ed.), Springer International Publishing AG 2017.

Verčič, D, Zerfass, A, Wiesenberg, M (2015). Global public relations and communication management: a European perspective. Public Relations Review 41(5): 785–793.

Vos M. (2015). Communication Health Check – Measuring Corporate Communication Performance, Journal of Business Studies Quarterly 2015, Volume 7, Number 1.

Vos & Schoemaker (2004). Accountability of Communication Management, A Balanced Scorecard for Communication Quality, Lemma Publishers, Utrecht, 2004.

Vos, M., & Schoemaker, H. (2011). Integrated Communication: Concern, Internal and Marketing communication. Amsterdam: Eleven Publishing.

Wilson, P. M., Petticrew, M., Calnan, M. W., & Nazareth, I. (2010). Disseminating research findings: What should researchers do? A systematic scoping review of conceptual frameworks. Implementation Science, 5, 91.

VIII

A CO-CREATED NETWORK COMMUNITY FOR KNOWLEDGE AND INNOVATIONS: PROMOTING SAFETY AND SECURITY IN THE ARCTIC

by

Ruoslahti Harri & Hyttinen Kirsi, 2017

Engaging People in a Disengaged World, Proceedings of the 23th International Public Relations Research Symposium BledCom, University of Ljubljana, pages 100–106

5

A Co-created Network Community for Knowledge and Innovations – Promoting Safety and Security in the Arctic

Harri Ruoslahti, Laurea University of Applied Sciences (Finland)
Kirsi Hyttinen, Laurea University of Applied Sciences (Finland)

Abstract

The cooperation between Arctic states – Russia, the United States, Canada, Denmark, Iceland, Norway, Sweden, and Finland – has been particularly peaceful while geopolitical tensions have risen elsewhere (Pezard et al., 2017). Discussions on prospecting Arctic natural resources (Haftendorn, 2016., p. 133) have raised new challenges also to knowledge and information management. Therefore, this paper argues that there is a need to develop a co-creation network among higher education and key end users, for knowledge and information sharing and promoting innovation, which will contribute on safety and security in the Arctic domain. The research question for this paper is: How can end users be involved in the process of creating a co-creation network for knowledge and information sharing to contribute on innovations to Arctic safety and security?

The method focuses mostly on the third phase of the Engeström's (2007) expansive learning process, *modeling a new solution*. This is a participatory work in progress. Beyond the desk review, the notes from co-creation network partner communication and meeting discussions have been and are gathered under the Chatham House rule (Chatham House, 2016) to ensure anonymity of all people participating in the process. Creating a new long-term co-operation program of higher education and end users, a co-creation network will attempt to engage a still disengaged field by affecting change to currently scattered and unlinked programs and systems, and build alignment of best practices. This co-creation network needs to be multi-disciplinary and multi-institutional to bring disparate security and safety management and other researchers and experts together with both one another, and with end-users. Online platforms can facilitate the information and knowledge sharing, as well as enable the co-creation of innovations among the network community. This paper provides a suggestion of the process for co-creation and knowledge exchange between the network members.

The enhanced Arctic research and study community aims to contribute to a safer, more secure and cleaner domain. Developing insights on sustainable economic growth, international processes and best practices, may lead to increased situational awareness as well as supports decision-making – for the benefit of the Arctic.

Key Words: Co-creation of knowledge, Innovation, Co-creation Network, Knowledge, Arctic Security

Introduction

The Arctic is the northern circumpolar region and its ice covered ocean (Heikkilä & Laukkanen, 2013). Economic and human activity is increasing there, partly because the climate of the Arctic is warming. The Arctic Ocean is projected to become nearly ice-free during the summer times within the next 30 to 40 years. Thus, global climate change is opening new Arctic possibilities, such as drilling for natural resources and new sea routes that cut distances between the Pacific and Atlantic oceans. But, these also present new challenges. "*Regardless of the risks involved, these Arctic routes and possibilities are a hot topic and shipping in the Arctic will most likely increase in the future*" (Salokannel, Knuuttila & Ruoslahti, 2015: p. 2).

The Northeast Passage between Europe and Asia is 30 – 40 % shorter than the route through the Suez Canal (Guy & Lasserre, 2016). There is still little traffic on the Northeast Passage, but it is constantly increasing. There is a growing need to cooperate and share information that benefits the security and safety of living, transport, and economic use in the Arctic environment (Ruoslahti & Knuuttila, 2016). "*The regulations concerning the safety of shipping, Arctic navigation services, and the readiness to prevent various accidents and to act in accident situations are badly inadequate… Surveillance arrangements in the Arctic sea area and cooperation between the authorities can be seen as an area of development …*" (Finland's strategy for the Arctic region, 2010, p. 28).
Also beyond the national strategies the necessitated additional multilateral strategies have been argued to ensure stable and harmonized priorities (Haftendorn, 2016. p. 134). European Maritime development, for example, seeks to respond to challenges facing the entire European maritime domain in an integrated and cross-sectorial way (European Coast Guard Functions Forum, 2014), which can serve as a working example also for the Arctic regions. The agreement of the Arctic Council on Cooperation in Aeronautical and Maritime Search and Rescue in the Arctic (Arctic Council, 2011) and the International Maritime Organization's (IMO) Guidelines for Ships Operating in Polar Waters (IMO, 2010) are important indicators of development towards proactive safety and security and coordinated coast guard functions related activities in the Arctic domain.

End users in this context are the affected communities living in the region, key political decision makers, private sector companies, shipping and drilling industries, with a presence on the Arctic seas; as well as the coast guard functions, who oversee security and safety in the region. Denmark, Norway, Russia, United States, and Canada have Arctic coastline. Also Sweden and Finland have Baltic Sea coast-line that becomes ice covered during winter months.

The focus of this paper is to investigate the process of involving public and private institutions, and, in particular of end users, in creating an enhanced Arctic research and study community. A network for knowledge and innovation contributing to Arctic safety and security that will involve the actors in active communication. A network of co-creation to promote safety and security on the Arctic domain (later: co-creation network) can add communication and new forms of cooperation through cross-sectorial and regional research and development in issues such as: common awareness, risk pictures, preparation against disaster, joint capacity building, resource pooling and innovations. Built network cooperation will benefit and add value to all sectors working towards a safer and more secure Arctic maritime domain.

This research question for this paper is: How can end users be involved in the process of creating a co-creation network for knowledge and information sharing to contribute on innovations to Arctic safety and security?

2. Literature review

2.1 A Safety and Security Gap in the Arctic

For a long time, the Arctic has been seen as an exceptional space, "an apolitical space of regional governance, functional co-operation, and peaceful co-existence" (Käpylä & Mikkola, 2015, p. 5).

The last decade has seen the Arctic re-emerge as a political component, due to the exceptionally rapid warming and reduction in the Arctic sea ice cover, which is especially noticeable during the summer months. The Arctic is opening up "and substantial natural resource bases as well as new maritime routes in the area were becoming more easily exploitable" (Käpylä & Mikkola, 2015, p. 6).

The Arctic includes the Northern fringes of Europe, Asia, and North-America. Besides the increasing economic and human activity in the Arctic regions, about 4 million people live there permanently. Research shows that the climate of the Arctic is warming (Heikkilä & Laukkanen, 2013). Between 2005 and 2010 was the warmest period ever measured in the Arctic and the extent of Arctic sea ice has never been recorded as low as it was in 2012 (European Commission, 2012).

The rate of the warming of the Arctic, and the decrease of the ice-cover have been surprisingly rapid. There is a great deal of pressure and increased strategic, political, and economic interest to the area. A future, where the Arctic Ocean could, much like the Baltic Sea around Finland today, freeze in winter and melt in summer is easily imaginable (Heikkilä & Laukkanen, 2013; Gascard, 2014).
Russia, for example is building an Arctic gateway of its sea route, the Northeast Passage. Its traffic is increasing and is expected to continue increasing (Zalyvsky & Eduardovna, 2015; Guy & Lassarde, 2016). Vessels are aided by nearly two dozen Russian icebreakers and protected by a string of 10 up-to-date search-and-rescue centres along the route. Continued increase in the near future on this Arctic gateway that the Russians are building between European and Asian ports is predicted. "*…to reduce risks, Russia imposed a mandatory piloting scheme along the northern sea route (NSR)*" (Guy & Lasserre, 2016; Gascarde, 2014).

Over 200 transit traffic vessels have passed through the Northeast Passage on Russia's Northern Sea Route between 2010 and 2014, with 71 in 2013 alone (Guy & Lasserre, 2016). Besides transit traffic, there are additional traffic, within the Arctic that load or unload cargo to and from the region, and transport of supplies to local communities or industry.

"*For the first time ever, an ice class 1A bulk carrier "Nordic Orion" 225 m long from the Nordic Bulk Carriers A/S Danish company, is using the North West Passage in September 2013 as a transit trade lane when transporting 75000 tons of coal from Vancouver, Canada to the port of Pori in Finland*" (Gascard, 2014, p. 13).

As activity in the Artic is increasing, the discussion on the safe use of Arctic resources is a very contemporary topic. This paper argues that there is a need to develop a co-creation network to increase knowledge and innovation, and to promote and ensure safety and security in the Arctic domain.

Fees paid by shippers, help cover costs of improvements to the sea route. This busier maritime transportation corridors are also starting to stimulate inland development; a railroad is planned to connect Russia's mineral-rich interior to its Arctic coast and liquid natural gas facilities on the coast are scheduled (Heininen, et. al., 2014; Lipponen, 2015).

The US Geological Survey (2011) estimates that the Arctic holds 30 % of undiscovered oil and 30% of undiscovered gas supplies, offshore and in depths of under 500 meters. This creates an increasing presence and development possesses specific safety and security challenges for maritime safety and security and Coast Guard functions (Guy & Lasserre, 2016; Salokannel, Knuuttila & Ruoslahti, 2015): Increasing economic activity and Arctic sea traffic may cause safety and environmental impacts. Arctic tourism, involving cruise ships in particular is increasing; and yet there are very limited monitoring and surveillance capabilities (Gascard, 2014).

Possible rescue operations will be extremely difficult in case of accidents and emergencies, as the northern coast of Russia, Alaska, and Canada are largely uninhabited and have few harbours. Possible oil discharges could inflict large areas while there is no real oil destruction response capacity available. Due to the lack of a regulatory framework, uncontrolled fishing may occur. There is a lack of international navigation aids and of common Risk analysis in Cost Guard Functions (Salokannel, Knuuttila & Ruoslahti, 2015; Ruoslahti & Knuuttila, 2016).

2.2 Knowledge and Innovations

Knowledge is an important source to competitive advantage and "*a key to the success of modern organizations and creative higher education*" (Pirinen, 2015, p. 1). The capability to create organizational knowledge is a key to innovate. The dynamic interactions among all level roles lead to creation of new

knowledge instead of individuals. Knowledge creation leads to continuous innovation and finally to competitive advantage. (Nonaka, I. & Takeuchi, H. 1995. p.6).

Co-created knowledge, knowledge from sharing experiences and knowledge with reflection, is a process of participation in work and social communities. These networks use common information sharing environments and build trust and confidence in one another through interactions between them. A collective responsibility to facilitate a collective R&D progress results in investigations; inventions and innovations (Pirinen, 2015). Co-creation feeds from common objectives and it can occur in both physical and digital arenas. (Bhalla, 2014), where the collaborators can share tools and collaborative processes. There should also be a structure of formal contracts between the collaborators. Valkokari et. al. (2012, p. 27), note that: "… *a strategic approach to knowledge management is a key element of success within networked innovation, both in the theory and in the practices*…".

The issue arenas model for organizational communication (Vos, Schoemaker, & Luoma-aho, 2014; Luoma-aho & Vos, 2010) explains multi-stakeholder communication, while Galvagno & Dalli (2014) note that co-creation is useful in promoting innovation, as is a strategic approach to knowledge management. A strategic approach is a key element of success in networked innovation, according to Valkokari, et. al. (2012).

Online platforms provide secured online possibilities for needed common information sharing environments, co-creative knowledge creation, and for sharing information and finally research results (Bhalla, 2014; Saarinen, 2012; Hosie, et. al., 2003). The computers made the delivery of education possible and the material were able to deliver both print and electronical media (Moore, 1990). The critical components of successful integration of technology innovations within education and training settings and influences the adoption rate of such technologies are transparency in user interface design and Human Computer Interaction (HCI) (Charalambos, 2004.). Shared information are needed in externally funded projects and innovation networks; participation in which is an important channel of knowledge transfer (Pirinen, 2015; Di Cagno, et. al., 2014); and where combining management of projects, networking, and learning is challenging (Ruoslahti, et. al., 2011).

3. Methodology

To build a basis for the creation of the co-creation network this study uses Engeström's (2007) expansive learning process together with the understanding of Nonaka & Takeuchi (1995) Knowledge Creation model to support innovations. The expansive learning process consists of the following phases: (1) Questioning existing practices, (2) Analysis of existing practices, (3) Modeling a new solution, (4) Exploring the new solution, (5) Adopting the new solution, (6) Evaluating the process, and (7) Solidifying and expanding new practices.
This paper focuses on the third phase of the expansive learning cycle, modeling a new solution. The method is participatory and a work in progress. Conclusions from co-creation network partner communication (meetings, discussions, workshops, events) are gathered under the Chatham House rule (Chatham House, 2016) to ensure anonymity of all people participating in the study. The data is collected from public sources, and from work completed 2011 – 2016. The data consists of the conclusions from discussions with policy maker representatives, and from the Laurea UAS internal documentation (documentation of European CISE (Common Information Sharing Environment roadmap and CISE Education Network). It also includes the notes from a cooperation workshop with World Maritime University in August 2014 and European Maritime Day 2015, and from Center for Island, Maritime, and Extreme Security – CIMES meetings 2011 - 2014. The data includes also the work conducted in ShipArc 2015.

4. Results

The results of this paper focus on the possible actors needed to a co-creation network in Arctic domain with its main aim. As this is still a work in progress, this paper is limited to the current situation and knowledge.

5.1 Coordination Structures on the Arctic Research and Development Actions

5.1.1 The Arctic Council

The Arctic Council is the most important international forum for cooperation in the region. The Artic Council is formally established in Ottawa Declaration of 1996 as high level intergovernmental forum which aims to provide a means for promoting cooperation, coordination and interaction among the Artic States (Arctic Council, 1996). The particular issues concentrate on sustainable development and environmental protection in the Artic. Canada, United States, Russia, Denmark (Greenland and the Faroe Islands), Iceland, Norway, Sweden, and Finland are member states of the Arctic Council together with permanent participants of six councils representing indigenous peoples of the Arctic. The Arctic Council promotes various forms of collaboration in the Arctic Region (Arctic Council, 1996).

The Arctic Council has a very broad scope, but the Agreement on Cooperation in Aeronautical and Maritime Search and Rescue (Arctic Council, 2011) demonstrates that safety and security in the Arctic domain are an important part of it. The co-creation network will be able to raise topics to the attention of the Arctic Council decision making and, thus increase awareness of safety and security related issues and solutions, and cooperation among its member states. The decision making may benefit from the work of co-created network community.

4.2 Networks of Researchers and University of the Arctic

An important form of collaboration are scientific research networks on Arctic issues; notable networks of Arctic research and education are the International Arctic Science Committee (IASC), providing guidelines for international science policy and research cooperation on the Arctic; the Association of Polar Early Career Scientists (APECS), promoting cooperation between students and researchers in

the early phase of their careers; and University of the Arctic, a network of close to 140 institutions from Arctic countries, enhancing research and student exchange, training between participating universities (University of the Arctic, 2013).
"*The University of the Arctic (UArctic) is a cooperative network of universities, colleges, and other organizations committed to higher education and research in the North. Our members share resources, facilities, and expertise to build post-secondary education programs that are relevant and accessible to northern students*" (University of the Arctic, 2013). To promote focus the UArctic has thematic networks. An alternative is, that the co-creation network be structured into a thematic network under the University of the Arctic.

5.3 Safety and Security on the Maritime Domain and Coast Guard Functions in Europe
European Maritime Policy seeks to respond to challenges facing the European maritime domain in an integrated and cross sectorial manner. Issues, named Coast Guard Functional activities, have been defined by the European Coast Guard Functions Forum (ECGFF) (European Coast Guard Functions Forum, 2014): The European coast guard functions are maritime safety and vessel traffic management; fisheries control; maritime border control, surveillance, security, customs activities, and law enforcement; also maritime environmental protection and response; accident and disaster response; and search and rescue at sea; plus other related activities (Figure 1).

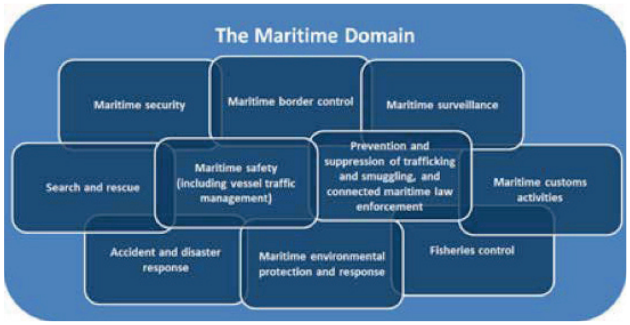

Figure-1: The Constructive Manner of the Terms of Reference (TORs) of Coast Guard Functions (European Coast Guard Functions Forum, 2014)

The European Union and its Member States are working towards a future of integrated non-military maritime surveillance and deeper Coast guard functions related coordination. This development will improve coordination and the wider implementation of platforms, such as EUROSUR (Frontex, 2015) and CISE – Common Information Sharing Environment, for example (European Commission, 2015).
Present national Coast Guard education systems mainly serve operational targets and are regulated by professional and organizational purposes; thus post-graduate, and post-doctoral, levels of education are not included.
A Co-creation Network could promote more unified requirements to educational institutions in the field (coast guard and other actors on the maritime domain). National authorities use, their own educational resources, and also those of other public and relevant private actors. To fully exploit the potential of an integrated maritime policy, the Coast Guard Functions approach could be extended to the academic and educational sectors (WMU Workshop, 2014).

Coast Guard Cooperation Networks
Coast Guard Cooperation Networks include: the Baltic Sea Region Border Control Cooperation (BSRBCC), the Northern Atlantic Coast Guard Forum (NACGF), the Black Sea Littoral States Border/Coast Guard Cooperation Forum (BSCF), the Mediterranean Coast Guard Services Forum (MEDFORUM), and the North Pacific Coast Guard Forum (NPCGF). They all have a regional maritime focus in maritime safety and security, environmental protection, combat of cross-border crime, and enhancement of information exchange (PERSEUS, FP-7 Project, 2013).

These networks represent the different authorities in charge of Coast Guard functions in each country. Thus each of these member organizations will also have educational and research structures and institutions such as mentioned above. The relevant coast guard cooperation networks for the arctic are the Atlantic, Baltic, and Pacific Coast Guard Forums (Figure 2), which cover the entire Arctic domain.

Figure-2: Relevant Northern coast guard cooperation networks for the co-creation network on the Arctic Domain

Today national Coast Guard educational institutions form bodies of knowledge through their interaction with practitioners on the field. Professional best practices are transferred from generation to generation both inside and outside of existing formal curricula. A coordinated, genuinely open and coast guard functions focused post graduate study environment for authority officers is now missing. For example, active coast guard personnel are not always as free, to address and discuss professional problems and lacking solutions in an open academic manner, as retired officers are (Third European Maritime Domain Security Planning Meeting, 2013).

5.5 The Added Value of an Arctic Co-creation Network Community
The Arctic co-created network community would benefit and add value to all sectors aiming towards a safer and more secure Arctic domain. As stated earlier current coast guard education systems lack post-graduate, and post-doctoral, levels of education, as well as matching levels of basic and applied

research and study. The co-creation network aims to be a multi-disciplinary cooperation body, bringing now disparate researchers and institutions together with other security and safety management, and coast guard functions oriented researchers and institutions. Thus, the co-creation network would have a clearly broader focus than existing coast guard institutions; but also a much more defined scope and focus than the University of the Arctic (Second European Maritime Domain Security Planning Meeting, 2012).

The purpose of this co-created arctic network community could add communication and new forms of cooperation through cross sectorial and regional research and development in issues such as common awareness, risk pictures, preparation against disaster, joint capacity building, resource pooling. All these developments will require open study and common mechanisms, such as the co-creation network would provide. One purpose is to complement existing coast guard forms of cooperation, one of the main ones being the European Coast Guard Academies Network Project initiative (Third ECGFF Secretariat Meeting, 2013).

The co-created arctic network community can broaden the focus of today's defined training oriented National Coast Guard Institution educational programs; while bringing focus to very broadly defined academic basic research and study networks, such as the University of the Arctic. Most added value will come from a cooperation and study platform for individual students and researchers interested in a multi-disciplinary approach toward security and safety of transport, and human and economic activity in the Arctic environment. The co-creation network will enhance information exchange and participation possibilities in EU and Government Agency funded research and development projects.

5.6 Participation and involvement

The co-created Arctic Network Community key participants will be institutes that either educate coast guard personnel or participate in research and development in topics, which are (loosely) under coast guard activities and processes topics as discussed above. Many educational and research institutions will not be official coast guard authority institutions, but have related programs to safety and security, maritime domain, and coast guard development and education issues. Potential institutions are those which focus on IMO based maritime safety aspects, security management focused institutions, relevant technological institutions, environmental research institutions, and those of customs authorities, etc. (WMU Workshop, 2014).

The co-creation network can help create long term involvements such as information and knowledge sharing which affect change into the current status quo of scattered and unlinked programs and systems. It can demonstrate new knowledge on how a cooperation should work in the future (e.g. in SAR) – not only technically, but also as a process to change the current mind-sets to cooperate more and share information to benefit the security and safety of living, transport, and economic use in the Arctic environment.

One working group of Arctic network community may focus on building the networks around research and studies that aim to lead to safer, more secure and cleaner seas, through sustainable economic growth. Better information and knowledge sharing will lead to better situational awareness and sound to decision-making – for the benefit of the Arctic seafarer. If the route of R&D related learning can be extended and generalized, higher education institutions will face new opportunities from their networked expertise (Pirinen, 2015): "… higher education institutions can increase their contribution to the innovation system; higher education institutions can keep co-creation and innovation processes alive at the regional, national and global levels;…"

Arctic network community development should also lead toward Artic security related online education. Education programs, which provide learning possibilities that are not tied to time or place. An as flexible of an approach as possible will empower students "to choose their own learning curriculum according their own interest. That is the benefit having so many universities and institutes on board" (Heinonen, 2016).

Artic safety and security education can be facilitated as online basis among and between network members. The platform can provide secured online possibilities for sharing the information and research results and related to the issued topics as well as facilitate the online learning. To integrate the social dimension into the pedagogy of online learning environments, Felix (2005) has proposed the synthesis of the cognitive constructivist and social constructivist approaches. This online learning will follow constructivist understanding and the constructivism can be manifested in online settings; e.g. as defined above (Hosie, Clifton, & Joe, 2003).

In a role of an individual expert (researcher, student, other expert), the expert will have the wide selection offering the various participating institutions sharing research results, created knowledge and information and finally study curriculum based on individual and professional preferences to result in a PhD or a multi-disciplinary Master's or Doctorate of Business Administration. Authority officials will have a broader venue of advancing their knowledge and education (Third European Maritime Domain Security Planning Meeting, 2013; Gröndahl, et. al., 2014).

The research of co-creation range between the smallest collaborative innovation in new product development processes to a wider theory of co-creation research stream (Galvagno & Dalli, 2014), and a co-creation network can be active throughout this spectrum. A co-creation network will need common objectives to work towards, it will exist and operate in both digital and physical arenas, share cooperation tools and collaborative processes, and we shouldn't forget contracts between the collaborators (Bhalla, 2014).

Conclusions

Creating a new long-term co-operation among Arctic experts, a co-creation network community can engage a still disengaged field by affecting change to currently scattered and unlinked programs and systems, and build alignment of best practices. New knowledge and more effective future cooperation, technically and as a process, may bring about a change of current mind-sets and provide further innovations to meet with the set objectives. This research aims to provide insights on ways to involve end users in the co-creation process. This could help other collaborative problem solving processes that need input of end users.

This co-created Arctic network community needs to be multi-disciplinary and multi-institutional, bringing disparate security and safety management and communication researchers together with both one another, and with end-users. An online platform will serve learning online and sharing research results and co-creation information between the network members and experts.

The co-creation network aims to broaden the focus of today's defined training oriented national coast guard institution educational programs, and create broadly defined academic basic research networks and larger community bringing all end users to the same network. This should provide an opportunity to experience a multi-disciplinary approach toward security and safety of activities in the Arctic. The enhanced Arctic research and study society aims to contribute to a safer, more secure and cleaner domain, and develop insights on sustainable economic growth, international processes and best practices, leading to increased situational awareness and decision making – for the benefit of the Arctic.

Also, the education programs in this context can provide learning possibilities that are not tied to time or place. A flexible approach may enable students across the network to choose a learning curriculum based on content and interest. This paper suggests that the co-created Arctic network community should also award higher levels of post post-graduate and post-doctoral education. The network can be a UArctic thematic network, having a much more defined scope and focus on coast guard functions, security, and safety on the Arctic maritime domain than the University of the Arctic itself; while also having a clearly broader higher education focus than any coast guard institution or their cooperation networks.

Further work will focus on the process of co-creation and knowledge exchange between the network members to identify ideal modes of cooperation.

Acknowledgements

With warm memories we acknowledge the influence to this idea of our dear friend and colleague Juha Knuuttila, who unfortunately passed away last in the fall of 2016. We miss you!

References

- Arctic Council (1996). Declaration of the Establishment of the Arctic Council – Joint Communique of the Governments of the Arctic Countries on the Establishment of the Arctic Council, 19th of September 1996, Arctic Council, Ottawa, Canada.
- Arctic Council, 2011. Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic. Arctic Council Secretariat, Tromsø: Norway.
- Artic Council (2014). About the Artic Council. From: www.artic-council.org.
- Artic Portal. 2014. http://www.arcticportal.org/, Accessed 25th April 2016.
- Bhalla,G. (2014). How to plan and manage a project to co-create value with stakeholders, Strategy & Leadership, 2014, 42, 2, 19-25, Emerald Group Publishing, Limited, Chicago, United Kingdom, Chicago.
- Charalambos, V., Michalinos, Z. Chamberlain, R. 2004. The Design of Online Learning Communities: Critical Issues. Educational Media International. ISSN 1469-5790 online © 2004 International Council for Educational Media.
- Chatham House, Royal Institute of International Affairs (2016). Chatham House Rule, Retrieved April 21, 2015, from http://www.chathamhouse.org/about/chatham-house-rule, Accessed 4th April 2016.
- Di Cagno,D., Fabrizi,A., & Meliciani,V. (2014). The impact of participation in European joint research projects on knowledge creation and economic growth, Journal of Technology Transfer, 2014, 39, 6, 836-858, Springer Science & Business Media, Indianapolis, Netherlands.
- Engeström,Y., Kerosuo, H., & Kajamaa, A. (2007). Beyond Discontinuity: Expansive Organizational Learning Remembered, Management Learning, 2007, 38, 3, 319-336, Sage Publications Ltd., Thousand Oaks, United Kingdom.
- European Coast Guard Functions Forum (2014). Non Paper - July 8th 2014. Unpublished.
- Felix, U. (2005). E-learning pedagogy in the third millennium: The need for combining social and cognitive constructivist approaches. ReCALL, 17(1), 85-100.
- Gascard, J-C. (2014). ACCESS – Arctic Climate Change, Economy and Society. Arctic research funded by the European Union. Research and Innovation, edited by Immler F., European Commission
- Guy, E., & Lasserre, F. (2016). Commercial shipping in the arctic: New perspectives, challenges and regulations. The Polar Record, 52(3), 294-304.
- European Commission DG-MARE (2015). From: http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/cise/index_en.htm, Accessed 16th April 2016.
- European Commission, Education & Training (2013). From: http://ec.europa.eu/education/higher-education/bologna_en.htm, Accessed 16th April 2016.
- Finland's Strategy for the Arctic Region (2010). Prime Minister's Office Publications 8/2010, 5 July 2010 Helsinki, Finland.
- Frontex (2015). From: http://frontex.europa.eu/intelligence/eurosur, Accessed 3rd March 2016.

- Galvagno,M., & Dalli,D. (2014). Theory of value co-creation: a systematic literature review, Managing Service Quality, 2014, 24, 6, 643, Emerald Group Publishing, Limited, Bedford, United Kingdom.
- Gröndahl, M., Hookana, R., & Rajamäki, J. (2014). Emergency Management Module UArctic Network Online Course, Interactive Collaborative Learning (ICL) International Conference on 3rd – 6th of Dec. 2014, Dubai.
- Haftendorn, H. (2016). Arctic Security – new challenges in a diverse region. In Krause, J. & Bruns, S. (2016). Routledge Handbook of Naval Strategy and Security. Routledge, 2016.
- Heikkilä, M. & Laukkanen, M. (2013), the Arctic Calls, Arctic University of Lapland & Ministry of Foreign Affairs, Finland.
- Heininen, L., Sergunin, A., & Yarovoy, G. (2014). Russian Strategies in the Arctic: Avoiding a New Cold War. Valdai Discussion Club, Moscow, September 2014.
- Heinonen, J. (2016). International Security MBA – Tailored Safety and Security. UArctic Shared Voices Magazine 2016.
- Hosie, P., Clifton, L. Joe, L. (2003). Security Management Education Online. http://www.ascilite.org.au/conferences/adelaide03/docs/pdf/244.pdf, Accessed 25th April 2016.
- International Maritime Organization (IMO) (2010). Guidelines for Ships Operating in Polar Waters. Resolution A.1024(26).
- Käpylä, J., & Mikkola, H. (2015). On Arctic Exceptionalism, Critical Reflections in the Light of the Arctic Sunrise Case and the Crisis In Ukraine. 85 FIIA Working paper, The Finnish Institute of International Affairs.
- Lipponen, P. (2015). A Strategic Vision for the North – Finland's prospects for economic growth in the Arctic región. Confederation of Finnish Industries EK, March 2015
- Luoma-aho, V., Vos, M. (2010). Towards a more dynamic stakeholder model: acknowledging multiple issue arenas. Corporate Communications: An International Journal, Vol. 15 No. 3, 2010, pp. 315-33, Emerald Group Publishing Limited.
- Moore, M. G. (1990). Background and overview of contemporary American distance education.
- Nonaka, I. & Takeuchi, H. 1995. The Knowledge-Creating Company – How Japanese Companies create the dynamics of Innovation. Oxford University Press. New York 1995.
- PERSEUS, FP-7 Project (2013). Baltic Sea Region Maritime Border Surveillance Cooperation, Laurea University of Applied Sciences.
- Pezard, S., Tingstad, A., Van Abel, K., Stephenson, S. (2017). Maintaining Arctic Cooperation with Russia: Planning for Regional Change in the Far North. Rand Corporation, 2017.
- Pirinen,R. (2015). Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers, Creative Education, 2015, 6, 3, 315-330, Scientific Research Publishing, Irvine, United States.
- Ruoslahti, H., & Knuuttila, J.S. (2016). Remotely Piloted Aircraft Systems (RPAS) for Extreme Missions in the Arctic and the monitoring of the Ukraine crisis by the Organization for Security and Co-operation in Europe (OSCE), Hawaii International Conference on System Sciences, HICSS-49, Grand Hyatt, Kauai, Hawaii, USA, 5-8 January 2016.
- Ruoslahti, H., Tiainen, S., Kortelainen, M., & Vesterinen, O. (2011), How Networking and Projects Can Best Promote Learning in Higher Education? Campus Encounters – Bridging Learners Conference "Developing Competences for Next Generation Service Sectors" April 13–14, 2011, Porvoo, Finland
- Saarinen, L. (2012). Enhancing ICT Supported Distributed Learning through Action Design Research. Aalto University publication series, Doctoral Dissertations 92 7 2012, Helsinki.
- Salokannel, J., Knuuttila, J., & Ruoslahti, H. (2015). Arctic Maritime Safety and Security– the Human Element seen from the Captain´s Table, International Conference on "Safe and Sustainable Shipping in a Changing Arctic Environment" ShipArc 2015, AUGUST 25-27, 2015, Malmö Sweden.
- Second European Maritime Domain Security Planning Meeting (2012). Hosted 10th – 11th of August 2012 by Laurea University of Applied Sciences, Meri-Teijo, Finland.
- Third ECGFF Secretariat Meeting (2013). Held in Athens, 04th of July 2013. Unpublished.
- Third European Maritime Domain Security Planning Meeting (2013). Hosted 2nd – 3rd of August 2012 by Laurea University of Applied Sciences, Meri-Teijo, Finland.
- University of the Arctic (2013). From: http://www.uarctic.org/Frontpage.aspx?m=3, Accessed 25th April 2016.
- US Geological Survey (2011). U.S. Geological Survey circum-arctic resource appraisal. Society of Petroleum Engineers - Arctic Technology Conference 2011 proceedings, pp. 219 – 222, February 2011, Houston, TX.
- Valkokari, K., Paasi, J., Rantala, T. (2012). Managing knowledge within networked innovation, Knowledge Management Research & Practice, 2012, 10, 1, 27-40, Palgrave Macmillan, Basingstoke, United Kingdom.
- Vos, M., Shoemaker, H., Luoma-aho, V., L. (2014). Setting the agenda for research on issue arenas. Corporate Communications: An International Journal, Vol. 19 No. 2, 2014, pp. 200-215. Emerald Group Publishing Limited.
- WMU Workshop (2014). Workshop between World Maritime University – Laurea University of Applied Sciences on European University of Coast Guard Functions, Hosted 29th of September 2014 by the World Maritime University, in Malmö, Sweden.
- Zalyvsky, N. P., & Eduardovna, T. V. (2015). The Northern Sea Route: the potential of expectations and the real functioning problems. Arctic & North, (20), 32-50.