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**A MODEL OF ADAPTATION TO
A DISTRIBUTED LEARNING
ENVIRONMENT**

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Abstract

The first objective of the study was to both develop and test empirically the hypothesized structural equation model (SEM) of adaptation to a distributed learning environment (DLE). Based on the literature reviewed, prior computing experience, computing skills, attitude toward computers, and knowledge of English were chosen as the variables affecting adaptation. The empirical data for the study were gathered by a web questionnaire on the Internet. The online study involved 64 adult learners and 38 instructors (n = 102) from the Finnish nationwide OpinNet –project, which is the project started and coordinated by the National Board of Education.

Consistent with the hypotheses, attitude toward computers was found to have an effect on adaptation to a DLE. In addition, prior computing experience, computing skills and language skill all had an effect on the attitude toward computers. Prior computing experience also had an effect on computing skills. An unexpected finding was the apparent lack of relationship between prior computing experience, computing skills, language skill and adaptation to a DLE. Adaptation to a DLE can therefore be regarded more as an attitudinal question than as one based on experience or skills.

The second objective of the study was to determine the role of learning styles in adaptation to a DLE. The analysis of learning style differences in adaptation to a DLE was performed outside the context of the model by using analysis of variance (ANOVA). As hypothesized, none of the four learning style groups differed in their adaptation to a DLE and therefore the results reinforced the view that a DLE is an adaptive learning environment for learners with different learning styles.

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Tutkielman tekijä
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Tutkielman nimi
Hajautettuun oppimisympäristöön sopeutumisen malli

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Asiasanat (hakusanat)
Asenne tietokoneita kohtaan, aiempi tietotekninen kokemus, hajautettu oppiminen, hajautettu oppimisympäristö, oppimistyyli, rakenneyhtälömalli, tietotekniset taidot

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Tiivistelmä

Tutkimuksen ensimmäisenä tavoitteena oli sekä kehittää että empiirisesti testata rakenneyhtälömalli sopeutumisesta hajautettuun oppimisympäristöön. Tarkasteltuun kirjallisuuteen perustuen aiempi tietotekninen kokemus, tietotekniset taidot, asenne tietokoneita kohtaan ja englanninkielen taito valittiin sopeutumiseen vaikuttaviksi tekijöiksi. Empiirinen aineisto tutkimukseen kerättiin Internetissä toteutetulla verkkokyselyllä. Tutkimukseen osallistui 64 aikuisoppijaa ja 38 ohjaajaa ($n = 102$) kansallisesta Opetushallituksen käynnistämästä ja koordinoimasta OpinNet –projektista.

Asetetun hypoteesin mukaisesti, asenteen tietokoneita kohtaan todettiin vaikuttavan hajautettuun oppimisympäristöön sopeutumiseen. Lisäksi aiempi tietotekninen kokemus, tietotekniset taidot ja englanninkielen taito vaikuttivat asenteeseen tietokoneita kohtaan. Tietoteknisellä kokemuksella oli myös vaikutus tietoteknisiin taitoihin. Odottamaton tulos oli yhteyden puuttuminen tietoteknisen kokemuksen, tietoteknisten taitojen ja kielitaidon sekä hajautettuun oppimisympäristöön sopeutumisen välillä. Tulosten mukaan hajautettuun oppimisympäristöön sopeutuminen voidaankin nähdä enemmän asenteellisena kysymyksenä kuin perustuen kokemukseen tai taitoihin.

Tutkimuksen toisena tavoitteena oli tarkastella oppimistyylien merkitystä suhteessa hajautettuun oppimisympäristöön sopeutumiseen. Analyysit oppimistyylieroista suhteessa sopeutumiseen suoritettiin mallin ulkopuolella käyttämällä varianssianalyysiä. Oletuksen mukaisesti, mikään neljästä eri oppimistyyli ryhmästä ei eronnut toisistaan suhteessa sopeutumiseen ja täten analyysin tulokset tukevat näkemystä hajautetun oppimisympäristön mukautumisesta eri oppimistyyliihin.

Työn ohjaajana on toiminut: professori Tapio Vaherva

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1 THE NEED FOR FLEXIBLE LEARNING OPPORTUNITIES

"...It might well be said that learning is an increasing occupation for us all; for every aspect of our life and work, to stay abreast of events and to keep our skills up to the 'state of the art' requires more and more of our time and energy".

Kolb 1984, 2

Nowadays, keeping up with the changes and progress is an "increasing occupation" for everyone. But at the same time as the term lifelong learning has become a vogue word and the need and desire for continuing education has arisen, the need for flexible learning opportunities has also been kindled. The spark was lighted by adults who were unable to attend courses or preparatory training because of the barriers of time and place.

The development of distance education made participation possible independent of time and place. As broadly defined, distance education means any approach to education delivery that replaces the same-time, same-place, face-to-face environment of a traditional classroom (Lotus Development 1996). At first, distance education was utilized mainly by postal courses, but this, however, ignored the power of group work –

the one important part of learning experience (see e.g. Hiltz 1994, Gokhale 1995, Kearsley & Shneiderman 1998, Oliver, Omari & Herrington 1998, Stacey 1998).

The introduction of personal computers along with global networking offered new opportunities and challenges for the development of flexible education and training in the form of distance education. In addition, new learning environment solutions supported not only flexible, but also collaborative learning. Collaborative learning means that both teacher and learner are active participants in the learning process; knowledge is not something that is “delivered” to students (cf. distance education), but rather something that emerges from active dialogue among those who seek to understand and apply concepts and techniques (Hiltz 1994, 23). A new possibility for lifelong learning saw the daylight, and the fire was extinguished.

One application tool combining the benefits of distance education and collaborative learning is a distributed learning environment (DLE) developed by Lotus, called LearningSpace.¹ In this study distributed learning refers to a type of distance education which is technology-enabled, learning-team focused, facilitated by a content expert, and delivered anytime and anywhere (Lotus Development 1996). Distributed learning as a new pedagogical paradigm is considered through the distributed learning framework which includes the learning objectives, instructional models and enabling technologies.

Previous studies indicate that the learning environment has significant effects on the learning process and its outcomes (e.g. Hayes & Allison 1997, Tynjälä 1998, Wong & Watkins 1998). Therefore adaptation to a learning environment by learners and instructors alike is important. However, the research concerning adaptation to a DLE is limited, in fact non-existent. More studies have been made of the learning outcomes in computer-assisted and web-based learning environments (e.g. Ester 1994, Hiltz 1994,) as well as of their implementation strategies (e.g. Oliver, Omari & Herrington 1998). The implementation is in most cases viewed as a kind of an external force, which is better assessed objectively by an “outsider”. Thus, implementation is regarded more as an administrative procedure than as a personal experience. At the same time most of these studies have focused on the technological features, overlooking the individual and the social content of the learning environment. The technology cannot, however, make a difference by itself; the learning and instructional paradigms need

¹ Lotus and LearningSpace are registered trademarks of Lotus Development Corporation.

to be reformed as well. Adaptation is, by contrast, considered a more internal process of learners, instructors, and learning teams as they begin to use the DLE for their educational purposes, and is best evaluated through learners' and instructors' self-reported, subjective experiences. Therefore, this technologic-pedagogical study tends to focus on the pedagogical, rather than on the technological aspects of a DLE.

Neilson (1997) has also called for additional research on factors that have been proposed to explain individuals' adaptation to, evaluation and use of collaborative technologies. In addition, Clegg, Carey, Dean, Hornby, and Bolden (1997) have expressed the need for the specification of multivariate models to guide further empirical, theoretical and practical developments of implementation and use of information technology. They also argue that models of this kind could be used as aids in managing the development, implementation and use of information technology and have therefore also some potential for practical application. The models can also be seen as a delineation of some necessary but not sufficient factors predicting successful outcome, adaptation to a DLE. (Clegg et al. 1997.)

The theoretical aim of this study is to both develop and test the structural equation model (SEM) for adaptation to a DLE. On the basis of previous research findings and theories, prior computing experience, computing skills, attitude toward computers, and knowledge of English were chosen as the latent variables affecting adaptation. Also an analysis of learning style differences in adaptation to a DLE is performed by using the analysis of variance (ANOVA) to see if adaptation varies between the four different learning styles. However, the purpose of this study is not only to consider this phenomenon theoretically for the first time, but also to provide practical information, which can be applied immediately to courses where implementation of a DLE is of current interest. Thus the aim is also to provide knowledge to guide subsequent implementation of a DLE, to offer information for instructors so that they can help learners to adapt to a DLE and to provide useful information for the future development of the DLE.

The structure of this study differs from "conventional" studies in that the hypotheses are presented along with the theory instead of presenting them with the methods, in a chapter separate from the theoretical basis. In this study, the previous research findings and theories serve as an important base for and are closely linked to the formation of the hypotheses. The theoretical basis guides the formation of the hypotheses and

also the development process of the structural equation model of adaptation to a DLE. The construction of the theoretical basis and the formation of the hypotheses together form a process where the two proceed simultaneously. Therefore the decision was made to present the hypotheses in their theoretical contexts. This decision was also made to help the readers to follow the formation of each hypothesis and to help them to find the premises for each of the hypothesis formed.

2 FROM DISTANCE EDUCATION TO DISTRIBUTED LEARNING

Distance education is primarily used to overcome the barriers of time and place. A basic definition of distance education describes it as the delivery of the educational process to receivers who are not in proximity to the person or persons managing or conducting the process (Lewis, Whitaker & Julian 1995, 14). In this study the term distance education is used broadly to mean any approach to education delivery that replaces the same-time, same-place, face-to-face environment of a traditional classroom (see Lotus Development 1996). However, in its instructional setting distance education itself is similar to the traditional classroom. As indicated by the definitions the “delivery” of education is seen as the main purpose. The education is delivered from point A to point B without much pedagogical consideration. As a result, distance education is often seen as a “half a loaf” pedagogy: better than nothing, but not as good as face-to-face instruction (Dede 1996a, 1996b).

The development of technology and worldwide networking together with innovative pedagogical changes made possible a transformation of conventional distance education into a new pedagogical paradigm: distributed learning (Dede 1996a, 1996b). Distributed learning is a type of distance education, which is defined as technology-

enabled learning-team focused education, facilitated by a content expert, and delivered anytime and anywhere (Lotus Development 1996). In addition to distance education, emerging forms of distributed learning are also reconceptualizing the mission, participants, process, and content of education (Dede 1996a). A pedagogical shift from an instructional paradigm to a learning paradigm is required in the transition from distance education to distributed learning. At the same time the role of computers in the learning process shifts from a delivery media to a communication tool (see e.g. Lotus Development 1996, Kearsley & Shneiderman 1998, Laurillard 1995). In distributed learning the aim is not to achieve the quality of face-to-face instruction, but to achieve even more; the growing need for flexible education is meant to be fulfilled not by sacrificing, but by improving the quality of the learning experience. A variety of technologies, learning methodologies, online collaboration, and instructor facilitation are used to achieve the applied learning results not possible in traditional education (Lotus Development 1998).

Dede (1996a, 1996b, 1997) has determined the three new forms of expectation that shape the emergence of distributed learning as a new pedagogical model. According to him the three novelties are: (1) knowledge webs such as the Internet and the World Wide Web complement teachers, texts, libraries, and archives as sources of information, (2) interactions in virtual communities complement face-to-face relationships in classrooms, and (3) experiences in synthetic environments extend learning-by-doing in real world settings. In addition, Dede (1997) has even predicted that the term distance education will become outmoded ten years from now. In his view there is going to be only distributed learning, which takes place sometimes face-to-face, sometimes across a distance and sometimes involving teaching-by-telling, but always involving the innovative pedagogy used in distributed learning.

2.1 A Framework for Distributed Learning

Lotus Development (1996) has constructed a framework for distributed learning, which integrates learning objectives, instructional models and enabling technologies (see Figure 1). It describes the improvement in the quality of learning, the changes in the learners - instructor relationship and the new opportunities for collaboration through the development of technologies. It also describes the progress from an instructor centered, information transfer type of distance education to a pedagogically more merited distributed learning.

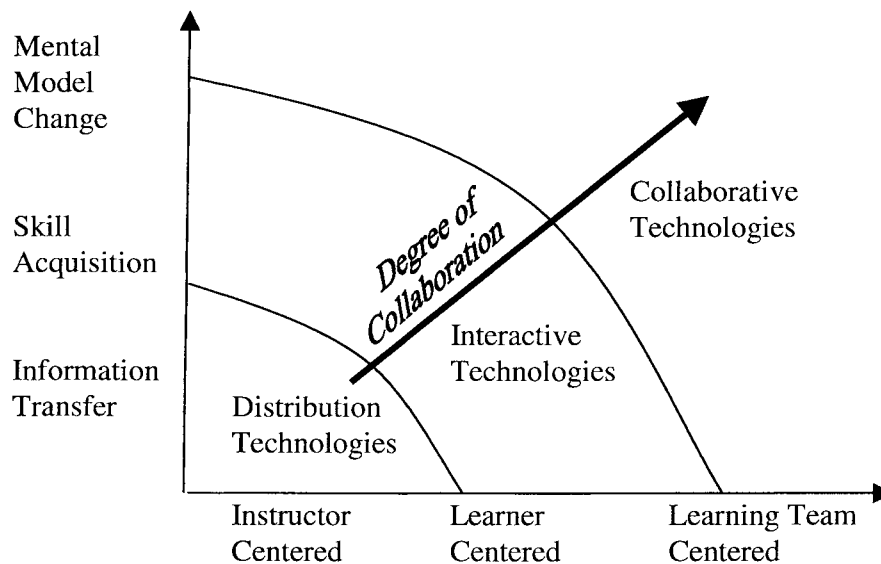


FIGURE 1 A Framework for Distributed Learning (Lotus Development 1996).

Considering the framework, it is important to note that the transformation from distance education to distributed learning doesn't mean that all 'traditional' learning methods have to be overlooked. For example, individual learning still has an important role in the learning process just like all the other categories in the distributed learning framework. In fact, most learning will probably require a mix of the categories: a mix of

learning objectives as well as of individual and team learning. Therefore the DLE should be constructed to support the full range of learning objectives and instructional approaches. For example, choosing the appropriate instructional model doesn't mean that the same model has to be used throughout the whole course; "mixed" models can be used to suit the learner, the learning objectives and so on.

2.1.1 Learning Objectives

Learning objectives, the desired outcomes of a learning process, are often thought of in very specific terms relating to a particular course and its content. Such learning is usually assessed by tests measuring the knowledge relating to the specific subject in question. Learning objectives can, however, be thought of more broadly in terms of *the type* of the desired learning outcome (see Hiltz 1994, Lotus Development 1996, Thach & Murphy 1995). For example, the Finnish nationwide competence-based qualification system is based on voluntary preparatory training, in which learning objectives include the vocational as well as the social skills required in working life. Vocational competence is assessed by skills test concluded under real life working situations.

Kolb (1984) classifies three learning objectives that must be considered in curriculum design: content objectives, learning style objectives, and growth and creativity objectives. Thach and Murphy (1995) again, divide the type of learning objectives to cognitive, performance-based, and attitudinal. These classifications resemble the three broad learning objective categories in the distributed learning framework, which are: (1) information transfer, (2) skill acquisition, and (3) mental model change.

Information transfer. In terms of learning this objective refers to acquiring and memorizing information rather than interpreting it. Learning is comprised only of memorizing facts, terminology, and methodology without understanding. It resembles the content objective of Kolb (1984), the cognitive objective of Thach and Murphy (1995), and the first level of Bloom's Taxonomy called a knowledge level (see e.g. Driscoll 1994, 334-338; Jonassen & Grabowski 1993, 7-9). Despite the fact that information transfer is nowadays often regarded as an undesirable learning outcome *on its own*, it plays an important part for instance in vocational education; the knowledge of

electrical regulation is essential for a person pursuing vocational qualification in Electrical Engineering. On the other hand, potential “information colic” in networks as well as in ‘closed’ educational environments may be a disadvantage for the learning process and its outcomes. Along with the development and increasing use of information networks, the challenge of not getting enough information is changing into the challenge of surviving too much information (Dede 1996a, Lotus Development 1996).

Skill acquisition. When learning and learning objectives are considered more widely than in terms of knowledge transfer, skill acquisition is often seen as the second, deeper level of learning; an ability to apply knowledge to doing. The performance-based learning objective of Thach and Murphy (1995, 44) also includes the view that “learners have to do something, such as soldering a piece of metal, using checklist, or demonstrating negotiation skills”. In these cases practicing is considered as the key word. Kolb (1984) handles the skill acquisition objective mainly through learning style objectives. He combines learning style with certain skills, and, therefore, by developing the features of one or more learning styles the learner can acquire an ability to learn from a variety of learning perspectives (Kolb 1984, 203). This view supports strongly the idea of lifelong learning, which has been one of the main issues in the notion of learning as an “increasing occupation”. In accordance with the principles of lifelong learning, the ability to combine work and studies along with vocational competence has increased in importance. Also, acquiring the “information society skills”, the basic skills of acquiring and managing information, communicating, and using information technologies, is described as one of the main objectives in the Finnish National Information Society program, both in education and in the whole society (see Ministry of Education 1995, 40-44). The supply of training opportunities related to information society skills is considered an important way to improve those skills in adult education.

Mental model change. When learners interact with the environment, for instance with other people or computers, they develop interpretive representations that drive their performance (Norman 1983). These representations are mental models, which Senge (1993, 8) defines as a set of deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action. Very often, people are not consciously aware of their mental models or the effects they have on their behavior. The attitude-related objectives of Thach and Murphy

(1995), as well as the growth and creativity objective of Kolb (1984), resemble mental model change. Dede (1997) describes the “knowledge webs” as a kind of a shared mental model for society.

Mental models change through learning and experience. The change can be understood either as the development of new models or as the revision of already existing ones. (Driscoll 1994, Hinsz 1995.) When considering learning and learning goals, mental models may be regarded as “higher order goals” – as Driscoll (1994) calls them – than the knowledge and skill objectives mentioned above. Constructivism as a new pedagogical paradigm is also connected to mental model change. The process of articulating mental models and the ability to use these models to explain, predict and infer, as well as the ability to reflect on their utility all play an important part in the construction of knowledge (see Driscoll 1994, Jonassen 1994).

2.1.2 Instructional Models

Effectively designing a course or a curriculum requires the matching of the learning objective with a specific instructional model (Lotus Development 1996). Thach and Murphy (1995) suggest that cognitive goals are best achieved by using presentation-type approaches like lectures, printed materials and videotapes. Performance-based objectives require approaches that allow learners to practice skills, like simulations, games and exercises, whereas attitude-related objectives are best taught through reflection and dialogue, using team discussions and projects. (Thach and Murphy 1995.) In accordance with these principles, instructional models have been divided in three categories also in the framework for distributed learning. The categories are: (1) instructor centered, (2) learner centered, and (3) learning team centered (Lotus Development 1996).

Instructor centered. The traditional instructor centered approach is most often used when the learning objective is transfer of information and knowledge. It assumes that the instructor is the expert controlling the learning process. When learners are taught in this way, as passive recipients of knowledge, they have no incentive to construct their own knowledge and have little motivation to retain information or transfer its use to novel situations. Most face-to-face classes, correspondence courses, and text-

book learning follow the instructor centered approach. (Berge & Collins 1995, Hiltz 1994, Lotus Development 1996.) On the other hand, many students are used to instructional designs like this and may even prefer an instructor centered approach in their training (see e.g. Miglietti & Strange 1998). So, this perspective must also be considered when adult education and training are planned and practiced, as well as in the planning of the use of computers and networks or in implementing new technology-based learning environments to education.

Learner centered. In the learner centered approach the instruction is arranged to meet individual learner needs, for instance by using personal study programs and self-paced learning. The pedagogical assumption of the approach lies in the interpretation of observed and experienced information. In this way, the risk of treating learners again like passive recipients, whose instruction is now just individualized, is tried to be avoided. However, independent learning can often leave a learner passive and inactive (Oliver, Omari & Herrington 1998). Computer-assisted learning as well as many computer simulations and term projects use the learner centered approach. (Lotus Development 1996, Cohen 1997.) This individual learning paradigm is often emphasized as being a notable advantage of distance education, whereas in distributed learning it is only regarded as one part of the learning process, which can be ‘completed’ with collaborative team learning.

Learning team centered. The fundamental idea of the learning team centered approach lies in the collaboration between the learners and the instructor. *Collaborative learning* means that both the teacher and the learner are active participants in the learning process; knowledge is not something that is “delivered” to students, but rather something that emerges from an active dialogue among those who seek to understand and apply concepts and techniques (Hiltz 1994, 23). Also Senge (1993, 10) mentions “dialogue”, the capacity of members of a team to suspend assumptions and enter into a genuine “thinking together” as a start of team learning. Marks (1998), on the other hand, talks about “the Gestalt learning model”, where the focus is on the group; learning is a communal instead of an individual process and competition between students is unnecessary. However, collaborative learning does not mean that the whole learning process has to be common for the whole team; it can also be self-paced and ‘individual’ when the objectives, the sequence and the ‘tempo’ of learning are considered. Collaborative

learning is also not meant to be used only for achieving changes in mental models, but also for attaining other learning objectives (Lotus Development 1996). Collaboration between learners can also be regarded as an overall learning object similar to acquiring the “information society skills” mentioned above (see e.g. Christiansen & Dirckinck-Holmfeld 1995).

Research frequently shows that there are clear educational advantages to be derived from collaborative activities among learners (e.g. Hiltz 1994, Gokhale 1995, Kearsley & Shneiderman 1998, Oliver, Omari & Herrington 1998, Stacey 1998). Especially the development of critical thinking is found to be a remarkable advantage (Gokhale 1995), as well as the preparation of learners for working life where teamwork is becoming more popular (Beckman 1990). Westera and Sloep (1998) emphasize also the dual function of collaboration. According to them, collaboration not only supports the use of effective discursive learning methods, but it also promotes the acquisition of essential social and communication skills. Schön (1983) emphasizes that collaboration skills not only make people responsive to change, but are also more likely to make people innovators of change through “reflection-in-action”. However, collaborative learning is not suitable and effective for every learner and in every situation (Wang 1998). Therefore it should not be applied to education and training implicitly, but with careful consideration. Because of this also the individual, learner-centered and self-paced learning should be maintained when instructional models are considered.

2.1.3 Enabling Technologies

There appear to be important pedagogical differences between technologies. Some technologies are ‘real-time’, synchronous; others asynchronous. Some technologies are one-way; others two-way. Some are permanent; others are transient. (Bates 1995, 9.) The features of different technologies must be carefully thought over when choosing the suitable medium or media for educational purposes. Learning objectives and instructional models serve as a meaningful base for the selection of a particular technology. Thach and Murphy (1995, 45) present the following rule of thumb for matching goals and approaches with technology: “If the goals are cognitive and the approaches are

presentation-based, a low-cost, noninteractive technology is sufficient. But if the goals are attitude- or performance-based and the approaches are interactive, the technology must be interactive". Thach and Murphy (1995) use the term interactive technology to indicate technologies containing a built-in channel for two-way communication, for example simulation and videoconferencing. In this study technologies are similarly divided into noninteractive distribution technologies and interactive technologies, but two different types of interactive technologies are distinguished: interactive and collaborative technologies.

Distribution technologies. Distribution technologies mostly support the instructor centered approach along with the information transfer type of learning objective. These technologies often require that learners receive the instruction at a specific time, although they do allow geographic flexibility, as for example in the case of educational television. (Lotus Development 1996.) Probably the best known – at least the most discussed - distribution technology today is the World Wide Web (WWW). The size of the Web has been increasing rapidly since the early 1990's, reaching some 100 million plus web pages by 1998 (Crampton 1998). However, the WWW has also caused the problem of information abundance and especially the challenge of separating proper knowledge from false or outdated information. In addition, it has to be remembered that access to data does not automatically expand a students' knowledge; the availability of information does not intrinsically create an internal framework of ideas that learners can use to interpret reality. Therefore these "information superhighways" are best utilized as information sources to complement instructors, texts, libraries and so on (see Dede 1996a, 1996b, 1997).

Interactive technologies. The skill acquisition learning objective along with the learner centered approach are most frequently pursued by interactive technologies like Computer-based training (CBT), CD-ROMs and simulations. These technologies provide anytime, anyplace access to learning sources, but interaction with the other learners or the instructor is limited; the student only interacts with the technology. (Lotus Development 1996.) In addition to being good communication channels between people, interactive technologies are also 'forcing' learners to actively participate, rather than passively receive information. Dede (1997) also mentions the possibility of extending learning-by-doing in a real world setting by experiences in synthetic environments.

Collaborative technologies. Collaborative technologies support the learning objective of mental model change in conjunction with the learning team centered approach. They offer an interpersonal, virtual course room for learners who share a common goal. Collaborative technologies can be divided in two groups: asynchronous and synchronous. Asynchronous collaborative learning is the most flexible form of online learning as it can be accessed anytime. Conversely, synchronous collaborative technologies, like chat groups, bulletin boards, and videoconferences, require same-time, 'live' contacts between participants. (Lotus Development 1996, 1998.)

Collaborative technologies have been found to support the collaborative learning process even more than the traditional classroom, particularly more than large classes (Hiltz 1994). By using collaborative technologies, discussion and communication become a continuous activity, rather than being limited to a short scheduled time once or twice a week. In addition, computer-supported collaborative learning is found to be motivating for many learners who would otherwise be uninterested in educational experiences delivered by instructional technology (Dede 1996a). However, in learning environments based on information technology, collaboration is not only regarded as an advantage, but also as a prerequisite for achieving these better learning outcomes (see e.g. Hiltz 1994). For instance, the misuse of videoconferencing may lead to the "talking heads" impression, and consequently make videoconferences resemble distribution more than collaborative technology.

2.2 Distributed Learning Environment

Constructivists (see e.g. Driscoll 1994, Jonassen 1994, Cennamo, Abell & Chung 1996) as well as experiential learning theorists (see Kolb 1984) emphasize the design of the learning environment rather than specific instructional sequences. But what is meant by learning environment? The term learning environment doesn't have one general definition and the content depends much on the person defining it and on the context where it is used. However, it is closely related to the constructivist movement and the develop-

ment of modern information and communication technologies (Mononen-Aaltonen 1998). Ropo (1996) defines learning environments as an entirety consisting of learning materials as well as of a physical, social and cultural environment. He further emphasizes that a learning environment is not only an entirety of external functions, but also an individual perception and experience.

Learning environments are usually divided in two groups: traditional learning environments and new or virtual learning environments. The term traditional learning environment is mainly used to describe face-to-face classroom environments, whereas the terms new or virtual learning environment are used to refer to a learning environment where the “new” information technology plays an important part (see e.g. Hiltz 1994, Pohjonen 1997). Auer and Pohjonen (1995), however, emphasize that the new technology is not the prerequisite for a new learning environment, but an essential factor which helps to produce new learning practices and opportunities.

There are also two kinds of views about the role of technologies in distributed learning. One emphasizes the role of enabling technology (see e.g. Lotus Development 1996, 1998) while the other regards distributed learning more as a new pedagogical way to be put into practice also in face-to-face course rooms (see e.g. Dede 1996a, 1996b, 1997). Therefore the content of a DLE may also differ according to different views. In this study the term DLE is used to mean that entirety, in which the possibility of achieving the full range of learning objectives and instructional models is enabled by using collaborative technology. The full range of learning objectives include information transfer, skill acquisition, and mental model change, whereas the instructional models are divided into instructor-, learner- and learning team centered approaches – as presented above in the distributed learning framework. The definition takes into account the fact that mental model change as a learning objective and the learning team centered instructional model are not the only correct, albeit important, pedagogical solutions to apply to adult education. The definition also emphasizes the importance of collaborative technology in the formation of a DLE; it is a tool for sources of education, for instance for learning materials, as well as a tool for bringing those geographically and temporally “distributed” learners and instructors together. Emphasizing technology as a part of – actually the base of - DLE, however, doesn’t mean that distributed learning as a peda-

gical paradigm couldn't or shouldn't be utilized also in the 'traditional' face-to-face learning situations.

Lotus LearningSpace, which is a solution developed to support the full range of learning objectives and instructional approaches, is a collaborative technology used in this study. On the one hand, LearningSpace could be understood as a DLE in its entirety. However, it has to be remembered that technology by itself cannot form a learning environment, but that it can turn into a learning environment as learners and instructors utilize it. For example, Kauppi (1994, 251) notes that the information and communication networks can be said to become learning environments only when the communication and activity via them become a unity, which supports and guides meaningful learning. Therefore a DLE is regarded as consisting of (a) collaboration between learners and instructors, peoples who function in the DLE, and (b) computer application, which supports the distributed learning paradigm.

After testing several solutions, Lotus LearningSpace was chosen as the common learning tool in the Finnish nationwide OpinNet –project, which also forms the subject group for this study. In order to fully understand the possibilities and demands a DLE brings to an educational setting, the features of LearningSpace are presented in brief. The presentation concentrates on the version 2.5, which was the version of LearningSpace used in the OpinNet -project during the study.

LearningSpace is a DLE, based on the Lotus Domino Server. It contains a central management tool called LearningSpace Central (see Figure 2) and five specialized interactive course database modules that support courses in the asynchronous, collaborative learning mode: the Schedule, the MediaCenter, the CourseRoom, the Profiles, and the Assessment Manager.

- *The Schedule* presents the learning objectives and the instructional design and structure for achieving them. It may be designed for either a self-paced or a team-paced course, or structured around deadlines.
- *The MediaCenter* is the knowledge base including all course-related contents as well as access to external sources of information, e.g. separate WWW-pages on the Internet. Information in the MediaCenter can take the form of text, video clips, multimedia, CBT, graphics, spreadsheets, simulation, etc., allowing a learner to explore in-

tuitively and learn in a way that is consistent with individual learning preferences and needs, e.g. with different learning styles.

- *The Course Room* is an interactive environment supporting collaborative learning. By allowing participants to choose levels of privacy, the CourseRoom supports multiple levels of communication within teams and between students and instructors.
- *The Profiles* module is a learner and instructor description database. It provides “personal home pages”, publicly accessible descriptions that learners and instructors have given of themselves, and supports the team’s sense of online community. Each student profile also contains a secure, private repository of the student’s assignments and assessments.
- *The Assessment Manager* is an “instructor-only” evaluation tool used to privately create and review tests and surveys and to give feedback. (Lotus Development 1996, 1998.)

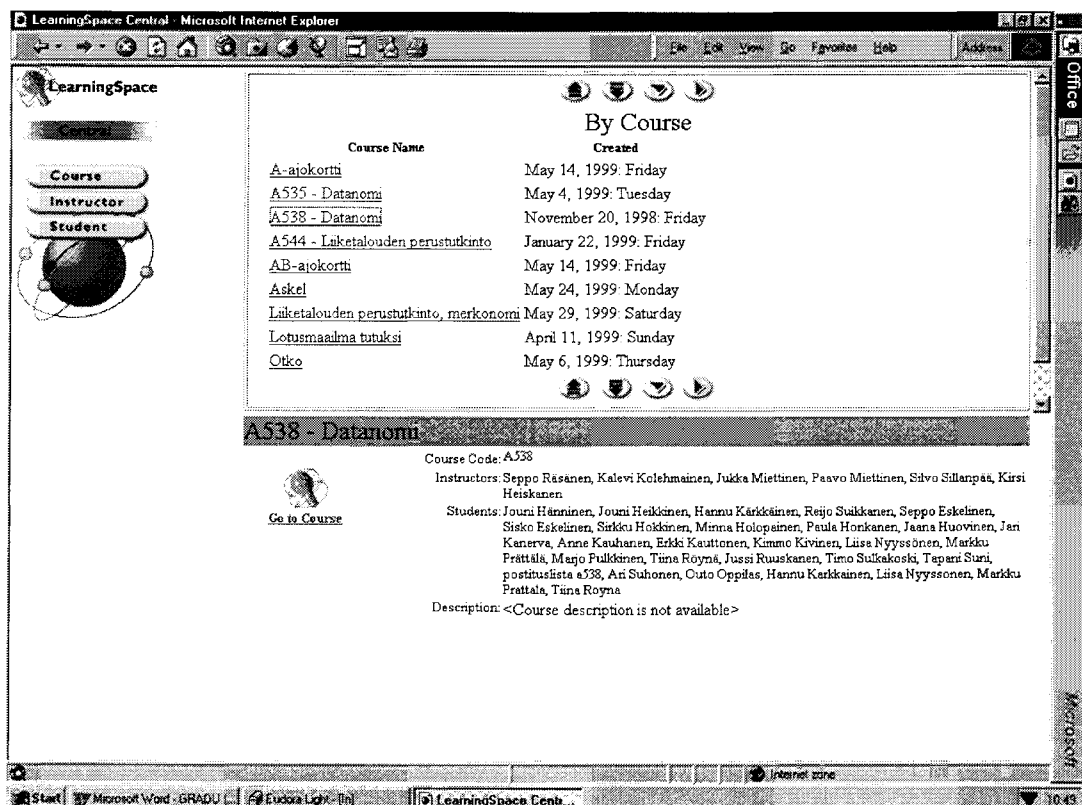


FIGURE 2 The View of LearningSpace Central

3 FROM IMPLEMENTATION OF A DISTRIBUTED LEARNING ENVIRONMENT TO ADAPTATION

Both the experiential learning theory (Kolb 1984) and the constructivistic learning approach (Jonassen 1994, Cennamo, Abell & Chung 1996) emphasize learning as a process instead of focusing on the outcomes, the learning products (c.f. e.g. Hayes & Allinson 1997). When viewed from the perspective of experiential learning, the tendency to define learning in terms of outcomes can even become a definition of nonlearning (Kolb 1984, 26). This, however, does not mean that there are no learning objectives, desired outcomes of the learning process. Learning objectives may – and should – be defined to guide the learning process in a desired direction, but learning itself should be considered more as a process, *how* learning objectives have been achieved, instead of as outcomes, *what* objectives have or have not been achieved.

Previous studies indicate that learning environment has significant effects on the learning process - and also on the learning outcomes (e.g. Hayes & Allinson 1997, Tynjälä 1998, Wong & Watkins 1998). Therefore it is important that the learning environment is constructed in a way that supports the learning process in the best possible way. This feature is emphasized even more because the use of learning environment solutions is seldom – hardly ever – the main learning object of education and training.

Too often more emphasis is placed on mastering the technology, and a new “tool” is viewed as the most exciting component of the learning and instruction, instead of as just a means to facilitate learning (Thach 1995). In the OpinNet –project, educational technology is used as a tool for learning, not as an end in itself. Therefore it is essential that the implementation of a special technology-based learning environment does not demand too much time and/or attention from the subject studied, but that the concentration can be directed to the main thing from the beginning of the preparatory training.

Adaptation to a DLE like LearningSpace is a learning process similar to learning any other thing. According to Kolb (1984), learning is a holistic process of adaptation to the world. But when has a person adapted to a DLE? Can he or she be ‘maladapted’? And where is the line between adaptation and ‘maladaptation’? One way of examining these questions is to identify different stages in the adaptation process. Gbomita (1997) used in his study the five stage model of adoption of educational innovations created by Rogers (1983). The stages are: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. In this study the interest focuses mainly on the fifth stage of the Rogers’ model of adaptation: confirmation. The other four stages are seen as preparations for adaptation.

In the case of adaptation to a DLE, some criteria have been set for the adaptation. Three criteria have been formed on the basis of the framework of a DLE and on the prevailing assumptions about learning. Adaptation requires that the pedagogical, collaborative and technological features of the DLE have been adopted. Adaptation to a DLE means that (1) constructivistic learning is specified as a learning objective, (2) a learning community is formed, and (3) the learner (the instructor) is emancipated from technology.

3.1 Constructivist Learning

The first prerequisite for adaptation to a DLE is determined as constructivist learning. Constructivist learning means that learners construct their own reality or at least interpret it based upon their perception of experiences, so that an individual's knowledge is a function of his or her prior experiences, mental structures, and beliefs that are used to interpret objects and events (Jonassen 1994, 34-35). Therefore, constructivist learning involves the learner's active and continuous process of constructing and reconstructing his or her conception of phenomena instead of passive reception of information. It emphasizes understanding things rather than merely memorizing and reproducing information and relies on social interaction and collaboration in the creation of meaning. (Tynjälä 1998.)

It is not purely by chance that constructivism is gaining popularity and momentum at the same time as collaborative computer technologies are becoming widely available. The computer offers an effective means for implementing constructivist strategies that would be difficult to accomplish by other media. (Driscoll 1994, 376.) However, it also seems that there is a considerable discrepancy between what an instructor believes should be done and what he or she does in practice. Practitioners, especially those utilizing the information and communication technology, quite commonly adopt new constructivist ideas about learning, but they are less likely to apply these ideas in practice. (Sinko 1998.)

Constructivist learning as a prerequisite in the case of adaptation to a DLE means that the learning environment is used for the purpose of achieving constructivist learning; learners are expected to be active in the learning process and to continuously interpret the information through their prior experience, mental structures and beliefs. The constructivist learning should be used not only in the learning objectives aiming at mental model change, but through all the learning objective categories from information transfer to mental model change. The fulfillment of this requirement can be viewed from three different perspectives: from the perspective of the learner, the instructor, and the technology. From the learner's perspective this means that he or she has realized the

idea of constructivist learning as a way of achieving the learning objective by utilizing the DLE – whenever the use of DLE is possible and appropriate. Therefore the learning objective is not determined only by the instructors or the curriculum, but it also has to be recognized by the learners. From the instructors' perspective, the fulfillment of this prerequisite means that the DLE is used to support constructivist learning; also the material prepared by instructors to be used in a DLE have to support the view. The instructors' role is also to guide and to “facilitate” – not to teach – learners through the process of obtaining new understanding. On the other hand, in the case of implementation of a DLE instructors are also learners and therefore the learners' perspective is also included in the instructors' perspective. As far as the technology is concerned, it naturally has to support the features that support constructivist learning, like collaboration.

3.2 Formation of a Learning Community

The second prerequisite for adaptation to a DLE refers to the formation of a learning community. This prerequisite is derived from Senge's (1993) ideas about learning organizations, but instead of focusing on building a learning organization the attention is drawn to the formation of a learning community in which learners can be employed either in the same or in different organizations, or they may be unemployed. Other researches have also made similar proposals, only the names differ. For example Dede (1996a, 1996b, 1997) talks about a virtual community, Hiltz (1994) about an online community of learners, and Westera and Sloep (1998) about a virtual company. By a virtual company in education Westera and Sloep (1998, 32) mean a collaborative DLE, built upon the notions of competence-based learning, collaborative learning, constructivist learning, open learning, and distance education. In this study the term learning community is selected because of the idea that distributed learning can also be used in face-to-face course rooms, not only in “virtual” or “online” classes – although in this study the term DLE is used to refer to technology based learning environments.

Creating a sense of communion among a distributed team linked by low to moderate bandwidth networking is a complex challenge. Some people (for instance learners who are shy) favor technology-mediated communication as for them it is the most comfortable way of sharing ideas and enjoying fellowship, while some people prefer face-to-face interaction. Thus, such a learning community is not created simply by transmitting information, but by a process in which the learners have a certain degree of obligation to each other. The learners may have different interests, hold various viewpoints and meanings, and make diverse contributions to the activities. However, the participants need to share an understanding about what they are doing, and what that means for their individual development processes and for the development of the learning community of which they are a part. A computer application designed for collaborative activities is also an important means of creating a community of shared experience and recognition. Therefore, such a community is created only if the computer-based application mediates the human actions in such a way that the individual learners have a feeling of participating in the community. (Dede 1995, 1996a, Fjuk 1995.) It is also important to note that even though technology and applications are used to support the development of a learning community, the learners and the instructors are in the key position in the formation of that community; technology alone cannot force it to be formed.

The formation of a learning community is therefore not an easy task in the process of adapting a DLE for educational purposes. However, the formation of this kind of a community is worth a try. Smith (1992), for example, lists three types of “collective goods” that bring together virtual communities enabled by computer-mediated communication: social network capital (an instant web of contacts with useful skills), knowledge capital (a personal, distributed brain trust with just-in-time answers to immediate questions), and communication capital (psychological/spiritual support from people who share common joys and trials) (Dede 1996a). Therefore, a learning community provides an environment that both initiates and supports development (Dixon 1994).

3.3 Emancipation from Technology – Technology as a Tool for Learning

The third prerequisite for adaptation to a DLE, emancipation from technology, means that the collaborative technology should be utilized in education and training without any specific attention given to its technological features at the expense of subject matter to be learned. It is clearly a disadvantage to use a particular technology if it takes learners and instructors several weeks to learn how to use it before they can start on the course content (Bates 1995). The learners' main attention in learning situations should be focused on the subject, not on technology. This objective of emancipation from technology crystallizes in Bates' (1995, 227) symbolic vision:

“Computers are more likely to become ‘transparent’ or ‘invisible’ in the learning process, as significant to the learner as the electricity that carries the power to a refrigerator: essential for its operation, but independent of the function that the refrigerator performs.”

For technology to become “transparent” or “invisible”, certain features are expected both of the technology and of the users. Technology has to have a certain functional reliability and it has to be easy-to-use. Bates (1995), for instance, mentions reliability as a critical factor in technology-based learning environments; if the technology breaks down or ‘crashes’, it can severely disrupt the learning process. He also notes that, in general, technologies that are easy to use will be used more than those that are difficult. Users, then, must have basic computing skills for using the technology. The goal is that the role of technology in the learning process is to serve as a tool for learning, not as an end in itself.

Nowadays, the essential function of computers in education is moving away from the notion of the computer as a substitute teacher towards that of ‘true’ technology, a set of tools to be used by learners and instructors to facilitate the task of learning and understanding. Nevertheless, the discussion about technology as a tool for learning is usually limited to the question: “Does technology actually improve learning and student

achievement?”. Some researchers say it does, some researchers say it doesn’t. Thomas (1998, 6), however, asks: “Is this really the issue?” According to her, the real issue is *what* we think about technology and its function in the learning process: do the learners and instructors think of it and use it as a tool for learning or as an end in itself? (Bates 1995, Thomas 1998.)

It is also important to remember that even though the use of technology is thought of as a tool rather than as the object of learning – and regardless of whether it can be proved if technology actually affects learning – the learners grow and develop with these tools so that they are better equipped to become productive members of society (Thomas 1998). So by using technology the learners as well as the instructors learn the needed “information society skills”, which help them use technology as a tool also outside education and training.

This vision of technology as a tool for learning is expected to become reality through adaptation to a DLE. Neither this nor either of the two prerequisites mentioned above – constructivist learning and formation of a learning community - are easy to fulfill and objectives are – undeniably - set quite high. But if these objectives, constructivist learning, formation of a learning community, and release from technology, are successfully achieved it can be said without a doubt that adaptation to a DLE has taken place.

4 WHAT CAUSES DIFFERENCES IN ADAPTATION TO A DISTRIBUTED LEARNING ENVIRONMENT?

Hiltz and Johnson (1990) note that interactive computer systems should be viewed as “socio-technical” systems whose acceptance is influenced by an interaction between the characteristics of the individual users, the groups and organizations in which they are implemented, and the computer systems themselves. Hiltz (1994) considers the theoretical and empirical approaches to studying the acceptance and diffusion of computer technology and its impacts on society through four major approaches: Technological Determinism, the Social-Psychological approach, the Human Relations school, and the Interactionist or System Contingency perspective. The same approaches can also be applied to the study of adaptation to a DLE and are therefore used in this study.

Technological Determinism, which refers to the characteristics of the hardware-software system, is in this case mainly included in the DLE in itself and in the features of LearningSpace software. On the other hand, software also has to support the characteristics of distributed learning in order to make the new pedagogical approach possible. However, based on previous studies and on the development process of LearningSpace as a DLE (see Lotus Development 1996, 1998), LearningSpace is al-

ready expected to include these features and is thus not re-examined in this study. The main questions concerning technological determinism are: have the features supporting distributed learning been utilized, and how? Can learners and instructors be emancipated from technology and learn to use it as a tool for learning?

The Social-Psychological approach or “individual differences” in the learning process can be examined from two different perspectives: from that of the learners and that of the instructors. But what are the variables to be taken into consideration? Firstly, every person has a unique background with a unique set of experiences and skills (prior computing experience, computing skills, and knowledge of English). Every learning situation is also unique, and so is the learner’s style of gathering information in different situations (learning style). Learners also have different attitudes towards the subject matter learned and towards the tools and approaches that are used in learning (e.g. attitude towards computers) As a result of these differences, the learning processes are not identical for all individuals, learning groups and situations, and also the objective (adaptation to a DLE) is achieved in different degrees. Adaptation to a DLE is therefore also experienced differently by learners and instructors.

The Human Relations school emphasizes the characteristics of the group. In this study the subjects of the group represent different vocational qualifications studied/instructed. From this viewpoint, collaboration as a part of adaptation to a DLE plays an important part in the formation of a learning community. It should also be remembered that the characteristics of the instructor and the way he or she organizes the training have an important effect both on individual and group learning. Therefore, in the model describing the parts of a DLE implementation (see Figure 3), the learners’ and the instructors’ individual differences are separated, as both have an influence on each others’ adaptation to a DLE.

The Interactionist or System Contingency approach deals with the social impacts of computing. According to the approach, none of the three classes of variables described above are expected to fully account for the differences in adaptation; all of them are expected to contribute to them. However, these sets of variables are not simply additive; they interact to form a complex system of determinants. (Hiltz 1994.) Similar “system contingency” is also presented in this study. In Figure 3, a model of variables affecting adaptation to a DLE is presented describing the interaction between the differ-

ent parts. Variables form four sectors that influence the adaptation to a DLE: Learners' and instructors' individual differences (The Social-Psychological approach), learning team differences (The Human Relation school) and software (Technological Determinism) and content differences.

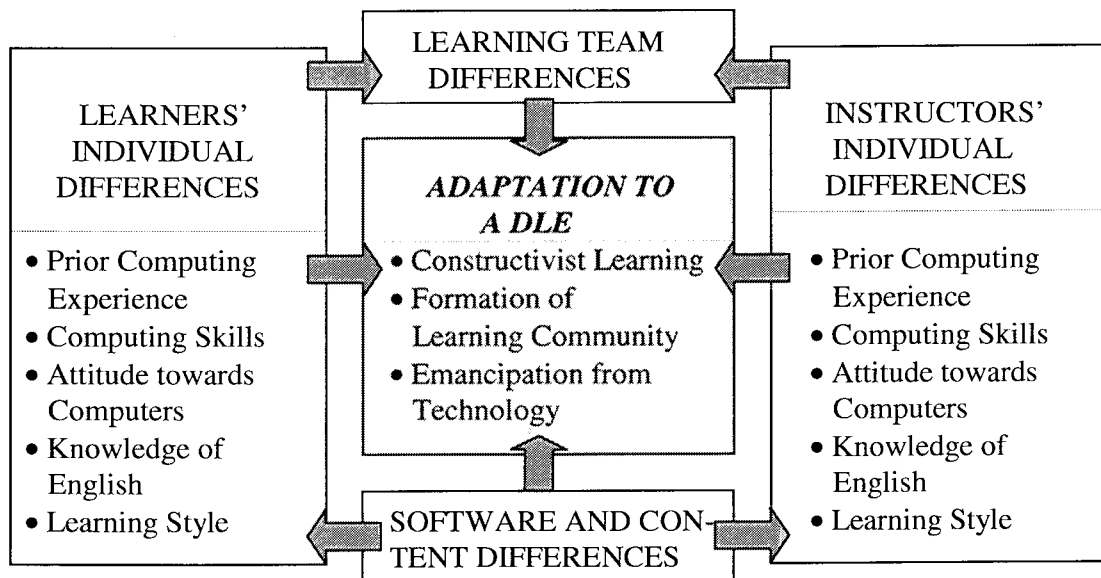


FIGURE 3 A Model of Variables Affecting Adaptation to a Distributed Learning Environment.

Next, the variables in the process of adaptation to a DLE are considered more closely and a more accurate structural equation model is constructed. It is important to note that in this case the instructors' and the learners' adaptation to a DLE is examined with the help of the same variables and in the same context. This decision is made because the adaptation process is expected to be the same for learners and instructors; instructors are learning to use a DLE for educational purposes in the same way as the learners are.

4.1 Prior Computing Experience

Prior computing experience can be examined from many perspectives. The most common way is to examine the amount of computer technology used. Thomson, Higgins and Howell (1994) studied the influence of prior experience on the utilization of personal computers. In addition to asking the length of time the respondents had used personal computers they also had the respondents estimate their own skill and used this self-reported skill level as an another variable describing prior experience. Also Mitra (1998) considers a user's skill level an attribute of experience by mentioning computer proficiency and computer literacy as similar definitions of the use. In this study the self-reported skill level is, however, used as a separate factor. Experience and skill are seen as closely related, but separate concepts. The separation has been made because an individual can use a computer for example to access electronic mail for several years without gaining notable computing skills. On the other hand, another individual could undergo an intensive training program on the use of computers and computer software over a short period of time, and gain remarkable skills in using computers and networks. In other words, although a learner might have substantial computing experience it does not guarantee successful performance with computers and networks. Experience can also be narrow in scope; a learner may have extensive experience with computers but no network experience.

According to the results of an extensive technology assessment project, Information and Communication Technologies (ICT) in Teaching and Learning, completed in Finland during 1997-98, about 40 % of the households in Finland have a personal computer and about a half of these have access to the Internet (Sinko 1998). In addition, Savolainen (1998) found in his study that about 10 % of Finns could be classified as active users of network services.

In this study, prior computing experience is considered from two perspectives: (a) *prior experience with computers*, and (b) *prior experience with networks* (e.g. Internet and electronic mail) (see Figure 4). The term prior computer experience is used to mean experience with "offline" computers as distinct from prior experience with "on-

line” computer networks. Therefore the term computing is considered a combination of computers and networks.

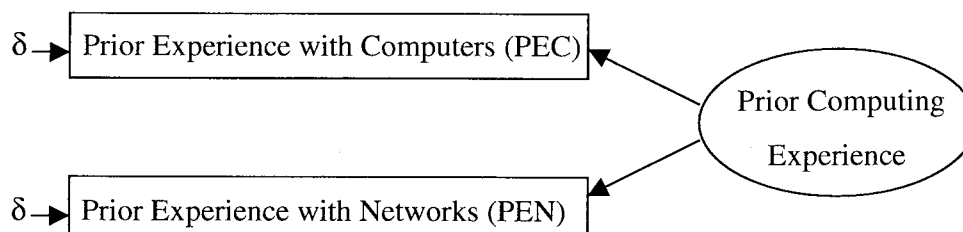


FIGURE 4 The Observed, Manifest Variables and the Latent Variable of Prior Computing Experience.

Earlier it was noted that in some cases (e.g Thomson, Higgins and Howell 1994, Mitra 1998) computing skills were treated as a part of prior computing experience. However, in this study the decision was made to separate experience and skills from each other; quantity and quality are, in other words, considered separately. This decision is also supported by Karsten and Roth (1998), who suggest, based on their research findings, that it is the relevance, rather than the quantity, of computer experience that the learners bring to class that is most predictive of performance (see also Bradley & Russell 1997). The decision to separate quantity and quality also renders possible the examination of the causal relationship between quantity and quality, between prior computing experience and computing skills. The perceived connection between prior computing experience and computing skills leads to the development of following hypothesis:

HYPOTHESIS 1: *There is a causal relationship between prior computing experience and computing skills.*

Prior computing experience is often mentioned as a significant factor affecting attitude towards computers; prior computing experience is positively linked to a positive attitude (Thomson, Higgins & Howell 1994, Busch 1995, Mitra 1998). In a study by Mitra

(1998) significant differences were observed between the mean attitudes of low and high users in all the different categories of use. Respondents who reported higher use of computers indicated a more positive attitude towards computers on all the different attitude scales. The results suggest that the level of use is related to attitude towards computers. According to these research findings it can be hypothesized that:

HYPOTHESIS 2: *There is a causal relationship between prior computing experience and attitude towards computers.*

Thompson, Higgins and Howell (1994) note as an implication of their study that prior experience is an important factor to be taken into account when models for information technology adoption are developed, tested, or applied. Hiltz and Johnson (1990) also found that those who had less previous experience with computers were less likely to feel constrained by the computer as a mode of communication. However, their findings also suggest that if people become used to using computers as computational or database tools only, they will find it harder to think of them as a good medium for personal communication. According to the previous findings the following hypothesis was set for this study:

HYPOTHESIS 3: *There is a causal relationship between prior computing experience and adaptation to a DLE.*

4.2 Computing Skills

The terminology concerning computing skills is diverse. Terms like computing competence, computing capability, and computing literacy are often used in connection with the term computing skills (see e.g. Karsten & Roth 1998). In this study, computing skills as a latent variable consists of two manifest variables: (a) *Computer skills*; skills in using computers, “offline” computing, like hardware or equipment-related skills (the

ability to use a mouse and a keyboard), system skills (the ability to use system interfaces), and application software skills (e.g. word processing skills), and (b) *Network skills*; skills in using networks, “online” computing skills, like the ability to use network procedures (e.g. electronic mail software and Internet browsers) (see Figure 5). Therefore a division between offline and online skills is made, similar to the division made in prior computing experience.

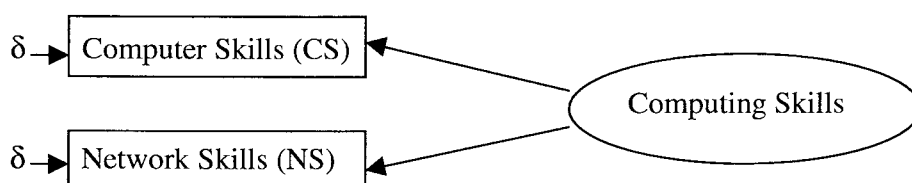


FIGURE 5 The Observed, Manifest Variables and the Latent Variable of Computing Skills.

Smith and Necessary (1996) studied the relationship between self-perceived computer literacy and attitude towards computers. They found statistically significant differences between perceived knowledge of computers and an attitude towards computers. Based on these findings better computing skills were connected to more positive attitudes towards computers. Also the pretest/posttest study by Woodrow (1992), measuring the change in knowledge of computers and attitude towards computers, supports the positive relationship between computing skills and a positive attitude towards computers. In her study, Woodrow found that during a course oriented towards developing basic computing skills, significant gains were achieved in attitudes towards computers (see also Hignite & Echternacht 1992). Also Siminson, Maurer, Montag-Torardi, and Whitaker (1987) came to the conclusion that, in addition to attaining the traditional cognitive competencies such as programming skills, computer application skills, and computer hardware use skills, the development and/or maintenance of a positive attitude towards computers was crucial for the computer literate person (Woodrow 1992). All these findings support the following hypothesis:

HYPOTHESIS 4: *There is a causal relationship between computing skills and attitude towards computers.*

In the same way as computing skills are expected to affect attitude towards computers, computing skills are expected to influence adaptation to a DLE. Also Neilson (1997) notes, based on his literature review, that prior knowledge of and experience with information technology has an influence on how easily users adapt and use collaborative technologies. This assumption is also supported by several previous research findings. Roberts and Ferris (1994), for example, state that barriers that render difficult technology integration include the lack of knowledge of available hardware and software. Also Dusick and Yildirim (1998) found in their path analytic study that the computing competence of teachers had a significant effect on computer use in the classroom (Dusick 1998). Morton (1996) found a notable dichotomy in faculty members with differing amounts of computer knowledge. “High tech” teachers assimilated computers in their teaching easily, whereas “low tech” teachers did not readily integrate computers into their pedagogical practices. According to these findings the following hypothesis was set:

HYPOTHESIS 5: *There is a causal relationship between computing skills and adaptation to a DLE.*

4.3 Attitude towards Computers

Attitudes towards computers have been investigated extensively in recent years (e.g. Bradley & Russell 1997, Divine & Wilson 1997, Mitra 1998, Zhang & Espinoza 1998). In these researches attitude towards computers has been defined to encompass various relationships, from simple like and dislike of computers to more complex attitudes including several variables. Divine and Wilson (1997) define attitude towards computers

as the level of affect one has for computers. In the same way, attitude toward computers is also understood in this study.

In this study the manifest variables for attitude towards computers are selected according to the Computer Attitude Scale developed by Loyd and Loyd (1985) and later remodified by Nash and Moroz (1997). The instrument consists of three subscales: (a) computer liking, (b) computer usefulness, and (c) computer comfort (computer anxiety/computer confidence) (see Figure 6). Computer liking generally refers to how much people enjoy using computers, computer usefulness to the perceived benefits of computer use, and computer comfort to one's perceived self-efficacy with computers and to the level of apprehension a person has with regard to using a computer.

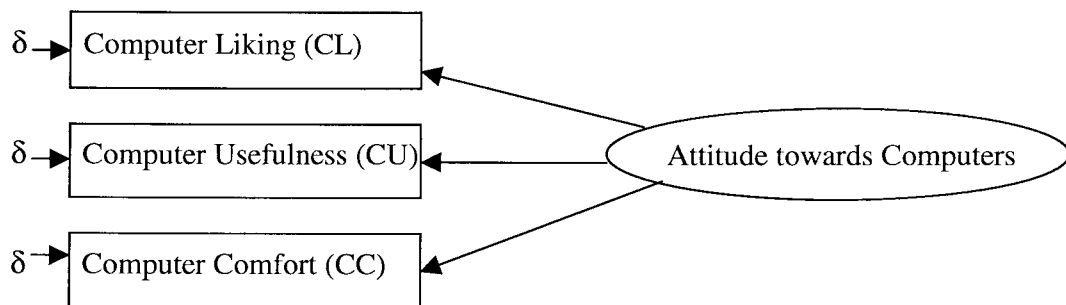


FIGURE 6 The Observed, Manifest Variables and the Latent Variable of Attitude towards Computers.

Divine and Wilson (1997) note that learners who have positive attitudes towards computers are more likely to become more involved with them and even to adopt them for their personal, academic, and professional use. Also Woodrow (1991) claims that the learners' attitudes towards computers were a critical issue in computer courses and computer-based curricula, and that monitoring the user's attitudes towards computers should, therefore, be a continuous process if the computer is to be used as a tool for learning and instruction. In addition, Delcourt and Kinzie (1993) propose that a positive attitude is an important factor in helping people learn about computers (Zhang & Espinoza 1998). Nearly two decades ago, Reece and Gable (1982) argued that introducing

microcomputers into schools would be a waste of time and money if the training curricula did not support the development of positive attitudes towards computers (Woodrow 1992). On the basis of these assumptions, the following hypothesis was set:

HYPOTHESIS 6: There is a causal relationship between attitude towards computers and adaptation to a DLE.

4.4 Knowledge of English

The studies regarding the language used in the new information technologies have mostly dealt with the language used in the Internet. Generally, the English language is often connected to the use of the Internet. Wah's study (1998), however, reveals that the number of speakers of other languages among Internet users worldwide is growing at a much faster rate than that of the English-speaking group. According to Wah, nearly 40 percent of the world's Internet users today access the net in languages other than English. Although Finland is a small country measured in population, three percent of Internet users are Finnish-speaking (see Wah 1998).

In contrast to studies concerning the languages used in the Internet, the importance of the languages used in DLEs, such as LearningSpace, has been ignored. This may be due to the fact that most studies concerning learning environments have been made among English-speaking learners and instructors using the English language version of the software. The case in Finland, among the Finnish-speaking adult learners and instructors using the English language version of DLE, is, however, more complicated. The importance of the language in the development of DLEs should not be ignored anymore and therefore the matter is brought up in this study. In LearningSpace, which is the DLE used in this study, the Finnish language can be used in the sections that the learners and instructors themselves have made, but for example the navigation buttons are in English.

Sartoneva (1998) found, in her study concerning the language skills of adults in Finland, that 66 percent of adults have a command of the English language; 32 percent of adults manage well or very well with English. In a study on Information Society in Finland (Nurmela 1997), the results indicate a “problem of a small language territory”. Only 25 percent of the respondents ($n = 3488$) thought that the English language used in software did not cause problems; this leads to the conclusion that three out of four persons experienced the foreign language used as a disadvantage. Therefore the following two hypotheses are proposed:

HYPOTHESIS 7: There is a causal relationship between language skill and attitude towards computers.

HYPOTHESIS 8: There is a causal relationship between language skill and adaptation to a DLE.

4.5 A Hypothesized Model of Adaptation to a Distributed Learning Environment

The first objective of the study was to both develop and test empirically the hypothesized structural equation model (SEM) of adaptation to a distributed learning environment (DLE). The developed model of adaptation to a DLE is based on previous research findings, both theoretical and empirical. Figure 7 presents the proposed model summarizing the eight hypothesized relationships among the variables affecting adaptation to a DLE. Causal relationships are indicated by straight lines with arrows and covariances by curved lines.

Observed variables are drawn as boxes, latent variables are drawn as ellipses. Chin (1998) warns researchers about the use of statistical jargon and mathematical or Greek symbols in describing the relationships. Therefore, in this study, the relationships between two – or more – variables are discussed by their names or by the number of

hypothesis. The following two research questions were guiding the development process of the model: (1) What are the variables causing the differences in adaptation to a DLE and (2) What are the relationships between those variables?

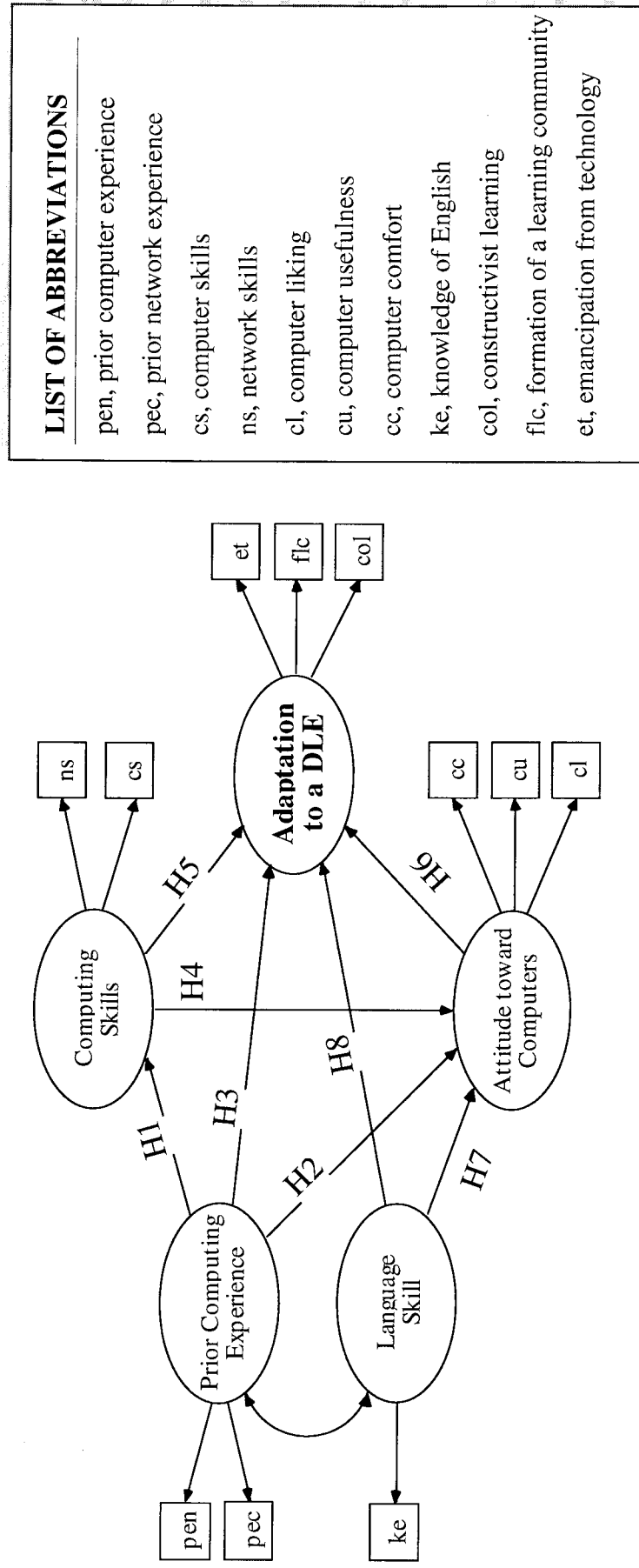


FIGURE 7 A Hypothesized Structural Equation Model of Adaptation to a Distributed Learning Environment.

5 DOES ADAPTATION TO A DISTRIBUTED LEARNING ENVIRONMENT DIFFER BETWEEN LEARNING STYLES?

In his experiential learning theory, Kolb (1984) has paid attention to the relationship between learning style and learning environment. He notes that “matching learning style with corresponding learning environment seems an easy and practical way to improve the learning process” (Kolb 1984, 202). According to him, any educational program, course design, or classroom – as well as a DLE like LearningSpace – can be viewed as having degrees of orientation towards each of the learning modes in the experiential learning model. The learning modes are labeled as affective (concrete experience), perceptual (reflective observation), symbolic (abstract conceptualization), and behavioral (active experimentation) (Kolb 1984, 197). This notion also suggests that learning styles should be considered an important variable in studies on the differences in adaptation to a DLE.

In this study learning styles are defined as a learner’s generalized and relatively stable ways of adapting him- or herself to a learning environment. Learning style is considered as ‘relatively stable’ because of the research indications that learning styles are

flexible rather than unchangeable (Nulty & Barrett 1996, cf. Kolb 1984). The view of learning as a holistic process of adaptation is also brought out by the use of the term ‘to adapt’ instead of giving a – potentially incomplete – list of the numerous processes of human adaptation. Learning environment is one of the key themes in this study and for that reason it is emphasized in the definition. Kolb (1984, 64) defines learning style as the complex structure of learning, which allows for the emergence of individual, unique possibility-processing structures. The concept of a possibility-processing structure describes the way in which a learner processes the possibilities of each emerging event by determining his or her range of choices and decisions. The choices and decisions a learner makes determine to some extent the events experienced, and influence future choices. Thus, people create themselves through their choices on the actual occasions they experience and ‘program’ themselves to grasp reality through varying degrees of emphases on apprehension or comprehension. Similarly, they program themselves to transform these “prehensions” via extension and/or intention. Furthermore, this self-programming conditioned by experience determines the extent to which a learner emphasizes the four modes of the learning process: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) (see Figure 8). (Kolb 1984.)

The central idea in the process of experiential learning is that learning requires both a grasp and a figurative representation of experience and some transformation of that representation. The simple perception of experience is not sufficient for learning; something must be done with it. The same requirement was also presented in the framework for distributed learning, in which information transfer as a learning objective was seen as an ‘incomplete’ learning objective, which could, however, be completed or substituted with more “high-order” learning objectives, like mental model change. Similarly, transformation alone cannot represent learning, there must be something to be transformed, some state or experience that is being acted upon. Thus learning results from the combination of *grasping* experience and of *transforming* it. (Kolb 1984.)

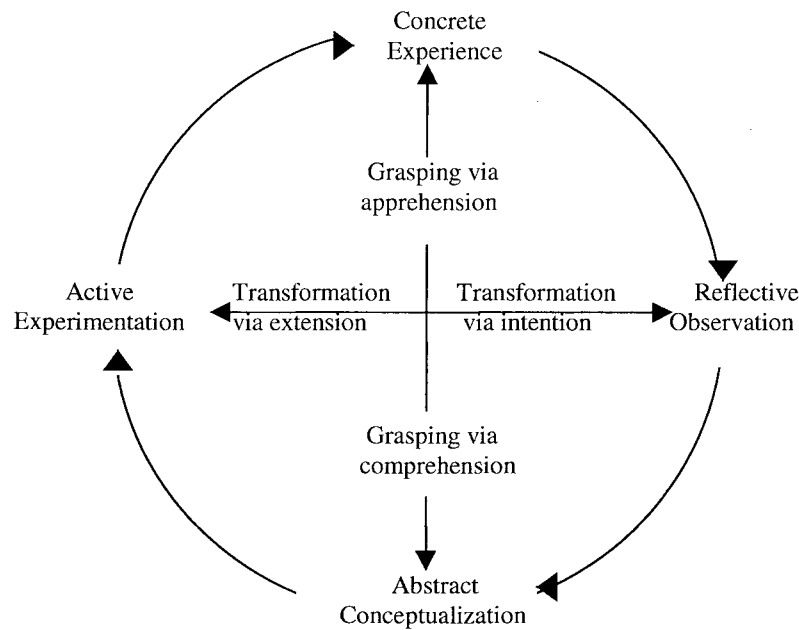


FIGURE 8 Structural Dimensions Underlying the Process of Experiential Learning (Kolb 1984, 42).

The dimension of *prehension* represents the two different and opposed processes of grasping experience in the world: apprehension and comprehension. In the process of apprehension the grasping occurs through reliance on tangible, felt qualities of immediate experience, whereas in the comprehension process it occurs through reliance on conceptual interpretation and symbolic representation. Thus, the prehension dimension opposes the process of apprehension and its orientation towards concrete experience against the comprehension process and its orientation towards abstract conceptualization. (Kolb 1984.)

The *transformation* dimension includes two dialectically opposed ways of transforming experience, either through intentional reflection called intention, or through active external manipulation of the external world called extension. The transformation processes of intention and extension can be applied to concrete apprehensions of the world as well as to symbolic comprehension. The transformation dimension con-

trasts the process of intention and reflective observation with the process of extension and active experimentation. (Kolb 1984.)

The two basic dimensions, prehension and transformation, are not continua. Both of them represent a dialectic opposition between two independent and mutually enhancing orientations. In the same way the stages of a learning process may be emphasized to different extents. Therefore, the four basic learning modes – CE, RO, AC, AE – are also called primary learning styles. (Kolb 1984.) The characteristics of these dimensions are as follows:

Concrete experience. The experiential learning process usually begins with the learner acquiring information by immediate concrete experience. Thus, the progress of this stage fulfills the requirements of the first learning objective: information transfer. This stage emphasizes feelings and an intuitive, "artistic" way of thinking. People with concrete-experience orientation enjoy, and are good at, relating to others. They are often good decision-makers and function well in unstructured situations. (Kolb 1984.)

Reflective observation. During the reflective observation stage the learner assimilates and organizes experienced information and examines it from different perspectives. The focus is on understanding the meaning of ideas and situations. Therefore, the learning objective is more than the transfer of information and the use of an instructor-centered model should be forgotten. Constructed and "reflected" information may also be compared with the more public knowledge of others and the use of interactive and collaborative technologies could be considered. People with a reflective orientation enjoy intuiting the meaning of situations and ideas and are good at seeing their implications. (Kolb 1984.)

Abstract conceptualization. A stage of abstract conceptualization, which emphasizes thinking, occurs when learners develop generalizations and hypothesis to help them internalize and integrate experiences. It focuses on using logic, ideas and concepts. The results may be enlarged ideas and convictions, or transformed perspectives (see Mezirow 1991). A person with an abstract conceptual orientation enjoys and is good at systematic planning, manipulation of abstract symbols, quantitatively analyzing ideas and the aesthetic quality of a neat conceptual system. (Kolb 1984.)

Active experimentation. Finally, in the fourth stage, the learner uses generalizations as a guide to conscious action in new concrete experiences. Orientation towards

active experimentation focuses on actively influencing people and changing situations. It emphasizes practical, “hands-on” applications and people with this orientation enjoy and are good at getting things accomplished. They are willing to take some risks in order to achieve their objectives. They also value having an influence on the environment around them and are therefore suitable users of a distributed, collaborative learning environment. (Kolb 1984.)

In this study the learning styles of learners and instructors are first considered through the following dimensions: (a) concrete experience – abstract conceptualization (CE – AC) and (b) reflective observation – active experimentation (RO – AE). In the second phase the learning styles are named using Kolb’s (1984) terminology as diverger, assimilator, converger, and accomodator. In literature also terms like *basic learning style* (see Kolb 1984) and *learning style type* (see Cornwell & Manfredi 1994) are used to describe these four learning style quadrants between the learning modes. In contrast, the term *primary learning style* (see Cornwell & Manfredi 1994) is used to describe the most actively used learning mode – CE, RO, AC or AE.

Divergers emphasize the stages of concrete experience and reflective observation. They are named after their adaptive ability to view concrete situations from many perspectives and to organize many relationships into a meaningful “gestalt”. They learn by sharing ideas and are good at “brainstorming”, imaging implications, and working in collaborative groups. (Kolb 1984.)

Assimilators are placed between reflective observation and abstract conceptualization. They are called assimilators because they can assimilate information into logical theories and models. These ‘thinkers’ prefer to work alone, like in traditional lecture-oriented, instructor-centered classrooms. (Kolb 1984.)

Convergers grasp information abstractly and process it actively. They are named based on their ability to do well in conventional intelligence tests, where there is only one correct answer or solution to a question or a problem. The greatest strength of this approach lies in problem solving, decision making, and practical application of ideas. They dislike ambiguity, working in groups, and wasting time. They tend to be impersonal and prefer “hands on” working with things rather than with people. (Kolb 1984.) Therefore it can be assumed that they prefer using interaction technologies rather than collaborative technologies. On the other hand, the very nature of a DLE encourages

students to adopt a hands-on approach which reflects a constructivist pedagogical approach (Crampton 1998) and in this way also supports the convergent style of learning.

Accommodators perceive reality through concrete experience and process it through active experimentation. They are called accommodators because they adapt well to new circumstances and to applying knowledge in new ways. They like to get information by talking to others and like to influence others. Those with accommodative learning styles are at ease with people but are sometimes seen as impatient and "pushy". (Kolb 1984.) The collaborative, learning team focused instructional model can however be assumed to suit accommodators well.

The second objective of the study is to determine the role of learning style in adaptation to a DLE. Previous studies examining the effects of learning style have mainly concentrated on the relationship between learning style and learning outcome. For example, Ester (1994) found that abstract learners demonstrated significantly higher achievement with lecture approach, while concrete learners performed equally well with both lecture and computer-aided instruction (CAI). Liu, Reed and Phillips (1992) found that there are no significant differences between cognitive style groups and achievement level, but the data suggested that cognitive style groups interacted differently with the computer program. So, instead of learning outcomes, it was the interaction with the computer that varied. However, there are also opposite findings on the relationship between learning style and interaction type. In the study by Ross (1997) regarding the relationship between learning styles and the way in which learners interacted with the computer-aided instructional software, no significant relationship was found. Neither were significant differences found in Larsen's (1992) study regarding the relationship between learning style preference and the effectiveness (learning gain score) and acceptance (students' satisfaction rating) of Interactive Video Instruction (IVI). However, several explanations for the similarities between the different learning style groups were suggested, including the possibility that the characteristic flexibility of interactive video instruction design and use accommodates equally well the varying perceptions and processing behaviors of students, regardless of learning style. Learning style differences were also considered when LearningSpace was designed. On the basis of the designing process it can be assumed that learners with different learning styles will adapt homoge-

neously to a DLE. Therefore the following hypothesis was set to anticipate a lack of relationship between adaptation to a DLE and the four different learning styles:

HYPOTHESIS 9: *Adaptation to a DLE does not differ between the different learning styles.*

6 RESEARCH METHODS

To carry out the study, data had to be gathered in order to test the structural equation model developed and to carry out an analysis of variance. Many different methods and procedures have been developed to aid the acquisition of data. In the following chapters the process and procedures of gathering data in this study are described. The analytical procedures used in the study are also explained.

6.1 Research Subjects

The research subjects were learners and instructors from the Finnish nationwide Opin-Net –project, which is the project started and coordinated by the National Board of Education. The project was launched in 1996 as a part of a national information society program to develop educational planning, student counseling and new pedagogical solutions to be used with new technologies. In 1998 the project involved 21 vocational adult education centers and 25 vocational qualifications. About 200 instructors and more than

1000 learners have already joined the development work, the work still continues, and the number of participants is growing. In the end of 1998, the project had offered LearningSpace licenses to 761 students and 100 instructors from 13 vocational adult education centers. At the time of the online web-survey approximately 100 students and 40 instructors were using the licenses. These participants using the LearningSpace licenses formed the group of research subjects in this study. For more information about the OpinNet –project see URL: <http://www.edu.fi/projektit/opinnet>.

A total of 102 completed questionnaires were returned; 64 questionnaires from learners and 38 questionnaires from instructors. The *estimated* response rate is 64 percent for learners and 95 percent for instructors, 73 percent as a whole. The response estimate is based on the number of licenses in use, not licenses offered. It also has to be remembered that the response rate in this case is only suggestive. This is because the information about the questionnaire was sent to instructors through electronic mail, and it is not certain that all the instructors have seen the message or that they have supplied learners with the information about the location of the questionnaire in the Internet or included the link in the LearningSpace Schedule as requested. The using rate of LearningSpace was based on the information gathered from LearningSpace contact persons in each of the vocational adult education centres involved.

Of the learner respondents, 42 were females (65,6 %) and 22 were males (34,4 %). Three learners were 25 years old or younger (4,7 %), 22 were aged from 26 to 35 years (34,4 %), 29 from 36 to 45 years (45,3 %), and 10 from 46 to 55 years (15,6 %). The learners were studying five different vocational qualification: Vocational Qualification in Home Economics and Cleaning Services (n = 23), Further Qualification of Cook (n = 5), Further Qualification of Computer Mechanic (n = 9), Further Qualification of Data Processing (n = 8), and Specialist Qualification of Cleaning Supervisor (n = 7). In addition, LearningSpace was used in Information Technology studies (n = 12), which is not a vocational qualification. The learner respondents were from six different adult education centers: Jyväskylä Vocational Adult Education Center (n = 15), Kuopio Vocational Adult Education Center (n = 12), Lahti Vocational Adult Education Center (n = 5), North Karelia Vocational Adult Education Center (n = 5), Rovaniemi Vocational Adult Education Center (n = 9), and Turku Vocational Adult Educational Center (n = 18).

Of the instructor respondents ($n = 38$), 21 were females (55,3 %), and 17 were males (44,7 %). 12 of the instructor respondents were aged from 26 to 35 years (31,6 %), 19 from 36 to 45 years (50,0 %), 6 from 46 to 55 years (15,8 %), and one was 56 years or older (2,6 %). Instructors represented nine different vocational qualifications: Vocational Qualification in Food Industry ($n = 2$), Vocational Qualification in Home Economics and Cleaning Services ($n = 9$), Vocational Qualification in Hotel, Restaurant and Catering ($n = 1$), Further Qualification of Computer Mechanic ($n = 5$), Further Qualification of Cook ($n = 4$), Further Qualification of Data Processing ($n = 4$), Further Qualification of Plater-welder ($n = 1$), Specialist Qualification of Cleaning Supervisor ($n = 2$), and Specialist Qualification of Dietary Cook ($n = 1$). In addition there were instructors from Information Technology studies ($n = 2$), and a group “other” ($n = 7$), including the instructors who did not have one specific qualification to instruct. Instructors were from 13 different adult education centers: Adulta, the Center for Further Education in Keski-Uusimaa ($n = 1$), Kalajokilaakso Adult Education Center ($n = 4$), Jyväskylä Vocational Adult Education Center ($n = 3$), Jyväskylä Catering Institute ($n = 1$), Kuopio Vocational Adult Education Center ($n = 3$), Lahti Vocational Adult Education Center ($n = 4$), Mikkeli Vocational Adult Education Center ($n = 2$), National Association of the Disabled in Finland Järvenpää Training Center ($n = 1$), North Karelia Vocational Adult Education Center ($n = 9$), Rovaniemi Vocational Adult Education Center ($n = 1$), Tampere Vocational Adult Education Center ($n = 1$), Turku Vocational Adult Educational Center ($n = 4$), and Ylä-Savo Vocational Adult Education Center ($n = 4$).

Neither the learners nor the instructors had used LearningSpace for long. 29,7 percent of the learners and 44,7 percent of the instructors had used the DLE (LearningSpace) for four weeks or less at the time of the web-survey. The length of time that the learners and instructors had used LearningSpace is presented in Figure 9.

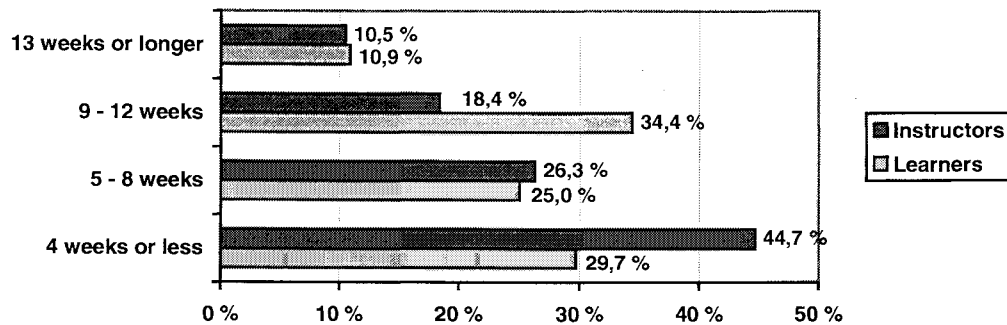


FIGURE 9 Length of Time Learners and Instructors had Used the DLE (LearningSpace) at the Time of the Web-survey.

The time of DLE use per week was not long either. 39,1 percent of the learners and 34,2 percent of the instructors used the DLE (LearningSpace) less than an hour per week. Time for using the DLE (LearningSpace) per week is presented more accurately in Figure 10.

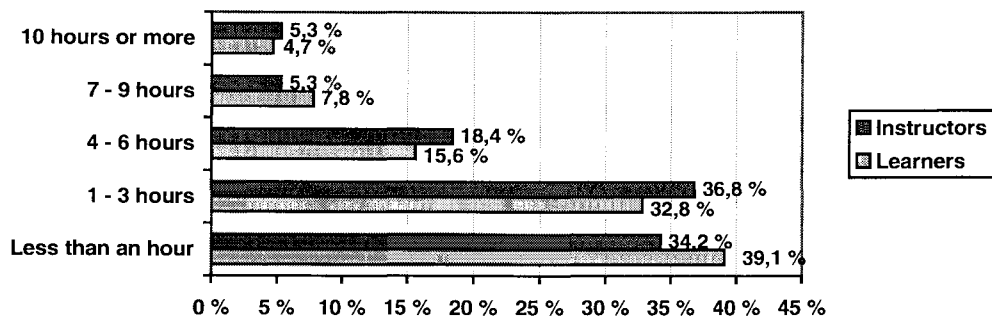


FIGURE 10 Time of DLE (LearningSpace) Use per Week at the Time of the Web-survey.

Formal training for using the DLE was also considered when LearningSpace was introduced in the OpinNet –project. Instructors were offered a possibility to attend two separate courses. The first one, called the “net-pedagogy” course, included two face-to-face weekend periods in addition to distance tasks and discussion via the Internet. The over-

all duration of the course was approximately three months. During the course instructors were offered the possibility to become familiar with LearningSpace as a DLE and some hands-on training was also offered. However, during the net-pedagogy course the use of LearningSpace was only dealt with as a part of a wider pedagogic-technological content. Of the instructor respondents, seven had participated in the “net-pedagogy” course. The second formal training for instructors was organized by IBM and it concentrated solely on LearningSpace. The duration of the course was three days. Of the instructor respondents, four had taken part in the IBM course. Participants for both courses were chosen by a project coordinator on the grounds that all adult education centers should have about the same number of instructors as participants; two to four participants from each institution (39 instructors altogether). Five instructors had participated in both courses, “net-pedagogy” and IBM, but there were also eight instructors who were not able to participate in either of the courses and 11 instructors who had participated in some other formal training instead of the “net-pedagogy” and IBM courses. “Other” training had been commissioned mainly from the outside by their own organizations. There was also one instructor who had participated in both the “net-pedagogy” and “other” courses. Since not all the instructors had an opportunity to participate in formal DLE training, it was agreed that the instructors who had participated in the courses would offer the other instructors from their organization the information they had got from their training periods. An electronic mail discussion list was also started for LearningSpace contact persons from each institution involved with the experimentation. The “tietosuo” electronic mail discussion list, founded earlier for the whole OpinNet –project, was also used as arena for exchanging experiences for the instructors using LearningSpace.

The learner respondents were also asked if they had participated in any formal training. However, none of the learners had taken part in formal “LearningSpace” training, the only form of training were the instructions offered by their “own” instructors.

6.2 Research Instruments

Data for the study was collected using a web-questionnaire. The questionnaire consisted of four parts: (1) Demographic Information, (2) the Computer Attitude Scale, (3) the Learning Style Inventory, and (4) the Adaptation to a DLE Scale (see URL: <http://www.jyu.fi/~msilvan/kysely.html>). In addition, at the end of the questionnaire there was an open space, where respondents had the opportunity to write about their experiences with the DLE used or comment on the questionnaire or the study in general. The Finnish language questionnaire was filled out anonymously and it took about 30 minutes to complete.

6.2.1 Demographic Information

The first section of the questionnaire, demographic information, included questions regarding (a) background information, (b) prior computing experience, (c) computing skills, (d) use of the DLE, and (e) training for using the DLE.

Background information. The first six questions of the questionnaire were gender, age, vocational qualification studied/instructed, the name of the vocational adult education center, and knowledge of English. Gender was asked by using radiobuttons female/male. Age was chosen from five alternatives: (1) under 25 years, (2) 26-35 years, (3) 36-45 years, (4) 46-55 years, and (5) 56 years or older. The name of the vocational qualification studied/instructed was asked by using an open question. Later, the vocational qualifications were coded. An open question was similarly used for the name of the organization where the learners were attending the preparatory training or at which the instructors worked. These organizations were also coded. The item measuring the knowledge of English required a response on a five-point scale: (1) none, (2) poor, (3) satisfactory, (4) good, and (5) excellent.

Prior Computing Experience. In this study prior computing experience was examined from two perspectives: (a) prior experience with computers, and (b) prior experience with networks, like the Internet and electronic mail. Respondents were asked to

indicate the frequency with which they had used computers and computer networks *before* taking part in the preparatory training where the DLE was utilized. The answer alternatives were: (1) not at all, (2) occasionally, (3) monthly, (4) weekly, and (5) daily or almost daily.

Computing Skills. The information regarding computing skills was gathered using two questions regarding (1) computer skills, and (2) network skills. The scale for the self-estimated computing skill level was the same for both questions: (1) poor, (2) fair, (3) good, and (4) excellent. It is important to note that in this study all the evaluations have been done by the participants themselves. Using a self-reported measure of skill may have some limitations. A learner who has used computers for a very short time and has mastered some basic skills may believe that he or she has mastered the use of computers in general and rates his or her skill level quite highly. In contrast, in the case of computer ‘experts’ the colloquial phrase “the more you know the less you think you know” may become true and influence the personal, self-reported skill level.

The use of the DLE (the use of LearningSpace). The use of the DLE was observed by (1) the total length of time of DLE use and (2) the time of DLE use per week. The total length of time was measured by a four-point scale: (1) 4 weeks or less, (2) 5 to 7 weeks, (3) 8 to 11 weeks, and (4) 12 weeks or longer. For the time used per week in the DLE there were five answer alternatives: (1) less than an hour, (2) 1 to 3 hours, (3) 4 to 6 hours, (4) 7 to 9 hours, and (5) 10 hours or more.

Training for Using a DLE. The question regarding participation in formal DLE training consisted of two answer alternatives: (1) no and (2) yes. If the answer ‘yes’ was chosen, instructors were offered three answer alternatives (a) “net-pedagogy” course, (b) IBM course, and (c) other. In addition there was also an open question ‘Other; state type and duration of the course’. For learners an open question was also added to the answer alternative ‘yes’ regarding the type and duration of formal training attended.

6.2.2 The Computer Attitude Scale

A number of instruments have been developed to measure attitude towards computers (Cambre & Cook 1985, Brock & Sulsky 1994, Jones & Clarke 1994). Perhaps the most widely accepted is the Computer Attitude Scale (CAS) developed by Loyd and Gressard (1984). The Computer Attitude Scale uses arguments similar to other instruments and has been tested numerous times for validity and reliability (Loyd & Gressard 1984, Loyd & Loyd 1985, Woodrow 1991). The first, original version of the Computer Attitude Scale consists of three subscales: anxiety of computers, liking of computers, and confidence in computers (see Loyd & Gressard 1984). Later, a computer usefulness subscale was added to the Computer Attitude Scale as a fourth dimension (see Loyd & Loyd 1985). At the same time the number of questions increased from 30 to 40. There are 10 questions per subscale and the questions for each subscale are distributed evenly throughout the instrument. The Computer Attitude Scale is a Likert-type instrument, where respondents are instructed to check whether they strongly agree, slightly agree, slightly disagree, or strongly disagree with each statement.

The results of the discriminant validity tests indicate however that the four computer attitude subscales represent three different factors: liking, usefulness and confidence/anxiety (see e.g. Woodrow 1991, Nash & Moroz 1997). Having confirmed by the results of the factor analysis that computer confidence and computer anxiety are parts of the same continuum, Nash and Moroz (1997), selected items from both subscales, confidence and anxiety, and created a collapse subscale relating to one's comfort with computers. Nash and Moroz also included one more response format: Not Sure. The scores from the following items were reversed: 1, 4, 6, 7, 11, 12, 14, 16, 17, 18, 19, 20, 23, 24, 25, 28, 29, and 30.

In this study the Computer Attitude Scale revised by Nash and Moroz (1997) was used. Therefore it included 30 items on a 5-point Likert scale: strongly disagree, slightly disagree, not sure, slightly agree, and strongly agree. However, some minor changes were also made to the version used by Nash and Moroz. The changes were based on the notion by Newell (1993, 106): "For most studies, hypothetical questions are best avoided. These questions usually begin with 'What would you do if...?' or

‘Would you like to...?’ What the respondent says he or she might do when faced with a given situation may not be a good guide to their actual future behavior.” In accordance with this statement all the hypothetical statements were rewritten as more actual statements. This change was also closely supported by the fact that all the respondents had used computers before – the questionnaire itself was located in the Internet and filled out by using computers - and therefore the use of hypothetical questions like “I think using a computer would be very hard for me” would have been unreasonable.

6.2.3 The Learning Style Inventory

Over the years several instruments have been developed for determining learning styles in accordance with the various theories. Kolb (1976) developed the Learning Style Inventory (LSI) for the purpose of measuring the learning style preferences defined by his theory of experiential learning. The development of this instrument was guided by four design objectives. Firstly, the test was to be constructed in such a way that people would respond to it in about the same way as they would in a learning situation; that is, it should require one to resolve the opposing tensions between the abstract-concrete and active-reflective orientations. In technical testing terms, Kolb was seeking a test that would be both normative, allowing comparisons between individuals in their relative emphasis on a given learning mode such as abstract conceptualization, and ipsative, allowing comparisons within individuals in their relative emphasis on the four learning modes. Secondly, a self-description format was chosen for the inventory, since the notion of possibility-processing structure relies heavily on conscious choice and decision. It was felt that self-image descriptions might be more powerful determinants of behavioral choices and decisions than would performance tests. Thirdly, the inventory was constructed in the hope that it would prove to be valid - that the measures of learning styles would predict behavior in a way consistent with the theory of experiential learning. The final consideration was a practical one. The test had to be brief and straightforward, so that in addition to research uses, it could be used as a means of discussing the learning process with those tested and to give them feedback on their own learning styles. The final form of the test is a nine-item self-description questionnaire. Each item

asks the respondent to rank-order four one-word adjectives in a way that best describes his or her learning style. One word in each item corresponds to one of the four learning modes - concrete experience (sample word, feeling), reflective observation (watching), abstract conceptualization (thinking), and active experimentation (doing). The norms for the scores of the Learning Style Inventory were developed from a sample of 1933 men and women ranging in age from 18 to 60 and representing a wide variety of occupations. (Kolb 1984, 67-69.)

The Learning Style Inventory has, however, received notable criticism. Critics have claimed that the design of the Learning Style Inventory is defective because of its ipsative format, forced-choice technique, dependent scores, and instrument bias (see e.g. Tennant 1988/1997). It has also been criticized of failing to display sufficient evidence of reliability and validity (see e.g. Atkinson 1991). Tennant (1988/1997, 105/92) for instance notes, that “the Learning Style Inventory has no capacity to measure the degree of integration of learning styles. Indeed, it really only measures the relative preference of one set of words over another in describing learning styles.”

In 1985, Kolb and his associates (Smith & Kolb 1986) revised the Learning Style Inventory to improve and refine its psychometric properties (Atkinson 1991). With the revision, designated the Learning Style Inventory 1985 (LSI-1985 or LSI-II), Kolb initiated a new phase of research in the attempt to measure learning styles effectively in accordance with the experiential learning theory (see Atkinson 1991.) The revised Learning Style Inventory consists of 12 items instead of nine. Rather than single adjectives, respondents must rank four sentence-completions for phrases such as “When I learn...” or “I learn best from...” to describe their learning preferences.

The revised Learning Style Inventory has, however, also received strong criticism. Loo (1996) notes that the revised Learning Style Inventory has not resolved the psychometric problems for which the original version was criticized. In a study by Sims, Veres III, Watson, and Buckner (1986) it was found that the internal consistency was much improved in the revised Learning Style Instrument, but that problems with low test-retest indices and classification stability continue to plague the instrument. The principal finding in a psychometric re-examination by de Ciantis and Kirton (1996) was that it was not possible for a single inventory to measure the style, level and process of learning all at the same time, as Kolb’s construct claims to do. Ruble and Stout (1994)

have even noted that the use of the Learning Style Inventory in research should be discontinued.

In 1992 Romero, Tepper and Tetrault developed new scales to measure Kolb's learning style dimensions. Instead of obtaining scores on the four problem solving modes and conducting additional analyses to assess the respondents' relative emphasis on each dimension – as do the Learning Style Inventories constructed by Kolb – they constructed a normative two-dimensional instrument. Each of the 14 items consists of two self-descriptive statement anchors and a 6-point response format. The preliminary evidence reported was encouraging; the current research provides support for the reliability, factor structure, and validity of the new scales. (Romero, Tepper & Tetrault 1992, see also Tepper & Tetrault 1993.) However, there are some expectations to be perceived in the questions. For instance question three has the dimension: "I like to be specific – I like to remain flexible". Therefore the expectation is that a respondent is flexible at the time of filling out the questionnaire and that he or she wants to *remain* like this. Also question number nine has similar expectations: "I like *to stay* flexible (*not get* too focused) – I like *to get* as focused as possible". For these reasons a normative two-dimensional instrument was adopted to this study, but the questions were revised to some degree.

The learning style questionnaire developed by Romero, Tepper and Tetrault (1992) was also used in this study. Learning Style scores for the respondents were calculated by summing up the responses for each of the 14 items in the way that the minimum score for the each continuum (CEAC, ROAE) was 7, and the maximum 42. In the second phase the dominant learning style of each individual was specified. The axes were defined as indicated by the results of the study by Romero, Tepper and Tetrault (1992). On the concreteness/abstractness (CEAC) dimension the scores over 23.53 reflect an emphasis on abstract conceptualization and on the reflection/action (ROAE) dimension the scores over 26.67 reflect an emphasis on active experimentation (see Figure 11).

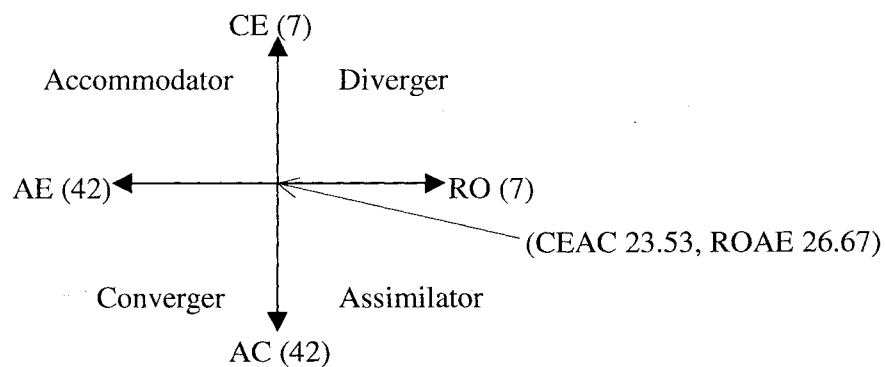


FIGURE 11 Learning Style Continua and the “Limits” of Dominant Learning Styles Quadrants According to Romero, Tepper and Tetrault (1992).

In accordance with these “limits”, based on previous research findings (see Romero, Tepper & Tetrault 1992), the dominant learning styles were indicated and numbered as follows: (1) diverger (emphasis on CE and RO), (2) assimilator (emphasis on RO and AC), (3) converger (emphasis on AC and AE), and (4) accommodator (emphasis on AE and CE).

6.2.4 Adaptation to a Distributed Learning Environment Scale

The items used to measure learners’ and instructors’ subjective adaptation to a DLE were developed on the basis of the literature reviewed and the criteria developed for adaptation to a DLE. Adaptation was conceptualized as being related to three dimensions: learning objectives (constructivist learning), instructional models (formation of a learning community) and the use of enabling technologies (emancipation from technology).

The adaptation to a DLE scale included 12 items; four items for each three dimensions. Questions 1, 4, 7, and 10 measured constructivist learning, questions 2, 5, 8, and 11 the formation of a learning community, and questions 3, 6, 9, and 12 the emancipation from technology. Questions 1, 3, 5, 7, 8, and 9 were reversed. Questions for learners and instructors differed in their point of view, but were otherwise the same. For

instance question number 12 for learners was “the use of LearningSpace does not demand any special technical attention from me and I can concentrate on the subject matter to be learned” and for instructors “...subject matter to be instructed”. The scale was a five-point Likert-type response scale: (1) strongly disagree, (2) disagree, (3) don’t know, (4) agree, and (5) strongly agree.

6.3 Online Web-Survey

The final data – as well as the data for the pilot study – was gathered using an online web-survey (see URL: <http://www.jyu.fi/~msilvan/kysely.html>). The instructors were first informed about the questionnaire by using the “tietosuo” electronic mail discussion list, which is an information medium for the OpinNet –project. The instructors were informed about the location of the online questionnaire in the Internet and they were asked to answer it themselves and to inform their learners about the questionnaire by adding a link and information about it in the LearningSpace Schedule. The main WWW-page included the information about the study and links to the separate questionnaires for the learners and instructors.

The questionnaires were constructed using radiobuttons and open answer spaces. The use of radiobuttons ensures that only one alternative is chosen for each question. The question number 12 for instructors was an exception in that it accepted several alternatives regarding participation in formal training. The advantage of the open answer spaces in web-based questionnaire is that they guarantee a sufficiently large – an almost unlimited - answer space for each open question. By pressing the “send the questionnaire” -button located at the end of the questionnaire the answers were sent to the researcher through the web.

6.4 Pilot Study

A small pilot study testing the measures and methods was carried out in the beginning of March 1999. Two preparatory training groups from two different vocational adult education centres (The Vocational Adult Education Centres in Turku and Jyväskylä) and from two different vocational qualifications (Further Qualification of Data Processing and Further Qualification in Institutional Cleaning) attended the pilot study. The instructors were contacted by electronic mail and asked to participate in the pilot study by informing their learners about the questionnaire in the Internet. The instructors were asked to complete the questionnaire designed for them. The respondents were asked to pay particular attention to the wording and meaning of each single question.

20 learners (10 from each vocational qualification) and three instructors (two instructors from Further Qualification for Data Processing and one from Further Qualification in Institutional Cleaning) filled out and commented on the questionnaire. Based on these comments minor amendments were made in the later study. However, data for the pilot phase increased later on. The data for the study was intended to be gathered later in March and information about the questionnaire in the Internet was transferred to the instructors of the OpinNet –project using LearningSpace. In a notification it was also asked that the instructors who themselves and their learning teams were offered with licenses, but did not use them yet, would inform researcher about it. Nineteen learners from two preparatory training courses (14 learners from Information Technology training and five learners from Further Qualification of Cook) filled out the questionnaire. Twelve instructors filled out the questionnaire also, but nine of them had not used the DLE with the learners and were therefore excluded. The remaining three instructors were from Further Qualification for Data Processing, Information Technology training and Further Qualification of Cook. In addition, twelve accounts for the non-use of the DLE were received. Because the degree of using the DLE was still so low (under 10 percent of the licenses offered were in use), gathering the final data was postponed for two months to the beginning of May and the answers received were added to the pilot data. Therefore the final pilot data consisted of 39 learner responses and six instructor responses from four different vocational adult education centres.

6.5 Analytical Procedures

Structural equation modeling (SEM) techniques were used to determine the extent to which the model of hypothesized relationships was supported. Analysis of variance (ANOVA) was instead used as an analytical procedure for testing the differences in adaptation to a DLE among the four different learning style groups. All the statistical procedures were performed using SPSS 8.0 and AMOS 3.6.

The structural equation model (SEM) evaluates how well a hypothesized conceptual model fits the associated data. The SEM is also sometimes called LISREL, which is the name of the computer program that was first developed to run it. Sometimes it is called a latent variable causal modeling because it is used to test causal models and theories, and because it involves the measurement of latent variables. The SEM is usually viewed as a confirmatory rather than as an exploratory procedure. It can also be seen as a family of statistical techniques which incorporates and integrates path analysis and factor analysis.

The model consists of two parts, the measurement model and the structural model. *The measurement model* specifies how latent variables or hypothetical constructs depend upon or are indicated by the observed variables. It describes the measurement properties (reliabilities and validities) of the observed variables. *The structural model* instead specifies the causal relationships among the latent variables. By “causal” is meant the assumption that, everything else being constant, a change in the variable at the tail of the arrow will result in a change in the variable at the head of the arrow (Loehlin 1987, 4). Therefore in a structural equation model each equation represents a causal link rather than a mere empirical association. Structural analysis is a method similar to path analysis, but it has been found to be more powerful than path analysis, because it yields more valid and reliable measures of the variables to be analyzed (Borg & Gall 1989).

Why is the structural equation model the chosen method for this study? In addition to the fact that many previous studies have supported the use of the structural equation model in this kind of research (see e.g. Clegg et al. 1997, Neilson 1997), structural equation modeling was also chosen because of its ability to define and test a comprehensive “System Contingency approach” (see Hiltz 1994) type of theoretical

models. For instance Chin (1998, vii) has mentioned that, “when applied correctly, SEM-based procedures have substantial advantages over first-generation techniques such as principal component analysis, factors analysis, discriminant analysis, or multiple regression because of the greater flexibility that researcher has for the interplay between theory and data”. Compared to these “first generation” techniques often used in these types of analysis, some of the advantages of the structural equation model include the ability to: (1) estimate the direct, indirect, and total effects of variables; (2) define and investigate relationships among latent constructs; (3) estimate the variance accounted for in each latent construct by other variables in the model; and (4) estimate error terms associated with each observed and latent variable. (Heck & Wolcott 1997, Li, Harmer Duncan, Acock & Boles 1998.)

Missing data. Structural equation modeling requires complete information for all the cases included in the model. However, it is undesirable to drop cases from the analysis because missing data is not likely to be distributed randomly. In this way their omission can introduce sample selection bias. (Garrett & Ferron 1994). In this study the percentage of the cases with missing data was very small; only eight cases had missing data, all in different variables. Borg and Gall (1989, 370) have mentioned the use of group mean and more precise regression analysis to estimate the missing data. In this study several methods based on available information and depending on the variables estimated were used to estimate the missing data.

Preliminary analyses. Because there was a large number of measures describing the adaptation to a DLE, several preliminary analyses were also used (e.g. exploratory factor and reliability analysis) to help determine which of the variables comprising the theoretical domains to include in the model. Empirical and theoretical knowledge of variables that influence the adaptation to a DLE were reflected upon statistical criteria. Therefore the reliability of the measures used to operationalize the variables in the study was tested against the statistical as well as the theoretical analysis. As a result of this analysis prior experience with web-based education, which was asked as the third question included in prior computing experience, as well as DLE skills, which was the third item included in computing skills section, were dropped from the final model.

As a very important part of the preliminary analysis normality tests of observed variables were also done. Comparison of means and medians, statistics for skewness and

kurtosis, and Kolmogorov-Smirnov and Shapiro-Wilk were used to test normality. As a result, it was found that most of the observed variables in the SEM were not normally distributed. Because of these results the asymptotically distribution free (ADF) method was chosen as the estimation method used in SEM. Like all the other estimation methods, also the ADF estimator has several advantages as well as drawbacks (see Bollen 1989). The most important of the advantages is that it makes minimal assumptions about the distribution of the observed variables, while the disadvantages are more computational. It is, however, difficult to know when the nonnormality is severe enough to require the ADF instead of Maximum likelihood (ML), the most common estimation method used. In this case, as the nonnormality, including multivariate nonnormality, was so severe, it was decided that ADF should be used. Another approach would have been to use bootstrapping capabilities. However, bootstrapping as a transformation method has received a lot of criticism and its capability to perform correct estimations has been made questioned (see e.g. Bollen & Long 1993). This supported the use of the ADF method instead of bootstrapping.

Also analysis of variance (ANOVA) assumes that the scores are normally distributed in the populations under study. Because this demand was not fulfilled the transformations needed were made (power for transformation 2,102). The results in Chapter 7.3 are, however, reported with the nontransformed results for reasons of clarity, but, to avoid type I error, analysis with the transformed data was also done to verify the similar results of the analyses with both the transformed and the nontransformed data. Homogeneity of the variances is the second assumption when using ANOVA. Therefore, as a preliminary analysis for ANOVA, tests checking for differences between variances were also done. The variances were found to be homogenous with the nontransformed as well as with the transformed data.

Analysis of variance. One way to compare adaptation to a DLE among four different learning style groups would have been to use simultaneous SEM analysis for several groups. Jöreskog and Sörbom (1994) have proposed this method of analysis that is highly appropriate for comparative studies (Yli-Luoma 1990) and can be used to analyze data simultaneously across several different populations. However, the simultaneous use of the SEM analysis and the ADF as an estimation method would have required more data. Therefore analysis of variance (ANOVA) was used as an analytical procedure for

testing the differences in adaptation to a DLE among different learning style groups. The purpose of the analysis of variance (ANOVA) in this situation is to determine whether the four different learning style groups differ significantly from each other on the adaptation to a DLE.

7 RESULTS

The data was analyzed in three stages. First the measurement model analyses were performed on the overall hypothesized structural equation model to determine whether the model provided a good fit to the data. These analyses assessed how well the overall model explained variables associated with adaptation to a DLE. Several goodness of fit tests were performed to find out if the model being tested should be accepted or rejected. In this study the model was accepted and the second step, the structural model analyses was performed on predicted variable relationships with the model. These analyses provided direct test results of the hypothesized relationships; the parameter estimates were examined to determine if their direction and magnitude were consistent with those hypothesized (hypotheses 1 to 8). As a reminder it has to be mentioned that *if* the model has not fulfilled the criteria for acceptance, the “significant” path coefficients in a poor fit model are not meaningful. Therefore it is important to follow the steps of the SEM analysis in this order and, if needed, to modify the hypothesized model so as to make it adequate before the structural analysis. The third step involved the analysis of variance (ANOVA) in order to determine whether learning style affected adaptation to a DLE (hypothesis 9). The results for the hypothesized structural equation model are presented in Figure 12.

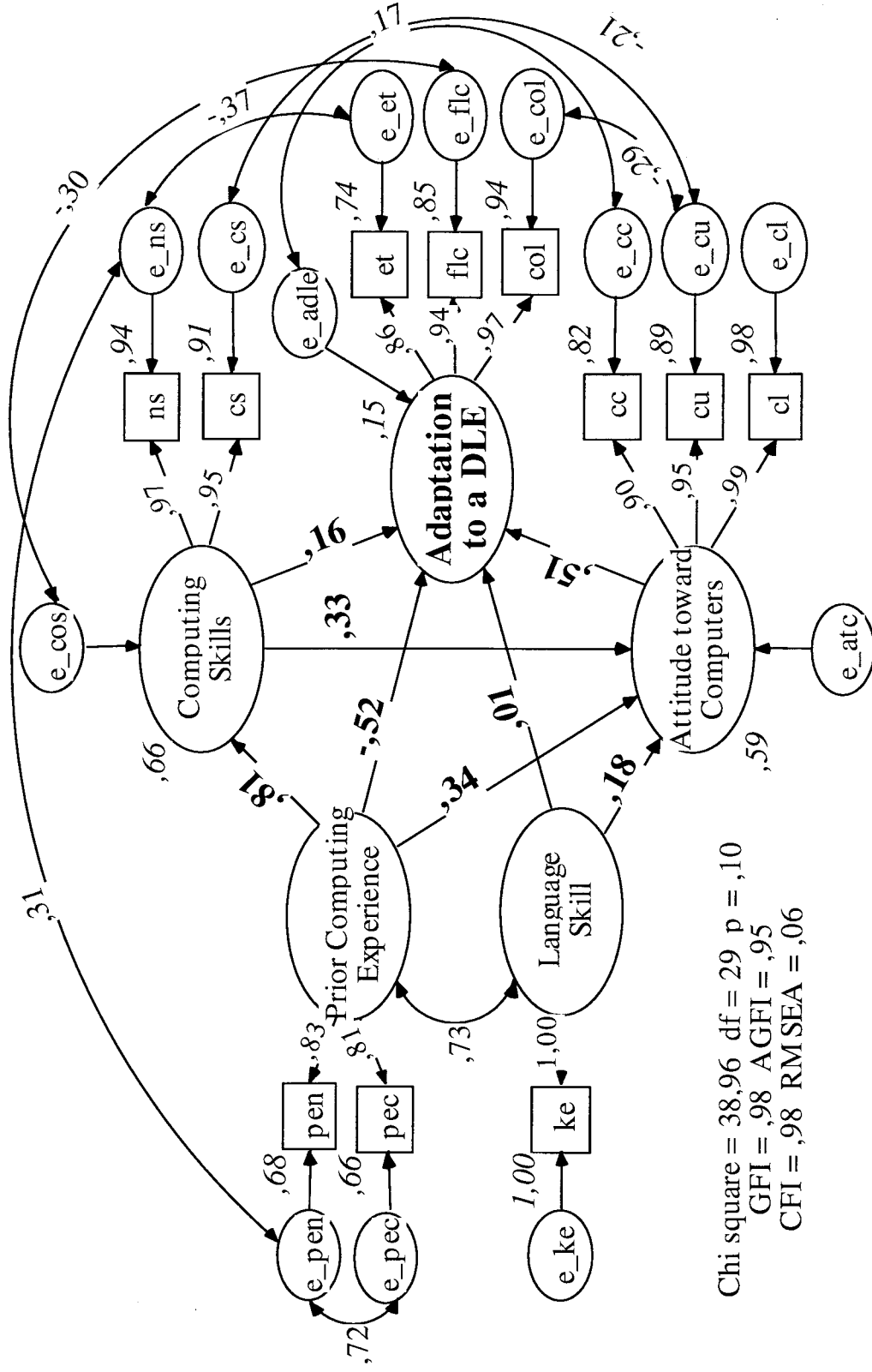


FIGURE 12 A Structural Equation Model of Adaptation to a Distributed Learning Environment.

7.1 Testing the Hypothesized Measurement Model

Structural equation modeling evaluates how well a hypothesized conceptual model fits the associated data. Goodness of fit tests determine if the model being tested should be accepted or rejected. There are many goodness of fit measures reflecting different considerations. The hypothesized model presented in Figure 7 was evaluated using several measures of goodness of fit. AMOS, for example, prints 25 different goodness of fit measures. However, there is wide disagreement as to which fit indexes to report, as “the shotgun approach” of reporting all of them should be avoided (see Structural Equation Modeling 1999). Usually - and also in this study - several few carefully selected goodness of fit measures are reported and considered more carefully. Often it is recommended to use three to four fit tests from different categories to reflect diverse criteria. In this study the measures of fit represented four different categories: the minimum sample discrepancy function, measures of parsimony, comparisons to baseline model and measures based on population discrepancy.

In addition to the hypothesized model presented in Figure 7, the model presented in Figure 12 shows the correlated error terms as specified to the hypothesized model. The correlated error terms refer to a situation in which knowing the residual of one indicator helps in knowing the residual associated with another indicator. As compared to other analytical procedures where only the variables are modeled, in the SEM the correlation of error terms may - and should be - explicitly modeled as well as the variables in it. (see Structural Equation Modeling 1999.)

The size of the chi-square ($\chi^2 = 38.96$) statistic relative to degrees of freedom ($df = 29$) is the most common means of assessing the goodness of fit. For the chi-square/degrees of freedom ratio, which is the measure of the minimum sample discrepancy function, some researchers allow values as high as 5.00 as being an adequate fit (see e.g. Yli-Luoma 1996), but the conservative use calls for rejecting models with a relative chi-square greater than 2.00. In this study, the chi-square relative to degrees of freedom (χ^2/df) ratio was 1.34, indicating a reasonable model fit for a set of data of this size ($n = 102$). The df alone is the measure of parsimony. The value of the chi-square

alone can - instead of being a measure of goodness of fit - also be called a 'badness-of-fit' measure in the sense that a small chi-square corresponds to good fit and a large chi-square to a bad fit. In this study the value of the chi-square is quite high, but as compared to the chi-square value of the independence model ($\chi^2 = 684.92$), the chi-square value of the hypothesized model can be better assessed, compared, and accepted.²

The p value of the chi-square can also be used for testing the hypothesis that the model fits perfectly in the population. The p value, which is the measure of the minimum sample discrepancy function, indicates how much the covariance matrix implied by the model differs from the covariance matrix of the observed data. In contrast to the traditional hypothesis testing, the goal in SEM analysis is to produce an insignificant result; the chi-square value should *not* be significant at .05 level if there is a good model fit. The reason of seeking insignificant result is that the researcher is attempting to develop a theoretical model that accounts for all the covariances among the measured items. In this study the p value exceeded the value not being significant ($p = .10$) and therefore supported the model's fit in the population. This also meant that there were no grounds for rejecting the model. The p value being not significant can be seen as a very important achievement of the modification process of the hypothesized model, because it is generally acknowledged that most models are useful approximations that do not fit perfectly in the population (see Arbuckle 1997).

The other reported fit indexes include the goodness of fit index (GFI), adjusted goodness of fit index (AGFI), and the comparative fit index CFI. The GFI measure shows how much better the hypothesized model fits as compared to no model at all. The AGFI also takes into account the degrees of freedom available for testing the model. The CFI measures how much better the model fits as compared to a baseline model, usually the independence model. (Jöreskog & Sörbom 1994, Arbuckle 1997.) The GFI, AGFI, and CFI are fit indicators that are scaled so that 1.00 represents a perfect fit be-

² For each model specified there are also two additional models called the "saturated" model and the "independence" model. In the saturated model, no constraints are placed on the population moments. It is the most general model possible and a vacuous model in the sense that it is guaranteed to fit any set of data perfectly. Therefore any model is a constrained version of the saturated model. The independence model goes to the opposite extreme. In it the observed variables are assumed to be uncorrelated with each other. When means are being estimated or constrained, the means of all observed variables are fixed at zero. The independence model is so severely and implausibly constrained that it provides a poor fit to any interesting set of data. The saturated model and the independence model can be viewed as two extremes between which the proposed models lie. (Arbuckle 1997.)

tween the model and the data. Values above .90 on these indices are generally recognized as providing a good fit (Heck & Wolcott 1997). However, many researchers also interpret the GFI, AGFI, and CFI scores in the .80 to .89 range as representing a reasonable fit (Doll & Xia 1994). In this study the values of all these fit indexes were indicating a good model fit (GFI = .98, AGFI = .95, and CFI = .98).

In contrast to the GFI, AGFI, and CFI, which have a perfect fit value at 1.00, the RMSEA, should be close to zero for a good model fit. RMSEA – sometimes also called RMS, RMSE or discrepancy per degree of freedom - is a measure of the average unexplained variances and covariances in the model. It is one of the fit indexes least affected by sample size. According to Browne and Cudeck (1993) a RMSEA value of .05 indicates a close fit and values up to .08 indicate a reasonable fit; a model with a RMSEA greater than .10 should not be employed (Jöreskog & Sörbom 1994, Arbuckle 1997). In this study the RMSEA value .06 represented a reasonable fit of the hypothesized model.

7.1.1 Validity of the Model

In a measurement model the path coefficients from observed variables to unobserved, latent variables, can be interpreted like factor loadings. The larger the factor loadings are, the stronger is the evidence that the measured variables of factors represent the underlying constructs. (Bollen 1989, Doll & Xia 1994.) Therefore the standardized factor loadings of observed variables on latent variables are also estimates of the *validity* of the observed variables. Most of the factor loadings should be at least .60 and ideally at .70 or above indicating that each measure is accounting for 50 percent or more of the variance of the underlying latent variable. In the hypothesized model all observed variables have meaningful (ranging from .81 to .99) and significant ($p < .001$) loadings on their corresponding factors, indicating evidence of good construct validity (see Figure 12). However, it has to be remembered that during the preliminary analysis some observed variables (prior experience with web-based education and DLE skills) not fulfilling the validity requirements were dropped from the model. There is also a variable indicating the English language skill, which is created to be latent, but which is measured by a sin-

gle indicator, having a loading specified with the value of 1.00. Descriptive statistics for each of the observed variables are presented in Appendix 1, and the matrix of correlation and covariances among the observed variables is displayed in Appendix 2.

7.1.2 Reliability of the Model

Because the error variables in the model represent more than just measurement errors, the squared multiple correlations (R^2) cannot be interpreted as estimates of reliabilities. Rather each squared multiple correlation may serve as a lower-bound estimate of the corresponding reliability. The squared multiple correlations are presented in Figure 12 and marked with italics. The squared multiple correlations in the hypothesized model vary between .66 and .98, indicating a good reliability of the observed variables (standardized). In network skills (ns), for instance, 94 percent of the variance is accounted for by computing skills. Hence its reliability can be estimated to be at least .94. The remaining 6 percent of the variance in network skills cannot be explained by this model, and is thus attributed to the unique factor e_{ns} . In addition there is also the one observed variable with a fixed single indicator, language skill, having the squared multiple correlation of 1.00.

In Figure 12, the squared multiple correlation coefficients calculated for the latent variables with the help of the observed variables are shown separately and marked with italics in the model. As well as assessing the reliability of individual observed variables, the SEM analysis also enables the estimation of the reliability of the latent variables (factors) – as well as that of the overall instrument. The determination coefficient is estimated by using the squared multiple correlation coefficient. Figure 12 shows that the explained variance in computing skills and in attitude towards computers were 66 percent and 59 percent. The model as a whole explained 15 percent of the variance in adaptation to a DLE (with 85% due to other causes).

7.2 Testing the Hypothesized Structural Model

Overall, all the goodness of fit statistics indicate that the hypothesized model is a good starting point for explaining adaptation to a DLE. After determining the adequacy of the hypothesized model, its individual parameters can now be examined more carefully and the second step in the analysis, the structural model analysis, can be performed. In Figure 12 all the standardized parameter estimates of the hypothesized model, the “path coefficients” between the latent variables, are also presented. The standardized estimates, as well as the squared multiple correlations, are independent of the unit of measurement and are based on correlation matrix (see Appendix 2). The unstandardized estimates of the analysis (regression weight estimations, standard errors and critical ratios) are displayed in Appendix 3. The unstandardized estimates of the analysis are based on covariance matrix (see Appendix 2).

7.2.1 Effects of Prior Computing Experience

Prior computer experience varied a lot between the learners. Of the learners who responded ($n = 64$) slightly over a quarter ($n = 17$) had no prior experience at all of using computers (26,6 %). Ten learners had used computers occasionally (15,6 %) and two learners monthly (3,1 %). Four of the learners had used computers weekly (6,3 %) and almost half of the learners ($n = 31$) daily or almost daily (48,8 %). In contrast to the varying prior computer experience of the learners, there was no variation at all among the instructors; all of the instructors who responded ($n = 38$) had used computers daily or almost daily. The difference was similar with *prior network experience*. The learners’ prior experience with networks varied a lot in contrast to the instructors’ consistent and considerably high prior network experience. Of the learners 25 had no prior experience with networks (39,1 %). Five had used networks occasionally (7,8 %) and two learners monthly (3,1 %). Nine learners had used networks weekly (14,1 %) and 23 of the learners daily or almost daily (35,9 %). Of the instructors 94,7 percent ($n = 36$) had used net-

works daily or almost daily and the remaining two weekly (5,3 %). For prior computing experience the mean for both learners and instructors as a whole was 2.58 and the median 3.00 (SD = .91). For prior network experience the mean was 2.53 and the median 3.00 (SD = X).

The first hypothesis (H1) stated the causal relationship between prior computing experience and computing skills. The data show that prior computing experience has a strong (.81) and significant ($p < .001$) direct effect on computing skills. Therefore the first hypothesis was supported. This result was expected and it indicates that learners and instructors having more prior computing experience before entering a DLE also have better computing skills.

Also the second hypothesis (H2) concerning the causal relationship between prior computing experience and attitude towards computers was supported. Prior computing experience was found to have a direct (.34) and significant ($p < .05$) effect on attitude towards computers. This means that learners and instructors having more prior computing experience have a more positive attitude towards computers. In addition to the significant direct effect, prior computing experience had also a relatively large indirect (.27) effect on attitude towards computers through computing skills.³ This indirect effect was not significant, but it was present in the total effect of prior computing experience on attitude towards computers so, that the total effect was found to be stronger (.61) and more significant ($p > .001$) than the direct effect alone.

In contrast to hypotheses one and two, the third hypothesis (H3) that predicted a causal relationship between prior computing experience and adaptation to a DLE was not supported. Prior computing experience was found to have a relatively large negative direct effect on adaptation to a DLE (-.52), but the effect was not statistically significant. Neither was significant the indirect effect (.51) of prior computing experience on adaptation to a DLE through the intermediaries of computing skills and attitude towards computers. The total effect (-.01) of prior computing experience on adaptation to a DLE was also found to be insignificant. The fact that the effect of prior computing experience on adaptation to a DLE is negative means that, all the other variables being equal, a

³ An indirect effect represents the effect of a particular variable on a second variable through its effects on a third mediating variable. It is the product of the path coefficients along an indirect route from cause to effect via tracing arrows in the headed direction only. When more than one indirect path exists, the total

relatively high adaptation to a DLE would be associated with a relatively low computing experience and vice versa.

7.2.2 Effects of Computing Skills

In general, the levels of the self-rated computer and network skills among the learners varied quite a lot. The learners' self-rated computer skills (Mean = 2.34, Md = 2.00, SD = .86) and network skills (Mean = 2.25, Md = 2.00, SD = .96) were generally low. In contrast to this the instructors self-rated computer skills (Mean = 2.97, Md = 3.00, SD = .85) and network skills (Mean = 3.00, Md = 3.00, SD = .81) were fairly high (see Figure 13). For learners and instructors together, the mean for computer skills was 2.58 (Md = 3.00, SD = .91) and for network skills 2.53 (Md = 3.00, SD = .97).

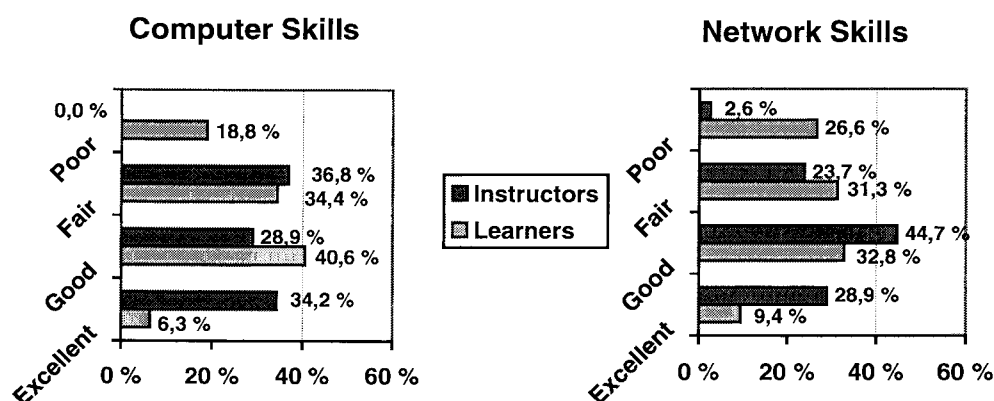


FIGURE 13 The Self-rated Computer and Network Skills of the Learners and Instructors.

Consistent with hypothesis four (H4) computing skills were found to have a direct positive (.33) and significant ($p < .05$) effect on attitude towards computers. Therefore hypothesis four was supported, which means that learners and instructors with better computing skills were also found to have a more positive attitude towards computers.

indirect effect is their sum. The sum of the direct and indirect effects reflects the total effect of the variable on the endogenous variable. (Igbaria & Zinatelli 1997.)

Inconsistent with hypothesis five (H5) the causal relationship between computing skills and adaptation to a DLE was not found to exist. This unexpected finding indicates the lack of a significant direct effect (.16) from computing skills to adaptation to a DLE. Even though computing skills had also an indirect effect (.16) on adaptation to a DLE, the total effect (.32) was not significant. This finding means that the learners and instructors that have better computing skills are not expected to adapt better to a DLE. Correspondingly this means that neither does the lack of computing skills have a negative effect on adaptation to a DLE.

7.2.3 Effects of Attitude towards Computers

The mean score for the learners of this study on the Computer Attitude Scale (CAS) was 122.58 (SD = 19.35) and for the instructors 126.84 (SD = 16.50). In general the results suggest that both the learners and the instructors held very positive attitude towards computers (Mean = 124.17 (SD = 18.37). Table 1 presents the means and standard deviations for each of the three subscales and for the whole CAS instrument.

TABLE 1. Means and Standard Deviations of the Computer Attitude Subscales						
Subscale	<u>Learners</u>		<u>Instructors</u>		<u>Both</u>	
	Mean	SD	Mean	SD	Mean	SD
Computer Liking	41.63	7.01	43.89	5.55	42.47	6.57
Computer Usefulness	41.75	6.86	42.58	6.20	42.06	6.60
Computer Comfort	39.20	6.18	40.37	5.74	39.64	6.02
CAS	122.58	19.35	126.84	16.50	124.17	18.37

The sixth hypothesis (H6) stated a causal relationship between attitude towards computers and adaptation to a DLE. The data supported the hypothesis and proved a strong (.51) and very significant ($p < .001$) direct effect from attitude towards computers to adaptation to a DLE. This finding means that learners and instructors who have a more positive attitude towards computers adapt better to a DLE. This also means that learners and instructors who have negative attitudes towards computers have more difficulties in adapting to a DLE. It is also important to notice that the attitude towards computers is

the only variable that has a direct or total significant effect on adaptation to a DLE (see Table 2).

TABLE 2. Direct, Indirect, and Total Effects on Adaptation to a DLE.

	<u>Adaptation to a DLE</u>		
	Direct	Indirect	Total
Prior Computing Experience	-.52	.51	-.01
Language Skill	.01	.02	.03
Computing Skills	.16	.16	.32
Attitude towards Computers	.51***	---	.51***
R ²	---	---	.15

*** $p < .001$ ** $p < .01$ * $p < .05$

All the other variables included in the hypothesized model (prior computing experience, computing skills and knowledge of English), except for attitude towards computers, have an effect on adaptation to a DLE only through attitude towards computers. All the other latent variables, however, have a significant direct (.34, .18, .33, $p < .05$) and total (from $p < .05$ to $p < .001$) effect on attitude towards computers (see Table 3).

TABLE 3. Direct, Indirect, and Total Effects on Attitude towards Computers.

	<u>Attitude towards Computers</u>		
	Direct	Indirect	Total
Prior Computing Experience	.34*	.27	.61***
Language Skill	.18*	---	.18*
Computing Skills	.33*	---	.33*
R ²	---	---	.59

*** $p < .001$ ** $p < .01$ * $p < .05$

7.2.4 Effects of Language Skill

Learners' knowledge of the English language ranged from not knowing English at all (10,9 %) to a good knowledge of English (23,4 %). 23,4 percent of the learners estimated their language skill as being poor and 42,2 percent as being satisfactory. The in-

structors' self-assessed language skill rated from poor (10,5 %) to good (55,3 %). 34,2 percent evaluated their language skill as being satisfactory. The median for the learners and instructors' language skill was 3.00, which was the value for satisfactory language skills (Mean = 3.03, SD = .91).

The seventh hypothesis (H7) stated the causal relationship between language skill and attitude towards computers. The direct effect of language skill on attitude towards computer was found to be quite strong (.18) and significant ($p < .05$). Thus, hypothesis seven was supported. The result received support also from many of the comments included in the open answer space of the web-survey, indicating the difficulties experienced with the English language when the DLE was used by Finnish speaking learners and instructors.

“LearningSpace as based on the English language, makes it much harder to study than if it were in Finnish”. (Student)

“The use of LearningSpace was very, very hard in the beginning, because of the English language used in it”. (Instructor)

The learners and instructors were also asked whether they found it inconvenient that the DLE (LearningSpace) was based on the English language. 83 percent of the learners and 63 percent of the instructors reported that the English language gave “a lot” or “very much” trouble in using the DLE as a tool for learning (see Figure 14). Only 11 percent of the learners and 16 percent of the instructors thought that DLE being an English language application did not have any effect at all on their use of the environment as a means to learn.

The eighth hypothesis (H8) stated a causal relationship between language skill and adaptation to a DLE. However, this hypothesis was not supported since the direct effect of language skill on adaptation to a DLE was found to be very weak (.01) and statistically insignificant. Even though language skill had a significant effect on attitude towards computers and this attitude a significant direct effect on adaptation to a DLE, the total effect (.03) from language skill to adaptation to a DLE was insignificant. There-

fore knowledge of English is not found to have an effect on adaptation to a DLE among Finnish-speaking learners and instructors.

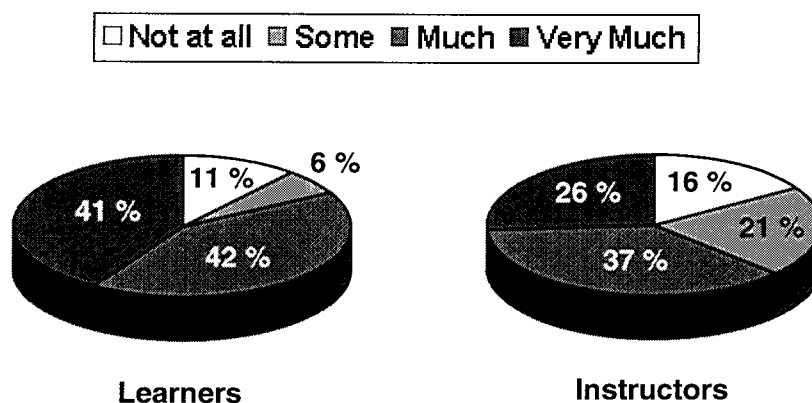


FIGURE 14 Inconvenience Experienced by Finnish-speaking Learners and Instructors when Using a Distributed Learning Environment based on the English Language.

7.3 Learning Style Differences and Adaptation to a Distributed Learning Environment

The descriptive statistics on the concreteness/abstractness scale of the Learning Style Inventory were as follows: Mean = 21.83, SD = 6.85, and alpha = .87. The descriptive statistics on the reflection/action scale were Mean = 27.62, SD = 6.45, and alpha = .82. In the second phase the dominant learning style of each responder was specified. Of the respondents (n = 102), 20 were divergers (19,6 %), 24 assimilators (23,5 %), 16 convergers (15,7 %), and 42 accommodators (41,2 %). Descriptive statistics of the adaptation of each learning style group to a DLE are shown in Table 4.

TABLE 4. Descriptive Statistics of the Adaptation of Each Learning Style Group to a DLE

Learning Style	N	Minimum	Maximum	Mean	SD	Std. Error
Diverger	20	36	51	40,85	4,91	1,10
Assimilator	24	36	60	42,58	6,22	1,27
Converger	16	35	53	42,81	4,78	1,19
Accommodator	42	26	55	41,57	6,34	,98
Total	102	26	60	41,86	5,80	,57

Hypothesis 9 stated that adaptation to a DLE does not differ between the four different learning styles; between divergers, assimilators, convergers and accommodators. Analysis of variance (ANOVA) was conducted to determine whether the difference in adaptation to a DLE occurred according to learning style. The results of the analysis of variance are presented in Table 5.

TABLE 5. The ANOVA Results of Learning Style Differences in Adaptation to a DLE

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	50,972	3	16,991	,498	,684
Within Groups	3341,107	98	34,093		
Total	3392,078	101			

Based on the results of the analysis of variance, adaptation to a DLE was found to be independent of the learning style differences; the F value (.498) was not statistically significant ($p > .05$), which means that the four learning style groups did not differ significantly from each other. Therefore the ANOVA results supported the ninth hypothesis.

8 DISCUSSION, IMPLICATIONS AND FUTURE STUDY RECOMMENDATIONS

The first objective of the study was to both develop and test empirically the hypothesized structural equation model (SEM) of adaptation to a distributed learning environment (DLE). The SEM was found to be an appropriate – albeit difficult - analytical procedure in this kind of a study because it emphasizes the relationship between conceptualization, operationalization, evaluating overall goodness of fit, and testing the strength of hypothesized relationships. Both the significant and insignificant paths revealed during this study - as well as the results of the analysis of variance (ANOVA) - provided important information about adaptation to a DLE. To sum up the findings (see also Appendix 4), attitude towards computers seems to be the only latent factor having a direct and a totally significant effect on adaptation to a DLE. Additionally, the data confirm the importance of prior computing experience, computing skills and knowledge of English in attitude towards computers both directly and indirectly. Prior computing experience was also found to have a direct positive effect on computing skills. The second objective of the study was to determine the role of learning styles in adaptation to a DLE. The analysis of variance proved the invariance in adaptation to a DLE between the four different learning styles (divergers, assimilators, convergers and accommodators).

The findings reveal the importance of attitude towards computers in the adaptation of adult learners and instructors to a DLE. Therefore the adaptation can be seen more as an attitudinal question among adult learners and instructors than as one based on experience or skills. This finding supports the view of Divine and Wilson (1997) that learners with positive attitude towards computers are found more likely to become more involved with computers and even adopt them for their personal, academic, and professional use. Also Woodrow's (1991) claim that learners' attitudes towards computers are a critical issue in computer courses and computer-based curricula is found to be true. Therefore his recommendation of continuously monitoring the user's attitudes towards computers during the courses where computers are used as a tool for learning and instruction should be taken more seriously. Also the warning by Reece and Gables (1982) that introducing microcomputers into schools will be a waste of time and money if the training curricula do not support the development of positive attitudes towards computers can be found to be true as late as nearly two decades after the statement. From the results that indicate that attitude towards computers have an effect on adaptation to a DLE also follows that influencing those attitudes has an effect on the adaptation (see also Thompson, Higgins and Howell 1994).

Applying distributed learning as a new pedagogical paradigm also to the implementation process of a DLE itself should be carefully considered. The implementation of a new DLE should not be seen only as a process, where the information about the DLE is transferred to users. The implementation process should also include both skill acquisition and, especially, mental model change objectives in order to achieve adaptation. Also the classification of learning objectives into cognitive, performance-based, and attitudinal learning objectives, made by Thach and Murphy (1995), is worth consideration. Since the adaptation to a DLE was found to be mainly affected by attitudes, the use of reflection and dialogue, team discussions and projects during the implementation process should be considered. These methods have been recommended by Thach and Murphy (1995) as the best ones for teaching the attitude-related learning objectives.

The most unexpected finding of this study was the apparent lack of significance of prior computing experience and computing skills in adaptation to a DLE. However, a study made by Thompson, Higgins and Howell (1994) implied that prior experience is an important factor to be included when developing, testing, or applying models for in-

formation adoption was noticed. But on the other hand, the findings indicating the lack of a significant effect from prior experience to adaptation to a DLE are also of high value. This finding may encourage the learners and instructors not having prior computing experience to adopt the DLE as a tool for their learning and instruction more easily. But looking the matter from another perspective gives less encouraging results. The relationship between prior computing experience and adaptation to a DLE was found to be negatively quite strong, but not significant. This negative relationship sheds new light on a finding by Hiltz and Johnson (1990). Their research finding was that if people become used to using computers as computational or database tools only, they will find it harder to think of them as a good medium for personal communication or as a tool for collaborative learning. However, the relationship between computing skills and adaptation to a DLE was found to be positive, but it was not significant against the expectations based on previous research findings (see Morton 1996, Neilson 1997, Dusick & Yildirim 1998). This finding may be explained by the possibility that the development process of the DLE (LearningSpace) has succeeded in making adaptation less dependent on the users' computing skills. And this is definitely one of the most important aims of the DLE development processes today.

The language of the DLE was the aspect, which clearly received the most attention in the open commentary space of the web-survey. Many respondents hoped that the DLE used (LearningSpace) would be translated into Finnish to help both learners and instructors in the use of the DLE. However, the study did not show a significant relationship between language skill and adaptation to a DLE although the relationship between language skill and attitude towards computers was found to be significant. Therefore the significance of the language in adaptation to a DLE can be seen as an attitudinal matter similar to the whole adaptation process studied. But since the attitude was found to be a very important factor affecting adaptation to a DLE, the factors affecting attitude towards computer negatively should be considered with specific attention in order to facilitate the adaptation process. Therefore the translation of the DLE to Finnish can be recommended so as to help Finnish-speaking learners and instructors in adaptation to a DLE.

The two other factors found to have a significant effect on attitude towards computers were prior computing experience and computing skills. The effect of these

factors on adaptation to a DLE was positive as expected (see Hignite & Echternacht 1992, Woodrow 1992, Thomson, Higgins & Howell 1994, Busch 1995, Smith & Necessary 1996, Mitra 1998). Because prior computing experience is a factor which cannot be affected in the implementation situation, computing skills play an important role when an effort is made to influence learners' and instructors' attitude towards computer and, furthermore, towards adaptation to a DLE. The training for using a DLE is certainly the one important factor in improving learners' and instructors' computing skills and especially the skills needed in adaptation to a DLE. In addition to this, both technical and pedagogical support should be guaranteed.

The second objective of the study was to determine the role of learning styles in adaptation to a DLE. The ANOVA results show that none of the learning style groups differed significantly. The results reinforced the view that the DLE is an adaptive learning environment for learners and instructors with different learning styles. The findings of this study also support previous research findings (see Larsen 1992, Ross 1997) as well as the success of planning and development processes of the DLE to accommodate equally well the varying perceptions and processing behaviors of different learning styles. An alternative explanation, however, could be that since learning styles are considered as being changeable, learners and instructors may have had the characteristic flexibility to apply their learning to the DLE. But even if learning styles have in several studies been found to be flexible (e.g. Nulty & Barrett 1996), their change is a long process and therefore flexibility of the learning environments instead of changes in learning styles seems to be a more reasonable explanation.

Although this study provides interesting insights into the factors affecting adaptation to a DLE, the results must be interpreted cautiously. Firstly, the model variables explained only 15 percent of the variance in adaptation to a DLE. The fact that 85 percent of the variance is unexplained suggests the need for additional research incorporating potential variables that were not measured in this study. Secondly, although the results of the structural equation model generally support many of the hypothesis, the use of self-report scales to measure the study variables suggests the possibility that common method variance may account for some of the results obtained. Thirdly, as the findings of this study apply only to 102 adult learners and instructors and all of them are involved in the same project, the generalizability of these results remains to be deter-

mined. Furthermore, an additional study might be conducted in which a larger sample is used. This would ensure better representation and possibly result in more reliable results. Also, as sample size increases, so does the ability to conduct more meaningful model comparisons; for instance the ability to run a simultaneous SEM analysis between the groups (e.g. between learning styles as well as between learners and instructors). It has to be remembered also that in this study LearningSpace was the DLE used and therefore the results of the study should not be applied to the adaptation process of other learning environments without special considerations. One very important focus for a future study would also be to explain why the implementation of the DLE took so long. Why about six months after the learners and instructors had been offered the licenses, less than 20 percent of all the licenses were in use? It is also recommended that future studies include personal interviews or in-depth case studies to validate adoption behavior.

The Internet as a research tool was found to be very practical. First of all the information about the study as well as reminders to the recipients could be transmitted in seconds. The answers to the survey were also received immediately by electronic mail, which made it possible to receive answers with ready-made coding, which also helped the future handling of the research data. The use of radiobuttons made it possible that only one answer alternative could be selected as was intended. Secondly, the use of the Internet as a research tool was very economical. Gaining the research data did not cost a penny, there were no postal or copying costs. The third advantage, mentioned by the learners and instructors, was the easiness of filling out the questionnaire. The respondents did not need to send back the questionnaires by mail and the risk of forgetting to answer the survey or doing it too late was smaller.

But just as there is no single recipe for successful teaching in the traditional, non-distance classroom, there are diverse techniques that can be successful in a DLE and in its implementation and adaptation process. Although a single recipe cannot be offered, some practical implications and further recommendations have been made concerning the factors affecting adaptation to a DLE. A new insight to the DLE was also offered. The aim was to find factors affecting the adaptation instead of the learning outcomes. Adaptation to a DLE was also considered as an extensive phenomenon in which all the variables together contribute to the adaptation instead of merely looking at one

relationship at the time. In this way the Interactionist or System Contingency approach (see Hiltz 1994) was introduced into the study and a complex system of the determinants affecting adaptation to a DLE was developed and tested. It is also notable that the indirect and total effects were considered in addition to the direct effects between the latent variables. Instead of studying a single learning outcome or a single relationship between two variables, studying adaptation as an interactionist and more extensive phenomenon is a new step in studying adult learners' and instructors' journey on the information superhighway leading to a information society. This study also proves that the journey among adult learners and instructors has already started. As one of the learners noted: "I think this training has been very interesting. It is nice to be involved in information society."

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APPENDIX 1: Descriptive Statistics of the Observed Variables

	Min	Max	Variance	Mean	Md	SD
<i>Prior Experience with Computers</i>	1	5	2.61	3.96	5.00	1.62
• Learners	1	5	3.15	3.34	4.00	1.77
• Instructors	5	5	.00	5.00	5.00	.00
<i>Prior Experience with Networks</i>	1	5	2.95	3.73	5.00	1.72
• Learners	1	5	3.27	3.00	3.50	1.81
• Instructors	4	5	.05	4.95	5.00	.23
<i>Computer Skills</i>	1	4	.82	2.58	3.00	.91
• Learners	1	4	.74	2.34	2.00	.86
• Instructors	2	4	.73	2.97	3.00	.85
<i>Network Skills</i>	1	4	.94	2.53	3.00	.97
• Learners	1	4	.92	2.25	2.00	.96
• Instructors	1	4	.65	3.00	3.00	.81
<i>Computer Liking</i>	25	50	43.16	42.47	45.50	6.57
• Learners	25	50	49.13	41.63	45.00	7.01
• Instructors	28	50	30.85	43.89	45.50	.81
<i>Computer Usefulness</i>	26	50	43.58	42.06	43.00	6.60
• Learners	27	50	47.02	41.75	43.00	6.86
• Instructors	26	50	38.47	42.58	43.50	6.20
<i>Computer Comfort</i>	22	50	36.25	39.64	40.00	6.02
• Learners	22	50	38.23	39.20	40.00	6.18
• Instructors	26	50	33.00	40.37	41.00	5.74
<i>Knowledge of English</i>	1	4	.82	3.03	3.00	.91
• Learners	1	4	.87	2.78	3.00	.93
• Instructors	2	4	.47	3.45	4.00	.69
<i>Constructivist Learning</i>	9	20	4.03	13.97	14.00	2.01
• Learners	11	20	3.92	13.78	14.00	1.98
• Instructors	9	18	4.16	14.29	14.00	2.04
<i>Formation of a Learning Community</i>	9	20	4.89	14.17	14.00	2.21
• Learners	10	20	4.28	13.77	13.50	2.07
• Instructors	9	19	4.80	14.50	15.00	2.19
<i>Emancipation from Technology</i>	8	20	4.34	13.73	13.00	2.08
• Learners	11	20	4.28	13.77	13.50	2.07
• Instructors	8	17	4.56	13.66	13.00	2.13
<i>Concrete Experience – Abstract Conceptualization</i>	7	39	46.89	21.83	23.00	6.85
• Learners	7	36	54.86	22.34	23.00	7.41
• Instructors	10	39	33.38	20.97	21.00	5.78
<i>Reflective Observation – Active Experimentation</i>	7	42	41.59	27.63	27.00	6.45
• Learners	7	42	52.40	28.02	27.00	7.24
• Instructors	18	36	23.56	26.95	27.50	4.85

APPENDIX 2: Matrix of Correlations and Covariances between the Observed Variables

		Prior Expe- rience with Computers	Prior Expe- rience with Networks	Computer Skills	Network Skills	Computer Liking	Computer Usefulness	Computer Comfort	Knowledge of English	Construc- tivist Learning
Prior Experience with Networks	Pearson Correlation Covariances	.937** .000 2.603								
Computer Skills	Pearson Correlation Covariances	.593** .000 .864	.593** .000 .923							
Network Skills	Pearson Correlation Covariances	.688** .000 1.080	.710** .000 1.186	.863** .000 .760						
Computer Liking	Pearson Correlation Covariances	.593** .000 6.296	.595** .000 6.715	.633** .000 3.765	.604** .000 3.857					
Computer Usefulness	Pearson Correlation Covariances	.445** .000 4.745	.460** .000 5.214	.557** .000 3.332	.538** .000 3.454	.902** .000 39.140				
Computer Comfort	Pearson Correlation Covariances	.415** .000 4.035	.442** .000 4.573	.525** .000 2.865	.503** .000 2.946	.853** .000 33.757	.865** .000 34.368			
Knowledge of English	Pearson Correlation Covariances	.623** .000 .912	.603** .000 .939	.594** .000 .488	.533** .000 .469	.638** .000 3.798	.518** .000 3.097	.456** .000 2.486		
Constructivist Learning	Pearson Correlation Covariances	-.144 .149 -.467	-.129 .198 -.444	.020 .839 .037	-.022 .823 .044	.156 .118 2.054	.182 .066 2.418	.234* .018 2.831		
Formation of a Learning Community	Pearson Correlation Covariances	-.109 .276 -.389	-.076 .445 -.290	.001 .993 .017	-.078 .434 -.168	.191 .055 2.772	.269** .006 3.931	.316** .001 4.210	.815** .000 3.619	
Emancipation From Technology	Pearson Correlation Covariances	.035 .727 .118	.029 .776 .102	.101 .314 .190	.072 .469 .147	.207* .037 2.833	.240* .015 3.303	.294** .003 3.682	.761** .000 3.180	.730** .000 3.363

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 3: Unstandardized Estimates of the Structural Equation Model Analysis

Hypothesis	Unstandardized Estimate	Standard Error (S.E)	Critical Ratio (C.R.)
H1 Prior Computing Experience → Computing Skills	.599	.060	10.001
H2 Prior Computing Experience → Attitude towards Computers	1.748	.870	2.009
H3 Prior Computing Experience → Adaptation to a DLE	-.838	.476	-1.760
H4 Computing Skills → Attitude towards Computers	2.291	.918	2.494
H5 Computing Skills → Adaptation to a DLE	.353	.376	.938
H6 Attitude towards Computers → Adaptation to a DLE	.159	.041	3.915
H7 Language Skill → Attitude towards Computers	1.324	.618	2.143
H8 Language Skill → Adaptation to a DLE	.024	.314	.077

APPENDIX 4: Summary of the Hypotheses in the Hypothesized Structural Equation Model

Hypothesis	Standardized effect	Supported/ Not Supported
H1 Prior Computing Experience → Computing Skills	.81***	Supported
H2 Prior Computing Experience → Attitude towards Computers	.34*	Supported
H3 Prior Computing Experience → Adaptation to a DLE	-.52	Not Supported
H4 Computing Skills → Attitude towards Computers	.33*	Supported
H5 Computing Skills → Adaptation to a DLE	.16	Not Supported
H6 Attitude towards Computers → Adaptation to a DLE	.51***	Supported
H7 Language Skill → Attitude towards Computers	.18*	Supported
H8 Language Skill → Adaptation to a DLE	.03	Not Supported

*** p < .001 ** p < .01 * p < .05

