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Tiina Mäkelä

A Design Framework and Principles for Co-designing Learning Environments Fostering Learning and Wellbeing

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ABSTRACT

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Increased understanding of the complex synergetic influences of psychosocial and physical learning environments (LEs) on learning and wellbeing has drawn attention to their careful design. Contemporary learner-centred educational paradigms emphasise the importance of learner involvement in the LE design. A gap exists, however, between the theoretical discourses of LE design and their application into educational practice. Furthermore, a lack of shared conceptual understanding among studies conducted in different cultural and disciplinary contexts undermines the comparability, generalisability, and build-up of a coherent body of knowledge on the LE design. This educational design research responds to the need for development of a theoretically, empirically, and practically sound design framework and principles for participatory LE design that involves learners. The constructs and contents of the design framework developed based on a literature review at the outset of the process were refined in three substudies. Substudy 1 focused on the 7 to 14-year-old Finnish learners' (n = 80) perceptions of LEs conducive to learning and wellbeing, while substudy 2 extended the scope to include Spanish learners' perceptions (n = 76) in the same age range. Numeric, written, visuospatial, and oral data collected using a survey, scale model construction, and group discussions were used to develop a Learning Environment Design (LED) framework and design principles. In substudy 3, the constructed framework guided the analysis of an LE redesign process involving Finnish learners (n = 186) aged 16 to 19 by means of co-design activities, written student feedback, professional design evaluation, and a student satisfaction survey. The LED framework and principles developed in this study draw attention to the importance of flexibility and functionality as well as balancing of critical LE dimensions, in particular communality with individuality, comfort with health, and novelty with conventionality. The results also suggest that learner involvement enhances LE design quality, fosters a participatory culture, and can have positive impact on learner-centred learning processes as well as learner wellbeing. The LED framework developed in this study can be employed to guide planning, information gathering, and evaluation of individual LE co-design initiatives, and to compare and generalise findings between them.

Keywords: Psychosocial and physical learning environments, design framework, design principles, educational design research, participatory design, student participation, learning and wellbeing

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The research articles 1-3 are reprinted with the kind permission of the publishers. Copies of the articles are appended to the thesis.

The author of the thesis is the first author of all three research articles. She had the main role in research design, data collection, conducting analyses, reporting the findings, and developing the framework and principles presented as major outcomes. The research was carried out by the first author in collaboration with the research group led by Professor Kankaanranta. Dr. Helfenstein contributed to the statistical data analysis and as a co-author to all three articles. Kankaanranta contributed to the work by directing the research, as a supervisor of this thesis, and as a co-author in Article 1. Professors Lerkkanen and Poikkeus contributed to the work as supervisors of this thesis and as co-authors in Article 3.

FIGURES

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1 INTRODUCTION

The aim of this study was to develop a design framework and principles for co-designing of psychosocial and physical learning environments (LEs) fostering learning and wellbeing. The focus was particularly on learners' perceptions and involvement in the LE design.

Contemporary LEs are expected to support the paradigm shift from teacher-centred knowledge transmission towards learner-centred knowledge construction. The paradigm shift is supported by associations identified between positive learner-centred teacher-student relationships (e.g., honouring students' voices, non-directivity) and cognitive, affective, and behavioural learning outcomes (Cornelius-White, 2007). This calls for the design of LEs, which consider each learner's individual needs, experiences, and preferences, and empowers them in constructing personally meaningful knowledge and skills in collaboration with others (APA Work Group, 1997; Land, Hannafin, & Oliver, 2012; O'Neill & McMahon, 2005), and in attaining cross-curricular, so-called 21st century skills (Binkley et al., 2012) or Key Competencies (European Parliament and Council, 2006) needed for the participatory citizenship.

The contemporary discourses on learning, wellbeing, and LEs are often reflected in the curricula. For instance, the Finnish National Core Curriculum for Basic Education (Finnish National Board of Education, 2016) intertwines learning and wellbeing by stating that the school community should promote individuals' wellbeing but also support learning to take care of the wellbeing of oneself and of others. Its cross-curricular or transversal skills entail skills such as "taking care of oneself and managing daily life" and "participation, involvement, and building a sustainable future". Curriculum also draws attention to learner participation in the design of physical, psychological, and social LEs, which are expected to support wellbeing, learning, and active participation.

The importance of research and design of psychosocial and physical LEs is supported by evidence of their complex synergetic influence on student learning and wellbeing. Examples of these are educational mixed-methods studies of Australian, Canadian (n = 1404; Zandvliet &Fraser, 2005), and Taiwanese (n = 2869; Liu, Zandvliet, & Hou, 2012) high school students identifying associations

between physical and psychosocial LEs, and findings of a survey amongst secondary school students (n = 7250) in Palestine, Lebanon, and Jordan showing relationships between physical and psychosocial LE, overall wellbeing, and learning (Awartani, Whitman, & Gordon, 2008). In a smaller scale study interviewing university students (n = 21) in Finland, physical LEs were found to contribute to learning and wellbeing by meeting students' basic psychological needs (Sjöblom, Mälkki, Sandström, & Lonka, 2016). In an educational study employing multi-level modelling conducted in US primary schools (24 schools, students: n = 1916; Tanner, 2008) and in an architectural study in UK (ten schools, students: n = 751; Barrett, Zhang, Moffat, & Kobbacy, 2013), qualities of physical LEs (e.g., amount of light or ease of movement) were found to contribute to better learning outcomes.

In a sociological mixed-methods study involving Australian students (n = 606) between six and 17 years, participants linked their wellbeing with the physical LEs and the types of teaching and learning processes (Simmons, Graham, & Thomas, 2015). In an environmental psychological study, data from observations and teacher interviews (n = 39) from 12 primary and secondary schools in the UK showed that physical LEs were connected with either teacher-centred or learner-centred pedagogies (Horne Martin, 2002). These findings are in line with Monahan's (2002) architectural conceptualisation on "the built pedagogy", i.e., the embodiment of pedagogical philosophies in educational spaces. As Guney and Al (2012) claimed, behaviourist teacher-centred school buildings are likely to be single buildings with several floors and classrooms, and minimal flexibility drawing attention to the teacher. Constructivist design, in turn, may include a variety of different spaces where it is possible to study independently or in social interaction with others.

Consistent with learner-centred views, learners are more frequently seen as co-designers of their learning and LEs (Brown, 1992; Scardamalia, Bransford, Kozma, & Quellmalz, 2012). Giving learners opportunities to express their views in all matters concerning themselves is rooted in children's rights (United Nations, 1989), and advocated in studies involving children and youth (e.g., den Besten, Horton, & Kraftl, 2008; Horelli, 1997). Learners are viewed as change agents or partners in improving the educational environments (Hargreaves & Shirley, 2009), and learners' active agency or "student voice" (Flutter, 2006; Lodge, 2005; Robinson & Taylor, 2012) is acknowledged and supported.

Involving learners in the LE design is expected to improve design quality (Flutter, 2006; Woolner, 2009), foster participatory culture (Parnell, Cave, & Torrington, 2008; den Besten et al., 2008) and contribute to both student learning processes and their wellbeing (Frost & Holden, 2008; Newman & Thomas, 2008). Having an opportunity to influence one's LEs has been seen to increase students' overall wellbeing (Simmons et al., 2015), sense of community (Flutter, 2006), engagement, motivation, and positive attitudes towards school (Parnell et al., 2008). Moreover, a congruence between learner's perception of actual (experience) and ideal (preferred) LEs is seen to have a positive impact on learning (Fraser, 1998).

The contemporary educational environments do not, however, often embody the state-of-the-art understanding of LEs fostering learning and wellbeing. In a survey conducted amongst ethnically diverse US secondary school students (n = 1046), negative perceptions of the psychosocial LE were found to be associated with lower behavioural, emotional, and cognitive engagement and academic achievement (Wang & Holcombe, 2010). In a qualitative study conducted in 23 Spanish educational institutions, physical LE (e.g., noise, poor lighting or indoor air quality) was found to affect learners' health and wellbeing (Crespo & Pino, 2007). Moreover, in an environmental psychological study conducted among ethnically diverse US university students (n = 158), poor physical LE conditions were found to negatively influence students' learning and affect (Marchand, Nardi, Reynolds, & Pamoukov, 2014).

Although learner-centred knowledge-building environments are acknowledged in the literature (Scardamalia et al., 2012), teacher-centred views of teaching as knowledge transmission still often prevail in educational practice. This conclusion was drawn in a study analysing Turkish primary school students' (n = 45) drawings (Cam Aktas, 2010) and in a study among students in two Austrian schools (Schrittesser, Gerhartz-Reiter, & Paseka, 2014). Teacher-centred LEs are fostered by elements such as physical arrangement of classrooms, with the teacher's desk occupying the control and focal point (Guney & Al, 2012). These arrangements frame hierarchical teacher-student relationships and emphasise teacher authority (e.g., Foucault 1975). Even the learner-centred LE design does not automatically guarantee that it is used as intended (Könings, Brand-Gruwel, & van Merriënboer, 2005).

Cleveland and Fisher (2014) concluded, based on their literature review, that students' opinions are rarely sought in physical LE design and evaluation. Various challenges have been identified in involving the learners in the LE design. Inadequate mechanisms for student participation or lack of commitment may lead to raised expectations, which cause disappointment and frustration when they are not met (Simmons et al., 2015). Recruiting a representative group of students into a participatory design process is challenging: often the more outgoing students are selected (Fielding, 2004; Woolner, 2009), while the disaffected and unengaged students are omitted (Lodge, 2005). The effect of student participation on the final design has been reported to be minor or difficult to identify (Parnell et al., 2008; Woolner, 2009) and little is known about how to maintain the positive effects in the long term or how to scale them up (Hargreaves, 2002; Woolner, 2009).

There is a growing body of research on learning environments representing various research approaches, disciplines, and educational contexts, many of them already cited above. Otherwise lively ongoing LE research lacks a systematic theoretical framework and shared concepts. This hampers comparability, generalisability, and build-up of a coherent body of knowledge. As criticised in the educational study of Gislason (2010, p.127), research typically either considers "teaching and learning apart from architectural settings" or studies are centred on "the built environment separately from classroom practices".

Ghaziani (2012, p.128) argued that studies on learners' opinions of their schools do not provide "a useful framework for architects and designers to use in the school design process". Ghaziani developed a framework for school design based on the literature on learners' perceptions and 11 and 12-year-old children's (n = 260) survey ratings in the UK. This framework gathers particularly well children's views of LEs promoting their wellbeing, but it lacks learning-related considerations. Gislason's (2010) case study of a Canadian open-plan high school contributed to the development of a theoretical framework on relationships between instructional spaces, teaching, and learning, but it does not consider aspects related to wellbeing. In a study analysing Finnish primary school students' (n = 92) writings on ideal LEs, Kangas (2010b) developed a model describing key features of creative and playful LEs. Her model combines aspects related to wellbeing, learning, and LEs. Similar to most of the other studies, it does not include analysis of possible gender, individual, age or contextual differences in preferences.

As an example of possible gender differences, a survey among Australian primary school students (n = 3000; Moroz, 2001) suggested that boys may perceive their LEs more negatively than girls. In a study analysing Finnish secondary school students' (n = 5796) PISA results, some individuals, more males than females, were found to have particularly low school engagement levels (Linnakylä & Malin, 2008). In a survey among Australian secondary school students (n = 1756; Clay, 2008), male and older students were found to view school more negatively than female or younger students, suggesting that age differences may need to be considered in the LE design. Regarding possible cultural differences, in a cross-cultural study conducted among high school students in Taiwan (n = 1879) and Australia (n = 1081), Taiwanese LEs were found to be more hierarchical, and Australian LEs more disruptive (Aldridge & Fraser, 2000).

The present study responded to the clearly identified demand to develop a systematic, empirically-tested, and validated learning environment design framework and principles to support the (re)design of LEs conducive to learning and wellbeing. The study merged perspectives from various theories and disciplines, and involved learners representing different age groups, genders, and cultural contexts (Finland and Spain) in a participatory LE co-design process in order to better consider learners' views and perceptions in the LE design.

The study contributed to both societal (practical) and research (theoretical) needs related to the LE design. From the societal perspective, the aims of the study were in line with international efforts in redesigning 21st century LEs initiated, e.g., by UNESCO (2012) and OECD (2013), and Finnish national efforts, e.g., those endorsed by the National Board of Education and the Finnish Funding Agency for Technology and Innovation (e.g., Kangas, 2010; Kuuskorpi & Cabellos, 2012; Mäkelä, Lundström, & Mikkonen, 2015). The work was also aligned with the vision and mission expressed in the Finnish national curricula (Finnish National Board of Education, 2004; 2016). From the theoretical perspective, the study contributed to the build-up of a coherent body of knowledge by

creating a design framework and principles based on theoretical and empirical considerations representing different educational, cultural, and disciplinary contexts, thus also better enabling the comparability and generalisability of studies in this multidisciplinary field, without forgetting the contextual particularities of each LE.

2 THEORETICAL BACKGROUND

2.1 Learning, wellbeing, and learning environments

The study drew insights from Dewey's (1907, 1916) educational philosophy considering the cognitive (intellectual), emotional (affective), social, and physical (bodily) dimensions of learning and viewing learning as a learner-centred, active, experiential, and reflective activity. In line with sociocultural and socio-constructivist paradigms inspired particularly by the work of Vygotsky (1978), it viewed social environments and the mediating artefacts as essential for human development and learning. Third, the study was influenced by Bronfenbrenner's (1979; 1994) ecological model's view that human development takes places in reciprocal interaction with people, objects, and symbols, particularly through proximal processes in an individual's immediate environment.

Similar multidimensional conceptualisation was also applied for understanding wellbeing. For instance, Awartani et al. (2008) view wellbeing as a realisation of one's *physical* (material or bodily), *emotional* (feelings), *mental* (cognition), *social* (relationships), and *spiritual* (e.g., purpose of life) potential and Dodge, Daly, Huyton, and Sanders (2012) consider it as a state of equilibrium between the individual's *psychological*, *social*, and *physical* resources and existing challenges. Conceptualisation of dimensions of wellbeing developed by Allardt within the context of welfare research (see Allardt & Uusitalo, 1972), i.e., having, loving, and being, was also found useful. These dimensions derive from the basic psychological needs approach and align with components influencing motivation, social development, and wellbeing presented in the Self-Determination Theory (e.g., Ryan & Deci, 2002), i.e., competence (cf. having), relatedness (cf. loving), and autonomy (cf. being). Allardt's conceptualisation has been applied in Finnish health sciences research on school wellbeing by Konu and Rimpelä (2002) and in an architectural case study by Nuikkinen (2009), aiming at understanding interrelations between school building, subjective and objective wellbeing, education, teaching, and learning. Table 1 illustrates conceptualisations of wellbeing based on Allardt's model.

TABLE 1. Conceptualisations of wellbeing based on Allardt´s model

	Allardt & Uusitalo, 1972	**Konu & Rimpelä, 2002**	**Nuikkinen, 2009**
Having	Individual resources (income, health, physical well-being, education)	School conditions (physical LE, learning arrangements, school services)	Possibilities for activities
Loving	Companionship (affection, belongingness, solidarity)	Social relationships (peers, teachers, home)	Social environment
Being	Personal growth and self-actualisation	Self-fulfilment (participation in decision making)	Psychological environment

This study viewed cognitive, emotional, social, and physical dimensions of both learning and wellbeing as highly interconnected. In line with Dewey´s conceptualisation, Cohen (2006) emphasises that not only *academic*, but also the *social*, *emotional*, and *ethical* domains of learning are relevant foundations for wellbeing (see also Thorburn & MacAllister, 2013). Kangas (2010a) notes similarly that in addition to *academic* knowledge and skills, it is important to consider the *cognitive*, *emotional*, *social*, *physical,* and *cultural* development and wellbeing of the whole person. Spratt (2016) argues that wellbeing should not only be seen as a prerequisite for learning, but learning can also enhance wellbeing. That is, wellbeing is seen to provide good conditions for learning, but, on the other hand, through learning, one can develop skills to take care of their own wellbeing and the wellbeing of others (Cohen, 2006; Kangas, 2010; Spratt, 2016).

Definition of learning environments (LEs) employed in this study goes back to Dewey (1916), who saw social and physical environments as conditions that promote or hinder, stimulate or inhibit human activities. According to Hansen (2002), in Dewey's thinking, individuals are in dynamic interaction with their environments. This organic relation with an environment distinguishes an environment from mere surroundings. Dewey (1916) considered that it is not possible to educate directly, only indirectly by means of the environment.

The following excerpt by Dewey (1907, p.48) illustrates how he views teaching-learning interaction and physical environments as interconnected:

> - - if we put before the mind's eye the ordinary schoolroom, with its rows of ugly desks placed in geometrical order, crowded together so that there shall be as little moving room as possible, desks almost all of the same size, with just space enough to hold books, pencils and paper, and add a table, some chairs, the bare walls and possibly a few pictures, we can reconstruct the only educational activity that can possibly go on in such a place. It is all made "for listening" - - for simply studying lessons out of a book is only another kind of listening; it marks the dependency of one mind upon another.

Dewey (1916; see also Hansen, 2002) argued that due to the important role of LEs, they should not be left up to chance but explicit and careful attention should be paid to their design.

In line with Vygotsky's (1978) theoretical considerations, this study acknowledged that artefacts (tools and signs) mediate the reciprocal interac-

tions between subjects and objects or individual and his or her response (see also Engeström, 2011). As Engeström (2009) described, in this mediated action, involving a triangular unity of subject, object and mediating mean, the dialectic between the object and mediating artefact is important. Inspired by Vygotsky's theorising, school environments have been viewed as social, spatial, and informational zones that may scaffold social construction of knowledge and growth towards autonomy (Dovey & Fisher, 2014; Velosa & Marques, 2017).

The conceptualisation of LEs in the study was also influenced by Bronfenbrenner's (1994, p.38) account of the reciprocal interaction between an active, evolving biopsychological human organism and the persons, objects, and symbols in its immediate environment. In his model, the set of nested structures of the ecological environment are divided into micro-, meso-, exo-, and macrosystems. According to Bronfenbrenner (1994, p.39),

> microsystem is a pattern of activities, social roles, and interpersonal relations experienced by the developing person in a given face-to-face setting with particular physical, social, and symbolic features that invite, permit, or inhibit engagement in sustained, progressively more complex interaction with, and activity in, the immediate environment.

Mesosystem, in turn, links two or more immediate environments (e.g., home and school), exosystem refers to less immediate settings (e.g., linkage between home and parents' workplace), and macrosystem to broader cultural settings (Bronfenbrenner, 1979; 1994). In line with Bronfenbrenner's views on the importance of considering various system levels and their interactions, Collins, Joseph, and Bielaczyc (2004) also argued that it is important to consider various LE levels such as cognitive, interpersonal, group or classroom, resource, and institutional or school level in the design.

The conceptualisation of LE in the study was also influenced by the human-environment model by Moos (e.g., 1987) often referred to in research of psychosocial LEs (see Fraser, 1998). The three main dimensions of this model are relationships, personal growth, and system maintenance and change. The model also acknowledges the role of physical classroom features. Inspiration was gained from studies representing environmental psychological theories. For instance, Marchand and his colleagues (2014, p.188) argue, based on Bronfenbrenner's ideas, that instead of focusing on a specific environmental factor's unique effect on learning, "a more ecologically valid approach may be to consider multiple factors in combination". Horne Martin (2004, p.77) viewed *physical*, *cultural*, and *social* environments as interrelated. Similarly, Piispanen's educational case study (2008a) on learners', parents', and teachers' perceptions of good LEs in a Finnish primary school, considered *pedagogical*, *social,* and *psychological*, and *physical* LE dimensions, and Kangas (2010a) focused on *educational*, *cultural*, *socio-emotional*, and *physical* LE dimensions.

Dewey (1916) distinguished time- or space-wise immediate and remote environments long before the introduction of modern information and communication technology (ICT), virtual LEs, discussions of synchronous and asynchronous learning situations, and virtual-physical or hybrid environments

(Fisher & Newton, 2014; Dovey & Fisher, 2014; Monahan, 2002). Zandvliet and Fraser (2005) adopted Gardiner's (1989) three overlapping spheres (ecosphere, sociosphere, and technosphere) of high technology workspaces to study technology-enhanced LEs. In their conceptualisation, LEs consist of partially overlapping *psychosocial*, *physical,* and *IT environments*.

Table 2 sums up the common types of learning, wellbeing, and learning environment dimensions utilised in the contemporary literature to support the conceptualisations of the present study. While acknowledging the importance of other dimensions (e.g., spiritual, ethical, or cultural), *cognitive, emotional, social, and physical dimensions of learning and wellbeing* were selected as the central dimensions for this study. This is also supported by the prevalence of these dimensions in the literature. Focusing on the *psychosocial (i.e., individual and social) and physical LE dimensions*, in turn, was considered the clearest way to conceptualise the interaction between human action (individual and social) and the physical environment. Virtual environments were considered in this study only in connection with the use of technology.

TABLE 2. Learning, wellbeing, and LE dimensions in the literature

Dimension	Learning	Wellbeing	Learning Environments
Cognitive/ Mental/ Intellectual/Academic	Cohen, 2006; Kangas, 2010a	Awartani et al., 2008; Kangas, 2010a	-
Affective/Emotional/ Socio-emotional	Cohen, 2006; Kangas, 2010a	Awartani et al., 2008; Kangas, 2010a	Kangas, 2010a
Psychological		Dodge et al., 2012	Piispanen, 2008b
Social/ Relationships	Cohen, 2006; Kangas, 2010a	Awartani et al., 2008; Dodge et al., 2012; Kangas, 2010a	Horne Martin, 2004; Piispanen, 2008b
Psychosocial	-	-	Zandvliet & Straker, 2010
Physical/ Material/ Bodily	Kangas, 2010a	Awartani et al., 2008; Dodge et al., 2012; Kangas, 2010a	Horne Martin, 2004; Kangas, 2010a; Piispanen, 2008b; Zandvliet & Straker, 2010
Technological/IT	-	-	Zandvliet & Straker, 2010
Spiritual/Ethical	Cohen, 2006	Awartani et al., 2008	
Pedagogical/ Educational	-	Kangas, 2010a	Kangas, 2010a; Piispanen, 2008b
Cultural/ Symbolic	Kangas, 2010a	Kangas, 2010a	Horne Martin, 2004; Kangas, 2010a

The conceptualisation of learning, wellbeing, and LEs of this study was based on partly theoretically and partly empirically supported assumptions of the close interplay, first, *between psychosocial and physical LEs* (e.g., Zandvliet & Fraser, 2005; Zandvliet & Straker, 2010; Liu et al., 2012), and, second, *between cognitive, affective, social and physical learning, and wellbeing* (e.g., Cohen, 2006; Kangas, 2010). Third, as central focus of this study, *the psychological and physical LEs were viewed to influence on cognitive, affective, social, and physical both learning and wellbeing* (e.g., Awartani et al., 2008; Simmons et al., 2015; Sjöblom et al., 2016).

Previous literature pays attention to the dynamic interaction between individuals and their environments. According to Dewey (1916), changes in environment and changes in life activities are interrelated, and individuals can actively influence their environments – something that takes place commonly in a shared activity with others. In Vygotsky's footsteps, Engeström (2009, p.25) said that in "expansive transformations, the community learns to widen its objects and possibilities for action by redesinging its own activity" and by "remediating the activity with new tools and signs". Bronfenbrenner (1979) connected human development with changes in the way a person perceives and interacts or deals with the environment, both physical and social. In his conceptualisation, chronosystem level refers to change in time (Bronfenbrenner, 1994). Also in Moos's conceptualisation (1987), a system maintenance and change dimension highlights the importance of managing change. Furthermore, Moos highlighted the importance of supporting people's adaptation to different environments.

In sum, this study conceptualised LEs as complex, closely interconnected *psychosocial and physical LE dimensions* that shape the overall conditions for *cognitive, emotional, social, and physical learning and wellbeing*, in a specific time and space, both physical and virtual. Attention is particularly in the face-to-face settings at the microsystem level (immediate environment), but also mesosystem linking, e.g., home and school environments, and wider societal and cultural environments, are considered (see Bronfenbrenner, 1994). Individuals were considered to be in *dynamic interaction with the social and physical environments*; while these environments can promote, permit, or hinder human activities, individuals can also actively influence them.

2.2 Construction of the preliminary conceptual framework

This section presents the groundwork conducted prior to empirical studies towards the construction of a preliminary conceptual framework (Version 1.0, henceforth referred to as V1.0). A literature review (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Plomp, 2007) was conducted to identify LE characteristics frequently presented in related journal publications, research reports, conference proceedings, and technical reports (Wang & Hannan, 2005) and to construct a conceptual understanding of key characteristics of LEs conducive to learning and wellbeing.

Significant electronic databases (e.g., ERIC, Google Scholar, JSTOR, and ScienceDirect) were searched. The most frequent keywords used were "learning environment(s)", "physical learning environment(s)", "psychosocial learning environment(s)", "technology-enhanced learning environment(s)", "classroom environment(s)", "school environment(s)", "school design", "school architecture", "educational facilities", "educational environment(s)", and "learning spaces". Keywords were used both separately and in various combinations. They were also combined with the keywords "learning" and "wellbeing".

Insights from various disciplines, mainly educational and architectural, as well as from fields such as environmental psychology and health sciences, were searched. Attention was paid to both theoretical and empirical literature, qualitative and quantitative studies, studies involving students, and studies involving various stakeholders or not involving any stakeholders in the LE design. Earlier literature reviews were also studied.

After reviewing around 150 publications selected based on their relevance in general (e.g., number of citations) and their relevance in relation to the research objectives, 55 publications were selected for a more in-depth analysis. Throughout the study, the literature review was also updated with the most recent findings of both qualitative and quantitative studies.

A holistic approach was applied; instead of emphasising isolated variables, the aim was to understand LEs as integral and meaningful phenomena (Brown, 1992; Collins et. al., 2004; Hoadley, 2004). The main LE characteristics of the conceptual framework V1.0 guiding the study were divided into the following three partially overlapping constructs: (I) Overall wellbeing, (II) Learning situation, and (III) Learning tools and space design (see Table 3).

The three constructs identified based on the literature have similarities with Cohen's (2006) considerations of school climate consisting of physical and social-emotional safety, relationships (cf., wellbeing), teaching and learning (cf., learning situations), and external environment (cf., learning tools and space). In line with the practical and societal aims of this study, the initial framework was also aligned with the descriptions of LEs in Finnish national core curricula for basic education (Finnish National Board of Education, 2004) and general upper secondary school (Finnish National Board of Education, 2003) with respect to students' psychological, social, and physical wellbeing, diverse learner-centred learning situations, and physical LEs, including both the school building and the wider surroundings.

TABLE 3. LE constructs and characteristics in the framework V1.0

I Overall wellbeing	**II Learning situation**	**III Learning tools and space**
- Shared vision about schooling - Safety - No behavioural disturbance - Teacher-student relations - Peer relations - Staff-student relations - Home-school relations - Wider community relations - No noise disturbance - No overload - Indoor air quality - Outdoor areas - Physical exercise - Presence of nature - Quality of meals	- Versatile teaching methods - Teacher-led instruction - Self-regulated learning - Involvement and self-expression - Personal relevance of studies - Personalisation - Collaborative work - Individual work - Personal relevance of assessment	- Versatile use of materials - Use of technology - Use of books and other traditional tools - Novel and conventional LE design - Ubiquitous (formal, non-formal, informal) LE - Luminosity - Spaciousness - No disorganisation - Aesthetics and colours - Sustainability - Adaptability - Functionality and practicality

2.2.1 Overall wellbeing

The LE characteristics grouped under the construct "overall wellbeing" were related to issues identified as important for individuals' cognitive, affective, social, and physical wellbeing (see Awartani et al., 2008; Kangas, 2010). The characteristic *shared vision about schooling* was included in the framework as a contributor to overall wellbeing based on Dewey's criticism of externally imposed educational aims (see also Bronfenbrenner, 1979). Its selection was also supported by the importance of relatedness for motivation, wellbeing, and development (Ryan & Deci, 2002) and school identification for students' emotional engagement (Wang & Holcombe, 2010). Characteristics of *safety* and *no behavioural disturbance* were based on Nuikkinen´s (2009) study connecting feelings of safety with wellbeing in a psychological environment ("being"). In a health sciences study by Kostenius (2011), collecting views of school from Swedish learners (n = 56) aged 10-12 by means of drawings, writings, and interviews, participants hoped for a friendly community free from problems such as bullying and linked caring and respectful relations with their learning and wellbeing (see also Simmons et al., 2015).

The importance of good social relations ("loving") for wellbeing was emphasised in Konu and Rimpelä's (2002) model. Good *teacher-student relations* and *peer relations* are associated with school engagement (Linnankylä & Malin, 2008), and students' perceived wellbeing (Awartani et al., 2008). The relevance of good *staff-student relations* was discussed in the literature to a lesser extent (as an exception see Nuikkinen, 2009). The inclusion of *home-school relations* and *wider community relations* in the framework was supported by several sources in the literature. Dewey (1907, p.89) considered the "interplay of influences, materials, and ideas between the home life and that of the school" as important, and argued that school, home, and the surrounding community should share common interests and concerns (Dewey, 1916). Similarly, Bronfenbrenner (1979) regarded it as important that schools are linked to other societal settings instead of isolation.

In addition to social components promoting wellbeing, this construct included characteristics related to health such as *no noise disturbance* suggested both by earlier theoretical considerations (Bronfenbrenner, 1979) and contemporary studies (Crespo & Pino 2007; Ghaziani, 2012; Marchand et al., 2014). A characteristic *no overload* was added to the framework based on Dewey's (1916) reflections of balancing work and play to promote health and habits of mind. More recently, in Kostenius's (2011) study, children hoped for a balance between work and play or recess. The importance of good *indoor air quality* was discussed in the recent literature (Crespo & Pino, 2007; Kostenius, 2011; Piispanen, 2008b). The relevance of good *outdoor areas* and opportunities for *physical exercise*, in turn, are in line with Dewey's (1907) reflections about the importance of spontaneous social activity, playground, game, and sport. The connections Dewey made with wellbeing, motor (practical), and mental development have been used to justify the importance of physical education in fos-

tering knowledge, values, skills, and habits to support healthy living and promoting beneficial wellbeing decisions (Thorburn & MacAllister, 2013). In a case study conducted in a primary school in the UK using drawings and focus group discussions (Papatheodorou, 2002), learners were found to value the outdoor grounds, which allow active and energetic play.

The inclusion of *presence of nature* in the framework was supported by studies linking children's emotional wellbeing with their ability to experience the natural environment (see UNESCO, 2012). In Konu and Rimpelä's (2002) model, connection with nature was related to "being". The value of nature has also been highlighted in the literature on restorative environments (Bagot, 2004; Kaplan, 1995). Nature and outdoors have been considered important by the learners themselves (Ghaziani, 2012; Kangas, 2010a). The final characteristic *quality of meals* was incorporated into the first construct based on Dewey's (1907) notion that school meals are not only a physiological necessity, but also that wellbeing and learning can be connected by including cooking as a part of learning activities. More recently, Wolff's (2002) educational study entailed access to food and beverages as part of LE design features (see also Ghaziani, 2012; Piispanen, 2008b).

2.2.2 Learning situation

The importance of *versatile teaching methods* was supported by Vygotsky's (1978) theory of mediated learning, which has led to a view of teachers as orchestrators of students' engagement in tasks and learners' interaction with one another, the teacher, and mediating tools in the LE. The need for balancing more direct instructional guidance or *teacher-led instruction* with *self-regulated learning* is supported by Vygotskian's view that direct guidance should be gradually diminished by the learner's increasing maturity, skill level, and self-regulation skills (see Pieters, 2004). Self-regulation and autonomy are also important components of Self-Determination Theory (Ryan & Deci, 2002). Moreover, learners' perceptions of psychosocial LEs are associated with the use of self-regulation strategies (cognitive engagement) contributing also to academic achievement (Wang & Holcombe, 2010). Associations with physical LEs and student autonomy have been identified (Liu et al., 2012; Zandvliet & Fraser, 2005). As Gislason (2010, p.140) notes, "open space, combined with the flexible schedule and the small size of the school, encourages socialising, noise and traffic, and therefore requires students to be self-motivated." In a study on Finnish university chemistry students' (n = 9) perceptions of their laboratory LEs, participants felt a need for both social and physical (e.g., instructions, labels) scaffolding (Sandström, Ketonen, & Lonka, 2014). Finally, in a survey-study conducted in Belgium amongst university students (n = 576), participants viewed student-centredness and teacher-centredness as mutually reinforcing features of the LE (Elen, Clarebout, Léonard, Lowyck, 2007), indicating that learners also see teacher-led instruction as relevant to them.

Inclusion of *involvement and self-expression* into the framework was based on Dewey's (1907; 1916) notions on the importance of artistic expression and the

use of imagination. Self-expression (Awartani et al., 2008) and self-fulfilment, e.g., participating in school's decision-making (Konu & Rimpelä, 2002; "being"), have been connected to student wellbeing. School participation is also linked with emotional engagement (Wang & Holcombe, 2010). According to Nuikkinen (2009), LEs should provide possibilities for influence and self-expression, e.g., through shaping the school environment. In the study by Kostenius (2011), learners wished to be involved and influence their school environment, schedules, and ways of working.

The characteristic of *personal relevance of studies* draws from Dewey's (1916) views claiming that education should be connected to real problems that are socially relevant. Bronfenbrenner (1979) also pointed out the importance of social and work-related activities. Intrinsic aspirations have been found to be positively associated with wellbeing (Ryan & Deci, 2002), and regarding school as relevant to one's future is found to contribute to school engagement and academic performance (Linnankylä & Malin, 2008). Personal relevance of studies can contribute to wellbeing, e.g., by increasing life satisfaction and experiences of a meaningful or purposeful life (Awartani et al., 2008; Dodge et al., 2012; Spratt, 2016). *Personalisation* was incorporated into the framework based on Dewey's (1916) notions about the relevance of flexible personal experiences and diverse use of methods according to each individual. Moos (1987) highlighted the importance of considering personal preferences related to physical LE design, organisational policies, and the social climate. Capacity for choice has also been linked with wellbeing (Awartani et al., 2008; Simmons et al., 2015). In Gislason's study (2010), students valued the opportunity to work at their own pace and participate in one-on-one coaching.

Collaborative work was included into the framework based on Dewey's (1907; 1916) notions of importance of cooperation, joint activity, and community life (see also Bronfenbrenner, 1979). Interacting with people in one's environment and cooperating with peers is also central to Vygotsky's theory (1978); intrapsychological, internalised functions are developed in interpsychological, collaborative action (see also Engeström, 2011). Moreover, previous studies indicate that the design of physical LEs may influence the possibility of cooperating in the classroom (Zandvliet & Fraser, 2005; Zandvliet & Straker, 2010).

In addition to collaboration, the framework incorporated *individual work*, which, with some exceptions (Nuikkinen, 2009; Piispanen, 2008b; Wolff, 2002), seems less frequently discussed in the recent literature. *Personal relevance of assessment* was the final LE characteristic included in this construct. Scardamalia and her colleagues (2012) have pointed out the importance of formative assessment, self and peer evaluation, and assessing transfer of knowledge and skills learned in classroom settings to everyday settings (see also Schrittesser et al., 2014). At best, assessment can support both learning and wellbeing by facilitating personal growth, self-acceptance, self-esteem, and confidence in one's capacities (Awartani et al., 2008; Dodge et al., 2012).

2.2.3 Learning tools and space design

The LE characteristics grouped under the construct "learning tools and space design" were related to physical tools (e.g., books and computers) and spaces (e.g., classroom and library) for learning as well as to qualities of physical LEs (e.g., aesthetic and adaptable). *Versatile use of materials* was included in the framework based on theoretical considerations (Dewey, 1916) and empirical studies. For instance, Piispanen (2008a, 2008b) showed that learners hoped for versatile spaces and equipment that enabled various ways of working. In relation to *use of technology*, Scardamalia and her colleagues (2012) argued that Vygotsky's considerations of how tools and technologies change the nature of tasks and the cognitive skills required to perform them are particularly valid for the ICT-enhanced LEs providing, for instance, access to online resources. In a study analysing UK primary school students' (n = 355) drawings, boys in particular were found to connect the use of ICT to free time, fun, and play (Selwyn, Boraschi, & Özcula, 2009; see also Ghaziani, 2010). The use of technology has been contrasted with *the use of books and other traditional tools* (see Kangas, 2010a; Zandliet & Fraser, 2005), and *novel LE design* (e.g., open spaces) has been contrasted with *conventional LE design* (e.g., classrooms). While novelty can be considered to provide challenge to thought (Dewey, 1916), students seem, however, to value a balance between novel and more traditional LE design (Gislason, 2010).

The notion of a *ubiquitous LE*, which bridges formal (e.g., school), non-formal (e.g., museum and library), and informal (e.g., free time) learning, was adopted based on the relevant literature. According to Dewey (1916), the role of the school is to coordinate the diverse influences of various formal and informal environments. Bronfenbrenner (1979) highlighted the importance of connecting informal and formal environments. In an educational research project on participatory LEs that bridge informal, non-formal, and formal LEs, Kumpulainen and her colleagues (2010) employed the concept "ubiquity of learning" to describe how learning takes place everywhere and how different environments offer different, both pre-planned and spontaneous, learning opportunities. An educational study on physical LEs involving secondary school students, teachers, head teachers, and administrative school authorities in Belgium, Finland, Holland, Portugal, Spain, and Sweden specified dimensions of both formal teaching and informal learning (Kuuskorpi, 2012; Kuuskorpi & Cabellos, 2011). Learners representing different ages (Kangas, 2010a; Sjöblom et al., 2016) seem to want to study in multiple contexts and informal settings.

In relation to *luminosity*, day lighting and views (Tanner, 2008), the amount of natural light, and high quality and quantity of lighting (Barret et al., 2013) have been linked not only to wellbeing but also to learning outcomes (see also Marchand et al., 2014). Good light seems to be important for learners (Ghaziani, 2010; 2012; Kangas, 2010a). With respects to *spaciousness*, already Dewey (1907) criticised crowded classrooms that do not give learners room to move. Tanner (2008) emphasised the importance of freedom of movement in the class-

room. Spacious schools allow better alternative learning activities and wide corridors can ease movement (Barret et al., 2013). LE characteristic of *no disorganisation* was included into the framework based on studies incorporating clear organisation in their criteria of ideal physical LEs (Barret et al., 2013; Nuikkinen, 2009; Tanner, 2008). Ghaziani (2010) and Papatheodorou (2002) showed that children pay attention to tidiness and cleanliness.

Aesthetics and colours were included into the framework based on prior findings showing that learners commonly wish for beautiful LEs (Kangas, 2010a), attractive interiors, decorative objects and nice colours (Ghaziani, 2010; 2012). Learners have also linked aesthetic environment with social and emotional needs (Simmons et al., 2015). Nuikkinen (2009) connected aesthetics with luminosity, architecture, art, materials, shapes, colours, peacefulness, and order. Some studies suggest that colours may foster concentration and be tranquilising, or in contrast may be perceived as uninviting or boring (Higgins, Hall, Wall, Woolner, & McCaughey, 2005). *Sustainability* was included into the framework based on the importance of sustainable design and development, and careful consideration of resources (Kuuskorpi, 2012; Nuikkinen, 2009).

Adaptability or flexibility was seen to enable varied learning activities and changing easily the space configurations when needed. *Functionality and practicality* were included into the framework as enablers of versatile use of tools and spaces (Kuuskorpi, 2012). Functionality associated with versatility, modifiability, flexibility, and usability has been featured in an architectural model by Sulonen and Sulonen (2014). In association with architectural design of university campuses, Jamieson and his colleagues (2000) pointed out the importance of multi-functionality, multiple uses and flexibility of spaces (see also Tanner, 2008). According to Monahan (2002), flexible properties of space entail fluidity (of individuals, sight, sound, air), versatility (multiple uses), convertibility (adaptation for new uses), scalability (expansion), and modifiability (quick reconfigurations).

3 RESEARCH DESIGN

3.1 Methodological approach

3.1.1 Educational design research

In line with van den Akker (2007) and Plomp (2007), the term "educational design research" was used in this study in a broad way to refer to various related research approaches considering education as a design science and intertwining educational design, practice, and theory development. These approaches include *design experiment* (Brown, 1992; Cobb et al., 2003), *design research* (Edelson, 2002; Collins et al., 2004), *development* (van den Akker, 1999) or *developmental research* (Richey, Klein, & Nelson, 2004) and *design-based research* (the Design-Based Research Collective, 2003).

The paradigm has evolved primarily as a means for studying innovative LEs, typically referring to digital solutions (Sandoval & Bell, 2004; Wang & Hannafin, 2005; Zheng, 2015). It aims at understanding, for example, how LE designs "affect dependent variables in teaching and learning" (Collins et al., 2004, p.17). In Finland, design research approach has been increasingly used in studies related to the use of technology in learning (Juuti, 2005; Leinonen, Keune, Veermans, & Toikkanen, 2016; Nousiainen, 2008; Oksanen, 2014; Rikala, 2015). Kangas (2010) employed design research in the development of creative and playful LEs. Ratinen (2016), in turn, used design research for developing inquiry-based and communicative science teaching.

According to the Design-Based Research Collective (2003, 8) the approach can be used for

- exploring possibilities for novel learning and teaching environments,
- developing contextualised theories of learning and teaching,
- constructing cumulative design knowledge, and
- increasing human capital for innovation.

Van den Akker (1999) highlighted the need to generate, articulate, and test both substantive and procedural design principles to support the development of educational interventions. *Substantive design principles* focus on the development of design framework describing the characteristics of the designed artefact while *procedural design principles* provide guidelines and methods for how to develop an intervention (van den Akker, 1999; see also Edelson, 2002; Plomp, 2007). These concepts are similar to *normative substantive* and *procedural theories of design* used, for example, in the fields of architecture and urban planning (Horelli, 1997).

The main focus of this study was in the development of the design framework and substantive or content-related design principles for the LE design. Procedural design principles were needed, however, to guide the research efforts. Table 4 summarises the general procedural design principles guiding the design of this study (cf., Wang & Hannafin, 2005).

TABLE 4. Procedural design principles applied in this study

Design principles	Application in this study
Theory development	A framework, whose content and construct validity is tested in empirical studies, merges various theoretical considerations.
Pragmatism and practicality	Research knowhow is employed in the actual LE design project during the study and can be used in the future LE design (external validity).
Contextuality and generalisability	The framework developed and tested in various contexts balances both fixed and emerging elements, thus allowing both contextualisation and generalisation between contexts.
Iterative development	The study consists of iterations, with each iteration considered a semi-independent research cycle leading to progressive improvement of the design framework and principles.
Mixed-methods approach and multiple data gathering tools	The study employs a mixed-methods approach by embedding statistical methods within predominantly qualitative research. Numeric, written, oral, and visuospatial data are collected and analysed concomitantly.
Stakeholder involvement	While the focus is on the learner participation in the LE design and evaluation, various internal and external stakeholders contribute to the study.

Theory development. As typical for educational design research (see the Design-Based Research Collective, 2003), this study was theory-driven as it was grounded on a theoretical framework that it sought to revise and refine (see Wang & Hannafin, 2005). It aimed at theoretically significant contributions and theoretical advances (van den Akker, 2007; Barab & Squire, 2004; Hoadley, 2004) by developing a theoretical framework for the LE design. The study was research-driven instead of design-driven (Edelson, 2002). Conceptual foundations for the study were set up through an extensive literature review (see Cobb et al., 2003; Plomp, 2007; Wang & Hannan, 2005) merging theoretical

considerations and disciplines (see section 2.2). The conceptual framework was further refined in the empirical studies with the aim of constructing an empirically grounded theory (see Oh & Reeves, 2010; Wang & Hannafin, 2005). Questions of *validity*, i.e., correct interpretation of findings, and *reliability*, i.e., independence of findings from accidental circumstances (Barab & Squire, 2004) were addressed in the study. In the framework development, *content validity* (relevance) and *construct validity* (consistency) were meticulously examined (see van den Akker, 1999; Plomp, 2007). Rather than seeking causal connections between variables, the framework was being developed based on a synergistic view of LEs according to which all of its components constitute a systemic whole (Brown, 1992). In line with characterisation by Cobb and his colleagues (2003, p.9), the aim was set for "greater understanding of a learning ecology - a complex, interacting system involving multiple elements of different types and levels".

Pragmatism and practicality. This study was pragmatic by nature (see Cobb et al., 2003; Oh & Reeves, 2010). Its conceptual and methodological choices were in line with John Dewey's pragmatic philosophy (see also Anderson & Shattuck, 2012; Brown, 1992; Hoadley, 2004). Barab and Squire (2004) stated based on Dewey's considerations that, in pragmatic lines of inquiry, theories are judged, not by their claims to truth, but by their ability to do work in the world. It was seen as vital when gathering evidence that the results are *practically significant* (McKenney & Reeves, 2013; Hoadley, 2004; Wang & Hannafin, 2005). Practicality refers to design solution's *utility* (Plomp, 2007) or *usefulness* (Barab & Squire, 2004; Edelson, 2002) in everyday educational contexts. Usefulness is also related to *external validity* (Barab & Squire, 2004). The study aimed to design educational solutions whose use would be *cost-efficient* (van den Akker, 2007) and *appealing* to their users (van den Akker, 1999). The practical significance of this study was tested by employing the constructed design framework in the actual LE design project. The aim was to create a design framework and substantive principles - aligned with curricular considerations - that can guide LE co-design projects and their evaluation and comparison. As Juuti and Lavonen (2006) point out, pragmatism goes beyond mere practicality as it intimately connects actions with knowledge by means of deep reflection. In this study, this connection was sought by intertwining the LE design and the theory development (see the Design-Based Research Collective, 2003).

Contextuality and generalisability. In line with other studies (Barab & Squire, 2004; Brown, 1992; Collins et al., 2004), this study considered the contexts of learning. Drawing from a cultural psychology approach and Vygotskian sociocultural theory, the study acknowledged the need for cultural variation and localisation (Bell, 2004). Testing the framework and its principles in authentic settings served to develop "effective learning environments and using such environments as natural laboratories" (Sandoval & Bell, 2004, p.200), where "complex variables associated with real problems and complicated dynamics of multiple stakeholders exist" (Oh & Reeves, 2010, p.266). The cyclical nature of the design research made it possible to ensure that the results are *applicable to*

specific contexts (Anderson & Shattuck, 2012; van den Akker, 1999; Wang & Hannafin, 2005). While acknowledging that it is not possible to study the phenomenon in isolation where it occurs (Barab & Squire, 2004), the study also aimed at generalisability (Collins et al., 2004). Instead of making statistical generalisations, *analytical* (van den Akker, 1999) or *tentative* (Hoadley, 2004) *generalisations* were aimed over time and across settings (the Design-Based Research Collective, 2003), thus considering *sustainability, scalability* (Plomp, 2007; Oh & Reeves, 2010) and *transferability* or *replicability* of the results in other contexts (Barab & Squire, 2004). The study aimed at developing a design framework in various educational and cultural contexts. The aim was balancing the use of pre-established themes and structures with possibilities for emerging new themes and structures, so as to allow specification and contextualisation on one hand, and comparison and generalisation between contexts on the other hand.

Iterative development. Design research is characterised by iterative design research cycles (van den Akker, 1999; Anderson & Shattuck, 2012; Edelson, 2002). This study consisted of iterations where each iteration comprised a semi-independent research cycle leading to theoretical and practical improvements (Wang & Hannafin, 2005), as well as to improve methods and tools (Zheng, 2015). Research was both prospective and reflective; it entailed both immediate *formative evaluations* between the design cycles for improving the design and posterior and retrospective analysis, and (*semi)summative evaluations* for deepening the theory and design principles (see Cobb et al., 2003; Oh & Reeves, 2010; Plomp, 2007). In the initial phases of the study, the aim was to evaluate the *consistency* between the theory and empirical studies by refining the theoretical framework based on the empirical findings. In posterior phases, the *feasibility* of the framework in the authentic contexts was evaluated by employing it in the actual LE design yet leading to some framework refinements (see Wang & Hannafin, 2005).

Mixed method approach and multiple data gathering tools. Choices made about research tools inevitably affect research. As stated by Dewey (1938, p.52), "a tool is also a mode of language, for it says something to those that understand it, about the operations of use and their consequences". Mixing quantitative and qualitative methods has been typical for design research since its early days (Brown, 1992). This study aimed at crossing traditional boundary lines and advancing understanding through use of various theoretical lenses (see Bell, 2004). Use of multiple research methods and data from multiple sources (Anderson & Shattuck, 2012; Cobb et al., 2003; Zheng, 2015) were expected to increase the *objectivity, validity*, and *applicability* of the research (Wang & Hannafin, 2005). *Triangulation* of methods, instruments, sources, and sites was used to strengthen the interpretation and lessen any potential biases (van den Akker, 1999; the Design-Based Research Collective, 2003; Plomp, 2007). In this study, statistical methods were utilised within a predominantly qualitative research. The measures were designed for gathering numeric, written, oral, and visuospatial data, which were analysed conjointly. In educational design research, samples are often relative small and selective, and methods and sample

sizes may vary during different stages of the study (see van den Akker, 1999). This study varied intensive data collection with small number of participants with quick data gathering involving a higher number of respondents in different design cycles.

Stakeholder involvement. As is customary in educational design research (Anderson & Shattuck, 2012; Collins et al., 2004; Oh & Reeves, 2010; Wang & Hannafin, 2005), the study was conducted in close collaboration and partnership between researchers and educational stakeholders. Collaboration extended the whole process of planning and design phases to impact evaluation and formulation of design principles. While the study focused on the learner participation in the LE design, various internal (school administration, teachers, teacher students, students) and external (researchers, professional designers, constructors, companies) stakeholders contributed to the study. Stakeholder involvement was seen as a way to build *commitment and ownership*, *alleviate potential resistance to change*, and to improve the *fit and sustainability* of the designed solutions in real-life contexts (van den Akker, 1999). Similar to other educational design research studies (see Bell 2004), local appropriation was sought by applying a participatory design.

3.1.2 Participatory design

The present educational design research utilised a participatory design approach. This approach has commonly been employed in the design of physical LEs (Newman & Thomas, 2008; Nuikkinen, 2009; Woolner, Hall, Wall, & Dennison, 2007). It has also been employed in instructional design (Könings, van Zundert, Brand-Gruwel, & van Merriënboer, 2007) and in the design of educational technology (e.g., Leinonen et al., 2016). Participatory design has been used to combine perceptions of designers, teachers, and students (Könings et al., 2005) as well as other school staff members, parents, and the wider community (Woolner, 2009), including, e.g., policymakers, local authorities, and contractors (Parnell et al., 2008).

Participatory design has its roots in *political, democratic, and emancipatory aspirations* particularly in Scandinavia (Bjögvinsson, Ehn, & Hillgren, 2012; Kujala, 2008; Sanders & Stappers, 2008). Ehn (2017) connected participatory design with Dewey's pragmatism, Schön's "reflective practicum", Freire's "pedagogy of the oppressed", and Engeström's "expansive learning". Participatory design is viewed not only as a tool for designing products but also as a way to improve the quality of people's lives (Iversen & Dindler, 2014). In informed participation, individuals act as designers, active researchers, constructors, and communicators of knowledge (Fischer, 2002). Participants are empowered to have control and ownership over the design processes, and the design process is considered a mutual learning experience for all participants (Fischer, 2002; Sanoff, 2001). This approach is in line with learner-centred educational views honouring learners' epistemological agency (Dewey, 1997, 1916; Cornelius-White, 2007). Similar ideas have also been expressed in approaches involving

students as (co)researchers (Fielding, 2004) and those focusing on students' voices (Frost & Holden, 2008; Lodge, 2005; Robinson & Taylor, 2012).

Participatory design has similarities and links with co-design, which is sometimes differentiated from more *democratic considerations* of participatory design and is seen to focus more on *collaborative creativity and inspirations* in the design process (Sanders & Stappers, 2008; Steen, Kuijt-Evers, & Klok, 2007). Both of these approaches reflect a "participatory mind-set" and emphasise end-user's knowledge. In Steen and his colleagues' (2007) view, co-design focuses more on *envisioning future situations* while participatory design is more anchored into the *current situation*. Sometimes a distinction is also made between co-design (collaborative or cooperative design) *between various design experts* and those in which *users participate* (Smeds, Huhta, & Pöyry-Lassila, 2010). In Sanders's and Stappers's (2008) view, however, co-design is creativity of *designers and people not trained in design* working together across the whole span of a design process.

In this study, concepts "participatory design" and "co-design" were used in a broad sense to refer to knowledge sharing and creation (in relation to the past, present, and future) between participants representing various backgrounds. The study represents an approach that can be characterised with the terms "participatory mind-set" and "designing with people" (Sanders & Stappers, 2008). The present study, however, also took into account pragmatic concerns such as economy, efficiency, and quality, which are associated more with *user-centred design* approaches (Kujala, 2008; Steen et al., 2007). User-centred design is sometimes viewed to represent an "expert mind-set" and "designing for people" (Sanders & Stappers, 2008) with a focus on researcher's and designer's knowledge rather that of users (Steen et al., 2007). This study aimed at balancing these perspectives by co-designing LEs with learners and other stakeholders, all considered "experts of their experience" (Sanders & Stappers, 2008, p.9).

Learner participation was, first, expected to lead to improvements in the design quality (Woolner, 2009) by leading to more adequate and desirable LE designs for students (Flutter, 2006; Woolner, 2009). Second, participation was expected to foster a democratic culture by empowering and engaging students in school decision-making (Hargreaves & Shirley, 2009; Parnell et al., 2008) and by providing them with opportunities to express their voices (den Besten et al., 2008; Frost & Holden, 2008). Third, participation was expected to lead to enhanced student learning and wellbeing. The design process itself was designed as an authentic learning experience (Flutter, 2006; Frost & Holden, 2008). During the design process, participants could gain an understanding of the interrelationships between psychosocial and physical LEs, learning and wellbeing (Flutter, 2006), which they could apply later. As suggested by Simmons and her colleagues (2015), possibilities to influence one´s LE may already positively influence learning and wellbeing. Increased ownership and dominance of the co-designed solutions were expected to lead to more efficient use of LEs in support of learning (Woolner, 2009).

Levels of participation in the design may vary considerably. In Arnstein's (1969) ladder of citizen participation, the lowest level is "non-participation", aiming at (1) *manipulating* or manipulatively educating people or (2) providing *therapy* or cure to the powerlessness. Next levels refer to "degrees of tokenism", in which people have a voice but there is no assurance of changing the status quo. These forms include (3) *informing* (one-way flow of information, no channel for feedback or negotiations), (4) *consultation* (people are consulted without an assurance that their ideas will be considered), and (5) *placation* (advisory committee advises but power holders have right to decide). Final level is "degrees of citizen power": (6) *partnership* allows negotiations with traditional powerholders, (7) *delegated power* provides authority over a particular program, and (8) *citizen control* grants citizens full managerial power.

Arnstein's ladder of citizen participation has also been applied to learner participation. Table 5 presents variations on the level of learner participation presented in the literature.

TABLE 5. Variation in levels of learner participation in the literature

Hart, 1992	**Fielding, 2001**	**Flutter & Rudduck, 2004**	**Lodge, 2005**	**Woolner, 2009**
- Child-initiated shared decisions with adults	- Student researchers	- Fully active participants or co-researchers		
- Child-initiated and directed	- Co-researchers			- Partnership
- Adult-initiated shared decisions with children		- Researchers - Active participants	- Dialogue	- Collaboration - Involvement
- Consulted and informed	- Active respondents		- Compliance and control	- Consultation
- Assigned but informed	- Data source	- Listening to	- Source of information	
- Tokenism				
- Decoration			- Quality control	
- Manipulation		- Not consulted		

In this study, student involvement was adult-initiated but learners were able to influence decisions (see Hart, 1992). Degrees of student participation varied in different research cycles between the following positions: fully active participants or co-researchers (Fielding, 2001; Flutter & Rudduck, 2004), dialectic relations (Lodge, 2005), partnership and collaboration (Woolner, 2009) being consulted and informed (Hart, 1992; Woolner, 2009), being an active respondent or data source (Fielding, 2001; Lodge, 2005), and being listened to (Flutter & Rudduck, 2004). Students also contributed to quality control (Lodge, 2005) in a positive sense by assuring the LE quality from their perspective. Learner involvement was particularly important so as to see what LE characteristics they considered as relevant to their learning and wellbeing.

3.2 Research questions

The aim of this study was to develop a Learning Environment Design (LED) framework and substantive design principles for the LE co-design based on the theoretical, empirical, and practical considerations. The framework aimed to capture and structure the main LE characteristics supporting cognitive, emotional, social, and physical learning and wellbeing with a focus particularly on learners' views. The following research questions were set:

1. What kind of structure can be identified as optimal for the LED framework (construct validity)?
2. What are the relevant LE characteristics of the LED framework (content validity) based on participant learners' views?
3. What substantive (content-related) design principles can be formulated for co-designing learning environments?

These questions were addressed in the three substudies. All substudies contributed to the testing and refining of the preliminary framework developed as the first step, based on a literature review as well as the formulation of substantive design principles. Table 6 summarises the focus of each substudy, participants, and more detailed research questions.

TABLE 6. Foci, participants, and research questions of each substudy

Study	Foci	Participants	Research questions
1	Applying the framework V1.0	Finnish learners (n = 80) 7 to 14 years	1.1. Do the data support the consistency (construct validity) of the framework V1.0? 1.2. Do participant learners' views support the relevance (content validity) of LE characteristics? Can gender- or age-based differences be identified? 1.3. What substantive design principles can be formulated based on the results?
2	Revision of framework V1.0 into versions V2.0 and V2.1	Finnish (n = 80) and Spanish (n = 76) learners 7 to 14 years	2.1. Do the data support the consistency of the framework V1.0 structure? Is there a need to reorganise the LE characteristics to improve construct validity? 2.2. Do participant learners' views support the cross-cultural relevance of LE characteristics selected for the framework V1.0? Are there any new emerging characteristics? 2.3. What substantive design principles can be formulated?

continues

3	Applying the framework V2.1 and developing the framework V2.2	Finnish learners (n = 186) 16 to 19 years	3.1. Does the data support the consistency of the framework V2.1? 3.2. Do older learners' views support the relevance of LE characteristics selected for the framework V2.1? Are there any new emerging LE characteristics? 3.3. What substantive design principles can be formulated?

Substudy 1 examined whether Finnish learners' (aged 7 to 14) views were in congruence with the preliminary framework V1.0 with respect to relevance and consistency. Focus was on learners' shared views but also some gender-, age-, and individual-based differences in views (see Fraser, 1998) were identified.

Substudy 2 extended the analysis from Finnish students to same-aged Spanish learners. This substudy focused on analysing learners' shared views and the cross-cultural relevance of learning environment characteristics selected for the framework V1.0. Only some individual differences were considered when they clearly arose from the data. Attention was paid to possible new LE characteristics that would complement the framework. Further, it was examined whether the collected data supported the consistency of the framework V1.0 structure or whether there was need to reorganise the LE characteristics to improve construct validity of the model. Based on the results of substudy 2, the framework versions V2.0 and V2.1 were formulated.

Substudy 3 involved Finnish students aged 16 to 19 as participants of school LE improvement. Framework V2.1 was applied in the analysis to examine whether older learners' views supported its relevance and whether new LE characteristics could be identified. Focus was again on students' shared views. Based on the results, the framework V2.2 was formulated. In substudies 1 and 2, no actual changes were directly made to the participants' school learning environments, but in substudy 3 it was possible to examine the extent to which students perceived that their ideas had been taken into account in the actual LE redesign, and whether they perceived improvements in the LE after the redesign.

3.3 Data collection

Participatory design involving learners typically employs a multisensory approach (Staffans, Teräväinen, Meskanen, & Mäkitalo, 2008). In this study, varying methods were used to collect numeric, written, oral, and visuospatial data, which were analysed with quantitative and qualitative methodology in order to provide a rich understanding of the learners' perspectives (Frost & Holden, 2008; Simmons et al., 2015; Woolner, McCarter, Wall, & Higgins, 2012).

Use of checklists, questionnaires, and rating scales are seen as particularly useful for collecting large amounts of data in a short time (Sanoff, Pasalar, &

Hashas, 2001; Sanoff, 2001). For the purpose of this study numeric and written data were collected by means of web questionnaires (substudies 1-3) and student feedback form (substudy 3). Similar to studies by Ghaziani (2012), surveys contained fixed items, but open questions were used for issues not raised previously.

Methods that make use of visual and spatial material are often viewed as emancipatory and widen participation by not relying heavily on participants' literacy skills (Woolner, Clark, Hall, Tiplady, Thomas, & Wall, 2010). Prototyping or modelling three-dimensional mock-ups or scale models are viewed as a particularly appropriate method for collecting data about physical LE design (Horelli, 1997; Iversen & Dindler, 2014; Staffans et al., 2008). In substudies 1 and 2, participants elaborated physical scale models (see Appendices 1 and 2) and, in substudy 3, virtual 3D models (Appendix 3).

Visual or visuospatial methods are, however, constrained by the participants' artistic skills (Selwyn et al., 2009) and they do not directly provide information on reasons behind the response, i.e., answers to why-questions (Woolner et al., 2010). There is also a danger of misinterpreting the data (Kostenius, 2011). This is why visuospatial data were combined with (semi-structured) interviews, giving participants an opportunity for explanations (Cam Aktas, 2010; Sanoff et al, 2001) and presenting their work or solution with verbalisations (Staffans et al., 2008). Methods such as peer briefing, member checking, consultation (Horelli, 1997), focus groups (Duarte et al., 2015), review or advisory boards (Sanoff, 2001) are often used to assure that researchers have interpreted the data correctly. For the purpose of substudy 3, this type of oral data was collected to assure that learners' wishes had been considered in the LE design.

Materials were designed in a way that they would enable versatile and engaging LE co-design sessions and authentic learning experiences (Staffans et al., 2008). Data collection was embedded in the participants' everyday schedules as a collaborative cross-curricular learning activity for practicing skills needed for participatory 21st century citizenship. Figure 1 summarises the research cycles of this study in relation to research aims and substudies. Design cycles numbered as 1 to 6 refer to learner involvement.

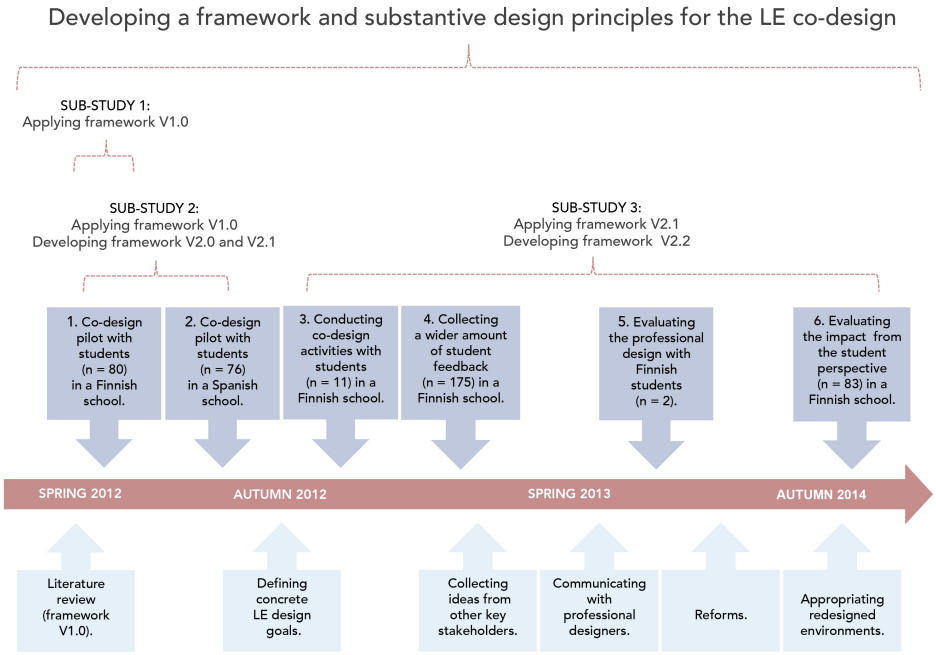


FIGURE 1 Design cycles in relation to research aim and substudies

Substudy 1 *(Cycle 1).* After the preliminary research consisting of the literature review, the development of the initial framework V1.0, and the planning of materials, procedures, and data analysis, co-design pilot sessions were conducted with learners (girls: n = 34; boys: n = 46) aged 7 to 14 years. The co-design pilot 1 took place in a Finnish university-affiliated teacher training school in late spring 2012 and early autumn 2012. The web questionnaire was used as an introductory pair work activity, followed by a collaborative scale model design (see Appendix 1) and group discussions. It was possible to conduct all the activities in two hours. In the data analysis, the qualitative data were analysed, coded, and classified using content analysis techniques. Descriptive statistics (means and standard deviations) of the key variables were calculated and group differences (independent samples t test) were analysed to support the analysis of the qualitative data.

Substudy 2 *(Cycles 1 and 2).* The same research design was employed in co-design pilot sessions conducted in Spain to test for the cross-cultural relevance and consistency of framework V1.0 (for pictures of scale models, see Appendix 2). Cycle 2 involved learners aged 7 to 14 years (girls: n = 34; boys: n = 46) in a publicly financed private school in Spain in late autumn 2012. An exploratory factor analysis was conducted to guide the restructuring of the initial framework with respect to theoretical constructs. Content elements (LE characteristics) confirmed by the quantitative and qualitative data were grouped un-

der the renewed constructs, which were further divided into thematic sub-blocks. If the cross-analysis revealed some apparent discrepancies, a more in-depth analysis was conducted to search for their possible origin and explain them in light of the overall data. This analysis led to the development of framework versions V2.0 and V2.1.

Substudy 3 *(Cycles 3–6).* Substudy 3 was carried out in the same teacher training school where the first pilot took place. Research objectives and procedures were aligned with the school community's vision, mission, curriculum, and concrete development goals, and adjusted to available resources. The LE redesign took place in a natural science classroom and its adjacent hallway (for the LE before the redesign, see Appendix 4), mostly used by upper secondary school students. The study focused on the participation of the upper secondary school students.

- *Cycle 3:* Co-design activities were part of a visual arts project course conducted during the autumn term of 2012. For their final coursework, the participating students (females: n = 8; males: n = 3) created LE designs consisting of 3D models/sketches and colour, furniture, and technology plans (for student designs, see Appendices 3 and 4).
- *Cycle 4:* The visual arts project course culminated in an exhibition displaying the student redesign plans, where other students (females: n = 104; males: n = 61; no information on gender: n = 10) had an opportunity to express their views on a structured student feedback form (see Appendix 5).

Student designs and summaries of student suggestions were next presented to teachers and teacher students who first evaluated students' ideas and subsequently gave their own suggestions. Suggestions from all participant groups were finally communicated to the professional designers.

- *Cycle 5:* Before implementing the changes to the actual redesign, the researchers invited participants of the co-design project course to evaluate the professional design (see Appendix 6). Two male upper secondary school students who had participated in the co-design project participated in this activity.

After some final revisions, the reforms were initiated in summer 2013 and completed during the first months of the autumn term of 2013 (for the redesigned LE, see Appendix 4).

- *Cycle 6:* After some months of appropriating the redesigned environments (December 2013 and January 2014), students were invited to answer an online student satisfaction survey (females: n = 45; males: n = 37). The survey's formulation was guided by the conceptual framework V2.1 but was based on the LE characteristics highlighted by the students in previous design cycles.

Thematic analysis and content analysis techniques were employed to analyse the student designs, written student feedback, and the transcriptions of professional design evaluation with the students. Furthermore, descriptive statistics (means, standard deviations, and frequencies) from the student satisfaction survey items were calculated. Table 7 summarises the participants, data, and data analysis of each substudy.

TABLE 7. Participants, data, and data analysis of each substudy

Study	Participants	Data	Data analysis
1	Learners (*n* = 80) age 7 to 14 years in a Finnish school	- A web questionnaire (numeric and written data) - Scale models/mock ups (visuospatial data) - Semi-structured group discussions (oral data)	Cross-analysis of - qualitative data: content analysis, and - quantitative data: descriptives (means and standard deviation) and group differences (Independent-Samples T Test).
2	Learners (*n* = 156) age 7 to 14 years in a Finnish (*n* = 80) and Spanish (*n* = 76) school	- A web questionnaire (numeric and written data) - Scale models/mock-ups (visuospatial data) - Semi-structured group discussions (oral data)	Cross-analysis of - qualitative data: content analysis, and - quantitative data: descriptives (means and standard deviation), exploratory factor analysis (principal axis extraction with direct oblimin rotation).
3	Learners (*n* = 186) age 16 to 19 years in a Finnish school	- Students' (*n* = 11) LE designs (3D models) - Written student feedback (*n* = 175) - Professional design evaluation (oral data) with students (*n* = 2) - Student satisfaction survey (*n* = 83)	Cross-analysis of - qualitative data: thematic analysis and content analysis, and - quantitative data: descriptive statistics (means, standard deviation and frequencies).

4 RESULTS

4.1 Substudy 1: "Considering Learners' Perceptions in Designing Effective 21st Century Learning Environments for Basic Education in Finland"

The substudy 1 employed the preliminary framework (V1.0) in analysing Finnish 7 to 14-year old learners' (n = 80) perceptions on LEs that foster learning and wellbeing. It contributed to the overall aims of this study by testing the consistency of the initial framework (construct validity) and its relevance (content validity). It also provided initial substantive design principles for the LE design. The focus was on participants' shared views, but also individual, gender, and age differences were examined. The substudy reported findings based on the cross-analysis of numeric (Likert-scale items), written, oral, and visuospatial data.

The three main constructs ("Overall wellbeing", "Learning situation", and "Learning tools and space design") of the framework V1.0 were found to be valid with respect to representation of relevant learner perceptions. The three constructs appeared, however, to be highly overlapping and interrelated. In relation to framework content validity, 24 LE characteristics out of 36 LE characteristics included into framework V1.0 were corroborated as the most relevant for participant learners based on the data. Table 8 presents these characteristics together with the 12 LE characteristics that were not so clearly present in all datatypes (in parenthesis).

Students' preferences with respect to *pair, group* (i.e., collaborative) or *individual work* were found to vary between individuals. Students with more negative feelings towards schooling seemed to view *behavioural disturbance* as less problematic than other students. Girls as a group appeared to have more conformist views of school than boys. *Safety* of LE was rated significantly higher by girls than by boys. The *use of technology* was the only aspect where boys provided on average higher and more homogeneous ratings (i.e., smaller variance) than girls. Older students' preferences with respect to the use of technology

were, however, less polarised between genders. Good *home-school relations* appeared to be more important for younger than older students. In comparison to younger students, older students seemed to be more likely to perceive school as a means to succeed in life, as an obligatory duty, or to express anti-school attitudes. *Spaciousness* was important for the youngest learners so as to be able to play, whereas the oldest learners wished for more space so as not to feel cramped or suffer from uncomfortably small furniture.

TABLE 8. LE characteristics corroborated as relevant in substudy 1

I Overall wellbeing		**II Learning situation**		**III Learning tools and space**	
Shared vision about schooling	√	Versatile teaching methods	√	Versatile use of materials	√
Safety	√	Teacher-led instruction (Self-regulated learning)	√ –	Use of technology	√
No behavioural disturbance	√	Involvement and self-expression	√	Books and other traditional tools	√
Teacher-student relations	√	Personal relevance of studies (Personalisation)	√ –	Novel and conventional design	√
Peer relations	√	Collaborative work	√	Ubiquitous LE	√
(Staff-student relations)	–	Individual work	√	Luminosity	√
Home-school relations	√	(Personal relevance of assessment)	–	Spaciousness	√
(Wider community relations)	–			(No disorganisation)	–
(No noise disturbance)	–			Aesthetics and colours	√
No overload	√			(Sustainability)	–
(Indoor air quality)	–			(Adaptability)	–
Outdoor areas	√			(Functionality and practicality)	–
Physical exercise	√				
Presence of nature	√				
(Quality of meals)	–				

Note: Corroborated characteristics marked with tick, non-corroborated marked with dash and shown in parenthesis.

The substantive LE design principles formulated in the substudy 1 can be encapsulated as follow:

I Overall wellbeing
- safety and peacefulness (e.g., no bullying);
- possibilities to socialise, be physically active, rest and enjoy nature (e.g., gardens, park areas); and
- support for diversified growth towards autonomy,

II Learning situation
- use of diverse but especially collaborative methods;
- connectedness with students' real-life aspirations; and
- opportunities to make choices related to own learning, and

II Learning tools and space design
- variable, both traditional and technological tools;
- ubiquitous formal (e.g., school, classrooms), non-formal (e.g., libraries, museums), and informal (both indoor and outdoor) learning spaces; and
- luminous, spacious, and aesthetic environments.

4.2 Substudy 2: "Developing a Conceptual Framework for Participatory Design of Psychosocial and Physical Learning Environments"

In substudy 2, the consistency and relevance of the initial framework (V1.0) was further explored based on the analysis of data from 7 to 14-year-old student samples in both Finland (n = 80) and Spain (n = 76). The main focus was on shared views of a cross-culturally relevant LE framework and design principles. In relation to framework consistency, factor analysis on the student ratings data supported restructuring of the three constructs of the initial framework into framework V2.0 with five constructs labelled as (I) Communality, (II) Individuality, (III) Comfort, (IV) Health, and (V) Versatile tools and spaces. A cross-analysis with other datatypes and theoretical, empirical, and practical considerations led to the construction of framework version 2.1.

The revised framework consisted of seven constructs (i.e., dimensions) each with two to four sub-themes, and a total of 41 characteristics, two of which emerged at this cycle. Further, characteristic *no overload* was divided into *rest* and *leisure time* and *ubiquitous LE* into *informal LE, non-formal LE,* and *formal LE.* Table 9 presents the framework version 2.1 developed in substudy 2.

Participant learners' views analysed using the diverse data types supported cross-cultural relevance (content validity) of all LE characteristics included into the initial framework V1.0. The relevance of some characteristics was, however, only confirmed after the cross-analysis of all data types. For instance, while participants did not generally give high ratings to the importance of *aesthetics* or *involvement and self-expression* in comparison to other LE items, the importance given to decorative elements of their scale models and the enthusiasm expressed toward the LE co-design indicated that participants valued these LE characteristics. In addition, new characteristics termed as *no distractions* (e.g., no parties, no free internet access, no traffic) and *comfortable furniture* (e.g., sofas, cushions) emerged.

TABLE 9. LE constructs and characteristics in the framework V2.1

I Communality	II Individuality	III Comfort	IV Health	V Novelty	VI Conventionality
(a) Social relations Teacher-student relations Staff-student relations Peer relations Home-school relations Wider community relations **(b) Teaching-learning interaction** Teacher-led instruction Collaborative learning **(c) Sense of belonging** Shared vision about schooling Involvement and self-expression **(d) Safety** No behavioural disturbance Safety	**(a) Privacy and peacefulness** No noise disturbance No disorganisation *No distractions* **(b) Individualisation** Personalisation Personal relevance of studies Personal relevance of assessment Individual work Self-regulated learning	**(a) Physical ease** Spaciousness *Comfortable furniture* **(b) Pleasantness** Aesthetics and colours Luminosity Presence of nature	**(a) Physical wellness** Quality of meals Indoor air quality Outdoor areas Physical exercise **(b) No overload** Rest Leisure time	**(a) Novel tools** Use of technology **(b) Novel spaces** Informal LE Novel LE design	**(a) Conventional tools and spaces** Use of books and other traditional materials **(b) Conventional tools and spaces** Sustainable design Non-formal LE Formal LE Conventional LE design
VII Flexibility and functionality Versatile use of materials; Adaptability; Functionality and practicality					

Note. Characteristics that emerged at this cycle are marked in italics.

Based on analysing the shared views of the cross-cultural data used in substudy 2, design principles were formulated as follows:

Balancing of (I) Communality with (II) Individuality by

- enabling socialising and collaborative work on one hand, and privacy and individual work on the other;
- balancing teacher-led activities with self-regulated and personally relevant learning situations;
- taking into account not only the shared vision but also differing views and personal preferences; and
- opening the school to the wider community, but ensuring that the LE is safe and disturbance- and distraction-free.

Balancing of learners' wishes for (III) Comfort with (IV) Health by ensuring that there are

- comfortable and spacious environments for learners to feel at ease physically, and also both indoor and outdoor environments that promote physical wellness; and
- pleasant spaces including elements of nature as well as time and spaces for leisure and rest.

Balancing of (V) Novelty with (VI) Conventionality by assuring that

- modern tools and spaces such as technological equipment and an informal LE are combined with conventional tools and spaces often used in formal or non-formal learning.

Ensuring that the LE is (VII) functional and flexible so that it can be easily utilised and modified to respond to the learning community's varying needs and requirements.

4.3 Substudy 3: "Student Participation in Learning Environment Improvement: Analysis of a Co-design Project in a Finnish Upper Secondary school"

Substudy 3 aimed at testing and further developing the constructs and contents of framework V2.1 in an actual LE co-design project with Finnish Upper secondary school students (n = 186) between 16 and 19 years of age. Framework V2.1 constructs were found to be feasible for this co-design project. Students stressed the importance of communality-related LE characteristics, but also paid attention to individuality. They viewed comfort as particularly important, but neither neglected issues related to health. They also wished that the LE would combine novelty with conventionality. In comparison to previous substudies with younger children, the participants in this substudy seemed to pay more attention to LE characteristics related to flexibility and functionality. Table 10 presents the findings with 26 replicated LE characteristics, 15 LE characteristics that were not directly replicated, and 11 LE characteristics that emerged from this data set. The results were generally in line with the earlier substudies. The framework V2.2 consisted of 52 LE characteristics.

Students' wishes were considered in the actual LE redesign, for example, by providing more spaces for socialising (*peer relations*) and comfortable sofa groups and cushions (*comfortable furniture and spaces*). Glass doors were selected to improve *transparency* (e.g., less risks for troublemaking or vandalism) and *luminosity*. *Safety* was improved by creating separate laboratory areas. Furthermore, varying smaller-scale learning stations were created both inside and outside the classroom and the tiered classroom floor was removed so as to better enable *collaborative work* and multiple configurations *(adaptability)*. *Noise disturbance* was reduced by acoustic panels and textiles. *Ergonomics* was improved with adjustable desks and chairs. Stimulating special effect *colours* were combined with calming colours and colour-changing lamps were chosen not only for aesthetic reasons but also to enable teaching colour theory. Following the idea of a planetarium ceiling proposed by the students (*educative design elements*), a solar system model was installed based on teachers' wishes. Some de-

sign proposals such as *private spaces* and interior plants (*presence of nature*) could not be implemented at this phase for economical and practical reasons.

Student satisfaction survey was constructed based on the framework V2.1 and LE characteristics highlighted in the student designs and written feedback. The findings of the survey indicated that participant students had experienced or perceived generally positive changes in relation to 58% of the LE characteristics evaluated in the survey. The most positively perceived changes were in relation to the constructs Novelty (e.g., *novel LE design*, u*se of technology*) and Flexibility and functionality. Students indicated, however, that teachers would need more support to use the novel technology. Students had not generally experienced or perceived changes in relation to 34% of characteristics. Least changes were perceived in relation to Individuality and Conventionality (e.g., *the use of traditional materials*). Students also perceived or experienced generally negative changes in relation to *teacher visibility*, *conventional LE design*, and *the presence of nature*. Results also indicated that sometimes considering one need (*enough tables and seats*; *collaborative work*) may lead to weakening effects concerning other needs (less *spaciousness*; less *teacher visibility*).

TABLE 10. Replicated, not replicated, and emerged characteristics (V2.2)

Replicated LE characteristics	
Communality	Peer relations, collaborative work, teacher-led instruction, no behavioural disturbance, physical safety
Individuality	No noise disturbance, no distraction, no disorganisation, personalisation, individual work, self-regulated learning
Comfort	Spaciousness, comfortable furniture and spaces, aesthetics and colours, luminosity, presence of nature
Health	Indoor air quality, rest, leisure time
Novelty	Use of technology, novel LE design
Conventionality	Use of books and other traditional materials, conventional LE design
Flexibility	Versatile materials, adaptability, functionality, and practicality
Not replicated LE characteristics	
Communality	Teacher-student, staff-student, home-school, and wider community relations, shared vision, involvement, and self-expression
Individuality	Personal relevance of studies, personal relevance of assessment
Comfort	-
Health	Quality of meals, outdoor areas, physical exercise
Novelty	Informal LE
Conventionality	Sustainable design, non-formal LE, formal LE
Flexibility	-
Emerged LE characteristics	
Communality	Teacher visibility, homelike environments, transparency
Individuality	Private spaces, studying during the breaks
Comfort	Enough seats, seating, and table space
Health	Indoor temperature, ergonomics
Novelty	Educative design elements, inspiring and motivating spaces
Conventionality	-
Flexibility	Versatile methods

Finally, the substantive design principles to support the LE design elaborated in the light of the findings presented in substudy, are summarised as follows:

Balancing needs for (I) Communality and (II) Individuality by combining
- cosy areas for socialising with private spaces and good soundproofing;
- teacher-led and collaborative learning with individual, personalised and self-regulated learning; and
- transparent surfaces with dimming curtains and safety working areas with good storage spaces.

Balancing (III) Comfort-wishes with (IV) Health-needs by providing
- spacious areas with enough seats, seating and table space, which have optimal air quality and temperature;
- comfortable and soft furniture on which to rest and relax, and ergonomic furniture to work; and
- aesthetically pleasing design and colours, luminous spaces, and interior plants.

Balancing (V) Novelty with (VI) Conventionality by blending
- use of technology and innovative educative design elements together with books and other traditional materials; and
- novel and inspiring design with conventional school design.

Assuring that tools, spaces, and ways of working are (VII) Flexible and functional so that they allow versatile ways of working and balance, both shared and individual learning- and wellbeing-related needs and wishes.

4.4 Summary of main results

The first research question focused on examining the kind of structure that is optimal for an LED framework fostering student learning and wellbeing in a school context (construct validity). In substudy 1, the constructs "overall wellbeing", "learning situation", and "learning tools and space design" of framework V1.0 were found useful for gathering and analysing data on learner perceptions. In the retrospective analysis, however, it seemed that separating LE characteristics related to wellbeing, learning, and physical LE did not sufficiently reflect the interconnectedness of these characteristics. In substudy 2, the restructuring of the original three constructs into five constructs (framework V2.0) was supported by the factor analysis of the survey data and confirmed by the cross-analysis with other data types. Further interpretation of the data led to framework V2.1 consisting of three pairs of concepts (communality-individuality, comfort-health, and novelty-conventionality) balancing one another, and a seventh construct, flexibility and functionality, supporting the other constructs. In addition, subthemes were proposed for clustering the LE char-

acteristics within each construct. In substudy 3, the seven main constructs of framework V2.1 were found useful for structuring the analysis of the data collected in four research cycles involving learners in the LE redesign and evaluation.

The second research question focused on identifying the relevant characteristics of the LED framework (content validity) based on participant learners' views. In substudy 1, participant learners' views based on various data types supported the relevance of 24 out of the 36 LE characteristics selected for framework V1.0. Some individual, gender, and age-based differences in preferences were identified. At this point, no new LE characteristics were added. In substudy 2, participant learners' views were in line with the 36 LE characteristics selected for the framework. Two new characteristics (*no distractions* and *comfortable furniture*) were added, and the characteristics *no overload* and *ubiquitous LE* were split into smaller units. In substudy 3, out of the total of 41 LE characteristics included in framework V2.1, 27 characteristics were replicated and 11 new characteristics were formulated based on participant learners' views.

The third research question focused on examining what substantive design principles could be formulated for the LE co-design with learners. In substudy 1, the design principles drew attention to the characteristics related to overall wellbeing, the learning situation, and the learning tools and space design. In substudies 2 and 3, the design principles highlighted the importance of maintaining equilibrium between communality and individuality, comfort and health, novelty and conventionality, as well as LE functionality and flexibility. While some design principles were replicated in each substudy, new design principles were also elaborated in each research cycle.

5 DISCUSSION

The aim of this educational design research was to develop a design framework and substantive (or content-related) design principles for co-designing psychosocial and physical learning environments fostering student learning and wellbeing. The framework and the principles were based on the theoretical, empirical, and practical considerations, focusing particularly on learners' perceptions. The research questions were related to the Learning Environment Design (LED) framework construct validity, content validity, and substantive LE design principles.

Inspired particularly by Dewey's educational philosophy, the design framework and principles aimed at capturing LE characteristics fostering cognitive, emotional, social, and physical dimensions of learning and wellbeing, which are viewed as highly interconnected (see also Cohen, 2006; Kangas, 2010a). Attention was on supporting the fulfilment of basic psychological needs of having, loving, and being (Allardt & Uusitalo, 1972; Konu & Rimpelä, 2002; Nuikkinen, 2009) considered fundamental for both learning and wellbeing. In harmony with the learner-centred paradigm giving learners an active agency in learning cross-curricular citizenship skills (e.g., Scardardamalia et al., 2012), and with the studies suggesting that involving learners in the participatory LE co-design may enhance student learning and wellbeing (e.g., Simmons et al., 2015), it was also natural to construct the framework by listening to learners' voices in the LE design processes. Guided by theoretical considerations of Dewey, sociocultural and socioconstructivist paradigms inspired by authors such as Vygotsky, and the ecological model of Bronfenbrenner, individual and social human activities (psychosocial LE) were seen as highly interconnected with physical LEs. Individuals were viewed to be in dynamic interaction with their social and physical LEs; while these environments can promote, permit, or hinder human activities, individuals and groups can also actively influence them. Insights from various disciplines (e.g., education, architecture, health science, psychology, environmental psychology, sociology) were sought to understand holistically this complex phenomenon.

Figure 2 visualises the final seven dimensions (i.e., constructs) and 53 characteristics of the LED framework V2.3 developed in this study. The spider web illustrative approach was adapted by van de Akker's (2007) model of interconnected curricular components. The visualisation technique draws attention to the importance of "comprehensive approach and systematic attention" (van den Akker, 2007, pp.40-41) to a wide range of cognitive, emotional, social, and physical learning- and wellbeing-related LE characteristics during the design process. The following chapters discuss the findings related to each research question one by one.

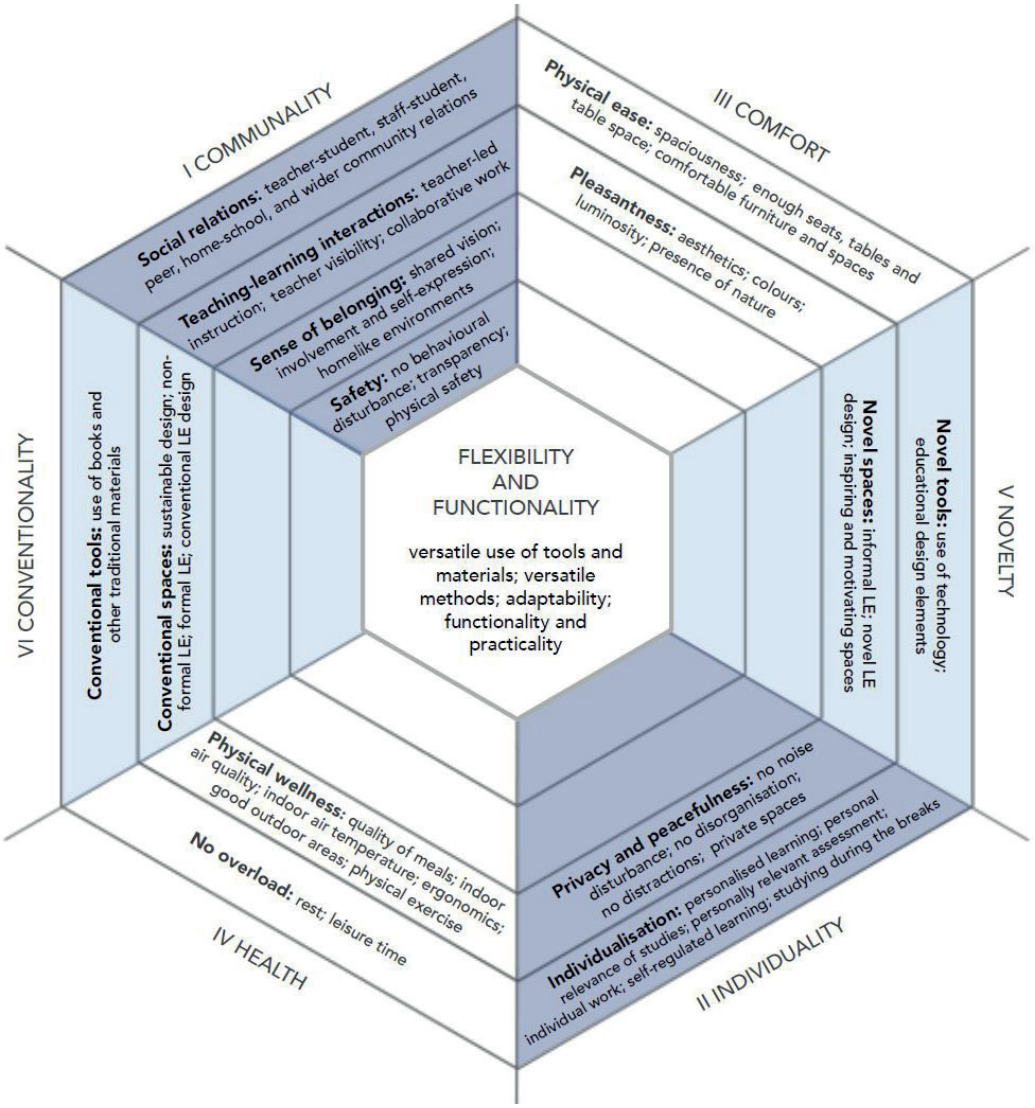


FIGURE 2 Visualisation of the LED framework V2.3

5.1 Construct validity of the framework

While there seems to be no prior models that have consistently been built around the idea of maintaining equilibrium between various human needs related to learning and wellbeing, some of the earlier models also consider the notion of "balancing". The pair of concepts "Communality" and "Individuality" are closely related to the dimensions "Relationship" and "Personal development" in Moos' (e.g., 1987) human environment model. Kuuskorpi (2012) conceptualised physical LEs in the context of social-individual dimension. Gee's (2006) "human-centred design guidelines" include dimensions "communality" and "solitude". The model by Barrett and his colleagues (2013) balances "open" with "private".

Comfort and health are notions typically reflected in architectural LE designs. Comfort, for example, was chosen as one of the main constructs in Sulonen and Sulonen's (2014) LE characteristics, while Gee's (2006) guidelines include the construct "Healthful". Also, the model proposed by Konu and Rimpelä (2002) included, in addition to constructs "having", "loving", and "being", the construct "Health". Health-related characteristics are related to both physical and mental health and wellbeing (Awartani et al., 2008; Dodge et al., 2012).

The concept of balancing novelty with conventionality is reminiscent of Moos' model's (1987) dimension, 'System Maintenance and System Change', i.e., an equilibrium between stability and responsiveness to change. The importance of balancing permanent and fresh elements has also been stressed in the contemporary literature (Higgins et al., 2005; UNESCO, 2012). The construct of "Novelty" shares properties with the design principle of "Stimulation", which Barrett and his colleagues (2013, p.681) described as an indicator of "the degree to which the school provides appropriate diversity (novelty)". Conventionality-dimension shares similarities with the construct "Durability" used in other LE conceptualisations (Sulonen & Sulonen, 2014; Wolff, 2002). Finally, the conceptual decision to place 'Flexibility and functionality' as the centric construct of framework is supported by recent architectural (Barret et al., 2013; Gee, 2006; Nuikkinen, 2009; Sulonen & Sulonen, 2014) and educational (Kuuskorpi & Cabellos, 2011; Wolff, 2002) literature.

5.2 Content validity of the framework

In the following chapters, the LE characteristics of each construct will be discussed in more detail. In addition to research literature, results are discussed in the light of the Finnish curriculum for basic education (Finnish National Board of Education, 2016) in order to demonstrate the curricular relevance of this study.

5.2.1 Communality

Table 11 presents four sub-themes and 14 characteristics related to communality together with substudies and example literature confirming their relevance. Most of these characteristics were confirmed in at least two substudies. The absence of some characteristics in substudy 3 may be explained by the specific LE design goals focusing on the redesign of a natural science LE, which did not raise all characteristics to students' attention.

TABLE 11. Communality-related LE characteristics

LED framework contents	Study	Confirmed by the literature (examples)
Social relations		Awartani et al., 2008; Bronfenbrenner, 1979;
Teacher-student relations	1, 2	Dodge et al., 2012; Dewey, 1907; 1916; Fisher
Staff-student relations	2	& Newton, 2014; Fraser, 1998; Ghaziani, 2010;
Peer relations	1, 2, 3	Gislason, 2010; Konu & Rimpelä, 2002; Nuik-
Home-school relations	1, 2	kinen, 2009; Moos, 1987; Piispanen, 2008a,
Wider community relations	2	2008b; Simmons et al., 2015; Vygotsky, 1978
Teaching-learning interaction		APA Work group, 1997; Cornelius-White,
Teacher-led instruction	1, 2, 3	2007; Dewey, 1907; 1916; Elen et al., 2007;
Teacher visibility	3	Fisher & Newton, 2014; Kangas, 2010a, 2010b;
Collaborative work	1, 2, 3	O´Neill & McMahon, 2005; Vygotsky, 1978
Sense of belonging		Awartani et al., 2008; Bronfenbrenner, 1979;
Shared vision	1, 2	Dewey, 1907; 1916; Kangas, 2010a; Konu &
Involvement and self-expression	1, 2	Rimpelä, 2002; Nuikkinen, 2009; Sanoff et al.,
Homelike environment	3	2001; Zandvliet & Fraser, 2005
Safety		Awartani et al., 2008; Barrett et al., 2013; Cle-
No behavioural disturbance	1, 2, 3	veland & Fisher, 2014; Cohen, 2006; Ghaziani,
Transparency	3	2010, 2012; Nuikkinen, 2009; Piispanen, 2008a,
Physical safety	1, 2, 3	2008b; Sanoff et al., 2001

Social relations. All substudies confirmed the importance of *peer relations* for students. Substudy 1 suggested that the relevance of *home-school relations* may diminish as students' wishes for independency increases by age.

Teaching-learning interaction. Participant students valued both *teacher-led-instruction* and *collaborative work*. The characteristic *teacher visibility* was added to the framework based on older students' wishes (substudy 3) related particularly to teacher-led activities which, also based on the literature (Dowey & Fisher, 2014; Elen et al., 2007), is supported as one component of quality teaching-learning interactions.

Sense of belonging. Substudy 1 indicated that older students may be more likely than younger ones to perceive school either as an obligatory duty or a means to succeed in life. This is in line with studies suggesting that adolescents may be at a higher risk of losing interest and developing negative emotions and behaviours towards schooling (see Dovey & Fisher, 2014), and that they may have a strong need for experience of meaningful connection of school studies with their future (see Linnankylä & Malin, 2008). While upper second-

ary school students participating in the LE redesing (substudy 3) did not explicitly express that *involvement and self-expression* was relevant for them, their participation in the redesing project per se indicated that they valued these opportunities. Further, the characteristic of *homelike environment* was added to the framework based on upper secondary school students' data, and it is in line with the importance given to positive, inviting, welcoming, and cosy environments in the literature (Ghaziani, 2010; Kangas, 2010a; Tanner, 2008).

Safety. Based on substudy 1, female students expressed a stronger need for *safety* than male students. In line with other studies (Linnankylä & Malin, 2008; Moroz, 2001), boys, in turn, seemed to express more anti-school attitudes. Students with more negative feelings towards schooling seemed also to view *behavioural disturbance* as less problematic. Finally, a LE characteristic *transparency* was added to the framework based on upper secondary school students' data, and it is also supported by other studies (Barrett et al., 2013; Kuuskorpi, 2012; Nuikkinen, 2009).

Communality-related LE characteristics are also in line with the Finnish curriculum for basic education (Finnish National Board of Education, 2016), highlighting the importance of shared views on learning and nurturing the sense of communality in school, not only between teachers and peers but also with families and the surrounding society. An atmosphere of trust, learners' active participation in the design and use of LEs, and their right to a safe learning environment free from bullying or violence are emphasised. Aspects related to communality such as self-expression, participation, and involvement are also included in the learning objectives of transversal competences.

5.2.2 Individuality

Table 12 presents two individuality-related subcategories and 10 LE characteristics confirmed based on empirical findings of this study as well as prior research literature. In this study, participant students seemed to consider individuality-related characteristics as somewhat less important than communality-related characteristics. Of these LE characteristics, only *personal relevance of studies* and *individual work* were amongst the most prominent 24 characteristics identified in the substudy 1.

TABLE 12. Individuality-related LE characteristics

LED framework contents	Study	Confirmed by the literature (examples)
Privacy and peacefulness		Bronfenbrenner, 1979; Barrett et al., 2013;
No noise disturbance	2, 3	Crespo & Pino 2007; Flutter, 2006; Ghaziani,
No disorganisation	2, 3	2010, 2012; Gislason, 201; Marchand et al.,
No distractions	2, 3	2014; Nuikkinen, 2009; Papatheodorou, 2002;
Private spaces	3	Piispanen, 2008b; Tanner, 2008
Individualisation		Awartani et al., 2008; Bronfenbrenner, 1979;
Personalised learning	2, 3	Dewey, 1907, 1916; Gislason, 2010; Jamieson
Personal relevance of studies	1, 2	et al., 2000; Kuuskorpi, 2012; Nuikkinen,
Personally relevant assessment	2	2009; Papatheodorou, 2002; Piispanen,
Individual work	1, 2, 3	2008b; Scardamalia et al., 2012; Tanner, 2008;
Self-regulated learning	2, 3	Vygotsky, 1978; Wang & Holcombe, 2010;
Studying during the breaks	3	Zandvliet &Fraser, 2005; Sanoff et al., 2001

Privacy and peacefulness. A characteristic *no distractions* emerged and was incorporated into the framework based on data from Finnish and Spanish students' (substudy 2), and it is also supported by the literature. In Gislason's (2010) study, participant students indicated that social activity could easily distract them from learning. As Zandvliet and Fraser (2005, p.849) concluded "an inadequate physical learning environment might affect psychosocial disharmony, perhaps disrupting or distracting the intended learning goals in these settings". Students participating in the substudy 3 viewed that augmented transparency of spaces may increase distractions. Furthermore, based on their responses, the characteristic *private spaces* was included in the framework (see also Dovey & Fisher, 2014; Nuikkinen, 2009; Tanner, 2008).

Individualisation. The absence of characteristics *personal relevance of studies* and *personally relevant assessment* in the substudy 3 may be explained by the specific focus of LE design not drawing attention on these issues. A high variety of substudies 1 and 2's responses in relation to *individual work* suggested that some individuals may prefer individual work to group work. Furthermore, a characteristic *studying during the breaks* was included in the framework based the substudy 3 and supported by, for example, Jamieson and his colleagues (2000), who pointed out the importance of availability of spaces for informal learning outside the scheduled classes.

Likewise, the Finnish curriculum (Finnish National Board of Education, 2016) draws attention to the importance of privacy and a calm, peaceful atmosphere, good acoustic conditions, order, and tidiness. Further, differentiation of instruction (e.g., rhythm and ways of learning) based on individual differences is viewed as critical. The national curriculum stresses supporting students' skills for learning to learn and self-regulation, and possibilities for independent study. Assessment aims at guiding and encouraging learning and self-assessment so as to understand one's personal learning processes.

5.2.3 Comfort

Comfort was divided into two subthemes comprising a total of seven LE characteristics (Table 13). Comfort-related LE characteristics were viewed as highly important by learners participating in this study. Most of these characteristics were confirmed by all substudies.

TABLE 13. Comfort-related LE characteristics

LED framework contents	Study	Confirmed by the literature (examples)
Physical ease		Barrett et al., 2013; Cleveland & Fisher,
Spaciousness	1, 2, 3	2014; Dewey, 1907; Ghaziani, 2010, 2012;
Enough seats, tables and table space	3	Flutter, 2006; Kangas, 2010a; Kostenius, 2011; Nuikkinen, 2009; Papatheodorou,
Comfortable furniture and spaces	2, 3	2002; Tanner, 2008
Pleasantness		Bagot, 2004; Barrett et al., 2013; Ghaziani,
Aesthetics	1, 2, 3	2010, 2012; Flutter, 2006; Kangas, 2010a;
Colours	1, 2, 3	Kostenius, 2011; Konu & Rimpelä, 2002;
Luminosity	1, 2, 3	Marchand et al., 2014; Papatheodorou,
Presence of nature	1, 2, 3	2002; Nuikkinen, 2009; Tanner, 2008

Physical ease. Students of different age seemed to value *spaciousness* but for different reasons: younger learners wished for more space to play while older learners felt uncomfortable in overly cramped spaces. A characteristic *comfortable furniture and spaces* was added into the framework based on substudies 2 and 3 (see also Kangas, 2010a; Tanner, 2008) and a characteristic *enough seats, tables, seating and table space* was added based on substudy 3 (see also Nuikkinen, 2009). These findings suggested that adolescents may have a stronger need for physical ease than younger learners. Substudy 3 indicated that sometimes considering one comfort-need (enough tables and seats) may lead to weakening of satisfaction of other needs (less spaciousness).

Pleasantness. In substudies 1 and 2, learners did not generally give high ratings to *aesthetics* in comparison to other LE characteristics, but other data types confirmed its importance for students. Based on attention participants gave to colours and its support by other research evidence (Barrett et al., 2013; Ghaziani, 2010; Piispanen, 2008b), *colours* were considered as a separate LE characteristic in the final framework.

While physical ease is not so directly discussed in the Finnish curriculum, aesthetics is mentioned as an important value (Finnish National Board of Education, 2016). Curriculum states that attractive environment contributes to a harmonious and pleasant working atmosphere. Also, aspects such as good lighting and presence of nature are included as LE requisites.

5.2.4 Health

Health-dimension included two sub-themes and eight LE characteristics confirmed by this study's empirical findings and by earlier research literature (Table 14).

TABLE 14. Health-related LE characteristics

LED framework contents	Study	Confirmed by the literature (examples)
Physical wellness		Bagot, 2004; Barret et al., 2013; Bronfenbrenner, 1979; Cleveland & Fisher, 2014; Crespo & Pino, 2007; Dewey, 1907; Duarte, 2015; Gee, 2006; Ghaziani, 2010, 2012; Jamieson et al., 2000; Kangas, 2010; Kostenius, 2011; Marchand et al., 2014; Nuikkinen, 2009; Papatheodorou, 2002; Piispanen, 2008b; Zandvliet & Fraser, 2005; Wolff, 2002
Quality of meals	2	
Indoor air quality	2, 3	
Indoor air temperature	3	
Ergonomics	3	
Good outdoor areas	1, 2	
Physical exercise	1, 2	
No overload		Bagot, 2004; Bronfenbrenner, 1979; Dewey, 1916; Ghaziani, 2010, 2012; Konu & Rimpelä, 2002; Nuikkinen, 2009; Piispanen, 2008b; Tanner, 2008
Rest	1, 2, 3	
Leisure time	1, 2, 3	

Physical wellness. Characteristics *quality of meals*, *good outdoor areas*, and *physical exercise* were not replicated in substudy 3, possibly because they were out of the scope of the specific redesign project. While students between 7 and 14 years seemed not to give a lot of importance to *indoor air quality*, it appeared as a more important aspect for older students (substudy 3), who also mentioned optimal *indoor air temperature* (see also Crespo & Pino, 2007; Marchand et al., 2014). Likewise, the *ergonomics* emerged in older students' wishes and it was also supported by the literature (e.g., Zandvliet & Fraser, 2005). It seems that younger learners may not be so conscious about the indoor air quality and temperature, and the importance of good ergonomics. It is also possible that ergonomics was considered a particularly relevant aspect in substudy 3 due to the particular requirements for science laboratories (see Duarte, 2015; Sjöblom et al., 2016).

No overload. *Rest* and *leisure* time were more clearly distinguished in the later versions of the framework (substudies 1 and 2). The distinction of leisure time activities (Konu & Rimpelä, 2002) and having spaces to relax or rest (Nuikkinen, 2009) is also supported by the literature.

In line with health-related considerations of this study, the Finnish curriculum (Finnish National Board of Education, 2016) links learning, health, and wellbeing. It stresses the importance of cost-free and nutritive school meals to support learners' overall wellbeing, healthy growth, ability to study, and knowledge of food. The curriculum states that activities during recess should support learning objectives, ability to cope with studies, versatile development, wellbeing, and social relationships. A transversal competence named as "taking care of oneself and managing daily life" entails issues such as the importance of sleep, rest, and a balanced daily rhythm.

5.2.5 Novelty

The five novelty-related LE characteristics are divided into novel tools and novel spaces (Table 15).

TABLE 15. Novelty-related LE characteristics

LED framework contents	Study	Confirmed by the literature (examples)
Novel tools		Fisher & Newton, 2014; Jamieson et al., 2000;
Use of technology	1, 2, 3	Kuuskorpi &Cabellos, 2011; Nuikkinen, 2009;
Educational design elements	3	Zandvliet & Fraser, 2005
Novel spaces		Bronfenbrenner, 1979; Barrett et al., 2013;
Informal LE	1, 2	Dewey, 1916; Fisher & Newton, 2014; Gee,
Novel LE design	1, 2, 3	2006; Gislason, 2010; Kangas, 2010a; Kuus-
Inspiring and motivating spaces	3	korpi & Cabellos, 2011; Tanner, 2008

Novel tools. The substudy 1 indicated that younger boys may value the *use of technology* (e.g., for playing) more than younger girls. This is in line with the study indicating that particularly primary school boys view ICT as important for game-playing and free activity (Selwyn et al. 2009). In the present study, no significant gender differences were found with older students. Further, the characteristic *educational design elements* was added to the framework based on student data in substudy 3 (see also Jamieson et al., 2000; Nuikkinen, 2009; Wolff, 2002).

Novel spaces. Characteristic of *informal LEs* was not replicated in substudy 3, possibly as its focus was on the formal LE design. On the other hand, the characteristic *inspiring and motivating spaces* was added to the framework and is supported by LE studies highlighting the importance of satisfaction, joy, and happiness for student learning and wellbeing (Awartani et al., 2008; Flutter, 2006; Kangas, 2010a). Bronfenbrenner (1979) was concerned about the lack of positive stimulus in institutional environments, and Tanner (2008, p.453) advocated creating "an atmosphere of excitement for learning".

The use of ICT is seen as a key part of versatile environments in the Finnish curriculum (Finnish National Board of Education, 2016) with the emphasis for transversal competences "multi-literacy" and "ICT competence". Creating connections between formal and informal learning, and creating motivational and inspirational LEs are encouraged in the national curriculum.

5.2.6 Conventionality

Conventionality-dimension contained two sub-themes and five characteristics (see Table 16).

Conventional tools. The relevance of *use of books and other traditional materials* for leaners was confirmed in all substudies.

Conventional spaces. While *sustainable design* was only confirmed in the substudy 2, its relevance has been noted by other Finnish studies (Kuuskorpi,

2012; Nuikkinen, 2009; Piispanen, 2008). Characteristics *formal and non-formal LE* were not replicated in a substudy 3, possibly as its focus was on formal LEs.

TABLE 16. Conventionality-related LE characteristics

LED framework contents	Study	Confirmed by the literature (examples)
Conventional tools		Barrett et al., 2013; Kangas, 2010a; Kuuskorpi &Cabellos, 2011; Kuuskorpi, 2012; Sulonen & Sulonen, 2014; Piispanen, 2008b
Use of books and other traditional materials	1, 2, 3	
Conventional spaces		Barrett et al., 2013; Gislason, 2010; Kangas, 2010a; Kangas, 2010b; Kuuskorpi &Cabellos, 2011; Kuuskorpi, 2012; Nuikkinen, 2009; Piispanen, 2008b; Sulonen & Sulonen, 2014; Wolff, 2002
Sustainable design	2	
Non-formal LE	1, 2	
Formal LE	1, 2	
Conventional LE design	1, 2, 3	

Value given to conventionality-related LE characteristics is in line with the Finnish curriculum (Finnish National Board of Education, 2016). For instance, exposure to multi-literacy is expected also in traditional ways. Importance is given to building sustainable ecologic LEs, as well as collaborating with libraries, sports, art, and environmental centres, museums, and many other partners offering non-formal education.

5.2.7 Flexibility and functionality

The conceptual decision to place "Flexibility and functionality" as a central construct of framework, with its four LE characteristics, is supported by the literature (see Table 17).

TABLE 17. LE characteristics related to flexibility and functionality

LED framework contents	Study	Confirmed by the literature (examples)
VII Flexibility and functionality		Barret et al., 2013; Bronfenbrenner, 1979; Cleveland & Fisher, 2014; Dewey, 1907, 1916; Gee, 2006; Kangas, 2010a; Kuuskorpi & Cabellos, 2011; Kuuskorpi, 2012 Nuikkinen, 2009; Piispanen, 2008b; Sulonen & Sulonen, 2014; Tanner, 2008; Vygotsky, 1978
Versatile use of tools and materials	1, 2, 3	
Versatile methods	3	
Adaptability	3	
Functionality and practicality	3	

The importance of *versatile tools and materials* were confirmed in all substudies. In substudy 3, *versatile methods* was added to the framework. While in substudies 1 and 2, participants did not directly refer to *adaptability* or *functionality and practicality*, they were valued by the older students (substudy 3). These differences may be explained by the age difference (concepts were too abstract for younger students) but also by the specific requirements for science learning (see Duarte et al., 2015; Sjöblom et al., 2016), which was the context of the redesign.

The Finnish curriculum (Finnish National Board of Education, 2016) underlines the importance of flexible learning arrangements and varying ways of working including, for instance, project-based learning, integrative instruction and multidisciplinary learning modules, use of different senses, experiential work, use of movement, drama, and other forms of creativity, and playful and game-based learning.

5.3 Substantive design principles

The substantive design principles formulated in this study for the LE co-design were constructed based on learners' views and, therefore, echo their voice. Their transferability to different educational contexts is supported by empirical findings of other studies presented below together with the formulated principles. However, it is important to adapt the design principles for "the specific needs of the schools, such as its organisational, social environment, space uses, and learning aims" (Veloso & Marques, 2017, p.246) in participatory design processes involving the school community.

(I) Communality and social relations may be fostered by applying the following design principles: **(I.1)** Design LEs that foster especially good *teacher-student relations* (substudies 1 and 2; Linnankylä & Malin, 2008), but also other s*taff-student relations* (substudy 2; Nuikkinen, 2009). **(I.2)** Good *peer relations* are particularly important for students and may be supported by areas for socialising and spending time with peers (substudies 1-3; den Besten et al., 2008). Social activity may be also encouraged by "open space and the school's compact interior" (Gislason, 2010, p.141). **(I.3)** In addition to promoting good *home-school relations* (Awartani et al., 2008), which may be specifically important for younger learners (substudies 1 and 2), it is good to search for ways to open the school to the *wider community* (substudy 2).

In teaching-learning interaction, it appears beneficial to **(I.4)** combine *teacher-led activities* with learner-centred *collaborative work* (substudies 1-3; Elen et al., 2007) in spaces and with furniture, which allow both *teacher visibility* and group work, e.g., tables allowing multiple configurations (substudy 3). Removing tiered classroom floors may create less favorable conditions for teacher-led instruction while collaborative work may be increased by group working tables, small and large group areas (substudy 3; Gislason, 2010; Tanner, 2008). Dovey and Fisher (2014, p.46) argued that more passive presentation activities and didactic teaching may form part of constructivist instruction but should be "reduced to a small portion of total time". Teacher-led activities may be needed when dealing with topics new for learners and when gradually guiding learners towards more self-regulated forms of learning (see Vygotsky, 1978). Based on studies by Sandström and his colleagues (2014), and Sjöblom and her colleagues (2016), students may perceive both social and physical (instructions, tags, signs, labels, information boards) scaffolding as useful. Teacher scaffolding and peer

collaboration may also be supported by novel technological tools (see Leinonen et al., 2016).

Sense of belonging may be fostered by **(I.5)** creating a *shared vision about schooling*, also considering the possible age- and gender-specific differences in attitudes and expectations towards school (substudies 1 and 2; Dovey & Fisher, 2014). **(I.6)** Providing possibilities for *self-expression and involvement* by means of LE co-design (substudies 1-3; Simmons et al., 2015) and creating *homelike environments* and cosy areas (substudy 3; Ghaziani, 2010) may also enhance learners' sense of belonging and overall wellbeing. Presenting school symbols and student works on the walls may foster shared vision, a sense of ownership of learning space and equipment, as well as cosiness (Nuikkinen, 2009).

In relation to safety, **(I.7)** increasing sense of belonging and school-liking may reduce *behavioural disturbance* (substudy 1-3; Nuikkinen, 2009) such as bullying (substudy 1), troublemaking or vandalism (substudy 3). As argued in other studies (Clay, 2008; Linnankylä & Malin, 2008), democratising classrooms, allowing for greater choice, and including the use of ICT may increase particularly male adolescent students' engagement levels and positive attitudes towards schooling and school rules. **(I.8)** *Transparency* and openness (Barrett et al., 2013) can be supported by transparent surfaces, e.g., glass walls or doors (substudy 3), possibly also augmenting feelings of safety (Nuikkinen, 2009), which may be particularly important for female students (substudy 1). **(I.9)** *Physical safety* (substudy 1-3) may be promoted by increasing security (substudies 1 and 2; Awartani et al., 2008) and by designing safety working areas for experiments (substudy 3). Social and physical scaffolding may also increase students' feelings of safety (Sandström et al., 2014). Safety can also be increased by assuring that it is easy to find one's way around at school (Ghaziani, 2012).

(II) Individuality, privacy, and peacefulness can be supported as follows: **(II.1)** *Noise disturbance* (substudies 2 and 3; Crespo & Pino, 2007) may be reduced by good soundproofing, acoustic panels, and textiles (substudy 3). **(II.2)** *Disorganisation* (substudies 2 and 3; Piispanen, 2008b) may be avoided by providing good storage spaces (substudy 3; Higgins et al., 2005). **(II.3)** Both pleasant and unpleasant *distractions* (substudy 2; Gislason, 2010; Flutter, 2006) may be reduced, e.g., by restricting the use of the internet (substudy 2) or providing dimming curtains (substudy 3). **(II.4)** The need for privacy may be supported by designing *private spaces* (substudy 3; Tanner, 2008).

Individualisation and **(II.5)** *personalisation* of learning (substudies 2 and 3) may be supported by creating opportunities to make choices related to one's own learning (substudy 1; Simmons et al., 2015) and creating various smaller-scale learning stations, enabling the selection of the working space based on personal preferences (substudy 3). **(II.6)** *Personal relevance of studies* (substudy 1 & 2) and *assessment* (substudy 2) can be promoted by increasing connectedness with students' real-life aspirations. This may be particularly important for older learners (substudy 1; Linnankylä & Malin, 2008). **(II.7)** *Individual work* (Piispanen, 2008b) requires desktops allowing individual configurations (substudy 3). It is also important to consider personal preferences for individual

work (substudies 1-3). **(II.8)** *Self-regulated learning* (substudies 1-3; Wang & Holcombe, 2010) may be fostered by providing spaces to *study autonomously during the breaks* or otherwise (substudy 3; Jamieson et al., 2000).

Providing areas for reading, reflection, and quiet time may also support individuality-aspects (Dovey & Fisher, 2014; Tanner, 2008). Further, "physically mediated guidance and the use of modern technological devices" may support students' sense of autonomy (Sjöblom et al., 2016, p.32).

(III) Comfort and physical ease can be supported by **(III.1)** designing *spacious* areas (substudies 1-3; Tanner, 2008) for children to play and for youngsters not to feel cramped and **(III.2)** providing *enough seats, seating and table space* (substudy 3; Nuikkinen, 2009), and *comfortable furniture and spaces*, e.g., sofa groups and cushions (substudies 2 and 3; Kangas, 2010a). Physical comfort may also be fostered by providing and grouping furniture based on the number of people, group size, and teaching situations and methods (Nuikkinen, 2009).

Pleasantness may be increased by **(III.3)** paying attention to *aesthetic* interior design and *colours* (substudies 1-3; Barret et al., 2013), e.g., by balancing colours that are stimulating, fresh, or not depressing, with calming, not disturbing colours or by colour-changing lamps so as to vary colours (substudy 3); **(III.4)** providing *luminous* spaces (substudies 1-3; Kangas, 2010a), e.g., by wide windows, glass surfaces, and good lighting design (substudy 3); and **(III.5)** assuring that LEs include *elements of nature* (substudies 1-3; Ghaziani, 2012), e.g., gardens, park areas (substudies 1 and 2) and interior plants (substudy 3).

(IV) Health and physical wellness may be nurtured by the **(IV.1)** healthy and tasty *school meal* (substudy 2; Piispanen, 2008b). Literature (Ghaziani, 2012; Wolff, 2002) supports the importance of paying attention to the type and quality of school canteen and catering, having sufficient time for eating, and access to water. Wolff (2002, p.55) argued that access to food and beverages may support project-based learning by enabling "different learning time frames and informal learning activities by providing something to eat and drink when it is convenient for the learner". It is also important to pay attention to **(IV.2)** optimal *indoor air quality* (substudies 2 and 3; Kostenius, 2011) and *temperature*; older students especially may be sensitive to indoor air quality (substudy 3). **(IV.3)** Good o*utdoor environments* (substudy 2; Jamieson et al., 2000) and opportunities for *physical exercise* (substudies 1 and 2; Papartheodorou, 2002) may support physical wellness as well as **(IV.4)** *ergonomic* furniture, e.g., adjustable desks and chairs (substudy 3; Zandvliet & Fraser, 2005). It is also important to pay attention to special ergonomic requirements in spaces such as science labs (substudy 3; Duarte, 2015; Sjöblom et al., 2016).

Overload may be avoided by **(IV.5)** providing time and spaces for *rest* (substudies 1-3; Nuikkinen, 2009), e.g., comfortable and soft furniture (substudy 3), and for more active recreation and *leisure* (substudies 1-3; Kostenius, 2011). Tanner (2008, p.453) recommended quiet inside areas, i.e. "solitary places where students may go to pause and refresh themselves in a quiet, supervised setting". Wolff (2002) proposed lounge areas and outdoor seating as a way to get away from formal learning activities.

(V) Novelty-related **(**novel tools and spaces) design principles comprise the following: **(V.1)** It seems recommendable to employ *technological tools* (substudies 1-3; Kuuskorpi, 2012) together with support for teachers for their use (substudy 3; Fisher & Newton, 2014); particularly young boys may wish to use ICT to play (substudy 1; Selwyn et al., 2009). Tanner (2008) recommended that technological equipment be placed so that its use is easy to integrate with curriculum, teaching, and learning. The layout of hardware and technical support materials should also be designed so that they do not limit the flexible use of spaces (Veloso & Marques, 2017). **(V.2)** *Educative design elements*, e.g., planetarium ceiling, solar system model, or color-changing lamps for teaching color theory (substudy 3) may be used so as to consider the whole school building as a tool for learning (see also Nuikkinen, 2009). Spaces with visible infrastructure provide a possibility to use the building structure as a learning tool (Wolff, 2002) and walls may be used as display areas for subject material or products of research activity (Jamieson et al., 2000). **(V.3)** It is good to take advantage of *informal*, outside school *LEs* (substudies 1 & 2; Kuuskorpi, 2012). Novel mobile technology may also be used to augment physical spaces and expand activities outside the classroom (Leinonen et al., 2016). Furthermore, **(V.4)** it seems beneficial to design spaces with novel, *inspiring and motivating* interior design (substudy 3; Barret et al., 2013).

(VI) Conventionality (conventional tools and spaces) can be respected in many ways; for example, by **(VI.1)** not abandoning *books and other traditional materials* (substudies 1-3; Kangas, 2010a). Zandliet and Straker (2005) recommended balancing computer access with adequate space for books and other non-digital learning materials. It is important to **(VI.2)** consider *sustainability* in the design (substudy 2; Piispanen, 2008b). As recommended by Nuikkinen (2009), the school building can serve as a physical model of ecologically, economically, socially, and culturally sustainable design. Attention should also be paid to **(VI.3)** creating connections between *non-formal LEs*, e.g., libraries, museums, science centres, and *formal LEs*, e.g., classrooms (substudies 1 and 2; Kangas, 2010a). Spaces that retain reversibility or convertibility to the traditional classroom may satisfy both student-centred and traditional learning (Dovey & Fisher, 2014).

Based on student perceptions gathered in this study, it seems to be better to give changes time and not design overly radical changes. This is also in harmony with the Finnish educational change, which merges renewal with traditions without completely abandoning them (Hargreaves, 2002; Hargreaves & Shirley, 2009; Sahlberg, 2011).

(VII) Flexibility and functionality can be assured by **(VII.1)** offering *versatile tools and materials and teaching methods* (substudies 1-3), supported e.g., by varying learning stations both inside and outside classroom (substudy 3), and **(VII.2)** providing *adaptable*, flexible, *functional and practical* tools, spaces, and ways of working that can be easily modified, e.g., furniture allowing multiple configurations (substudy 3) and adapting the LE design in accordance with age-, subject- and other context-specific requirements (substudies 1-3).

Dovey and Fisher (2014) point out that student-centred activities such as presentations; large, medium or small interactive activities; creative work (e.g., art, laboratory); and reflection (reading, writing, research) require a wide range of different spaces: classrooms, commons, meeting areas, fixed areas, spaces for outdoor learning, and so on. There is also need for fluidity or adaptability, i.e., the space capacity or agility for flow and change between activities. As Veloso and Marquez (2017) observed, flexible and adaptable spaces do not, however, necessarily lead to the expected uses of these spaces. For instance, so-called flexible tables may maintain a teacher-centred approach by being face-the-front. Indeed, users may need training and support to use spaces flexibly or to apply specific pedagogical approaches in the designed spaces.

5.4 Evaluation, limitations, and future directions

The study is evaluated in light of procedural design principles guiding research design (see section 3.1.1). Further, limitations and possible future directions are discussed.

Theory development. The study advanced the understanding of key characteristics of psychosocial and physical LEs, and their complex synergetic influence on learning and wellbeing by creating a theoretically and empirically grounded framework merging various disciplines. As recommended in educational design research (Wang & Hannafin, 2005; Oh & Reeves, 2010), the theoretical starting points were presented and justified with respect to relevant literature. The framework's *content* and *construct validity* (van den Akker, 1999) were tested and improved in empirical studies in different educational contexts and by comparing findings with those from other studies.

It is acknowledged, however, that there are multiple ways to structure the LE characteristics, and caution is necessary to avoid over-rigid categorisations. The framework is limited in its capacity to consider individually each LE characteristic or various theoretical considerations. It was also challenging to investigate a range of interrelated elements at the same time (see van den Akker, 1999) and to deal with a high number of relevant variables (contextual, individual and group factors) (Hoadley, 2004). Flexibility and flexible design revisions were required (Collins et al., 2004) to adjust research design to the complex real-world situations (Barab & Squire, 2004; Brown, 1992). As recommended by Plomp (2007), the coherence in theory development was maintained by being explicit with changes in the framework contents and structure.

Merging various theoretical considerations and disciplines (e.g., education and architecture) and synthesising a wide range of LE characteristics helped in the construction of a richer and more complete view of the phenomenon (Wang & Hannafin, 2005) and a greater understanding of the complex learning ecology (Cobb et al., 2003). Furthermore, combining insights from the learning and physical environments contributed to diminishing the gap between the studies focusing merely on psychosocial or physical LEs (Cleveland

& Fisher, 2014; Gislason, 2010). In the future research cycles, more attention could be paid to issues related to virtual LE and the varied ways of using technology to support learning and wellbeing. For instance, the discourse on ubiquitous computing and learning environments, particularly those employing mobile devices (e.g., Hwang, Yang, Tsai, & Yang, 2009), could be used to further develop the virtual LED framework dimension.

Pragmatism and practicality. The *pragmatic value* of this study was assured by intertwining the LE design and the theory development (see Juuti & Lavonen, 2006). *Practical significance* (McKenney & Reeves, 2013; Wang & Hannafin, 2005) of the framework was demonstrated by employing it in the actual LE redesign project (substudy 3), which also demonstrated the actual impact of the co-design with the students on the redesinged LEs. *Practicality and cost-efficiency* (van den Akker, 2007) was considered by embedding the research in participants' everyday life and adjusting it to available resources. The framework has already been employed in an LE co-design project at another Finnish upper secondary school where its use was reported to be practically relevant and appealing, thus supporting its *external validity* (see Barab & Squire, 2004) and usefulness.

Contextualisation and generalisation. The LED framework balances both fixed and emerging elements, thus allowing both contextualisation and generalisation across contexts. It was tested and further developed by involving learners representing different ages, genders, and cultures in the LE design. While the overall focus was on learners' shared perceptions and generalisability across contexts, some examples of possible age- and gender-differences were provided (see Wang & Hannafin, 2005). In the future, more attention could be paid to cultural differences (see Aldridge & Fraser, 2000; Liu et al., 2012). For instance, based on the literature reviewed in this study, considerations related to wellbeing and sustainability seem to appear more frequently in Finnish (Nordic) research than in Anglo-Saxon literature. In addition to cultural differences in LE preferences, some differences may also lie in how actual LEs are locally in congruence with widely shared preferences (Fraser, 1998). For example, although Spanish and Finnish learners valued nature and noise-free environments equally strongly, Finnish LEs may generally better respond to these preferences.

The study employed *analytical generalisations* (van den Akker, 1999; Plomp, 2007) by comparing findings with other empirical studies representing different educational settings. Details of these studies were also explicitly presented in the text, thus supporting the readers to reflect on the potential transfer of the findings in their own contexts. Further, *transferability* of the findings was increased by discussing them with experts from different contexts (see Mäkelä, Kankaanranta & Gallagher, 2014). In the future, the *replicability* of findings could be tested in contexts with less favourable conditions. The LED framework could be employed on a large scale (see Anderson & Shattuck, 2012) to test it statistically (Edelson, 2002; Zheng, 2015). Also, challenges of *scalability*, *sustainability*, and *diffusion* both within one context and between contexts remain.

Iterative development. Design principles are seen as particularly powerful if they have been *validated* and *replicated* in successful design cycles in various contexts (van den Akker, 1999; Plomp, 2007). In this study, each iteration led to progressive improvement of the design framework and principles. There was relatively little time, however, between design cycles to analyse the data and interpret them. During the LE redesign project, it was necessary to focus first on identifying overall trends, which were summarised and quickly communicated to designers. Some refinements to the framework were made only in the *retrospective analysis*. In the actual LE redesing, some changes were also left out due to high costs (e.g., private spaces) or were deemed as unpractical (e.g., more interior plants), but were considered in the future design cycles. Furthermore, providing conditions, spaces, and tools for change does not necessarily lead to change in practice (Schrittesser et al., 2014; Veloso et al., 2014). It is important, therefore, to support school community in the appropriation phase so as to reach actual and long-term impacts (Björgvinsson et al., 2012).

Mixed-methods approach and multiple data gathering tools. Measures for gathering multiple data types were developed and employed to augment the *trustworthiness* of findings and to provide a rich understanding of the learner perspectives (see Frost & Holden, 2008; Simmons et al., 2015; Woolner et al., 2012). Combining use of more interactive co-design with smaller number of participants and surveys involving higher number of participants seemed to augment both *representativeness* and *cost-efficiency* of the study. Open-ended questions helped identify issues that had been left out from the structured ratings but were relevant for students (e.g., no distractions, enough table space). Group discussions (substudies 1 and 2) and "member checking" (substudy 3) were used to assure that learners' perceptions were understood and interpreted as reliably as possible. Mixed-methods approach also supported identifying aspects that may have been left unnoticed based on the quantitative data (e.g., relevance of aesthetics, participation, and involvement). Due to a large amount of data collected during the process, there was not, however, always enough time or resources to analyse it (see Collins et al., 2004), thus making efficient use of the extensive and comprehensive data challenging (Wang & Hannafin, 2005).

Stakeholder involvement and participatory design. While the focus was on learner perceptions and involvement, teachers, teacher students, principals, interior designers, architects, researchers, and other experts were also involved in the LE design. Learners played an important role particularly in envisioning spaces that foster physical and psychosocial wellbeing. In the future, more emphasis could be given to teachers' views, possibly further enriching the framework with respect to pedagogical and practical perspectives (see Veloso & Marques, 2017). Parents could be involved in the LE design so as to better understand their views. As concluded by Piispanen (2008a), learners may emphasise the physical, parents the social and psychological, and teachers the pedagogical LE dimensions. It is also important to consider views of architects, ergonomists, experts in technology (Fisher & Newton, 2014; Cleveland & Fisher, 2014), and educational administrators or planners (Veloso & Marques, 2017),

even when it is challenging to manage participatory co-design involving various stakeholders representing different disciplines and perspectives, and to assure that various perspectives are considered in a balanced manner.

In substudy 3, students' mature and insightful contributions were seen to improve first the design quality, by leading to a more adequate and desirable LE for students. Student participation deepened the understanding of the interrelatedness of characteristics of psychosocial and physical LEs (e.g., good peer relations supported by areas for socialising, teacher-led instruction supported by good teacher visibility). It also helped to avoid designing overly radical changes. Second, providing plenty of opportunities for students to participate in the change process fostered a participatory culture. Third, the co-design project offered authentic learning experiences and led to increased understanding of the LEs fostering learning and wellbeing, which were applied in the actual LE redesign.

It was challenging, however, to tease apart the direct impact of student involvement as they commonly (e.g., increasing collaborative learning opportunities) complied with the staff's intentions (see Newman & Thomas, 2008; Simmons et al., 2015). In the future, more effort could also be exerted to communicate how participants' views had been taken into account and why some of their ideas were not implemented (Mäkelä et al., 2014). Justifying design choices with clear criteria is likely to decrease experiences of disappointment (Simmons et al., 2015). Further, while unengaged students were not purposefully omitted, the challenge of how to get them involved and have their voices heard remains (Lodge, 2005; Newman & Thomas, 2008).

5.5 Ethical aspects

The study was planned, conducted, and reported according to the ethical guidelines of the Finnish Advisory Board on Research Integrity (2016) and instructions provided by the University of Jyväskylä Ethical Committee complying with national guidelines. The research was carried out and results were reported in compliance with scientific community practice. General diligence, accuracy, meticulousness, integrity, and ethical guidelines were followed throughout the study. Scientific openness and transparency were set as strong goals.

Data were collected following responsible conduct of research. Teachers and students participated in the study voluntarily, and participants had the right to withdraw at any point without further obligation. With respect to participants under 18 years old, parental consent was asked prior to the study. Data gathering was conducted at schools during school hours. Participants were informed about the study's aim, the data collection methods, and methods of reporting. The participants' privacy was also considered. Only information on participant´s gender, age, nationality, and school was asked without linking any other personal data to their responses. The results of the study were reported in a way that individuals could not be identified. Data were stored securely

at the Agora Centre of the University of Jyväskylä and later moved to the secure storage of the Faculty of Education and Psychology.

Various researchers participated in the data analysis (researcher triangulation). Researchers presented data to other colleagues and understanding was deepened through discussions. Results were also presented to participants who had changes to evaluate their truthfulness (a member check). The theoretical and methodological background was made transparent to readers in order to unveil the origins of the results and interpretations. Research and its preliminary results were presented at several national and international meetings and conferences. Original articles went through a double-blind peer review process resulting to important feedback and improvements. Finally, other researchers' work and achievements have been referred in an appropriate way according to good scientific practice, the funding sources, and other associations relevant to the study have been reported.

5.6 Conclusion

This educational design research responded to the need for the development of a theoretically, empirically, and practically sound design framework and principles for co-designing learning environments that foster learning and wellbeing. The study merged perspectives from various disciplines and involved learners representing different age groups, genders, and cultural contexts. The LED framework and design principles developed in this study draw attention to flexibility and functionality as well as the balancing of communality and individuality, comfort and health, and novelty and conventionality in the LE design. The results suggest that involving learners in the LE co-design can improve the design quality, participatory culture, and student learning and wellbeing. In addition to learners, it is important to involve various stakeholders, both internal and external, in the LE design to take into account various points of view in a balanced manner. The LED framework can be used for planning, gathering information, classifying data, structuring the evaluation of individual co-design initiatives, and comparing and generalising findings between them. At best, the participatory LE design would comprise an iterative process, thus providing continuous possibilities for the whole school community to participate in the LE design-for-use, design-in-use, and redesign-in-use processes.

YHTEENVETO (SUMMARY IN FINNISH)

Suunnitteluviitekehys ja periaatteita oppimista ja hyvinvointia edistävien oppimisympäristöjen yhteissuunnitteluun

Lisääntynyt ymmärrys psykososiaalisten (psykologisten ja sosiaalisten) ja fyysisten oppimisympäristöjen vaikutuksista oppimiselle ja hyvinvoinnille korostaa niiden huolellisen suunnittelun tärkeyttä. Aikaisemmassa tutkimuksessa on tunnistettu monimutkaisia yhteisvaikutuksia psykososiaalisten ja fyysisten ympäristöjen (Zandvliet & Fraser, 2005), kouluympäristön, oppimisen ja hyvinvoinnin (Awartani, Whiteman, & Gordon, 2008), ja rakennetun ympäristön ja oppimisen (Barret, Zhan, Moffat, & Kobbacy, 2013) välillä. Fyysisellä ympäristöllä on myös havaittu olevan yhteys joko opettajakeskeiseen tai oppijakeskeiseen pedagogiaan (Horne Martin, 2002). Esimerkiksi pulpettirivit suunnattuna opettajanpöytään saattavat viestiä opettajajohtoisuudesta (Dovey & Fisher, 2014).

Oppijakeskeisen paradigman mukaisesti oppijat nähdään yhä enemmän oman oppimisensa ja oppimisympäristönsä yhteissuunnittelijoina (Brown, 1992; Scardamalia, Bransford, Kozma, & Quellmalz, 2012). Osallistuminen omaan elämään vaikuttaviin valintoihin on Yhdistyneiden Kansakuntien (1989) lapsille määrittelemä perusoikeus. Oppimista ja hyvinvointia edistävien oppimisympäristöjen yhteissuunnittelu on myös harmoniassa suomalaisen kansallisen opetussuunnitelman kanssa. Oppijoiden osallistamisen oppimisympäristöjen suunnitteluun odotetaan parantavan niiden laatua tekemällä niistä oppijoille sopivampia ja haluttavimpia (Flutter, 2006). Samalla edistetään demokraattista toimintakulttuuria (Parnell, Cave, & Torrington, 2008). Yhteissuunnittelun odotetaan myös parantavan oppimisprosesseja ja edistävän oppijoiden hyvinvointia (Simmons, Graham, & Thomas, 2015). Ihanteet oppimisympäristöistä ja niiden yhteissuunnittelusta eivät kuitenkaan aina toteudu käytännössä. Oppimisympäristöjen yhteissuunnittelua vaikeuttaa myös se, että tarjolla ei ole monitieteellisiä (mm. kasvatustiede, arkkitehtuuri, terveystiede, psykologia, ympäristöpsykologia, sosiologia) viitekehyksiä, jotka ohjaisivat oppimista ja hyvinvointia edistävien oppimisympäristöjen suunnittelussa.

Tämän tutkimuksen tavoitteena oli vastata tähän haasteeseen kehittämällä suunnitteluviitekehys ja periaatteita psykososiaalisten ja fyysisten oppimisympäristöjen yhteiskehittämiseen. Viitekehys ja periaatteet huomioivat sekä oppimista että hyvinvointia edistäviä oppimisympäristöjen ominaisuuksia. Ne perustuvat teoreettisiin, empiirisiin ja käytännöllisiin huomioihin. Keskiössä ovat erityisesti oppijoiden näkemykset. Tutkimusta ohjasi etenkin Deweyn (1907; 1916) oppijakeskeinen ajattelu sekä sosiaalikulttuuriset ja sosiaalikonstruktivistiset (Vygostky, 1978) ja ekologiset (Bronfenbrenner, 1979) näkemykset oppimisesta. Hyvinvointikäsitettä määriteltiin muun muassa Allardtin teoreettisten käsitteiden pohjalta muokattujen mallien (Konu & Rimpelä, 2002; Nuikkinen, 2009) avulla. Dynaamista vuorovaikutusta yksilöiden ja oppimisympäristöjen välillä hahmotettiin niin ikään Deweyn ja Vygoskyn jalanjäljissä. Ympäristöjen nähtiin joko tukevan, sallivan tai estävän toimintaa. Toisaalta yksilöiden nähtiin voivan

vaikuttaa ympäristöihinsä aktiivisesti, usein yhdessä muiden kanssa. Huomio oli oppimisympäristöissä, jotka tukevat monimutkaisissa ja monisuuntaisissa vaikutussuhteissa keskenään olevia kognitiivisia, emotionaalisia, sosiaalisia ja fyysisiä oppimisen ja hyvinvoinnin ulottuvuuksia. Virtuaaliset oppimisympäristöt huomioitiin tutkimuksessa sisällyttämällä viitekehykseen teknologian käyttö oppimisessa. Ennen empiiristä osuutta, tutkimuksessa kehitettiin alustava viitekehys kirjallisuuskatsauksen avulla. Alustava viitekehys jakoi oppimisympäristön ominaisuudet kolmeen dimensioon: I) yleinen hyvinvointi (mm. turvallisuus, kaverisuhteet), II) oppimistilanne (mm. monipuolisuus, yhteistyö), ja III) oppimisen välineet ja tilat (mm. perinteiset vs. uudet, innovatiiviset materiaalit, välineet ja tilat). Alustava viitekehys sisälsi yhteensä 36 oppimisympäristön ominaisuutta.

Metodologisia valintoja tuki etenkin kasvatustieteellinen design-tutkimus (educational design research, ks., van den Akker, 2007; Brown, 1992; Collins, Joseph, & Bielaczyc, 2004; Wang & Hannafin, 2005), jonka mukaisesti tutkimus-ta ohjasi: 1) teorian kehittämisintressi, 2) Deweylainen pragmatismi ja käytän-nöllisyys, 3) sekä kontekstuaalisuuden että yleistettävyyden vaatimukset, 4) iteratiivisen kehittämisen logiikka, 5) monimenetelmäisyys ja monipuolisten aineistonkeruuvälineiden käyttö, ja 6) sidosryhmien osallistamisen merkitys. Metodologiset valinnat noudattivat osallistavan yhteissuunnittelun periaatteita (Sanders & Stappers, 2008) kohdistettuna etenkin lasten ja nuorten osallistumiseen (Flutter & Rudduck, 2004).

Päätutkimuskysymykset olivat: 1) Millainen on validi rakenne oppimisympäristöjen suunnitteluviitekehykselle? 2) Mitkä oppimisympäristöjen ominaisuudet oppijat kokevat relevanteiksi oppimiselleen ja hyvinvoinnilleen? 3) Millaisia sisällöllisiä suunnitteluperiaatteita voidaan muodostaa tutkimuksen tulosten perusteella? Aineistonkeruuta varten kehitettiin materiaaleja kvantitatiivisen kyselyaineiston, kirjallisen, suullisen ja visuospatiaalisen datan keräämiseksi. Tutkimus suunniteltiin siten, että se oli mahdollista sisällyttää osaksi koulujen arkea monialaisena projektina ja autenttisena oppimiskok-muksena. Aineiston analyysissä yhdistettiin laadullisia ja määrällisiä analyysimenetelmiä. Empiirinen tutkimusosuus koostui kolmesta osatutkimuksesta, jotka on julkaistu tieteellisissä aikakauslehdissä.

Ensimmäisessä osatutkimuksessa hyödynnettiin alustavaa viitekehystä. Tutkimus koostui oppimisympäristöjen suunnittelutyöpajoista, joita järjestettiin 7-14-vuotiaille (n = 80) suomalaisille oppijoille osana koulun toimintaa. Työpajoja pohjustettiin kyselyllä, jonka jälkeen osallistujat rakensivat ryhmissä oppimista ja hyvinvointia edistäviä oppimisympäristön pienoismalleja. Lisäksi kullekin ryhmälle annettiin mahdollisuus kuvailla suullisesti pienoismalliensa sisältöjä ja ilmaista oppimisympäristöihin liittyviä toiveita. Huomiota kiinnitettiin myös esimerkiksi mahdollisiin ikään tai sukupuoleen liittyviin eroihin preferensseissä. Toisessa osatutkimuksessa edelleen kehitettiin alustavaa suunnitteluviitekehystä. Ensimmäisen osatutkimuksen aineistoa laajennettiin järjestämällä vas-

taavanlaisia oppimisympäristötyöpajoja 7-14-vuotiaille oppi-joille (n = 76) espanjalaisessa koulussa. Huomio oli kahta kulttuurista kontekstia edustavien oppijoiden jaetuissa näkemyksissä ja viitekehyksen kehittämisessä niiden pohjalta.

Kolmannessa osatutkimuksessa sovellettiin ja edelleen kehitettiin toisessa osatutkimuksessa luotua viitekehyksen versiota. Toisin kuin ensimmäisessä ja toisessa osatutkimuksissa, kolmannessa suunniteltiin ja toteutettiin konkreettisia muutoksia oppimisympäristöön, tässä tapauksessa lukion luonnontieteiden oppimistiloihin. Tässä osatutkimuksessa osallistettiin 16-19-vuotiaita lukiolaisia (n = 186). Ensimmäiseksi järjestettiin projektikurssi, jonka loppu-tuotoksena lukiolaiset (n = 11) tuottivat 3D-tilasuunnitelmia, jotka sisälsivät myös väri-, huonekalu- ja teknologiasuunnitelman. Toiseksi lukiolaisille (n = 175) annettiin mahdollisuus ilmaista toiveita keräämällä heiltä kirjallista palautetta oppimisympäristösuunnitelmia esittelevässä näyttelyssä. Ammattilais-suunnittelijat tekivät sitten lopulliset tilasuunnitelmat pohjautuen sekä lukiolaisten että koulun henkilökunnan toiveisiin ja esityksiin. Ennen varsinaisia tilamuutoksia projektikurssilaiset kutsuttiin arvioimaan ammattilaissuunnitelmaa. Kaksi oppijaa osallistui arviointiin. Kun tilamuutokset oli toteutettu, lukiolaiset (n = 83) arvioivat niitä tyytyväisyyskyselyn avulla.

Ensimmäisessä osatutkimuksessa alustavaan viitekehykseen ei tehty vielä muutoksia vaan sitä sovellettiin sellaisenaan oppijoiden näkemysten keräämiseen ja analysointiin. Aineiston analyysin osoitti, että yleiseen hyvinvointiin, oppimistilanteeseen ja oppimisen välineisiin ja tiloihin liittyvät oppimisympäristön ominaisuudet ovat sidoksissa toisiinsa. Eri aineistotyyppien analyysissä alustavan viitekehyksen 36:sta oppimisympäristön ominaisuudesta tärkeimmiksi nousi 24 ominaisuutta. Myös joitakin ikään ja sukupuoleen liittyviä eroja havaittiin. Tytöt vaikuttivat pitävän oppimisympäristöjen turvallisuutta poikia tärkeämpänä kun taas nuorimmat pojat pitivät teknologian käyttöä nuorimpia tyttöjä tärkeämpänä. Ylemmillä luokilla sukupuolten välinen ero ei ollut enää tilastollisesti merkittävä. Ensimmäisessä osatutkimuksessa laadittiin viitekehyksen ohella myös alustavat suunnitteluperiaatteet oppimisympäristöjen yhteissuunnittelulle.

Toisessa osatutkimuksessa laadullinen ja määrällinen analyysi (mm. faktorianalyysi) johti alustavan viitekehyksen uudelleenrakentamiseen. Nyt viitekehys muodostui toisiaan tasapainottavista ulottuvuuksista, joita olivat: yhteisöllisyys-yksilöllisyys, mukavuus-terveys, ja uudenaikaisuus-perinteisyys. Lisäksi joustavuus ja toimivuus nähtiin keskeisenä oppimisympäristöjen suunnittelua ohjaavana dimensiona. Alustavan viitekehyksen 36 oppimisympäristön ominaisuuden lisäksi tunnistettiin kaksi uutta piirrettä (”ei huomiota hajottavia tekijöitä”, ”huonekalujen mukavuus”), jotka lisättiin viitekehykseen. Lisäksi joitakin ominaisuuksia eroteltiin tarkemmiksi kokonaisuuksiksi (esim. levon ja vapaa-ajan tarpeen erottelu). Näin viitekehys sisälsi yhteensä 41 ominaisuutta. Tuotettiin myös lisää oppimisympäristöjen suunnitteluperiaatteita.

Kolmannessa osatutkimuksessa sovellettiin toisessa osatutkimuksessa kehitettyä viitekehystä oppimisympäristöjen yhteissuunnitteluun ja aineiston ana-

lysointiin. Yhteissuunnittelu lukiolaisten kanssa vahvisti 27 aikaisemmin tunnistetun oppimisympäristön ominaisuuden tärkeyden. Lisäksi viitekehykseen lisättiin 11 uutta ominaisuutta (mm. ”läpinäkyvyys”, ”ergonomia”, ”inspiroivat ja motivoivat tilat”) ja joitakin ominaisuuksia tarkennettiin. Tuotettiin myös lisää suunnitteluperiaatteita.

Tutkimus tuotti teoreettisiin ja empiirisiin havaintoihin perustuvan oppimisympäristöjen suunnitteluviitekehyksen (LED framework, Learning Environment Design framework) ja periaatteita oppimisympäristöjen yhteiskehittämiseen oppijoiden ja muiden sidosryhmien kanssa. Lopullinen LED viitekehys koostuu 53 oppimisympäristön ominaisuudesta, joista suurin osa voitiin replikoida kahdessa tai useammassa osatutkimuksessa ja vahvistaa muun tutkimuskirjallisuuden avulla. Viitekehyksen keskiössä ovat oppijoiden näkemykset oppimista ja hyvinvointia edistävistä oppimisympäristöistä. Suunnitteluviitekehys ja periaatteet ohjaavat suunnittelemaan joustavia ja funktionaalisia ympäristöjä, joissa yksilöllisyys-dimensio (yksityisyys ja rauha, oppimisen yksilöllistäminen) tasapainottaa yhteisöllisyys-dimensiota (sosiaaliset suhteet, opetus-oppiminen vuorovaikutus, yhteenkuuluvuus, turvallisuus), terveys-dimensio (fyysinen hyvinvointi, ei ylirasitusta) tasapainottaa mukavuus-dimensiota (fyysinen mukavuus, miellyttävyys) ja perinteisyys-dimensio (pe-rinteiset välineet ja tilat) tasapainottaa uudenaikaisuus-dimensiota (uudenaikaiset välineet ja tilat).

Tutkimuksessa rakennettu monitieteellinen viitekehys ja suunnitteluperiaatteet syventävät teoreettista ymmärrystä oppimisympäristöjen suunnittelusta. Toiseksi, ne vastaavat pragmaattisuuden ja käytännöllisyyden vaatimuksiin tukemalla evidenssiin pohjautuvaa oppimisympäristöjen suunnittelua ja arviointia. Viitekehys on myös yhdenmukainen suomalaisen opetussuunnitelman tavoitteiden kanssa. Kolmanneksi viitekehys taipuu kontekstuaalisuuden vaatimuksiin mahdollistamalla sen muokkaamisen kontekstiin sopivaksi mahdollistaen samalla kuitenkin vertailun ja yleistykset eri kontekstien välillä. Neljänneksi, iteratiivinen suunnittelu mahdollistaa sekä oppimisympäristöjen että niitä koskevan teorian jatkuvan edelleen kehittämisen. Viidenneksi, monimenetelmäisyys ja monipuolisten aineistonkeruuvälineiden hyödyntäminen vahvistavat analyysin luotettavuutta ja tuottaa vuoropuhelua eri koulukuntien ja tieteen traditioiden välillä. Kuudenneksi, osallistava yhteissuunnittelu eri sidosryhmien mutta erityisesti oppijoiden kanssa voi edistää laadukkaiden oppimisympäristöjen suunnittelua, demokraattista kulttuuria, oppimista ja hyvinvointia.

Haasteena oppimisympäristöjen suunnittelussa on lukuisten oppimisympäristölle tärkeiden ominaisuuksien yhtäaikainen huomioiminen – esimerkiksi istumapaikkojen ja pöytätilan lisääminen saattaa lisätä tilojen ahtautta tai ryhmätyöhön tarkoitetut pöydät saattavat vaikeuttaa näkyvyyttä opettajaan. Myös rajalliset resurssit suunnitteluun aiheuttavat haasteita. Valintoja on usein tehtävä niin kasvatuksellisiin, hyvinvoinnillisiin kuin käytännöllisiinkin kriteereihin ja preferensseihin perustuen. Osallistavassa yhteisuunnittelussa on myös omat haasteensa: voi olla vaikea saada edustava joukko osallistumaan suunnitteluun. Tässä tutkimuksessa edustavuutta edistettiin yhdistämällä syvällisiä suunnitte-

lutoimia pienemmällä ryhmällä kyselyyn perustuvaan aineistonkeruuseen suuremmalta joukolta. Haasteena on myös se, että oppimisympäristöjen suunniteltu käyttö edellyttää tukea suunnitteluvaiheen lisäksi käytön aikana. Parhaimmillaan oppimisympäristöjen yhteissuunnittelu on iteratiivinen prosessi, joka osallistaa kouluyhteisön jatkuvaan etukäteissuunnitteluun, suunnitteluun käytön aikana, ja uudelleen suunnitteluun.

REFERENCES

van den Akker, J. (1999). Principles and Methods of Development Research. In J. van den Akker, R.M. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design Approaches and Tools in Education and Training*. Boston: Kluwer Academic: 1-14.

van den Akker, J. (2007). Curriculum Design Research. In T. Plomp & N. Nieveen (Eds.), *An Introduction to Educational Design Research.* Enschede, the Netherlands SLO, 37-50.

Allardt, E. & Uusitalo, H. (1972). Dimensions of welfare in a comparative study of the Scandinavian societies, *Scandinavian Political Studies, Bind 7*, 9-27.

Aldridge, J.M., & Fraser, B.J. (2000). A Cross-cultural Study of Classroom Learning Environments in Australia and Taiwan, *Learning Environments Research 3*, 101-134.

Anderson, T. & Shattuck, J. (2012). Design-Based Research: A Decade of Progress in Education Research?, *Educational Researcher 41*(16), 16-25.

APA Work Group of the Board of Educational Affairs (1997). *Learner-centered psychological principles: A framework for school reform and redesign*. Washington, DC: American Psychological Association.

Arnstein, S.R. (1969). A ladder of citizen participation, *AIP Journal,* 216-224.

Awartani, M., Whitman, C.V., & Gordon, J. (2008). Developing Instruments to Capture Young People's Perceptions of How School as a Learning Environment Affects of Their Well-Being, *European Journal of Education, 43*(1), 51-70.

Bagot, K.L. (2004). Perceived Restorative Components: A Scale for Children, *Children, Youth and Environments, 14*(1), 120-140.

Barab, S. & Squire, K. (2004). Design-Based Research: Putting a Stake in the Ground, *The Journal of the Learning Sciences, 13*(1), 1-14.

Barrett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2013). A Holistic, Multi-level Analysis Identifying the Impact of Classroom Design on Pupils' Learning, *Building and Environment,* 59, 678-689.

Bell, P. (2004). On the Theoretical Breadth of Design-Based Research in Education, *Educational Psychologist*, *39*(4), 243-253.

den Besten, O., Horton, J., & Kraftl, P. (2008). Pupil involvement in school (re)design: Participation in policy and practice, *CoDesign: International Journal of CoCreation in Design and the Arts*, *4*(4), 197-210.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In: P. Griffin, B. McGaw and E. Care (Eds.), *Assessment and Teaching of 21st Century Skills*. Dordrecht: Springer, 17-66.

Bjögvinsson, E., Ehn P., Hillgren, P.-A. (2012). Design things and design thinking: Contemporary participatory design challenges, *DesignIssues, 28*(3), 101-116.

Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge, MA: Harvard University Press.

Bronfenbrenner, U. (1994). Ecological models of human development. In: *International Encyclopaedia of Education* (pp. 37-43). Vol. 3, 2nd Ed. Oxford: Elsevier.

Brown, A., L. (1992). Design Experiments: theoretical and methodological challenges in creating complex interventions in classroom settings, *The Journal of the Learning Sciences, 2*(2), 141-178.

Cam Aktas, B. (2010). Investigating Primary School Students' Perceptions Regarding 'Teacher' Through Their Drawings, *The International Journal of Learning, 17*(8), 408-425.

Clay, V. (2008). Gender Differences in Measures of Satisfaction with School and General and Academic Self-Concept, *The International Journal of Learning*, 15(8), 31-40.

Cleveland, B. & Fisher, K. (2014). The Evaluation of Physical Learning Environments: a Critical Review of the Literature, *Learning Environment Research 17*, 1-28.

Cobb, P., Confrey, J. diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research, *Educational Researchers*, *32*(1), 9-13.

Cohen, J. (2006). Social, Emotional, Ethical, and Academic Education: creating a climate for learning, participation in democracy, and well-being, *Harvard Educational Review, 76*(2), 201-237.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues, *The Journal of the Learning Sciences, 13*(4), 15-42.

Cornelius-White, J. D. (2007). Learner-centered teacher-student relationships are effective: A meta-analysis, *Review of Educational Research* 77, 113–143.

Crespo, J., & Pino, M. (2007). Description of Environmental Factors in Schools: lessons from a study in North-west Spain, *Review of Education,* 53, 205-218.

The Design-Based Research Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry, *Educational Researcher, 32*(1), 5-8.

Dewey, J. (1907). *The School and Society.* Chicago: University of Chicago Press.

Dewey, J. (1916). *Democracy and Education: an introduction to the philosophy of education.* Electronic version by the University of Virginia American Studies Program 2003. Available from http://xroads.virginia.edu/~hyper2/Dewey/TOC.html (Retrieved 30th of May, 2017)

Dewey, J. (1938). *Experience & Education.* New York, NY: Kappa Delta Pi.

Dodge, R., Daly, A.,P., Huyton, J., & Sanders, L.D. (2012). The challenge of defining wellbeing, *International Journal of Wellbeing 2*(3), 222-235.

Dovey, K. & Fisher, K. (2014). Designing for adaptation: the school as socio-spatial assemblage, *The Journal of Architecture*, 19(1), 43-63.

Duarte, A., Veloso, L., Marques, J., & Sebastiao, J. (2015). Site-specific focus groups: analysing learning spaces in situ, *International Journal of Social Research Methodology, 18*(4), 381-389.

Edelson, D.C. (2002). Design Research: What We Learn When We Engage in Design, *The Journal of the Learning Sciences, 11*(1), 105-121.

Ehn, P. (2017). "Learning in Participatory Design as I Found it (1970-2015)". In B. DiSalvo, J. Yip, E. Bonsignore, and C. DiSalvo (eds), *Participatory Design for Learning. Perspectives from Practice and Research* (pp. 7-21). New York: Routledge.

Engeström, Y. (2009). From Learning Environments and Implementation to Activity Systems and Expansive Learning, *An International Journal of Human Activity Theory*, 2, 17-33.

Engeström, Y. (2011). From Design Experiments to Formative Interventions, *Theory & Psychology*, *21*(5), 598-628.

Elen, J., Clarebout, G., Léonard, R., & Lowyck, J. (2007). Learner-centred and Teacher-centered Learning Environments: what students think, *Teaching in Higher Education, 12*(1), 105-117.

European Parliament and Council (2006). "Key Competences for Lifelong Learning: European Reference Framework", *The Official Journal of the European Union*, 30 December 2006/L394.

Fielding, M. (2001). Students as radical agents of change, *Journal of Educational Change* 2, 123-141.

Fielding, M. (2004). Transformative approaches to student voice: theoretical underpinnings, recalcitrant realities, *British Educational Research Journal, 30*(2), 295-311.

Finnish National Board of Education (2016). *National Core Curriculum for Basic Education 2014.* Vammala: Vammalan Kirjapaino oy.

Finnish National Board of Education (2003). *National core Curriculum for General Upper Secondary Intended for Young People.* Vammalan Kirjapaino oy. Vammala.

Finnish National Board of Education (2004). *National Core Curriculum for Basic Education 2004.* Vammala: Vammalan Kirjapaino oy.

Finnish Advisory Board on Research Integrity (2016). http://www.tenk.fi/en/frontpage (Retrieved 30th of May, 2017)

Fischer, G. (2002). Beyond 'Couch Potatoes': from consumer to designers and active contributors, *First Monday*, *7*(12).

Fisher, K. & Newton, C. (2014). Transforming the twenty-first-century campus to enhance the net-generation student learning experience: using evidence-based design to determine what works and why in virtual/physical teaching spaces, *Higher Education Research & Development*, *33*(5), 903-920.

Flutter, J. & Rudduck, J. (2004), *Consulting Pupils: what's in it for schools.* London: Routledge Falmer.

Flutter, J. (2006). 'This place could help you learn': student participation in creating better school environments, *Educational Review, 58*, 183-193.

Foucault, M. (1975). *Discipline and Punish: the Birth of the Prison.* New York: Random House.

Fraser, B. J. (1998). Classroom Environment Instruments: development, validity and applications, *Learning Environments Research 1*, 7-33.

Frost, R. & Holden, G. (2008). Student voice and future schools: building partnerships for student participation, *Improving Schools*, *11*(1), 83-95.

Gardiner, W. L. (1989). Forecasting, planning, and the future of the information society. In P. Goumain (Ed.), *High technology workplaces: Integrating technology, management, and design for productive work environments* (pp.27-39). New York: Van Nostrand Reinhold.

Gee, L. (2006). Human-Centered Design Guidelines. In D. G. Oblinger (ed.), *Learning spaces.* Educause.

Ghaziani, R. (2010). School Design: researching children's views, *Childhoods Today*, *4*(1), 1-27.

Ghaziani, R. (2012). An Emerging Framework for School Design Based on Children's Voices, *Children, Youth and Environments 22*(1), 125-144.

Gislason, N. (2010). Architectural Design and the Learning Environment: a framework for school design Research, *Learning Environment Research* 13, 127-145.

Guney, A. & Al, S. (2012). Effective Learning Environments in Relation to Different Learning Theories, *Procedia, Social and Behavioural Sciences 46*, 2334-2338.

Hansen, D.T. (2002). Dewey's Conception of an Environment for Teaching and Learning, *Curriculum Inquiry*, *32*(3), 267-280.

Hargreaves, A. (2002). Sustainability of educational change: The role of social geographies, *Journal of Educational Change 3*, 189-214.

Hargreaves, A. & Shirley, D. (2009). *The fourth way: The inspiring future for educational change*. Thousand Oaks, CA: Corwin.

Hart, R. A. (1992). *Children's participation: from tokenism to citizenship.* Florence: UNICEF.

Higgins, S., Hall, E., Wall, K., Woolner, P., & McCaughey, C. (2005). The Impact of School Environments: a literature review, *The Centre for Learning and Teaching. School of Education, Communication and Language Science.* University of Newcastle.

Horelli, L. (1997). A Methodological Approach to Children's Participation in Urban Planning, *Scandinavian Housing and Planning Research*, *14*(3), 105-115.

Horne Martin, S. (2002). The Classroom Environment and its Effects on the Practice of Teachers, *Journal of Environmental Psychology 22,* 139-156.

Horne Martin, S. (2004). Environment-Behaviour Studies in the Classroom, *The Journal of Design and Technology Education, 9*(2), 77-8.

Hoadley, C. (2004). Methodological alignment in design-based research, *Educational Psychologist, 39*(4), 203-212.

Hwang, G.J., Yang, T.C., Tsai, C.C., & Yang, S.J.H. (2009). A context-aware ubiquitous learning environment for conducting complex science experiments, *Computers & Education 53*(2), 402-413.

Iversen, O.S. & Dindler, O. (2014). Sustaining Participatory Design Initiatives, *CoDesign: International Journal of CoCreation in Design and the Arts*, 1-18.

Jamieson, P., Fisher, K., Gildings, T., Taylor, P.G., & Trevitt, A.C.F. (2000). Place and Space in the Design of New Learning Environments, *Higher Education Research and Development*, 19, *221-237.*

Juuti, K. (2005). *Towards primary school physics teaching and learning. Design research approach.* Academic Dissertation. University of Helsinki, Faculty of Behavioural Sciences, Department of Applied Sciences of Education.

Juuti, K. & Lavonen, J. (2006). Design-Based Research in Science Education: One Step Towards Methodology, *NorDina*, 4, 54-68.

Kangas, M. (2010a). *The school of the future: Theoretical and pedagogical approaches for creative and playful learning environments*. Doctoral dissertation. Acta Universitatis Lapponiensis 188. University of Lapland, Faculty of Education, Finland. Rovaniemi: University of Lapland Printing Centre.

Kangas, M. (2010b). Finnish Children's Views on the Ideal School and Learning Environment, *Learning Environments Research 13*, 205-223.

Kaplan, S. (1995). The Restorative Benefits of Nature: Toward an Integrative Framework, *Journal of Environmental Psychology*, 15, 169-182.

Konu, A. & Rimpelä, M. (2002). Well-being in schools: a conceptual model, *Health Promotion International*, *17*(1), 79-87.

Kostenius, C. (2011). Picture This – Our Dream School! Swedish schoolchildren sharing their visions of School, *Childhood 18*(4), 509-525.

Kujala, S. (2008). Effective user involvement in product development by improving the analysis of user needs, *Behaviour & Information Technology*, 27(6), 457-473.

Kumpulainen, K., Krokfors, L., Lipponen, L., Tissari, V., Hilppö, J., & Rajala, A. (2010). *Learning Bridges. Toward Participatory Learning environments.* Cicero learning. University of Helsinki.

Kuuskorpi, M. & Cabellos, N. (2011). The Future of the Physical Learning Environment. School Facilities that Support the User. *CELE Exchange, Centre for Effective Learning Environments*, 2011/11. OECD Publishing.

Kuuskorpi, M. (2012). *Tulevaisuuden fyysinen oppimisympäristö. Käyttäjälähtöinen muunneltava ja joustava oppimistila*. (Future physical learning environment. User oriented flexible and changeable teaching spaces). Doctoral thesis in Education University of Turku Faculty of Education. Department of Teacher Education in Rauma.

Könings, K. D., Brand-Gruwel, S., & van Merriënboer, J.J.G. (2005). Towards More Powerful Learning Environments Through Combining the Perspectives of Designers, Teachers, and Students, *British Journal of Educational Psychology*, *75*, 645-660.

Könings, K.D., van Zundert, M., Brand-Gruwel, S., & van Merriënboer, J.J.G. (2007). Participatory Design in Secondary Education: is it a Good Idea? Students' and Teachers' Opinions on its Desirability and Feasibility, *Educational Studies, 33*(4), 445-465.

Land, S. M., Hannafin, M. J., & Oliver, K. (2012). Student-centered learning environments: Foundations, assumptions, and design. In D. Jonassen & S.

Land (Eds.), *Theoretical Foundations of Learning Environments.* New York, NY: Routledge, 3-25.

Leinonen, T., Keune, A., Veermans, M., & Toikkanen, T. (2016). Mobile Apps for Reflection in Learning: A Design Research in K-12 Education, *British Journal of Educational Technology, 47*(1), 184-202.

Linnankylä, P. & Malin, A. (2008). Finnish Students' School Engagement in the Light of PISA 2003, *Scandinavian Journal of Educational Research, 52*(6), 583-602.

Liu, C.J., Zandvliet, D.B., & Hou, L.-L. (2012). The Learning Environment Associated with Information Technology Education in Taiwan: Combining Psychosocial and Physical Aspects, *Learning Environment Research, 15*, 379-402.

Lodge, C. (2005). From hearing voices to engaging in dialogue: Problematising student participation in school improvement, *Journal of Educational Change, 6*, 125-46.

Marchand, G. C., Nardi, N. M., Reynolds, D., & Pamoukov, S. (2014). The Impact of the Classroom Built Environment on Student Perceptions and Learning, *Journal of Environmental Psychology 40*, 187-197.

McKenney, S. & Reeves, T.C. (2013). Systematic Review of Design-Based Research Progress: Is a Little Knowledge a Dangerous Thing, *Educational Researcher*, *42*(2), 97-100.

Monahan, T. (2002). Flexible space & build pedagogy: Emerging IT embodiments, *Inventio, 4*(1), 1-19.

Moos, R.H. (1987). Person-Environment Congruence in Work, School, and Health Care Settings, *Journal of Vocational Behaviour, 31*, 231-247.

Moroz, W. (2001). Boys Will Be Boys: Implications of Students' Perceptions of Their Learning Environments, Proceedings of the *Learning Conference 2001, Greece, 4.-8. of July, 2001.*

Mäkelä, T., Kankaanranta, M., & Gallagher, C. (2014). Involving students in the redesign of learning environments conducive to learning and wellbeing. Proceedings of the *6th Architectural Research Symposium in Finland 2014: Designing and Planning the Built Environments for Human Well-Being,* 23-25 October, Oulu, Finland, 268-282.

Mäkelä, T., Lundström, A., & Mikkonen, I. (2015). Co-designing learning spaces: Why, with whom, and how? In S. Nenonen, S. Kärnä, J. Junnonen, S. Tähtinen, N. Sandström, K. Airo, O. Niemi (Eds.), *How to co-create campus?* (pp. 197-211). Tampere, Finland: Suomen Yliopistokiinteistöt.

Newman, M. & Thomas, P. (2008). Student Participation in School Design: One School's Approach to Student Engagement in the BSF Process, *CoDesign: International Journal of CoCreation in Design and the Arts*, *4*(4), 237-251.

Nousiainen, T. (2008). *Children's Involvement in the Design of Game-Based Learning Environments.* Doctoral dissertation. Jyväskylä, Finland: University of Jyväskylä. Jyväskylä Studies in Computing, 95.

Nuikkinen, K. (2009). *Koulurakennus ja hyvinvointi. Teoriaa ja käytännön kokemuksia peruskouluarkkitehtuurista* (School building and well-being.

Theory and practical experiences of school architecture). Doctoral dissertation. Acta Universitatis Tamperensis; 1398, Tampere University Press, Tampere.

Oh, E. & Reeves, T.C. (2010). The Implications of the Differences between Design Research and Instructional Systems Design for Educational Technology Researchers and Practitioners, *Educational Media International*, *47*(4), 236-275.

Oksanen, K. (2014). *Serious game design: supporting collaborative learning and investigating learners' experiences.* Doctoral dissertation. University of Jyväskylä, Finnish Institute for Educational Research. Tutkimuksia / Koulutuksen tutkimuslaitos 31. Jyväskylä

Papatheodorou, T. (2002). How We Like Our School to Be… Pupils' Voices, *European Educational Research Journal, 1*(3), 445-467.

Parnell, R., Cave, V., Torrington, J. (2008). School Design: Opportunities Through Collaboration, *CoDesign: International Journal of CoCreation in Design and the Arts*, *4*(4), 211-224.

Pieters, J.M. (2004). Designing Artefacts for Inquiry and Collaboration When the Learner Takes the Lead, *European Educational Research Journal*, 3(1), 77-100.

Piispanen, M. (2008a). *Good Learning Environment. Perceptions of Good Quality in Comprehensive School by Pupils, Parents and Teachers.* University of Jyväskylä. Kokkola University Consortium Chydenius.

Piispanen, M. (2008b). *Hyvä oppimisympäristö. Oppilaiden, vanhempien ja opettajien hyvyyskäsitysten kohtaaminen peruskoulussa.* (Good Learning Environment. Perceptions of Good Quality in Comprehensive School by Pupils, Parents and Teachers.) Doctoral Thesis in Pedagogics. University of Jyväskylä. Faculty of Pedagogics. Kokkola University Consortium Chydenius.

Plomp, T. (2007). Education Design Research: An introduction. In T. Plomp & N. Nieveen (Eds.), *An Introduction to Educational Design Research* (pp. 9-35). Enschede, the Netherlands: SLO.

Rikala, J. (2015). *Designing a Mobile Learning Framework for a Formal Educational Context.* Doctoral dissertation. Jyväskylä, Finland: University of Jyväskylä, Studies in Computing, 220, Jyväskylä.

Richey, R.C., Klein, J.D., & Nelson, W.A. (2004). Developmental Research: Studies of instructional design and development, in D. Jonassen (Ed.) *Handbook of Research for Educational Communications and Technology* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum, 1099-1130.

Robinson, C. & Taylor, C. (2012). Student voice as a contested practice: Power and participation in two student voice projects, *Improving Schools,* 16(1), 32-46.

Ryan, R. M. & E. L. Deci (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, *American psychologist*, 55(1), 68-78.

Sahlberg, P. (2011). The fourth way of Finland, *Journal of Educational Change, 12*, 173-185.

Sanders, E. B.-N. & P.J. Stappers. (2008a). Co-creation and the new landscapes of design, *CoDesign: International Journal of CoCreation in Design and the Arts*, March 2008.

Sandoval, W.A. & Bell, P. (2004). Design-Based Research Methods for Studying Learning in Context: Introduction, *Educational Psychologist*, *39*(4), 199-201.

Sandström, N., Ketonen, E., & Lonka, K. (2014). The Experience of Laboratory Learning –How Do Chemistry Students Perceive Their Learning Environment?, *Social & Behavioural Sciences, 11*, 1612-1625.

Sanoff, H., Pasalar, C., & Hashas, M. (2001). *School Building Assessment Methods.* School of Architecture, College of Design, North Carolina State University with support of the National Clearinghouse for Educational Facilities.

Sanoff, H. (2001). A visioning process for designing responsive schools, *AIA, School of Architecture, College of Design, North Carolina State University with support from the National Clearinghouse for Educational Facilities.*

Scardamalia, M., Bransford, J., Kozma, B., & Quellmalz, E.E. (2012). New Assessment and Environments for Knowledge Building. In P. Griffin, B. McGaw & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills.* Dordrecht: Springer.

Schrittesser, I., Gerhartz-Reiter, S., & Paseka, A. (2014). Innovative Learning Environments: about traditional and new patterns of learning, *European Educational Research Journal*, *13*(2), 143-154.

Selwyn, N., Boraschi, D., & Özcula, S.M. (2009). Drawing digital pictures: and investigation of primary pupils' representations of ICT and schools, *British Educational Research Journal, 35*(6), 909-928.

Simmons, C., Graham, A., & Thomas, N. (2015). Imagining an ideal school for wellbeing: Locating student voice, *Journal of Educational Change*, *16*, 129-144.

Sjöblom, K., Mälkki, K., Sanström, N., & Lonka, K. (2016). Does Physical Environment Contribute to Basic Physchological Needs? A Self-Determination Theory Perspective on Learning in the Chemistry Laboratory, *Frontline Learning Research, 4*(1), 17-39.

Smeds, R., Huhta, E., & Pöyry-Lassila, P. (2010). Using Process Simulations to Co-design Future School Networks. In M. Taisch, J. Cassina, R. Smeds (Eds.) *Experimental Learning in Sustainable Management, Economics and Industrial Engineering.* Proceedings of 14th Workshop of the Special Interest Group on Experimental Interactive Learning in Industrial Management of the IFIP Working Group 5.7. Poliprint – Politecnico di Milano, Italy, 196-205.

Spratt, J. (2016). Childhood wellbeing: what role for education?, *British Educational Research Journal*, 42(2), 223-239.

Staffans, A., Teräväinen, H., Meskanen, S., & Mäkitalo, A. (2008). Collaborative Planning and Design and Students' Epistemic Agency, *Conference Architectural Inquiries,* Göteborg, Sweden.

Steen, M., Kuijt-Evers, L., & Klok, J. (2007). Early User Involvement in Research and Design Projects: A Review of Methods and Practices, *Proceeding of the 23rdEGOS Colloquium, Vienna, July 5-7, 2007.*

Sulonen, J. & Sulonen, K. (2014). The Grammar of a Modern School Building. A comparative study on schools and the changing ways of learning. In M. Kuuskorpi (Ed.) *Perspectives from Finland –Towards new learning environments.* Finnish National Board of Education. Publications 2014:1.

Tanner, K.C. (2008). Explaining Relationships Among Student Outcomes and the School's Physical Environment, *Journal of Advanced Academics 19: 444-471.*

Thorburn, M. & MacAllister, J. (2013). Dewey, Interest, and Well-being: Prospects for Improving the Educational Value of Physical Education, *Quest*, 65(4), 458-468.

UNESCO (2012). *A Place to learn: lessons from research on learning environments.* Technical paper No. 9. Montreal: United Nations Educational, Scientific and Cultural Organization, Institute for Statistics.

United Nations (1989). *Convention on the Rights of the Child.* Geneva: United Nations.

Veloso, L., Marques, J.S., & Duarte, A. (2014). Changing education through learning spaces: impacts of the Portuguese school buildings' renovation programme, *Cambridge Journal of Education, 44*(3), 401-423.

Veloso, L. & Marques, J.S. (2017). Designing science laboratories: learning environments, school architecture and teaching and learning models. *Learning Environment Research*: 20, 221-248.

Vygotsky, L. S. (1978). *Mind in Society. The Development of Higher Psychological Processes.* (M. Cole, Ed.) Cambridge, MA: Harvard University Press.

Wang, F. & Hannafin, M.J. (2005). Design-based Research and Technology-Enhanced Learning Environments, *ETR&D, 53*(4), 5-23.

Wang, M.-T. & Holcombe, R. (2010). Adolescents' Perceptions of School Environment, Engagement, and Academic Achievement in Middle School, *American Educational Research Journal,* 47(3), 633-662.

Woolner, P. Hall, E., Wall, K., & Dennison, D. (2007). Getting together to improve the school environment: User consultation, participatory design and student voice, *Improving Schools* 10, 233-248.

Woolner, P. (2009). Building schools for the future through a participatory design process: Exploring the issues and investigating ways forward, *Proceedings of BERA 2009, 2-5 September,* Manchester.

Woolner, P., Clark, J., Hall, E., Tiplady, L., Thomas, U., & Wall, K. (2010). Pictures Are Necessary But Not Sufficient: using a range of visual methods to engage users about school design, *Learning Environment Research 10, 1-22.*

Woolner, P., McCarter, S., Wall, K., & Higgins, S. (2012). Changed learning through changed space: When can a participatory approach to the learning environment challenge preconceptions and alter practice? *Improving Schools* 15(1), 45-60.

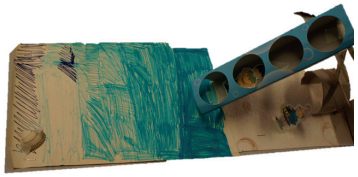
Wolff, S.J. (2002). *Design Features for Project-Based Learning.* Oregon State University.

Zandvliet, D.B. & Fraser, B.J. (2005). Physical and Psychosocial Environments Associated with Networked Classrooms, *Learning Environment Research* 8, 1-17.

Zandvliet, D.B. & Straker, L.M. (2001). Physical and psychosocial aspects of the learning environment in information technology rich classrooms, *Ergonomics*, 44(9), 838-857.

Zheng, L. (2015). A Systematic Literature Review of Design-based Research from 2004 to 2013, *Journal of Computer Education*, Published online: 24 June 2015.

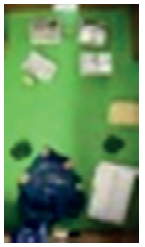
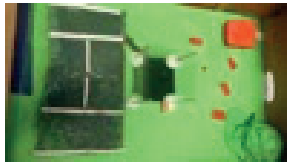
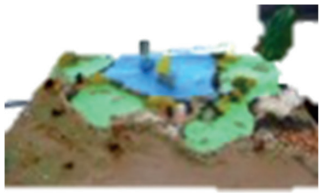
APPENDIX 1. Scale models by Finnish learners aged 7 to 14

Gra-de	1. Learning by studying	2. Learning by doing	Learning by socialising	4. Learning by reflecting	5. Learning by exploring
	Classroom	*Teaching kitchen*	*Beach*	*Math calculation castle*	*City*
2					
	Classroom	*Nuclear power plant*	*Disco*	*Library and swim-ming hall*	*Gyms*
4					 

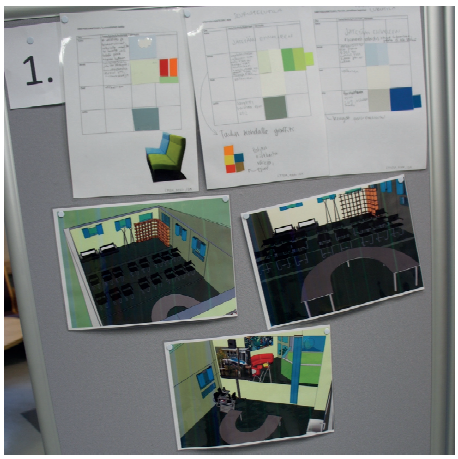
6	*Classroom*	*Nuclear power plant*	*Park*	*Computer classroom*	*Ice-hockey rink and theatre*
					 
8	*Classroom*	*Gym*	*Café*	*Lounge*	*Park*
					

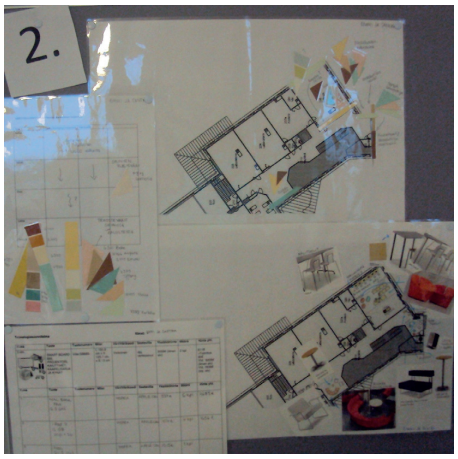
APPENDIX 2. Scale models by Spanish learners aged 7 to 14

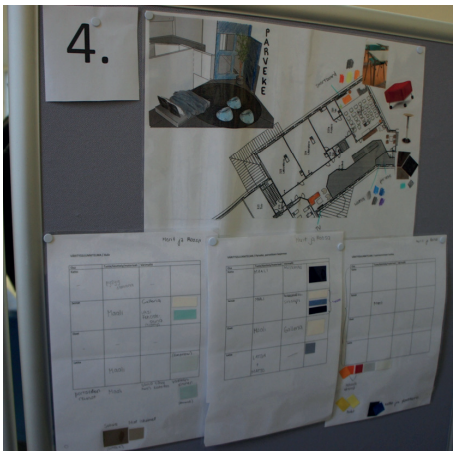
Gra-de	1. Learning by study-ing	2. Learning by doing	3. Learning by socialis-ing	4. Learning by reflecting	5. Learning by exploring
	School	*Science club*	*House with a fish pond*	*Silent room with a bathtub*	*Park*
3A					
	Libraries	*Football stadium*	*Parks*	*Library*	*Natural park*
3B	 		 		

	Classrooms	Hobby club	Tennis court and bar	Media centre	Park
8						

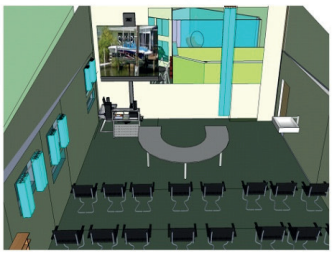
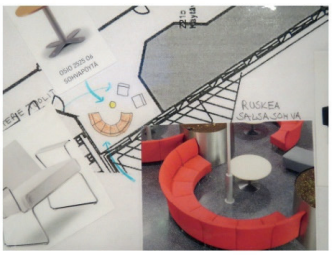
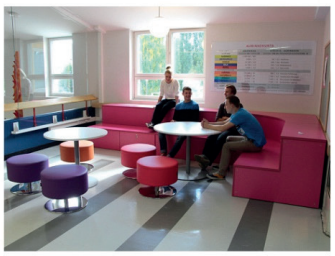
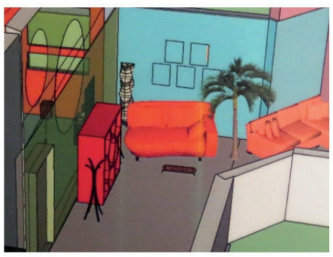
APPENDIX 3. LE designs by Finnish learners aged 16 to 19





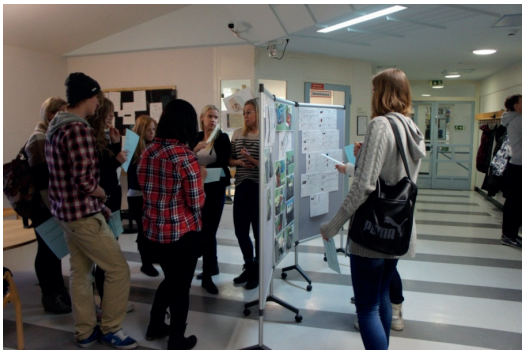


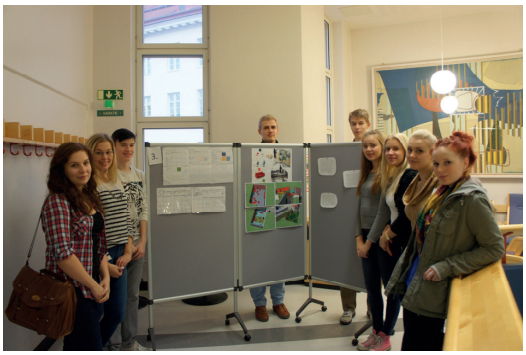
APPENDIX 4. Redesign of a natural science LE

Before the redesign	Student designs	After the redesign
		
		
		
		

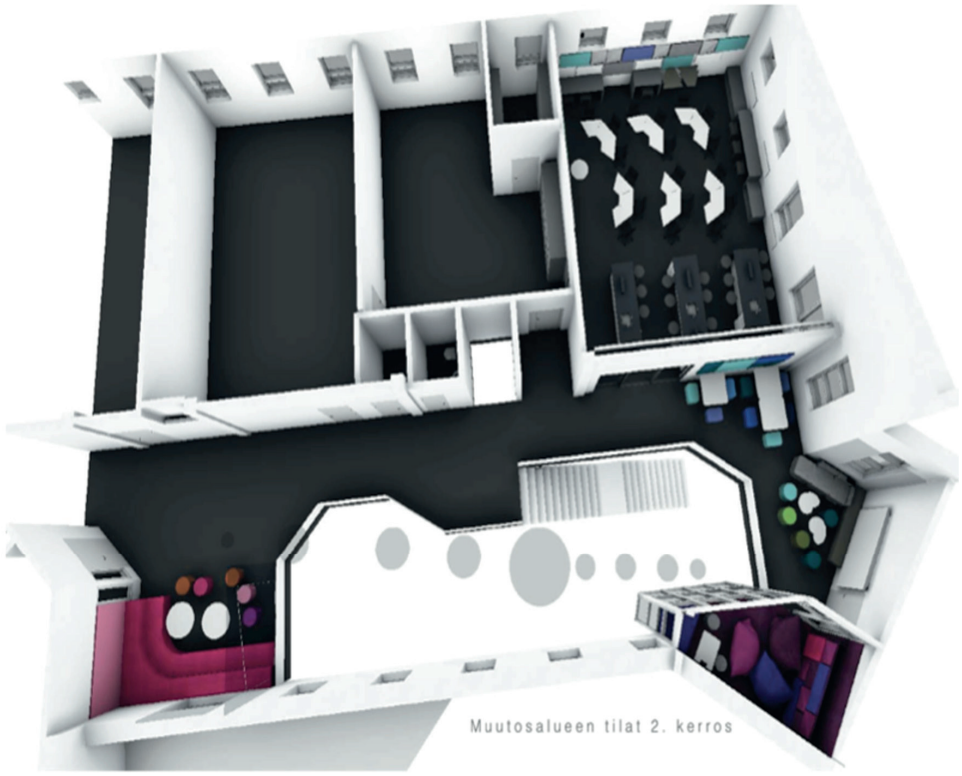
APPENDIX 5. Exhibition gathering feedback from students

Student co-designers (upper left), students familiarising themselves with the designs (lower left), students providing feedback and voting on their favourite designs (right)





APPENDIX 6. Professional interior design (general view)



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ORIGINAL PAPERS

I

CONSIDERING LEARNERS' PERCEPTIONS IN DESIGNING EFFECTIVE 21ST CENTURY LEARNING ENVIRONMENTS FOR BASIC EDUCATION IN FINLAND

by

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Considering Learners' Perceptions in Designing Effective 21st Century Learning Environments for Basic Education in Finland

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Abstract: Focusing on so called Key Competences or 21st Century Skills urges educational organizations to redesign their psychosocial and physical learning environments. Inspired by studies indicating that considering learners' perceptions of learning environments can have a positive impact on learning and wellbeing, our study aims at developing design principles for involving learners in the learning environment design. This pilot case study analyzed 7- to 14-years old Finns' (n = 80) perceptions by using web questionnaires and design workshops. The results are in line with research indicating that Finnish learners value aspects such as safety and peacefulness, the possibilities for rest and physical activity, the presence of nature, and good social relations. They also value versatile, personally meaningful and collaborative learning situations, including both traditional and novel tools and spaces for learning. The study offers educational administrators tools and data for redesigning learning environments.

Keywords: Educational Organization, 21st Century Skills, Learning Environments, Learners' Perceptions, Participatory Design, Design Research

Introduction

The importance of designing psychosocial and physical learning environments is supported by the increasing understanding of the influence of factors such as student wellbeing, quality of teaching-learning interaction, and physical surroundings on learning outcomes and school effectiveness (see e.g., OECD 2009[1]; UNESCO 2012[2]). From an institutional viewpoint, learning environments can be considered effective if they support educational organization's mission and objectives (e.g., Guney and Al 2012), which nowadays commonly consist of so called 21st Century Skills (Binkley et al. 2012) or Key Competencies (European Parliament and Council 2006) such as critical thinking, technological skills, and active citizenship. It is believed that these kinds of learning objectives are best supported by learner-centered "knowledge-building environments" (see Scardamalia et al. 2012), which bridge ubiquitous formal, informal, and non-formal learning situations (Kumpulainen et al. 2010) and where learners can be "designers of their own learning" (Brown 1992, 150; see also Dewey 1899/1980; Vygotsky 1978).

However, existing educational practices and physical infrastructures often obstruct applying these principles. For instance, teacher-centered views of teaching as knowledge transmission prevail (e.g., Cam Aktas 2010; Hutchison 2012) and are fostered by infrastructural elements, such as physical arrangement of classrooms where the teacher's desk is a control and focal point (e.g., Guney and Al 2012; see also Foucault 1975). Further, due to discrepancies between designers', educators', and learners' perceptions, even novel 21st century learning environments may be utilized inefficiently (see van den Akker 2007; Hutchison 2012; Könings et al. 2005).

It is often argued that the gap between the objectives set by educational organizations and the actual outcomes can be diminished by involving various stakeholders in the design process (e.g., van den Akker 2007; Könings et al. 2005). The importance of considering learners' perceptions, in particular, is supported by the research indicating that the congruence between a learner's perception of actual (experienced) and ideal (preferred) learning environment can impact learning positively (Fraser 1998). In addition, we ascertain that to foster competences such as active citizenship, the design process itself should respect the principles of a participatory culture and involve learners in the *co-design* (i.e. collaborative design) of learning environments with other important stakeholders, all "experts of their experience" (see Sanders and Stappers 2008, 9).

Yet, to date there are only a few cases reported where different stakeholders, and especially learners, have participated in learning environment design (see Ghaziani 2010; UNESCO 2012). Recently, these

[1] Teaching and Learning International Survey (TALIS) on effective teaching and learning environments conducted in 23 countries published by OECD (the Organization for Economic Co-operation and Development)
[2] a multidisciplinary review of 58 studies on learning environments published by UNESCO (the United Nations Educational, Scientific and Cultural Organization)

initiatives have started to emerge in Finland (see e.g., Kangas 2010; Meskanen 2009; Piispanen 2008), a country in which all citizens, even children, have a right to participate in planning their own "safe, healthy, pleasant, and socially functional living and working environment" (Land Use and Building Act 2000, Chapter 1, Section 5). The mission of Finnish basic education is likewise thought to be best supported by safe, diversified, collaborative, ICT-enhanced, and aesthetically pleasing learning environments, whose design takes into account learners' views (see Finnish National Board of Education 2004, 12-17).

Despite this awareness, aspects such as student participation in decision-making (see e.g., Linnankylä and Malin 2008) and the ICT-enhanced learning (Kankaanranta and Puhakka 2008) continue to be a challenge also in Finland. It has even been suggested that increased student involvement and the use of ICTs could address the rather unique educational challenge, which in Finland is not high dropout rates or generally low academic achievement levels, but low school-satisfaction and engagement levels, particularly amongst some specific learner subgroups consisting primarily of male adolescent students (see Linnankylä and Malin 2008).

This article contributes to addressing the international and national challenge of designing effective environments for 21st century learning by including learners' voices to this discourse and asking students' own views about learning environments conductive to learning and wellbeing. Our study forms part of a wider research collaboration aiming at developing a guiding framework for the design of 21st century learning environments. It consists of various research cycles in educational organizations representing varying cultural contexts. The findings presented in this paper are based on the first research cycle conducted in a Finnish comprehensive school in 2012. It adds to previous Finnish studies especially by focusing more on age and gender differences (see e.g., Kangas 2010).

Conceptual Framework

Our study employs educational design research approaches, often considered prone to complex, context-dependent problems in real-life settings (Brown 1992; Plomp 2007), including "exploring possibilities for novel learning and teaching environments" (the Design-Based Research Collective 2003, 8) and investigating "how different learning environment designs affect dependent variables in teaching and learning" (Collins et al. 2004, 17). In doing so, these studies typically empower various educational stakeholders (van den Akker 2007).

The preliminary research framework of the study was developed based on multidisciplinary review of research literature and official documents, many of which we have already cited in the introduction. The framework analyses learning environments holistically as complex webs consisting of closely interconnected psychosocial and physical factors that shape the overall conditions for learning and wellbeing in a specific time and space, both physical and virtual (see UNESCO 2012; see also Bronfenbrenner 1994). It entails (a) procedural design principles consisting of the characteristics of design interventions and (b) substantive (content-related) design principles pertaining to the characteristics of effective 21st century learning environments (see also Plomp 2007). During the first research cycle we tested and evaluated the content and construct validity as well as practicality of the preliminary framework to be used and developed further in various educational organizations.

This paper focuses on the development of content-related learning environment design principles. The present understanding about the interrelations between aspects related to overall wellbeing, learning and physical environments (see e.g., UNESCO 2012) led us to divide our preliminary framework in three partially overlapping constructs:

- overall wellbeing including items such as safety, feelings of satisfaction, and good social relations (see e.g., Awartani et al. 2008),
- learning situation focusing more directly on ways of teaching and learning (e.g. personal relevance of contents, teaching methods, and grouping; see e.g., Fraser 1998), and
- learning tools and space design referring to tools and technologies (see e.g. Scardamalia et al. 2012) and characteristics of physical learning environments (see e.g., Ghaziani 2010).

This article presents the main findings of the analysis of all three constructs. A more comprehensive description of the development of the framework is presented elsewhere. Instead of attempting to understand the learner's perception per se, the design principles developed during the first research cycle are the result of collaborative meaning making and knowledge construction with learners (see Scardamalia et al. 2012). During this pilot study we analyzed learners' *consensual beta press*, in other words shared views, in general as well as between genders and age groups. Nevertheless, *private beta press,* or private views, were considered when they clearly arose from the data. (See Fraser 1998.)

Method

Participants

Four volunteering teachers and their student groups were recruited for the pilot study from a teacher training school located in Central Finland. This school provides 12 years of primary, lower, and upper secondary education to approximately 1000 children, beginning at the age of 7 (the age when Finnish children start their 9 years of basic education). It *promotes* its teaching and teacher training mission in a science-based manner and is keen, for instance, to develop a high-quality ICT-learning environment for preparing both young learners and teacher trainees for the needs of a 21st century society. In order to gather data from learners at different ages and schooling stages, the study was conducted with 2nd (girls n=10, boys n=10), 4th (4, 15), 6th (9, 12) and 8th (11, 9) graders; in total 80 children aged 7 to 14 years (34, 46). 4th and 6th graders participated in the study in the late spring 2012 and 2nd and 8th graders in the early fall 2012.

Data Collection

Multidimensional and rich data were collected through 1) a web questionnaire and 2) design workshops. Materials were designed based on the preliminary framework. Nonetheless, students were encouraged to express freely their views "beyond the framework". Instead of using strongly pre-framed standardized questionnaires (see Fraser 1998), we created a customized questionnaire comprising a total of 35 items rated on a 5-point Likert scale (1="very little" to 5="very much", for examples see Table 1 in the Result section) and 6 open-ended questions (e.g., the purpose of schooling, personal preferences, good or impossible places to learn, elements that and people who should or should not be present). The language of the questionnaire was kept understandable also for the youngest learners.

During the design workshops, information about varied learning situations was gathered by asking learners to create quick scale models or mock-ups within one situation: learning by 1) studying, 2) doing, 3) socializing, 4) reflecting, or 5) exploring the world (see Table 2 in the Result section). Visuospatial data were supported by half-structured group discussions, during which learners were asked to describe the contents of their space design and express their opinions related to different learning environment dimensions.

Procedures

Sessions lasting 2 to 3 hours were designed to provide cross-curricular learning experiences for practicing skills needed for participatory 21st century citizenship. They also provided educators professional development opportunities and new ideas for their work. Two researchers conducted sessions together with a teacher, who facilitated the organization, for example, by forming pairs and small groups within each student group. First, collaborative reflection was fostered by filling out the web questionnaire in pairs. Learners were asked to negotiate and seek consensus before grading the Likert statements but to convey both students' opinions on open-ended questions. Work was done in gender-homogeneous pairs (when possible) in order to facilitate the analysis of gender differences.

Second, learners were asked to co-design and create quick scale models mostly out of recycling materials. They worked in five mixed-gender subgroups, and each subgroup was asked to design a space for a specific learning situation. Learners could build any kind of spaces they wished, with the stipulation that they must justify how these spaces provide good conditions for the assigned learning situation. Finally, civic participation was practiced by group discussions held in an authentic partnership with external educational stakeholders (i.e. researchers). In the spring 2012, these discussions were held during the ongoing construction of the scale models in the classroom. In the autumn 2012, we chose to move the group discussions to a separate, more peaceful space.

Data Analysis

The reliability of findings has been augmented by collaborating with several researchers within a research group and by cross-analyzing different data types. The qualitative data were analyzed, coded, and classified using content analysis techniques. As an example, responses to the open-ended question "What is the most important thing for you at school?" were coded into two main categories, namely answers related to leisure time (e.g., friends, breaks, school meals) versus learning situation (e.g., learning some specific subjects). The coding approach allowed for one or more distinct and significant content elements per received response. With the scale models and transcriptions of group discussions we identified the most common themes and calculated their frequency (e.g., physical activity, presence of nature,

traditional vs. novel elements). As the objective of the first design cycle was to test our preliminary framework and approach in general and because the sample size (especially for each grade level) was small, at this phase running extensive and multiple statistical tests was not considered relevant. Instead, in the current analysis, numeric trends pertaining to variable distributions (means and standard deviation) and group differences (Independent-Samples T Test) were only used to support the analysis of the qualitative data. In the following Results section, we have focused our numeric analysis on 19 Likert-scale items that clearly could be associated with both the verbal and visuospatial data types.

Results

Table 1 presents first the mean scores and standard deviation of the Likert-ratings. Due to a slight variation in how the questionnaire was administered, of the total of 43 unique responses on Likert items; 32 came from single-gender pairs, 5 from mixed-gender pairs, and 6 from individuals. In general the students rated the items of all three constructs considerably high, with girls typically giving higher average ratings and exhibiting more homogenous answer patterns than boys.

Second, Table 2 presents 22 scale models constructed during the workshops. They are numbered and referred in the text so that the first number refers to the grade and the second number to the type of learning situation (e.g., 2.1 = 2nd graders' space for Learning Situation 1, learning by studying). The scale models constructed represent informal (e.g., 8.4. a lounge), non-formal (e.g., 4.5 a. a gym), and formal (e.g., 2.1. a classroom) learning spaces, both indoor (e.g., 8.3. a café) and outdoor (e.g., 6.3. a park).

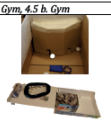
The reporting of the results is structured under the three section subheadings each representing one construct of our framework. The numeric findings are linked and presented together with qualitative insights. Content elements extracted from the data are referred to in percentage form so as to facilitate the comparison.

Table 1: Mean scores and standard deviation, M (SD), of the Likert ratings of the positive effect of the items on learning as assessed via a web questionnaire.

How much, in your opinion, can the following items improve and make learning more enjoyable? (1 = very little, 2 = a little, 3 = some, 4 = much, 5 = very much)	*All n= 43*	*Girls n= 16*	*Boys n= 22*	*Grade 2 n=10*	*Grade 4 n=10*	*Grade 6 n=13*	*Grade 8 n=10*
Overall wellbeing							
Safety	4.3 (1)	4.7 (0.5)	3.9 (1.2)	4.9 (0.3)	4.2 (0.9)	3.8 (1.4)	4.4 (0.7)
No behavioral disturbance	3.8 (1.3)	4 .1(1.2)	3.5 (1.3)	4.3 (1.3)	3.9 (1.3)	3.8 (1.3)	3.2 (1.1)
Enough breaks and rest	4.2 (1.2)	4.6 (0.6)	3.9 (1.6)	4.4 (0.8)	3.9 (1.6)	3.9 (1.4)	4.7 (0.9)
Good peer relations	4.3 (1)	4.4 (0.9)	4.2 (1.1)	4.6 (0.7)	4 (1.3)	4.2 (1)	4.6 (0.7)
Good teacher-student relations	4.2 (1)	4.6 (0.6)	3.8 (1.2)	4.7 (0.5)	4 (1.2)	3.8 (1.3)	4.3 (0.7)
Good home-school relations	4.2 (1.1)	4.3 (1.1)	4.0 (1.2)	4.9 (0.3)	4.6 (0.7)	3.7 (1.2)	3.7 (1.3)
Learning situation							
Usefulness of studies in own life	4 (1)	4.3 (0.8)	3.9 (1.2)	4.6 (0.7)	3.8 (1.3)	3.9 (1)	3.8 (0.9)
Designing own learning and learning environments.	3.8 (1.2)	3.9 (0.8)	3.6 (1.5)	4.3 (0.8)	3.8 (1.2)	3.3 (1.3)	4.1 (1.4)
Teachers' professional skills	4.1 (1.1)	4.5 (0.7)	3.7 (1.3)	4.3 (1.3)	4 (1.2)	3.9 (1.1)	4.3 (0.8)
Versatile teaching methods	4.2 (1.1)	4.6 (0.6)	3.9 (1.2)	4.4 (0.8)	3.8 (1.5)	4.1 (1)	4.4 (0.8)
Pair work	4.1 (1.1)	4.4 (0.9)	4 (1.1)	4.5 (0.7)	3.3 (1.2)	4 (1.2)	4.7 (0.5)
Group work	3.9 (1.1)	4.3 (1)	3.5 (1)	4 (0.9)	3.1 (1.1)	4 (1)	4.3 (0.9)
Individual work	3.2 (1.4)	3.2 (1.5)	3 (1.4)	3.7 (1.4)	3.5 (1.4)	3.2 (1.4)	2.4 (1.5)
Learning tools and space design							
Versatile materials	4 (1)	4.2 (0.8)	3.8 (1.1)	4.1 (0.9)	3.9 (1.4)	3.8 (1)	4.2 (0.9)
Use of technology	4.1 (1.2)	3.8 (1.2)	4.3 (1)	3.7 (1.4)	3.7 (1.6)	4 (0.8)	4.8 (0.4)
Interesting school books	4 (1.3)	4.3 (0.8)	3.8 (1.5)	4.4 (0.7)	3.8 (1.5)	3.8 (1.3)	4.1 (1.4)
Luminosity	4.2 (0.9)	4.3 (0.8)	4.2 (0.9)	4.4 (0.8)	3.7 (1.1)	4.1 (1)	4.7 (0.5)
Spaciousness	4.2 (0.9)	4.3 (0.8)	4.2 (0.9)	4.3 (0.8)	4.1 (1.2)	4 (0.8)	4.6 (0.7)
Aesthetics	3.3 (1.3)	3.3 (1)	3.4 (1.4)	3.3 (1.3)	3 (1.4)	3.4 (1.3)	3.7 (1.2)

Note: n refers here to the number of questionnaires analyzed. Mixed-gender pairings were excluded from the gender-related analysis.

Table 2: Scale models of learning environments constructed by learners.

Grade	1. Learning by studying	2. Learning by doing	3. Learning by socializing	4. Learning by reflecting	5. Learning by exploring
	2.1. Classroom	*2.2. Teaching kitchen*	*2.3. Beach*	*2.4. Math calculation castle*	*2.5. City*
2					
	4.1. Classroom	*4.2. Nuclear power plant*	*4.3. Disco*	*4.4. Library-swimming hall*	*4.5 a. Gym, 4.5 b. Gym*
4					
	6.1. Classroom	*6.2. Nuclear power plant*	*6.3. Park*	*6.4. Computer classroom*	*6.5 a. Ice-hockey rink, 6.5 b. Theater*
6					
	8.1. Classroom	*8.2. Gym*	*8.3. Café*	*8.4. Lounge*	*8.5. Park*
8					

Overall Wellbeing

> Two 4th grade boys: Friends and breaks are the most important things at school.
> Two 6th grade girls: It's impossible to learn if you can't concentrate because other people make noise or because you're tired.

As shown in Table 1, learners in general—but significantly more strongly, $t(35) = 3.00$, $p = 0.006$, the girls ($M = 4.7$) compared to boys ($M = 3.9$)—rated highly the item *safety.* A related item *no behavioral disturbance* was rated slightly lower ($M = 3.8$) but with a relatively high variability ($SD = 1.3$). Also, in the open-ended questions as well as during the group discussions students frequently referred both to safety and security issues (e.g., criminals, guns) and to issues related to a disturbance (e.g., bullying, troublemakers).

Significant as well was the importance placed on ample *breaks and rest* ($M = 4.2$; Table 1). This result is also supported by the responses received to the question "What is the most important for you at school?": 57 % of 41 content elements (36 unique responses) were related to leisure time and 43 % to learning situation. The percentage of answers related to leisure time was notably higher in answers received from boys (68 %) than from girls (42 %). The importance of breaks and rest to learners is exemplified in the following excerpt from the conversation with the 8th graders constructing a model of a lounge for learning by reflecting (8.4; Table 2):

> Boy 1: This'd be a lounge including sofas and so on.
> Boy 2: So after relaxing there, you'll go back to the classes more refreshed.
> Researcher: Could you just close your eyes and have a nap there?
> Boy 1: Yes, and when opening your eyes, the colorful space gives you energy!

All data types together revealed that in addition to breaks, students consider physical exercise and the presence of nature crucial for their learning and wellbeing. Of the 22 scale models (Table 2), 10 included possibilities for physical activity and 8 featured elements from nature including 6 with water featured prominently. One novel example was the 4th graders' model of a library-swimming hall for learning by reflecting (4.4; Table 2) for which they explained that when getting tired from reading, it is good to go swimming as, after a refreshing swim, it would be easier to concentrate on books again.

Furthermore, the items *good peer relations* ($M = 4.3$) and *good teacher-student relations* ($M = 4.2$) were deemed important and highlighted in all group discussions. Item *good home–school relations* was

rated significantly higher, t (41) = -3.55, p = 0.01, by 2nd and 4th graders in comparison to 6th and 8th graders. The result is also in line with older learners' preference for more autonomy, which was expressed in group discussions.

Learning Situation

> Two 2nd grade girls: We go to school to learn new things.
> Two 8th grade boys: We go to school to get a job we like.

In answers to the question "Why do you think we go to school?", as much as 80 % of the 44 content elements (43 unique responses) were related to learning, 11 % to obtaining success in life, and 9 % to schooling as a compulsory duty. Frequently, learning was referred to as something useful and learning contents were criticized as being useless only in few responses. Also the item *usefulness of studies in own life* was rated relatively high (M = 4.0; Table 1). It is interesting that grade 8th pairs were more likely to perceive school as a means to succeed (e.g., professionally, financially) in life (36 % of 11 content elements) or to report that they attend school because it is obligatory (18 % of content elements).

The item *designing own learning and learning environments* received only moderate ratings (M = 3.8; Table 1). Nevertheless, the enthusiasm shown towards the workshops and the comments received from learners imply that learners do value these possibilities. The items *teachers' professional skills* and *versatile teaching methods* were rated again highly (M= 4.1 and 4.2; Table 1). During the group discussions students attached a lot of importance to teachers' role and their comments frequently referred to teacher-led instruction. For example, when discussing with students about the teacher's position in learning spaces, 5 groups expressed that teacher should have their own corner and a table, although the teacher would not be only sitting down but would move around and guide learners. Instead of organizing desks in a circle, it would be better to have teachers in the front so as to enable direct eye contact, reflected 8th grade students designing a classroom (8.1; Table 2). On the other hand, 5 groups were challenging teachers' special position, for example, by suggesting that they should sit at their desk like students or that students should have equally comfortable chairs and furniture as teachers have in the classrooms and staffroom.

The majority of learners valued collaborative learning. Table 1 shows that items *pair work* (M = 4.1) and *group work* (M = 3.9) were rated higher than *individual work* (M = 3.2). The value attached to individual work appeared, however, to have high variability (SD = 1.4). The following excerpt from the conversation with 8th graders documents this in terms of both general preferences as well as how individual preferences may differ:

> Researcher: How would you organize your learning spaces?
> Girl 1: Nobody would be sitting alone but we'd work more in groups.
> Researcher: Do you think that it's nicer to work in groups or pairs instead of working alone?
> Girl 1: It's nicer in a group.
> Girl 2: I think with a pair.
> Researcher: Is it that you don't like studying alone?
> Girl 1: Exactly.
> Girl 2: …well, on the other hand, studying by myself may be easier for me.

Learning Tools and Space Design

> Girl and boy in 6th grade: You can learn everywhere if you want and make an effort.
> Boy in 8th grade: Using tablets would bring nice variation to studying.

As Table 1 presents, students rated favorably the items *versatile materials* (M = 4) as well as both the *use of technology* (M = 4.1) and *interesting school books* (M = 4). Technology (e.g., interactive whiteboards, laptops, tablets) was included explicitly in 9 different scale models. Its use was the only aspect where boys (M = 4.3, SD = 1) provided on average higher and more homogeneous ratings than girls (M = 3.8, SD = 1.2). The following excerpt from the discussion with 2nd graders illustrates the typical gender difference rendered statistically significant among 2nd and 4th graders, t (15) = -2.91, p = 0.01, but not among 6th and 8th graders, t (18) = 0.42, p = 0.68:

> Researcher: Do you prefer studying using technology or traditional materials?
> Boy 1: We should have huge computers to play with!
> Researcher: What about tablets and mobiles?
> Boy 1: Everyone should have them!

Boy 2: Yes, it'd be cool!
Researcher: What about girls?
Boy 1: Then we could have LANs…
Girl 1: Something in between.
Girl 2: Also something in between.
Boy 1: … and play twelve hours, the whole school day!
Girl 1: Twelve hours?
Boy 1: Yes, twelve hours!
Boy 2: Now you've got a point there!

As a whole, 8th graders gave especially high ratings to the use of technology (M = 4.8) and their answers were polarized less between genders. In the group discussions both girls and boys expressed both pros and cons (e.g., distraction vs. engagement) concerning ICT-enhanced learning.

Table 1 shows that learners also rated high the items *luminosity* (M = 4.2) and *spaciousness* (M = 4.2). In the group discussions, the youngest learners wished for more space to play, whereas the oldest learners complained about overly cramped spaces or uncomfortably small furniture. Finally, although the item *aesthetics* received very low scores (M = 3.3; Table 1), student designs show that learners paid a lot of attention to decoration, colors and beauty (Table 2).

As Table 2 illustrates, all scale models included traditional (e.g., desks, chalkboards) as well as novel (e.g., spacious multipurpose rooms, enormous glass walls) elements. Most of the designs represented elements that are employed already either for Finnish curricular or extra-curricular activities (see Finnish National Board of Education 2004). In addition to canteens (8.3. a café), libraries (4.4), traditional classrooms (2.1, 4.1, 6.1, 8.1), computer classrooms (6.4), typically forming part of all school premises, spaces such as teaching kitchens (2.2) are used already in secondary school. Further, according to the designers, the disco (4.3) could be used for Home Economics and Physical Education. Parks (6.3, 8.5), gyms (4.5 a, 4.5 b, 8.2), ice rinks (6.5 a), and swimming halls (4.4) are also commonly used for Physical Education and recreation. Even nuclear power plants (4.2, 6.2)—the inclusion of which apparently was influenced by the news regarding their construction in Finland—could be employed for Introduction-to-working-life periods during which time secondary school students work in genuine work environments. The theatre (6.5b), city (2.5), and beach (2.3), in turn, are examples of non-formal or informal environments that are at time destinations for study projects or school trips. (Table 2.)

All in all, younger learners seemed to express more courageously imagination and creativity and boys more so than girls. For example, one group of 2nd graders designed a math calculation castle for learning by reflecting (2.4; Table 2). Another group of 2nd graders envisioned converting the whole school into a bouncy castle. Further, some 2nd grade boys were hoping for chairs that move with electricity and a book that reads by itself.

Discussion

Although effectiveness of learning environments is goal- and domain-specific and depends on the cultural context and professional traditions of each educational organization (see OECD 2009, 97), learners' perceptions' on ideal learning environments seemed to be very much in congruence with our preliminary framework built on the basis of national and international literature. This makes us think that, even though the sampling approach used in this pilot does not allow statistical generalization of our results, it allowed "'analytical' forms of generalization" (see van den Akker 2007, 49) to be presented in line with contemporary discussions.

1. We found that learners' shared perceptions resonated with studies suggesting that wellbeing, including aspects such as safety and good social relations, affect learning and school satisfaction (e.g., Awartani et al. 2008; OECD 2009). The importance of factors such as good home-school relations, however, seemed to diminish along with older students' growing needs for autonomy. Moreover, students clearly expressed that rest, breaks, socializing, physical exercise, and being close to nature are essential to their wellbeing (similar findings, see e.g., Piispanen 2008; Kangas 2010; Meskanen 2009; Ghaziani 2010). It is interesting that the Finnish school system is known already for considering well these elements (e.g., UNESCO 2012, 36).

2. Learner's perception of the learning situation was in harmony with research suggesting that perceived usefulness of studies to one's own life, as well as varied, collaborative and learner-centered instructional practices, can improve affective and cognitive learning outcomes (e.g., OECD 2009). However, instead of valuing designing one's own learning and learning environments particularly high, learners seemed to give a lot of importance to teacher's role in the design and leadership of teaching-learning interaction. Nevertheless, when learners were given opportunities to express their voice, they were very enthusiastic about it. Hence, considering learners' perceptions can actually mean that self-

regulated and self-directed learning should be fostered without completely abandoning so called teacher-centered practices, such as teacher-regulated instruction (see also Kumpulainen et al. 2012).

3. Similar to other studies (e.g., Kangas 2010), learners seemed to value both traditional and novel tools and spaces for working as well as the ubiquity of learning environments. However, the freshest design ideas came from the youngest learners. If one of the objectives of educational organizations is to foster creativity, more effort may be needed so as not to hinder innovativeness in later years. Moreover, attention should be given to good lighting conditions and learners' wishes for colorful and aesthetically pleasing environments (see also Meskanen 2009; Ghaziani 2010). Finally, there should be enough space for younger learners, in particular, to play (see Ghaziani 2010) and for older learners not to feel uncomfortably crowded.

The overall results are also in line with studies suggesting that girls as a group have more conformist views of school than boys (Moroz 2001; Clay 2008; Linnankylä and Malin 2008). Also, in harmony with other studies (e.g., Moroz 2001), boys in general valued the use of technology more than girls. The gender difference was, however, statistically significant only among younger learners. Our results are also in harmony with other studies suggesting that "efforts to democratize classrooms and allow for greater choice in learning and assessment" (Clay 2008, 35) as well as more versatile use of ICT (see Linnankylä and Malin 2008) could have positive academic and affective impacts especially on subgroups consisting primarily of male and adolescent students with low engagement levels and negative attitudes towards schooling. We think that enhancing opportunities to design one's own learning environments is already a significant step toward more participatory school culture and can contribute to increasing school satisfaction of both genders. Furthermore, based on our findings, we argue that although girls as a whole may need more support in order to develop critical thinking, some subgroups of boys and older learners may need to be guided to convert anti-school attitudes into constructive criticism. Also more efforts may be needed so as to actively support diversified growth of both feminine and masculine identities and thus provide tools to deal with the conformist pressure typical to many organizations (see also Clay 2008).

One could argue that learners tended to interconnect aspects related to their overall wellbeing, learning situation, and physical environment only because of the framework we used and that the interactive knowledge-construction process guided them to do so. Nonetheless, similar observations made in studies using the grounded theory approach (e.g., Kangas 2010) indicate that our results do reflect the learners' perceptions reliably. It is possible, however, that focusing on consensual beta press instead of private beta press led us to construct a less critical and more homogeneous image of learners' perceptions (see Fraser 1998). In the future, more attention could be paid to individual views or to specific student groups such as disengaged learners with school-adverse attitudes.

Concluding Remarks

The results considered in this article led to the formulation of the collaboratively developed substantive design principles for the effective 21st century learning environments that can be encapsulated into the following characteristics:

- Overall wellbeing:
  - safety and peacefulness;
  - possibilities to socialize, be physically active, rest and enjoy nature; and
  - support for diversified growth towards autonomy,
- Learning situation:
  - use of diverse but especially collaborative methods;
  - connectedness with students' real-life aspirations; and
  - opportunities to make choices related to own learning, and
- Learning tools and space design:
  - variable, both traditional and technological tools;
  - ubiquitous formal, non-formal, and informal (both indoor and outdoor) learning spaces; and
  - luminous, spacious and aesthetic environments.

The power of these design principles lays in the fact that they were co-designed with learners and, therefore, echo their voice. In this sense they are not transferable directly to other educational organizations or cultural settings, but have to be designed collaboratively within every educational organization. Naturally, design principles formulated with different stakeholders can be proved effective only if they are subsequently put into practice.

All in all, learners' views on psychosocial and physical learning environments conductive to learning and wellbeing seemed to be very realistic and pragmatic. Learners' wishes for both novel and traditional ways, tools and spaces for working also appeared in harmony with the Finnish educational change, which is often considered as evolutionary instead of revolutionary (e.g., Sahlberg 2009). Hence, we think that adding this kind of learners' real-life expertise to the design of the effective 21st century learning environments could even be used to mitigate "overly big innovation ambitions" of some school reformists (see van den Akker 2007, 42).

The design principles developed in this pilot have served already as a base for the design of the second research cycle at the participating teacher training school, in which we have co-designed new social practices and infrastructure for secondary school Natural Science classes (see Mäkelä, Mikkonen, Lundström, 2013). Redesigned and reformed spaces have been deployed and their effectiveness is currently being evaluated. Furthermore, the possible cross-cultural generalizability of our study has been investigated by comparing these results with a similar case study in Spain.

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REFERENCES

van den Akker, Jan. 2007. "Curriculum Design Research." In T. Plomp & N. Nieveen (Eds.), *An Introduction to Educational Design Research*. Enschede, the Netherlands SLO: 37-50.

Awartani, Marwan, Cheryl Vince Whitman, and Jean Gordon. 2008. "Developing Instruments to Capture Young People's Perceptions of How School as a Learning Environment Affects of Their Well-Being." *European Journal of Education,* 43 (1): 51-70.

Binkley, Marilyn, Ola Erstad, Joan Herman, Senta Raizen, Marting Ripley, Mat Miller-Ricci, and Mike Rumble. 2012. "Defining Twenty-first Century Skills." In P. Griffin, B. McGaw & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills.* Dordrecht: Springer: 17-66.

Bronfenbrenner, Urie. 1994. "Ecological Models of Human Development." *International Encyclopedia of Education, Vol. 3, 2nd Ed*: 1643-1647. Oxford: Elsevier.

Brown, Ann, L. 1992. "Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings." *The Journal of the Learning Sciences,* 2(2): 141-178.

Cam Aktas, Bilge. 2010. "Investigating Primary School Students' Perceptions Regarding 'Teacher' Through Their Drawings." *The International Journal of Learning, Vol. 17, Num. 8:* 408-425.

Clay, Victoria. 2008. "Gender Differences in Measures of Satisfaction with School and General and Academic Self-Concept." *The International Journal of Learning,* vol. 15, num. 8: 31-40.

Collins, Allan, Diana Joseph, and Katerine Bielaczyc. 2004. "Design Research: Theoretical and Methodological Issues." *The Journal of the Learning Sciences,* 13 (4): 15-42.

The Design-Based Research Collective. 2003. "Design-Based Research: An Emerging Paradigm for Educational Inquiry." *Educational Researcher*, Vol. 32, No. 1: 5-8.

Dewey, John. 1899/1980. *The School and Society*. Carbondale, IL: Southern Illinois University Press.

European Parliament and Council. 2006. "Key Compentences for Lifelong Learning: European Reference Framework." *The Official Journal of the European Union*, 30 December 2006/L394.

Finnish National Board of Education. 2004. *National Core Curriculum for Basic Education 2004.* Vammala, Vammalan Kirjapaino oy.

Foucault, Michel. 1975. *Discipline and Punish: the Birth of the Prison.* New York: Random House.

Fraser, Barry J. 1998. "Classroom Environment Instruments: Development, Validity and Applications." *Learning Environments Research* 1: 7-33.

Ghaziani, Rokhshid. 2010. "School Design: Researching Children's Views." *Childhoods Today*, 4(1), 1-27.

Guney, Ali, and Selda Al. 2012. "Effective Learning Environments in Relation to Different Learning Theories." *Procedia, Social and Behavioural Sciences* 46: 2334-2338.

Hutchison, Alan. 2012. "Mind the Gap: Education Reform Policy and Pedagogical Practice." *The International Journal of Educational Organization and Leadership*, Vol. 19: 1-12.

Kankaanranta, Marja, and Eija Puhakka. 2008. *Kohti innovatiivista tietotekniikan opetuskäyttöä. Kansainvälisen SITES 2006 –tutkimuksen tuloksia.* (Towards Innovative Use of Technology in Teaching. Results from the International SITES 2006 Study) Jyväskylän yliopisto: Koulutuksen tutkimuslaitos (University of Jyväskylä: Finnish Institution for Educational Research.

Kangas, Marjaana. 2010. "Finnish Children's Views on the Ideal School and Learning Environment." *Learning Environments Research* 13: 205-223.

Kumpulainen, Kristiina, Leena Krokfors, Lasse Lipponen, Varpu Tissari, Jaakko Hilppö, and Antti Rajala. 2010. *Learning Bridges. Toward Participatory Learning environments.* Cicero learning. University of Helsinki.

Könings, Karen D., Saskia Brand-Gruwel, and Jeroen, J.G. van Merriënboer. 2005. "Towards More Powerful Learning Environments Through Combining the Perspectives of Designers, Teachers, and Students." *British Journal of Educational Psychology,* 75: 645-660.

Land Use and Building Act (132/1999, amendment 222/2003 included) Chapter 1 Section 5. Unofficial translation available from http://www.finlex.fi/en/laki/kaannokset/1999/en19990132.pdf

Linnankylä, Pirjo and Antero Malin. 2008. "Finnish Students' School Engagement Profiles in the Light of PISA 2003." *Scandinavian Journal of Educational Research*, 52: 6, 583-602,

Meskanen, Sini. 2009. *Future School – Designing With Children.* Publications in Architecture 2009/100. Helsinki, University of Technology.

Moroz, Wally. 2001. "Boys Will Be Boys: Implications of Students' Perceptions of Their Learning Environments." Proceedings of the *Learning Conference 2001*.

Mäkelä, Tiina, Inka Mikkonen, and Anette Lundström. 2013. "Co-designing 21st Century Secondary School Natural Science Learning Environments." Case study. *European Schoolnet*, Brussels.

OECD. 2009. *Creating Effective Teaching and Learning Environments: First Results from TALIS*. OECD.

Piispanen, Marika. 2008. "Good Learning Environment. Perceptions of Good Quality in Comprehensive School by Pupils, Parents and Teachers". *University of Jyväskylä. Kokkola University Consortium Chydenius*.

Plomp, Tjeerd. 2007. "Education Design Research: an Introduction." In T. Plomp & N. Nieveen (Eds.), *An Introduction to Educational Design Research*. Enschede, the Netherlands SLO: 9-35.

Sahberg, Pasi. 2009. "Educational change in Finland." In A. Hargreaves, M. Fullan, A. Lieberman & D. Hopkins (Eds*.) International Handbook of Educational Change*. Kluwer Academic Publishers.

Sanders, Elizabeth B.N., and Jan Pieter Stappers. 2008. "Co-creation and the New Landscapes of Design." *CoDesign, Taylor & Francis,* March 2008.

Scardamalia, Marlene, John Bransford, Bod Kozma, and Edys. E. Quellmalz. 2012. "New assessment and environments for knowledge building." In P. Griffin, B. McGaw & E. Care (Eds.), *Assessment and teaching of 21st century skills.* Dordrecht: Springer.

UNESCO. 2012. *A Place to learn: Lessons from Research on Learning Environments.* Technical paper No. 9. Montreal: UNESCO Institute for Statistics.

Vygotsky, Lev Semyonovich. 1978. *Mind in Society. The Development of Higher Psychological Processes.* (M. Cole, Ed.) Cambridge, MA: Harvard University Press.

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II

DEVELOPING A CONCEPTUAL FRAMEWORK FOR PARTICIPATORY DESIGN OF PSYCHOSOCIAL AND PHYSICAL LEARNING ENVIRONMENTS

by

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ORIGINAL PAPER

Developing a conceptual framework for participatory design of psychosocial and physical learning environments

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Abstract The present study shows how the mixed-methods approach can be used in capturing and organising learning environment (LE) characteristics for the participatory design of psychosocial and physical LEs involving learners. Theoretical constructs were tested and further elaborated on in the analysis of two similar educational design research studies: one conducted with 7- to 14-year-old learners in Finland ($n = 80$); and the other in Spain ($n = 76$). Cross-analysis of the numeric, visuospatial and verbal data collected, combined with theoretical and practical considerations, was used to develop a conceptual framework for LE co-design, which draws attention to the importance of balancing communality with individuality, comfort with health, and novelty with conventionality. In line with other studies, in this conceptualisation, flexibility and functionality are seen as central enablers for quality twenty-first century LEs. The knowledge exchange between two countries and the constructs developed in this cross-cultural analysis contribute to the creation of shared content-related design principles for future learning environments.

Keywords Conceptual framework · Educational design research · Mixed-methods approach · Participatory design · Physical learning environment · Psychosocial learning environment

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Introduction

Recently, the design of both psychosocial and physical learning environments (LEs) has come under intensified international scrutiny. LEs are expected, amongst other things, to support the paradigm shift from learning via teacher-centred knowledge transmission towards learner-centred knowledge construction in which learners are (co-) designers of their own learning and LE (Scardamalia et al. 2012; see also Pieters 2004). Further, interrelations—although not always direct and linear—found between psychosocial and/or physical LE and wellbeing, emotions, engagement, satisfaction, attendance and learning outcomes (Awartani et al. 2008; Higgins et al. 2005; Linnankylä and Malin 2008; Liu et al. 2012; Marchand et al. 2014; Wang and Holcombe 2010; Zandvliet and Fraser 2005) call for a holistic and multidisciplinary design for learning environments that is supportive to both learning and wellbeing, and pays attention to the personal, social, physical and also virtual LE dimensions. In this vein, our research aimed to fill the gap between theoretical discourses on LE designs and their application in educational research and practise. Therefore, the current paper contributes to the creation of a conceptual framework for capturing and structuring the main psychosocial and physical LE characteristics that are supportive to learning and wellbeing.

Educational stakeholders' everyday perceptions of the contemporary LE indicate that the aforementioned visions of twenty-first century LEs have not yet been fulfilled in practice. For instance, an Austrian study revealed that, although local schools that participated in the OECD project for Innovative Learning Environments (ILE) had made clear efforts to meet the requirements, learning still appeared "as a reproduction of the knowledge and information presented to the pupils by the teachers" (Schrittesser et al. 2014, p. 150). A major burden on LE design research and practice, however, has been the lack of a shared theoretical framework and concepts among studies conducted in different cultural and disciplinary contexts, which undermines the comparability, generalisability and build up of a coherent body of knowledge (e.g. Cleveland and Fisher 2014). This circumstance is in contrast to the otherwise lively ongoing LE research, which includes (1) qualitative small-scale studies that give learners active agency and involve them in the LE design (e.g. Kangas 2010; Kostenius 2011; Papatheodorou 2002), as well as (2) several studies that contribute to the understanding of interrelations between psychosocial and physical LEs. These studies include the following:

- Educational studies, such as research in Canada that links facility design, educational practice, school culture and learning (Gislason 2010) and mixed-methods studies on physical and psychosocial computer classroom environments in Australia and Canada (Zandvliet and Fraser 2005) and in Taiwan (Liu et al. 2012).
- Architectural studies such as the research that led to 'environment-human-performance model' in the United Kingdom for identifying the impact of classroom design (e.g. flexibility and light) on learning (Barrett et al. 2013) and research eliciting British children's views about school design (Ghaziani 2010).
- Environmental psychological studies, such as the one conducted in the United States that provided evidence for the impact of a classroom-built environment on student perceptions and learning (Marchand et al. 2014) and the study in the UK that demonstrated a connection between teaching environments and teacher-centred or child-centred pedagogies (Horne Martin 2002).

With the increase in the attention paid to LE design, substantial shortcomings were revealed not only with regard to the current practical implementations of LE but also, more

importantly, with regard to the conceptual understanding of LE (see also Engeström 2009). This situation poses a major conundrum in that the demand for and execution of LE (re)design is inherently undermined by a lack of understanding about the LE design's core content and procedural constituents.

Our research responded to this need with a manifold, longitudinal program. The current paper reports the initial, explorative phase of the research, which contributes to the creation of a trans-national, or shared, conceptual framework for capturing and structuring the main LE characteristics supportive to learning and wellbeing. However, in this phase, we have not focused on the scope of sociocultural differences in LE preferences (Aldridge and Fraser 2000; Liu et al. 2012). The targeted framework is particularly applicable to participatory LE co-design (i.e. collaborative design) that involves various stakeholders but emphasises learners' active roles as designers (Pieters 2004). The framework can be used both in individual LE co-design projects and in comparing and generalising their findings across cultures.

Development of the preliminary conceptual framework (version 1.0)

This study is part of a long-term educational design research initiative that aims to develop a research-based toolkit including both substantive (i.e. content-related) and procedural (i.e. process- or method-related) design principles and requirements for the participatory co-design of learning environments (Mäkelä et al. 2014). As is typical in educational design research (Plomp 2007; van den Akker 2007), the study consists of iterations, with each iteration considered a semi-independent research cycle leading to progressive improvement of the research design (i.e. the conceptual framework in this paper's context). This progress is driven by means of in situ action and reflection, as well as formative evaluation between each research cycle, until the next desired outcome is reached.

One of the very first tasks of the study was gathering and structuring into a preliminary conceptual framework the main characteristics of LEs that are supportive to learning and wellbeing (Version 1.0, henceforth referred to as V1.0). The theoretical foundations of our study were investigated both in contemporary discourses representing various fields of study, many of which were also discussed in earlier literature reviews (e.g. Higgins et al. 2005; UNESCO 2012) and in earlier considerations to which these studies often refer to (e.g. Bronfenbrenner 1979; Dewey 1907, 1916; Vygotsky 1978). The main learning environment characteristics of conceptual framework V1.0 were initially divided into three partially-overlapping constructs: (I) Overall wellbeing, (II) Learning situation and (III) Learning tools and space design (Table 1). The aim of having these constructs was to capture the most frequent and prominent internationally-shared characteristics related to the psychosocial (i.e. personal and social) and physical LE dimensions of learning and overall wellbeing. The virtual LE dimension was included at this stage only from the viewpoint of considering the use of technology in LEs (see also Cleveland and Fisher 2014; Zandvliet and Fraser 2005).

Overall wellbeing

The LE characteristics grouped under the initial construct named Overall Wellbeing reflected individuals' cognitive, affective, social and physical wellbeing (Awartani et al. 2008; Kangas 2010). A *shared vision about schooling* was included as a contributor to

Table 1 Main constructs and LE characteristics of the preliminary conceptual framework (V1.0)

Construct	LE characteristics
I. Overall wellbeing	Shared vision about schooling Safety No behavioural disturbance Teacher–student relations Peer relations Staff–student relations Home–school relations Wider community relations No noise disturbance No overload Indoor air quality Outdoor areas Physical exercise Presence of nature Quality of meals
II. Learning situation	Versatile teaching methods Teacher-led instruction Self-regulated learning Involvement and self-expression Personal relevance of studies Personalization Collaborative work Individual work Personal relevance of assessment
III. Learning tools and space design	Versatile use of materials Use of technology Use of books and other traditional tools Novel and conventional LE design Ubiquitous (formal, non-formal, informal) LE Luminosity Spaciousness No disorganization Aesthetics and colours Sustainability Adaptability Functionality and practicality

overall wellbeing based on the opinions of authors such as Dewey (1916), who criticised externally-imposed educational aims (see also UNESCO 2012). The characteristics of *safety*, *no behavioural disturbance* and (good) *teacher–student relations* and *peer relations* have been stressed in a study conducted in the UK with children aged 5–7 years (Ghaziani 2010), in a study in Finland involving primary-school pupils (Piispanen 2008), and in a study in the Middle East with secondary-school students (Awartani et al. 2008). Teacher–student relations and peer acceptance, in particular, have also been viewed as important socio-cultural components of school engagement (Linnankylä and Malin 2008). The construct Overall Wellbeing also entailed consideration of *staff–student relations, home–school relations* and *wider community relations* (e.g. Dewey 1907, 1916; Vygotsky 1978; see also Higgins et al. 2005). In addition to the social components promoting wellbeing, this construct covered characteristics related to health such as *no noise disturbance, no overload* and *indoor air quality*, which are discussed in studies conducted in 23 Spanish educational institutions offering nursery education (Crespo and Pino 2007) and with primary-school pupils in Sweden (Kostenius 2011). In harmony with studies on primary

school students in Finland (Kangas 2010) and the UK (Papatheodorou 2002), this construct also included (good) *outdoor areas*, opportunities for *physical exercise* and the *presence of nature* (see also Dewey 1907; Sanoff et al. 2001; UNESCO 2012). The value of nature and playgrounds that allow both rest and physical activity has also been highlighted in the literature on restorative environments (Bagot 2004; Kaplan 1995). Finally, *quality of meals* (Higgins et al. 2005; Wolff 2002) was incorporated into the first construct as a contributor to overall wellbeing.

Learning situation

Versatile teaching methods (e.g. Bronfenbrenner 1979; Dewey 1907) was the first characteristic selected for the second initial construct labelled Learning Situation (see Table 1). In line with studies such as the one which indicated that Belgian higher-education students viewed teacher-centredness and student-centredness as "mutually reinforcing features of high quality education" (Elen et al. 2007, p. 105), this construct contained characteristics often associated with both teacher-centredness and learner-centredness. In addition to *teacher-led instruction*, it included characteristics such as *self-regulated* (autonomous) *learning* (e.g. Pieters 2004; Vygotsky 1978; Zandvliet and Fraser 2005), *involvement and self-expression* (e.g. Dewey 1907, 1916; Zandvliet and Fraser 2005), *personal relevance of studies* (e.g. Papatheodorou 2002; Scardamalia et al. 2012) and *personalisation* or opportunities to work at the students' own pace (e.g. Gislason 2010). The choice of many of these characteristics is also reinforced by a study in which American secondary-school students' perceptions of psychosocial LE were found to be associated with school participation (behavioural engagement), school identification (emotional engagement) and the use of self-regulation strategies (cognitive engagement), all of which contributed to academic achievement (Wang and Holcombe 2010). Moreover, a study of Finnish secondary school students participating in PISA 2003 (Linnankylä and Malin 2008) indicated that regarding school as relevant for one's own future contributes to school engagement and academic performance. Further, in addition to including *collaborative work*, which is often viewed as centric to twenty-first century LEs (Gislason 2010; Scardamalia et al. 2012; Zandvliet and Fraser 2005), we incorporated *individual work* in the Learning Situation construct in order to gauge the value that participants assigned to this way of learning. With some exceptions (Wolff 2002), this is less frequently discussed in the recent literature. *Personal relevance of assessment* was the final LE characteristic included in this construct (Scardamalia et al. 2012).

Learning tools and space design

The LE characteristics grouped under the construct Learning Tools and Space Design (see Table 1) aimed at representing *versatile use of materials and spaces* (e.g. Dewey 1916; UNESCO 2012; Wolff 2002). This construct included *use of technology* as a natural part of twenty-first century LEs, which is emphasised, for instance, in a study on school authorities, teachers and secondary-school students in Belgium, Finland, Holland, Portugal, Spain and Sweden (Kuuskorpi and Cabellos 2011; see also Scardamalia et al. 2012; Zandvliet and Fraser 2005); moreover, it was combined with the *use of books and other traditional tools* (e.g. Kangas 2010). The third construct also contained characteristics related to both *novel* (e.g. open spaces) and *conventional* (e.g. classrooms) *LE design* (see Gislason 2010; Kuuskorpi and Cabellos 2011). The notion of a *ubiquitous LE,* which bridges *formal* (e.g. school), *non-formal* (e.g. museum and library) and *informal* (e.g. free time) learning, was

also adapted based on the relevant literature (e.g. Bronfenbrenner 1979; Dewey 1916; Scardamalia et al. 2012). Further, the Learning Tools and Space Design construct covered physical characteristics such as *luminosity*, *spaciousness*, *no disorganisation* (e.g. Barrett et al. 2013; Sanoff et al. 2001; Wolff 2002), *aesthetics and colours* and *sustainability* (UNESCO 2012). To conclude, *adaptability* as well as *functionality and practicality* were included in this construct as enablers of the versatile use of tools and spaces. This was supported, for example, by the North American 'Human-centred design guidelines' for higher education environments and its architectural notion of 'adaptable' (Gee 2006) and the British architectural design principle 'flexibility', which indicates "the degree to which the room plan allows varied learning methods and activities" (Barrett et al. 2013, p. 681; Kuuskorpi and Cabellos 2011; Wolff 2002). 'Functionality' associated with characteristics such as versatility, modifiability, flexibility and usability, in turn, has been featured in, for example, a Finnish architectural model on LE characteristics (Sulonen and Sulonen 2014).

In accordance with the design research approach and because of real-life design and development needs, this preliminary conceptual framework was put directly into practice in order to examine its workability in real-life situations. Analysis of the first research cycle conducted in Finland in 2012 (Mäkelä et al. 2014) indicated that learners' perceptions of a good LE were in line with the literature used to select the contents of our framework. The second cycle, part of which is reported in the present paper, focuses on more comprehensive development of the framework contents and constructs by consolidating insights from the first research cycle conducted in Finland and its replication in Spain.

The re-construction of a shared conceptual framework presented in this paper is based on the evaluation of relevance or content validity and consistency or construct validity (Plomp 2007) and is guided by the following research questions:

1. Do participant learners' views support the cross-cultural relevance of LE characteristics selected for the preliminary framework (V1.0)? Are there any new LE characteristics that were not previously represented in the framework?
2. Do the collected data support the consistency of the preliminary framework structure? Or do the empirical, theoretical and practical considerations suggest the need to reorganise the LE characteristics to improve their construct validity and model fit?

Method

Participants

The participating schools were recruited on a voluntary basis, with participant learners aged 7–14 years (total $n = 156$) in Finland and Spain. Because of their differing socio-cultural and educational contexts, these two countries were deemed appropriate for comparison in a European cultural context. The samples, however, were convenience samples based on the first author's cultural intimacy and linguistic knowledge of these countries as well as the accessibility and proximity of the schools to the researchers. Both schools were of similar size, with approximately 1000 students each.

The participant school in Finland is university affiliated and is used for teacher training in a town in Central Finland. As is typical in Finnish teacher training schools, the school is actively involved in pedagogical research and development projects locally, nationally and internationally. It follows the Finnish national core curriculum and offers free primary,

lower and upper-secondary school education for children and youth aged 7–19 years. The language of instruction is Finnish and, although we did not gather information about the participants' family background, only few immigrant participants were noted. In Finland, two researchers conducted the study with four 2nd, 4th, 6th and 8th grade teachers and their students (number of students = 80; 34 females, 46 males) in late spring and early autumn 2012.

The Spanish school participating in the study is located in a city in Catalonia, in northeastern Spain, and is a publicly-financed private school (*escuela concertada*). The school is very keen to be at the forefront of educational innovation. It follows the Catalan curriculum and offers, on the basis of the school fee, early childhood, primary, lower and upper-secondary education for 3- to 19-year-old learners in Catalan, Spanish and English. Within our sample, seven participants reported that their native language was not Spanish, Catalan or English (with their native languages including German, Armenian, French, Russian, Portuguese and Swedish). In Spain, the researcher conducted the study in collaboration with a Finnish interior design student (who participated as part of her Master's thesis on Finnish and Spanish school architecture and interior design), four teachers (a class teacher, a computer science teacher and two art teachers) and two 3rd grade student groups and one 9th grade student group (number of students = 76; 40 females and 36 males) in late autumn 2012.

Measures

The measures were designed for gathering numeric, verbal (written and oral) and visuospatial data so as to neither rely overly on participants' literacy skills (Woolner et al. 2010) nor only collect easily misinterpreted visual data (Kostenius 2011). The various types of materials as a whole covered all the learning environment characteristics included in our preliminary framework (V1.0, Table 1), while also allowing the capture of newly-emerging themes. Materials were also designed in a way that would enable versatile and engaging LE co-design sessions and authentic learning experiences (Staffans et al. 2008), without tiring the participants (Bagot 2004). The following paragraphs describe the main elements of each type of material. The structure of the complete material package is provided in the "Appendix".

First, instead of using strongly pre-framed standardised questionnaires (e.g. Fraser 1998), for the purpose of this study, a customised web-based questionnaire called Students' Perceptions of Good Learning Environments was created in Finnish and translated into English. In Spain, a 3rd grade classroom teacher reviewed the final wording of the statements in English to determine if they matched the participants' linguistic capacity (Bagot 2004). At this point, for instance, the expression 'adaptable' was considered as too abstract and was thus reworded as 'easy to modify'. In addition to background information (age, gender and, in Spain, home languages), the questionnaire was used to gather numeric and written data on students' perceptions of:

- (Possibly shared) views related to schooling:
  - Two open-ended questions were asked, namely, "Why do you think we go to school?" and "What is the most important thing for you at school?"
    Positive effects of the LE items on learning and wellbeing:
  - 34 5-point LE Likert-scale items (for the complete list of statements, see Table 2) were used.

Table 2 Statements in the questionnaire students' perceptions of good learning environments

Construct	Statements
I. Overall wellbeing	Safety
	Fresh indoor air which is not too hot or cold
	Spaces that are not too noisy
	Tasty and healthy school meals
	Good relations with all pupils
	That there are no trouble makers at school
	Good relations with teachers and other staff members
	Good relations between school and parents
	A sufficient amount of pauses and breaks
	Sufficient sleep
	Not too long school days
II. Learning situation	Nice teachers
	Teachers who teach well
	Interesting and different types of classes
	Working in groups
	Working in pairs
	Studying quietly alone
	Learning in peace at your own rhythm
	That we can use what we have learned in our own life
	Doing exams and getting grades
	Opportunities for creativity and self-expression
	Opportunities for designing your own learning and learning environments
III. Learning tools and space design	Functionality and practicality
	Easy to modify
	Environmental friendliness
	Tidiness and order
	Aesthetics and beauty
	Lots of light
	Lots of space
	Lots of different learning materials
	Use of technology
	Interesting school books
	Well-stocked pen case
	Good library

How much, in your opinion, can the following items improve and make learning more enjoyable? (scale: 1 = very little, 2 = a little, 3 = some, 4 = much, 5 = very much)

- Learning companions:
  - One multiple-choice question required the participant to select all the preferred learning companions from a list consisting of school community members (peers, teachers, principal), family members, members of a wider community, and 'other'.
  - One open-ended question, namely, "Who should not come to your learning environments?" was asked.
- Spaces for learning:
  - One multiple-choice question required the participant to select all the preferred spaces for learning from a list consisting of indoor, outdoor, nature, formal, non-formal, informal settings and 'other'.

- Two open-ended questions were asked, namely, "What is there that should not be in your LE?" and "Where do you think it is impossible to learn?" (For more information, see "Appendix").

Second, quick LE scale modelling or mock-up construction (Staffans et al. 2008) was used to gather visuospatial data from various learning situations. For this, teachers were instructed to ask their students to bring to school recyclable material, which they could use to create scale models in small groups for learning by either (1) studying, (2) doing, (3) socialising and (4) reflecting or (5) exploring the world (for more information, see Appendix). These learning situations were thought to sufficiently represent a variety of learning situations that set different requirements for the physical space design (Sanoff et al. 2001; Wolff 2002) and were also considered to be sufficiently comprehensive for 7- to 14-year-old participants.

Third, semi-structured group discussions on good LEs were employed to collect more first-hand information about the content of the LE scale models that the participants had designed. In addition to providing lots of space for free expression, we collected oral data, particularly on students' preferences (see also "Appendix") on:

– teaching–learning interaction (e.g. "Where would the teacher be in your learning environment")
– tools (e.g. "Would you prefer technological or traditional work and communication equipment?")
– space design (e.g. "Would the design be antique and traditional or new and modern" and "What kind of colours, shapes and surface materials would you like to have there?")

Procedures

Data collection was embedded in the participants' everyday schedules as a collaborative cross-curricular learning activity. Unlike in the traditional single-respondent method, the web questionnaire (filled out in a computer classroom or using laptops in a classroom) was first used as an introductory pair work activity. This choice was guided by pedagogical, design-related and practical considerations: It was thought to stimulate participants' thinking and give them an opportunity to practise their negotiation skills (Staffans et al. 2008). From a practical point of view, in this way, it was possible to fill out the web questionnaire as a short (not too time-consuming) introduction activity. Moreover, this method was also convenient in case the school did not have resources for each student to fill in the questionnaire separately. Further, especially for many of the youngest participants, it was the first time when they had responded to an online survey. Pair work enabled them to help one another both linguistically and technically. When filling out the survey, learners were asked to negotiate and come to a consensus before grading the LE Likert-scale items and to convey their opinions in response to the open-ended questions. Researchers and teachers clarified the concepts when and if needed (for a similar procedure, see Bagot 2004).

The introductory activity was followed by the collaborative scale model design via the 'learning by doing activity' conducted in an ordinary or art classroom. The groups were allowed to design any kind of space that they wished to, as long as they were able to justify how these spaces provided good conditions for the assigned learning situation. Finally, group discussions (conducted, apart from a few exceptions, in a separate and quieter space) not only gave the participants opportunities to express their views orally, but were also a

way for researchers to ensure that they would not later misinterpret students' visuospatial LE representations (Kostenius 2011). In Finland, group discussions were held in Finnish. In Spain, participants were encouraged to use all the languages (English, Catalan or Spanish) mastered by the researcher conducting the group discussions. It was possible to conduct all the activities in two hours but, if the teachers wished, we extended the time spent on the scale model design (see also "Appendix").

Data analysis

The study employed a mixed-methods approach with 'concurrent nested strategy', which means that statistical methods were embedded, or nested, within a predominantly interpretative and reflective data analysis, and that both quantitative and qualitative data types were collected concurrently and analysed as conjuncts (Creswell 2003, p. 218; also see Aldridge and Fraser 2000; Liu et al. 2012; Zandvliet and Fraser 2005). The data analysis was theory-driven in the sense that it was based on the learning environment characteristics selected for the preliminary framework (V1.0) (Table 1). Nevertheless, space was also given for new, emergent characteristics.

LE characteristics or content elements identified in written (open-ended questions), visuospatial (scale models) and oral (transcribed group discussions) data sources–coded using the Atlas.ti programme–were first quantified by calculating their frequency in percentages. Nevertheless, because of varying group assignments, quantitative results drawn from the scale models and group discussions were only considered to be indicative. As a rule of thumb, we included in the analysis only the content elements that were featured in more than 10 % of the analysed responses, scale models and group discussions. Yet, our primary focus was less on exact counts and more on overall trends and frequencies which were supported, contradicted or enriched by the numeric data (i.e. means and standard deviations of the Likert-scale ratings and responses to multiple-choice questions).

The actual analysis was then started by performing an exploratory factor analysis (principal axis extraction with direct oblimin) on the LE Likert-scale items to explore their underlying dimensionality and to serve as a guide for restructuring the preliminary theoretical constructs (see Table 2 and the next section). Our next objective was to investigate to what extent this statistically-developed LE content structure was resonated in, and supported by, the cross-analysis of various data types. For this purpose, we applied our 5-factorial model based on the Likert-scale ratings in the cross-analysis with all the data types collected. Content elements (LE characteristics) confirmed by numeric data and more-qualitative data were combined, merged and grouped under the renewed constructs, which were further divided into thematic sub-blocks. If the cross-analysis revealed some apparent discrepancies, a more in-depth analysis was conducted in order to search for their possible origin and explain them in light of the overall data (Aldridge and Fraser 2000). The conceptual framework restructuring process was finally completed based on the overall interpretations of the analytical efforts and the relevant research literature (see later "Discussion" section).

Results

A total of 81 unique web questionnaire responses (43 from Finland and 38 from Spain) and 40 learning environment scale models and related group discussions (22 from Finland and 18 from Spain) were collected. The following subsection reports the factor analytical LE

content structure based on the Likert-scale ratings. This is followed by the subsection describing the framework restructuring and refinement (V2.0) based on cross-analysis of various types of data.

Factor analytical LE content structure

The results of the exploratory factor analysis based on all the responses to the 34 LE Likert-scale items are presented in Table 3, along with the item distribution parameters and the internal consistency coefficient (Cronbach Alpha, α) for each factor scale. To highlight the evolution of the restructuring process, the first column further indicates the location of each LE Likert-scale statement under the three preliminary constructs (see Table 2). Each statement is represented by an abbreviated version of it.

In the factor analysis (principal axis extraction with direct oblimin), a solution with five factors was found to render the clearest pattern matrix and was the most promising from a theoretical perspective. Further, the total variance explained by all five factors was 58 %, more than half of which was attributable to Factor 1 and nearly 5 % to Factor 5, and it dropped below the 5 %-mark from Factors 6 onwards. With the exception of Factor 3 ($\alpha = 0.59$), the extracted dimensions were reinforced by strong scale internal consistencies, at 0.80 and above, which suggests that the items belonging to these factors assessed a common concept. For the current explorative research purpose, the consistency of Factor 3 was deemed sufficient within the context of the overall model fit. As can be seen from Table 3, a few items either cross-loaded above 0.35 on different factors, which indicates low divergent validity, or had loadings below 0.35, indicating low convergent validity. At this phase of framework development, we chose to group these items under the construct that they best suited thematically so as to be able to test their content and construct validity in the light of other data types.

Factor 1 (F1), which explained roughly a third of the overall variance (32 %, Table 3), was composed of 12 items that were initially grouped under the constructs (I) Overall Wellbeing (5 items) and (II) Learning Situation (7 items) (see Table 2). The common denominator for item loadings on F1 seemed to be related to the social LE dimension. F2 was composed of six items from all the three initial theoretical constructs (Tables 2, 3). These items seemed to represent aspects related to personal LE dimensions. F3 consisted of only three items originally grouped under the construct (III) Learning tools and space design (Tables 2, 3). These items appeared to be associated with comfort and pleasantness. F4 contained five items that all formed part of the original Overall Wellbeing construct (Tables 2, 3) and appeared to be related to health issues. Finally, F5 consisted of eight items that were previously all grouped under Learning Tools and Space Design (Tables 2, 3) and still seemed to best reflect these contents. Based on these thematic interpretations, we labelled the five factors as Communality (F1), Individuality (F2), Comfort (F3), Health (F4) and Versatile Tools and Spaces (F5).

Development of conceptual framework V2.0

The results of content refinement based on cross-analysis of various data types are presented in Table 4. This is followed by the overall results presented construct by construct.

(I) Communality

As can be seen from Table 3, the mean of the strongest factor, Communality, was high and its standard deviation was the lowest of all of the factors. The means of the responses

Table 3 Structure, distribution and factor loadings for the 34 Likert-scale items, including construct consistencies

Original no.	New item number and name	M (SD)	Factor loadings				
			F1	F2	F3	F4	F5
2.1.	I.1. Teacher–student relations	4.5 (.9)	0.67				
1.7.	I.2. Staff–student relations	4.3 (1)	0.65				
2.2.	I.3. Teachers' professional skills	4.4 (1)	0.60				
2.11.	I.4. Involvement	3.8 (1.1)	0.54				
2.10.	I.5. Self-expression	4 (1)	0.52				
1.8.	I.6. Home-school relations	4.4 (1)	0.49				
2.6.	I.7. Group work	4 (1.1)	0.48		0.50		
1.5.	I.8. Peer relations	4.4 (.9)	0.44				
2.3.	I.9. Versatile teaching methods	4.2 (1.1)	0.42				
1.6.	I.10. No behavioural disturbance	3.8 (1.3)	0.42				0.46
2.5.	I.11. Pair work	4.3 (0.9)	0.40		0.48		
1.1.	I.12. Safety	4.4 (0.9)	0.38				
2.6.	II.1. Individual work	3.4 (1.5)		−0.70			
2.7.	II.2. Personalization	3.8 (1.3)		−0.62			
2.8.	II.3. Personal relevance	4.2 (1)		−0.60			
3.4.	II.4. No disorganization	3.8 (1.1)		−0.43			
1.3.	II.5. No noise disturbance	4.1 (.9)		−0.42			
2.9.	II.6. Assessment	3.9 (1.2)	0.30	−0.31	0.33		
3.5.	III.1. Aesthetics	3.6 (1.2)			0.68		
3.7.	III.2. Spaciousness	4.3 (.9)			0.48		
3.6.	III.3. Luminosity	4.2 (1)			0.41		
1.9.	IV.1. Enough breaks and rest	4.1 (1.2)				0.78	
1.11.	IV.2. Length of school day	4 (1.3)				0.71	
1.10.	IV.3. Enough sleep	4.2 (1.2)				0.53	
1.4.	IV.4. Quality of school lunch	4.2. (1.3)				0.50	
1.2.	IV.5. Indoor air quality	4.3 (0.9)				0.48	
3.10.	V.1. Interesting school books	4 (1.2)					0.67
3.8.	V.2. Versatile materials	4 (1.1)					0.59
3.1.	V.3. Functionality and practicality	4 (.9)					0.55
3.11.	V.4. Writing and drawing supplies	3.6 (1.4)					0.55
3.12.	V.5. Library	3.7 (1.1)					0.49
3.2.	V.6. Adaptability	3.8 (1.3)					0.46
3.9.	V.7. Use of technology	4 (1.2)					0.44
3.3.	V.8. Sustainability	4.2 (1)				−0.35	0.30
	% of variance explained		32	7	6	8	5

Table 3 continued

Original no.	New item number and name	M (SD)	Factor loadings				
			F1	F2	F3	F4	F5
	Eigen value		11.0	2.4	2.0	2.8	1.6
	Alpha reliability		0.90	0.79	0.59	0.80	0.81
	Construct M(SD)		4.2 (0.7)	3.9 (0.8)	4.0 (0.8)	4.2 (0.9)	3.9 (0.8)

Loadings below 0.30 omitted

F1 Communality; F2 Individuality; F3 Comfort; F4 Health; F5 Versatile tools and spaces

to the 12 items associated with it ranged from 3.8 to 4.5. As Table 4 illustrates, cross-analysis of various data types led us to distinguish four thematic clusters related to communality, namely, (a) social relations, (b) teaching–learning interaction, (c) sense of belonging and (d) safety.

(A) Social relations Items I.1 (*teacher–student relations*), I.2 (*staff–student relations*), I.6 (*home–school relations*), and I.8 (*peer relations*) received the highest ratings among all the Communality items (Table 3), thus confirming the relevance of these LE characteristics for participant students. In the multiple-choice questionnaire responses on preferred learning companions, peers were chosen by 98 % of the respondents, both teachers and family members by 72 %, members of a wider community by 52 %, and the director only by 35 % of the respondents. Scale models and related group discussions confirmed the relevance of teachers and peers for learners, as teacher persona appeared in approximately half of the scale models, and peers appeared in all the scale models. Further, learning was deemed to be connected with the *wider community* in most of the scale models representing informal or non-formal out-of-the-school learning environments such as a city, football stadium and theatre (See Table 4).

(B) Teaching–learning interaction The high ratings for items I.3 (*teachers' professional skills*), I.7 (*group work*), I.9 (*versatile teaching methods*) and I.11 (*pair work*) (Table 3) also indicated that varying teaching–learning interaction was valued by the participants. Most of the scale models constructed for learning by studying featured elements that were associated both with teacher-led instruction (e.g. teacher's desk and a board in front of the classroom) and with collaborative learning (e.g. tables for group work). Collaboration was also featured prominently in other scale model types such as various team sport facilities and a teaching kitchen designed for learning by doing (see Fig. 1). The overall strengths of these two elements of teaching–learning interaction led us to confirm the significance of both *teacher-led instruction* and *collaborative learning* for participant students (see Tables 1, 4).

(C) Sense of belonging With regard to the LE characteristics that fed a sense of belonging into the school community (Table 4) and, although the ratings for items I.4 (*involvement*) and I.5 (*self-expressio*n) were relatively modest (Table 3), it was evident from the workshops that most of the participants valued the possibility of expressing themselves (artistically or otherwise) or participating in the design of their own LEs. Moreover, the importance of the LE characteristic *shared vision about schooling* was confirmed in the open-ended questions about views related to schooling in which half of the participants expressed a shared 'learning-centred' vision by indicating that they viewed learning both as the purpose of schooling and as personally relevant.

Table 4 Constructs and LE characteristics of the refined conceptual framework (V2.0)

Constructs	LE characteristics
I. Communality	
(a) Social relations	Teacher–student relations Staff–student relations Peer relations Home–school relations Wider community relations
(b) Teaching–learning interaction	Teacher-led instruction Collaborative learning
(c) Sense of belonging	Shared vision about schooling Involvement and self-expression
(d) Safety	No behavioural disturbance Safety
II. Individuality	
(a) Privacy and peacefulness	No noise disturbance No disorganization No distractions
(b) Individualisation	Personalization Personal relevance of studies Personal relevance of assessment Individual work Self-regulated learning
III. Comfort	
(a) Physical ease	Spaciousness Comfortable furniture
(b) Pleasantness	Aesthetics and colours Luminosity Presence of nature
IV. Health	
(a) Physical wellness	Quality of meals Indoor air quality Outdoor areas Physical exercise
(b) No overload	Rest Leisure time
V. Versatile tools and spaces	
(a) Novel tools and spaces	Use of technology Informal LE Novel LE design
(b) Conventional tools and spaces	Use of books and other traditional materials Sustainable design Non-formal LE Formal LE Conventional LE design
(c) Flexibility and functionality	Versatile use of materials Adaptability Functionality and practicality

(D) Safety The topics related to the Communality construct's two remaining items, I.10 (*no behavioural disturbance*) and I.12 (*safety*) (Table 3), also surfaced in the responses to open-ended questions and in the group discussion, mainly as being related to people or things (e.g.

Fig. 1 Learning by doing: a teaching kitchen

guns, strangers and criminals) that harm LE. These topics were grouped under a fourth main theme related to safety (Table 4). Although item I.10 (*no behavioural disturbance*) received relatively low ratings (Table 3), problems caused by behavioural disturbance (e.g. disturbing during the class and bullying) were thematised in almost a third of the responses to open-ended questions and close to half of the group discussions. The discrepancy between the ratings for item I.10 and thematic prevalence in the qualitative data was also reflected in the response variance deviation, which was the highest amongst all the Communality items (Table 3). A more in-depth cross-analysis between this item and the open-ended questionnaire responses led us to discover that the lowest ratings for item I.10 (1: 9.9 %, 2: 4.9 %) came from a quarter of the respondents, who also had expressed negative views on schooling in the open-ended questions (e.g. schooling as an obligatory or useless duty).

(II) Individuality

As shown in Table 3, the scale mean and the average ratings for the six LE items attributed to the construct Individuality were generally lower than those for Communality, ranging from 3.4 to 4.2. In accordance with this, the topics relevant to individuality were also less prevalent in the scale models and group discussions. Cross-analysis of distinct data types still indicated that participants generally valued LE based on their individual needs. The topics identified were grouped into (a) privacy and peacefulness and (b) individualisation (Table 4).

(A) Privacy and peacefulness Under the theme of privacy and peacefulness, we grouped participants' evaluations of items II.4 (*no disorganisation*) and *II.5* (*no noise disturbance*) (Table 3). The significance of quiet LEs was reiterated in roughly one-fifth of the open-ended responses and one-tenth of the group discussions. In addition, a new topic, *no distraction*s, was extemporaneously raised by two out of five responses to open-ended questionnaire items and one out of five group discussions, revealing that many participants hoped that there would not be pleasant (e.g. a party and free access to the Internet) or unpleasant (e.g. traffic) distractions when they were studying.

(B) Individualisation With regard to the items grouped under individualisation (II.1 *individual work*, II.2 *personalization*, II.3 *personal relevance* and II.6 *assessment*), the

highest ratings were assigned to II.3 (*personal relevance*) and the lowest to II.1 (*individual work*), which also had higher variability (Table 3): one-fourth of the respondents assigned a low value to it, whereas more than half of the participant students voted in favour of this way of learning (1: 19.8 %, 2: 6.2 %, 3: 16 %, 4: 29.6 %, 5: 28.4 %). This topic spontaneously emerged from a few group discussions, where some students expressed that they found working either in pairs or alone to be easier than group work. Lastly, the relevance of the LE characteristic *self-regulated learning* was confirmed by more than half of the scale models for learning by doing, socialising, reflecting and exploring the world environment, which represented LEs such as libraries (see Fig. 2) and media centres that enable autonomous learning.

(III) Comfort

This construct entailed only three items with an overall scale mean of 4 (SD = 0.8; see Table 3). In our cross-analysis with other data types, these items were grouped under the themes of (a) physical ease and (b) pleasantness.

(A) Physical ease We first grouped item III.2 (*spaciousness*) under the theme of physical ease (Table 4). In addition to higher than average item ratings (Table 3), the relevance of having enough space was reinforced in close to two-thirds of the group discussions. In addition, *comfortable furniture*, as the second aspect of physical ease, was represented in more than half of the scale models. During the group discussions too, participants wished for sofas or soft carpets on the floor for sitting or laying down on when reading or studying for examinations. This LE characteristic was thus added to the framework.

(B) Pleasantness The remaining items (III.1 *aesthetics* and III.3 *luminosity*) were grouped under pleasantness (see Table 4). The higher than average rating assigned to III.3 (*luminosity*) (Table 3) was reinforced in more than half of the group discussions, with students wishing for big windows or glass walls. Although III.1 (*aesthetics*) was assigned a lower rating (Table 3), it was valued by the majority of participants, with scale modelling and group discussions revolving around aspects of pleasant LE decoration and colours. Finally, more than half of the student base confirmed that the *presence of nature* was an important LE characteristic, either by choosing nature among their preferred learning spaces in the multiple-choice question (53 %) or by including parks (Fig. 3), trees or interior plants in their scale models.

Fig. 2 Learning by studying: a library

Fig. 3 Learning by socialising: a park

(IV) Health

The five health-related items were generally highly rated, with the means ranging between 4.0 and 4.3 (Table 3). After considering the health-relevant topics that emerged from the more qualitative data, we formulated two main themes: (a) physical wellness and (b) no overload.

(A) Physical wellness Items IV.4 (*indoor air quality*) and IV.5 (*quality of school lunch*) were grouped under 'physical wellness'. The relevance given to meals was indicated in two out of five scale models, including the opportunity to enjoy snacks or meals. Although air quality was less directly mentioned, 59 % of the students selected *outdoor areas* as one of the preferred learning spaces in the multiple-choice questions. The relevance of outdoor settings, as well as the possibility of engaging in physical exercise (e.g. in a park, at gym, in a swimming hall or on a beach), was also confirmed in nearly half of the scale models.

(B) No overload The relevance of items IV.1 (*enough breaks and rest*), IV.2 (*length of school days*) and IV.3 (*enough sleep*), which are all related to the second health-related theme, was supported by approximately a quarter of the responses to the open-ended questions. This is evidenced by references to free time as being personally important, which was further underscored by close to half of the scale models by the inclusion of solutions such as beds, sofas, hammocks for resting (see Fig. 4) and spaces for active recreation. Based on these findings, the theme no overload was divided into two LE characteristics: *rest* and (active) *leisure time* (cf. Tables 1, 4).

(V) Versatile tools and spaces

To conclude the analysis, we focused on the items and LE characteristics associated with Factor 5, which comprised 8 items for which the ratings ranged from 3.6 to 4.2 (Table 3). Two prominent themes emerged from the cross-analysis, especially from the data from group discussions, which concerned strong balance-seeking in learners' LE tools and space preferences between novel and conventional tools and space design: (a) novelty and (b) conventionality (Table 4). The remaining LE characteristics were grouped under the main theme of (c) flexibility and functionality, which can be seen as cross-cutting properties applicable to both versatile novel and conventional tools and spaces, as well as to the psychosocial elements of LE.

Fig. 4 Learning by reflecting: a lounge

(A) Novelty With regard to novelty-related characteristics, participants considerably valued item V.7 (*use of technology*) (Table 3) and incorporated modern technological elements (e.g. tablets, laptops and interactive whiteboards) in nearly two-third of the scale models. Further, unconventional *informal LEs* were selected in 79 % of the multiple-choice responses as preferred learning spaces. Three-quarters of the scale modelling groups also designed informal hands-on and real-life LEs such as cities, parks, nature (see Fig. 5) and workplace environments, including completely *novel LE designs* (Table 4), such as a combination of a library and a swimming hall.

(B) Conventionality Analysis of the overall data, however, revealed that most of the participant students wished to combine novel tools and space solutions with LE characteristics related to conventionality (Table 4), under which we grouped items V.1 (*interesting school books*), V.4 (*writing and drawing supplies*), V.5 (*library*) and V.8 (*sustainability*) (Table 3). Item I.V (*interesting school books*), for instance, received the same average ratings as V.7 (*use of technology*) (Table 3). Further, in group discussions, the pros and cons of modern technological aids were often debated (e.g. tablets are lighter to carry than books, but come at the cost of tired eyes and being possibly distracting). Two out of five scale models also included traditional materials (e.g. books and chalkboard), thus confirming the relevance of books and other traditional materials for participants (Table 4). In addition, although item V.5 (*library*) was rated as moderate (Table 3), conventional *non-formal LEs* (libraries and museums) were selected by 68 % of the participants in the multiple-choice questions on learning spaces and were covered in approximately half of the scale models. *Formal LEs* (schools), in turn, were selected by 83 % of the respondents and were featured in close to half of the scale models (see Fig. 6). In particular, the group discussions confirmed most of the students' wishes to conserve the *conventional LE design* (Table 4) while introducing novel design elements.

(C) Flexibility and functionality Finally, because the use of versatile novel and conventional materials requires flexibility, we grouped item V.2 (*versatile materials*) under the theme of flexibility and functionality, along with items V.3 (*functionality and practicality*) and V.6 (*adaptability*) (Table 3). Although these concepts were not directly highlighted in the students' responses and were addressed in only a few group discussions, they can be viewed as characteristics that support the design of LE considering learners' perceptions.

Fig. 5 Learning by exploring: mountains

Fig. 6 Learning by studying: a classroom

Discussion

Summary of the results

The first aim of the study was to decide whether the views of the participant students' supported the cross-cultural relevance (content validity) of the learning environment characteristics covered by framework V1.0 (Table 1) and whether new LE characteristics that needed to be added emerged (see "Development of the preliminary conceptual framework (version 1.0)" section). First, the cross-cultural relevance of the LE characteristics selected in the preliminary framework (V1.0) was confirmed by the substantial mean ratings assigned to all the Likert-scale items, as well as by the wide prevalence of the selected characteristics in other data types. Second, based on the general relevance of distraction-free (i.e. *no distractions)* learning highlighted in the responses to open-ended questions together with group discussions, and *comfortable furniture* emphasised during scale model-constructions and group discussions, we added these two characteristics in

framework V2.0. Further, in various types of data, students referred clearly to the significance of active recreation or leisure, on the one hand, and rest, on the other hand, which is something that was not so clearly distinguished in our preliminary framework (*no overload*) but was divided here into the characteristics of *rest* and *leisure time* (Table 4).

The second aim was to determine whether the data collected supported the consistency of the preliminary framework structure or whether empirical, theoretical and practical considerations suggested a need to reorganise the LE characteristics to improve their construct validity and model fit. Here, factor analysis suggested restructuring of the original three constructs (Overall Wellbeing, Learning Situation, and Learning Tools and Space Design) to yield five constructs of Communality, Individuality, Comfort, Health and Versatile Tools and Spaces. By a cross-analysis with other data types, we were then able to

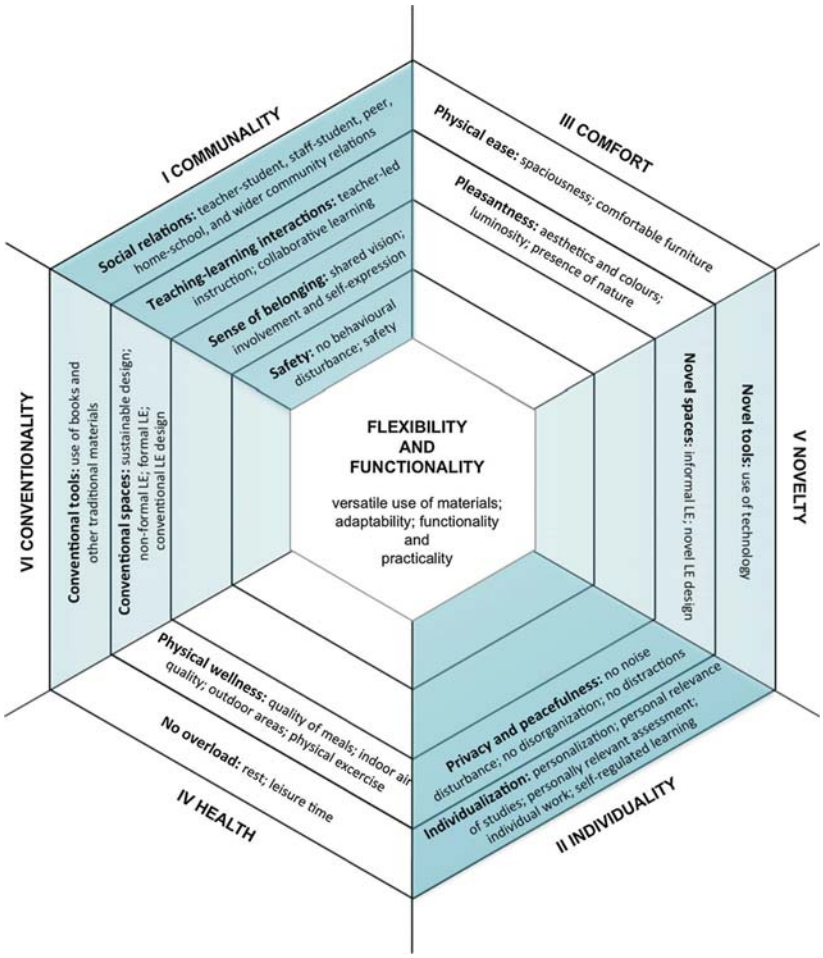

Fig. 7 Visualisation of the conceptual framework (V2.1) for guiding co-designing learning environments conducive to twenty-first century learning and wellbeing

confirm the relevance and consistency of these thematic areas and to propose the main themes for clustering the LE characteristics within each of the five constructs.

Development of conceptual framework V2.1

The final aim of the study was to develop a conceptual framework for capturing and structuring the main characteristics of a learning environment that is supportive to learning and wellbeing. Implicit to the analysis presented, we repeatedly noticed an important additional structural paradigm identified as pairs of concepts balancing one another. The first four constructs –Communality and Individuality as a concept pair, and Comfort and Health as another concept pair—were intuitively suggested, based on the notion that individuality balances communality and health needs balance wishes for comfort. The same idea of thematic equilibrium re-emerged in two of the main themes identified in the analysis of the fifth construct, that is, balancing novel and conventional tools and spaces (Table 4). Therefore, we promoted these two themes as constructs in our conceptual framework V2.1, which now consists of six primary-order constructs including the newly-added Novelty and Conventionality. This left us with the third and last main theme under the fifth factor (Flexibility and Functionality). An overall interpretation of the nature of this LE theme suggested its conceptualisation as a meta-construct that can be applied to all other LE constructs. This conjecture supported their representation as a second-order construct called Flexibility and Functionality.

Figure 7 depicts conceptual framework V2.1, including its construct dimensions, main themes and LE characteristics, by adapting the spider web illustrative approach proposed by van den Akker (2007) that is used to display interconnected curriculum components. This visualisation technique draws attention to the importance of "comprehensive approach and systematic attention" to all components during the design process (van den Akker 2007, pp. 40–41) instead of emphasising isolated variables. The same applies to the LE constructs and characteristics of our framework. Flexibility and Functionality is therefore placed in the centre so as to highlight its core role as an enabler of diversity, and to reach a proper balance or equilibrium position between the various and varying needs and wishes of school community members. Also, following the overall logic of the model, the constructs of Novelty and Conventionality were divided into the sub-themes of 'novel tools' and 'novel spaces' and 'conventional tools' and 'conventional spaces' (Fig. 7).

Although the way in which the LE constructs, main themes and characteristics are grouped in the emergent model is novel and exploratory by nature, it has many similarities with the frameworks presented in the literature (Barrett et al. 2013; Gee 2006; Higgins et al. 2005; Sanoff et al. 2001; Sulonen and Sulonen 2014; Wolff 2002). Some of the earlier models also consider the notion of 'balancing', as applied to 'communality' and 'solitude' (Gee 2006), 'open' and 'private', and 'quiet visual environments' and 'complexity'/'novelty' (Barrett et al. 2013). To our knowledge, however, there are no prior models that have consistently been built on the idea of maintaining equilibrium between various human needs related to learning and wellbeing. We believe that this paradigm of concept pairing and balancing can add significant value to earlier guidelines on (participatory) LE design.

The content of each conceptual construct is discussed in the following paragraphs in the context of three balancing pairs and the core construct Flexibility and Functionality. In addition to presenting literature support for each construct and main theme, we discuss parts of the framework that will be revised in the future research cycles.

Communality balanced with individuality

The constructs Communality and Individuality are closely related to the dimensions of Relationship and Personal Development in Moos' human environment model, which is used as a base for many instruments for assessing psychosocial LE dimensions (Fraser 1998). As already mentioned in previous paragraphs, the notion of equilibrium between communality- and individuality-related considerations can also be found in other models (Barrett et al. 2013; Gee 2006). With regard to the relationship between the communality and individuality aspects of LEs, our findings suggest that the former characteristics are more relevant.

In general, the reports in the literature (e.g. Awartani et al. 2008; Dewey 1907, 1916; Fraser 1998; Vygotsky 1978) are in agreement with our participant students' views of the relevance of (a) social relations, which are represented as the first main theme under Communality (see Table 4; Fig. 7). Multiple-choice questions on preferred learning companions suggested, however, that staff members such as principals were not so centric for learners. This result revealed the need to revise the item (good) *staff–student relations* by distinguishing between teachers and other staff members (see Table 2), as it was problematic to measure clearly distinct relations in the same statement.

Because data also indicated the relevance of varying (b) teaching–learning interactions for learners, this was therefore chosen as the second main communality-related theme (Table 4; Fig. 7). In line with the results of a study on innovative practices in Austrian schools (Schrittesser et al. 2014), the value given to teacher-led instruction could be interpreted as an indicator of whether both teachers and students still need time in order to move towards more student-centred approaches. Based on our findings and in harmony with other studies (e.g. Elen et al. 2007), we argue that stimulating and interactive teacher-led instruction should not be viewed separately from a student-centred approach, but as an important part of the twenty-first century teaching–learning interaction. Finally, cross-loadings of the items *group work* and *pair work* on both Communality and Comfort (Table 3) could be interpreted here as evidence of the high interconnectedness of psychosocial (i.e. collaboration) and physical (i.e. comfortable spaces for collaboration) LE dimensions in learners' perceptions (Cleveland and Fisher 2014; Ghaziani 2010; Zandvliet and Fraser 2005). These items, however, should be reviewed in future research cycles.

Supported by theoretical (e.g. Bronfenbrenner 1979; Dewey 1907, 1916; Sanoff et al. 2001; Wolff 2002) and empirical considerations both in this study and elsewhere (e.g. Linnankylä and Malin 2008; Wang and Holcombe 2010), (c) sense of belonging was chosen as the third main communality-related theme (Table 4; Fig. 7). Although the items *involvement* and *self-expression* were moderately rated (Table 3), the majority of the participants clearly enjoyed the possibility of participating and expressing themselves in the LE co-design workshops. This led us to conclude that participatory LE design could be used to increase the sense of belonging of all the learners, including students with low school engagement levels expressing negative views of schooling (Linnankylä and Malin 2008; Mäkelä et al. 2014).

Our framework's consideration of (a) safety as the fourth most important aspect of Communality (Table 4; Fig. 7) was confirmed both by this and other studies (e.g. Awartani et al. 2008; Piispanen 2008). Whilst acknowledging the need for further refinement of the item *no behavioural disturbance*, its cross-loading on both constructs Communality and Versatile Tools and Spaces (Table 3) could again be interpreted as evidence of the high interconnectedness of psychosocial (disturbance by people) and physical (disturbance experienced in physical spaces) LE dimensions.

Despite the stronger relevance of communality-related LE characteristics, our participants' voices echoed the results of the previous literature on the value assigned to the individuality-related themes (a) privacy and peacefulness (e.g. Kostenius 2011; Papatheodorou 2002; Sanoff et al. 2001) and (b) individualisation (e.g. Barrett et al. 2013; Dewey 1907, 1916; Scardamalia et al. 2012). For instance, although the LE item *individual work* received the lowest ratings among all the items (Table 3), group discussions, in particular, revealed that some learners also preferred working alone over group work. The overall findings with regard to the wishes for privacy, peacefulness and individualisation suggest that the design of LEs should give more consideration to quiet, reflective or restorative spaces (Bagot 2004; Kaplan 1995), which are themes that have generally been ignored in the Industrial Age school design for the masses. Further, the relevance given to both *teacher-led instruction* (grouped under Communality) and *self-regulated learning* (related with Individuality; see Table 4) supports the promotion of cooperative or collaborative LE designs in which learners are gradually given more agency as co-designers of their own learning and LEs according to factors such as their self-regulation skills (Pieters 2004; Wang and Holcombe 2010; see also Vygotsky 1978). Finally, the low values and cross-loadings of the item *assessment* on Communality, Individuality and Comfort (Table 3) suggest the need to refine this item.

Comfort balanced with health

Comfort and health are notions that are typically reflected in architectural LE design. Comfort, for example, was chosen as one of the main constructs in Sulonen and Sulonen's (2014) LE characteristics, while Gee's (2006) 'human-centred design guidelines' include the construct Healthful. Similar to our framework, Sulonen and Sulonen (2014) relate comfort to characteristics such as lighting and colours. Gee (2006), in turn, views lighting as a characteristic related to health. Further, Gee (2006) connects nature and colours which, according to our framework are related to comfort, with stimulation. These differences illustrate how LE characteristics can be grouped in multiple ways, rendering over-rigid categorisation questionable.

Consistent with earlier literature (e.g. Ghaziani 2010; Kangas 2010; Kostenius 2011; Papatheodorou 2002), the learners participating in our study valued both (a) physical ease and (b) the pleasantness of LE as two main comfort-related themes (Table 4; Fig. 7). Although the item *aesthetics* received one of the lowest ratings in the responses to the questionnaire (Table 3), the amount of attention that participants paid to the decoration and colours of their scale models suggests that learners in general do value aesthetically-pleasant environments.

Further, participants shared the viewpoint that LEs should not only be comfortable and pleasant but also promote good health. Based on our findings and those of other studies (Bagot 2004; Higgins et al. 2005; Kaplan 1995; UNESCO 2012), we named the first health-related main theme (a) physical wellness and the second one (b) no overload (Table 4; Fig. 7). In future framework versions, in addition to separating the LE characteristics *rest* and *leisure time*, more attention could be paid to health-related themes such as 'good ergonomics' (Gee 2006; Zandvliet and Fraser 2005).

Novelty balanced with conventionality

Our concept of balancing novelty with conventionality is reminiscent of Moos' model's third dimension of System Maintenance and System Change (Fraser 1998): that is, an equilibrium between stability and responsiveness to change. The Novelty construct shared

properties with the design principle of Stimulation, which is described in the architectural study by Barrett et al. (2013, p. 681) as an indicator of "the degree to which the school provides appropriate diversity (novelty)" (see also the guidelines on stimulating environments by Gee 2006). Moreover, Conventionality shared similarities with the construct Durability used by Sulonen and Sulonen (2014; see also 'spaces with durable building materials and finishes' by Wolff 2002).

The value that participants assigned to both novelty- ('novel tools' and 'novel spaces') and conventionality-related ('conventional tools' and 'conventional spaces') characteristics (Table 4; Fig. 7) is also reflected in other recent studies involving primary- or secondary-school students (e.g. Kangas 2010; Kuuskorpi and Cabellos 2011). Lastly, cross-loading of the item *sustainability* on the factors Health and Versatile Tools and Spaces (see Table 3) suggests that some respondents might have viewed it as a requirement for healthy environments, while other responders interpreted it as a part of the sustainable design of physical learning tools and spaces. To capture this dual connotation, this item should be revised in the future.

Flexibility and functionality

Although the relevance of Flexibility and Functionality as enablers of versatile twenty-first century LEs and as the universal property of LE characteristics was not expressed as such spontaneously by participants (possibly partly because of their abstract nature for young learners), they were integrated in the framework as important enablers of versatile twenty-first century LEs. The conceptual decision to place Flexibility and Functionality as the centric construct of framework V2.1 (Table 4; Fig. 7) is supported by recent architectural (Barrett et al. 2013; Gee 2006; Sulonen and Sulonen 2014) and educational (Kuuskorpi and Cabellos 2011; Wolff 2002) literature.

Limitations

Despite the several strengths of this study, there were also some limitations that need to be taken into account. To begin with, the reader needs to bear in mind that this paper describes the initial research cycles for conceptual framework development. As discussed in the previous section, future iterations are likely to lead to changes in both the conceptual model and materials developed in these pilot studies. In particular, the aspects of sampling, stakeholder involvement and research design need to be developed.

With regard to the type of participants and sample size, the current data were collected using a highly-heterogeneous and non-random convenience sample representing only two schools and seven learner groups (aged 7–14 years) from two specific sociocultural contexts. As a result, the framework does not include, for instance, notions of minimum health and hygiene standards because they were already anticipated to be generally established in the learning contexts upon which our study focused (Crespo and Pino 2007; UNESCO 2012). Further, the statistical methods used here only supported a highly-exploratory study and an interpretative analysis of the data from a small sample. For example, there was very little variation in the ratings of the LE Likert-scale items (the means ranged from 3.4 to 4.4, see Table 3). This could indicate that learners perceived all items as almost equally important, but to confirm whether this is the case, we should replicate the study with a larger number of participants.

With regard to stakeholder involvement, the focus of this emergent framework has been learner perception. Gathering learners' views, however, should be combined with the involvement of other key educational stakeholders such as directors, teachers or parents. For example, in a Finnish study involving primary school pupils', parents' and teachers'

perceptions, the pupils emphasised the physical LE dimension, the parents emphasised the social and psychological dimensions, and the teachers, emphasised the pedagogical dimension (Piispanen 2008). It has also been argued that not only learners but also teachers need support in order to become designers of their own teaching environments for supporting the set educational goals (Horne Martin 2002). The framework development also might have benefitted from more active collaboration with architects, ergonomists or experts in technology to ensure that it covers characteristics such as circulation, way finding and accessibility (e.g. Sanoff et al. 2001) or workspace ergonomics and technological infrastructure (e.g. Zandvliet and Fraser 2005).

As far as limitations related to research design are concerned, the use of factor analysis for refining the framework constructs was incomplete because not all of the LE characteristics were formulated into Likert-scale item statements. The questionnaire items therefore should be revised based on the refined framework. This revision should also entail an examination of the equivalency, readability and comprehensibility of these statements in different languages (Aldridge and Fraser 2000). Further, while asking participant learners to complete the web questionnaire in pairs can be considered as an inspiring twenty-first century introductory learning activity supporting co-design and collaborative knowledge construction (Scardamalia et al. 2012; Staffans et al. 2008), we are aware of its possible drawbacks and implications with regard to the degree of freedom of a single participant when compared to traditional single-respondent methods. The same can occur during any collaborative work such as scale modelling and group discussion. The collaborative research design also might partially explain why individuality-related LE characteristics were less prominent in the data set. As the aim of this analysis was to identify the communalities between learners in order to create a shared framework, we do not consider the collaborative design to be problematic. However, despite many communalities and shared views between participants, the high standard deviations of some LE items and some of the clearly negative or critical perceptions identified indicate that it is also important to consider possible individual, age-based, group-based, gender-based and cultural differences, something that was beyond the scope of this study but can be considered separately.

Finally, the aim of the framework to gather a wide range of psychosocial and physical LE characteristics is limited in its capacity to consider individually each theme or characteristic. For example, we acknowledge that within the subtheme ‘teaching–learning interaction’ or ‘individualisation’, there could be a long list of pedagogical activities that teachers could use and offer for learners, for example, based on learners’ preferences. At this point, however, we have chosen to limit these characteristics to more general notions (e.g. teacher-led instruction, collaborative learning and individual work).

Conclusions

The conceptual framework developed in this study based on empirical, theoretical and practical considerations contributes to understanding of a learning environment design’s core constituents. The framework’s constructs and content can help to bring together and structure LE characteristics supportive to learning and wellbeing and can therefore be used as a guide in planning, gathering information, classifying data and structuring the evaluation of individual co-design projects, or when comparing and generalising findings. In the spirit of our conceptual framework that emphasises the value of flexibility and balancing various viewpoints, we argue that research and development projects aimed at contributing to theory and praxis should balance the use of fixed themes and structures with possibilities

for emerging new themes and structures (Cleveland and Fisher 2014). In this way, the results can be compared and generalised on the one hand, and can be specific and contextualised on the other hand.

In light of the findings of this cross-cultural study, the substantive LE design principles could be summarised as follows:

- The balancing of communality with individuality by:
  - enabling socialising and collaborative work on the one hand, and privacy and individual work on the other hand
  - balancing teacher-led activities with self-regulated and personally-relevant learning situations
  - taking into account not only the shared vision, but also differing views and personal preferences
  - opening the school to the wider community, but ensuring that the LE is safe and disturbance- and distraction-free.
- The balancing of learners' wishes for comfort with health by ensuring that there are:
  - comfortable and spacious environments for learners to feel at ease physically, as well as both indoor and outdoor environments which promote physical wellness
  - pleasant spaces including elements of nature, as well as time and spaces for leisure and rest.
- The balancing of novelty with conventionality in the LE by ensuring that:
  - modern tools and spaces such as technological equipment and an informal LE are combined with conventional tools and spaces often used in formal or non-formal learning.
- Ensuring that the LE is functional and flexible so that it can be easily utilised and modified to respond to the learning community's varying needs and requirements.

The communalities and shared views identified by female and male participants of varying ages representing two cultural contexts, as well as the similarities of these findings with other studies, could indicate that differences, at least in the Western context (Aldridge and Fraser 2000; Liu et al. 2012), lie not so much in what kind of LEs are preferred but in how well actual LEs are in concurrence with these preferences (Fraser 1998). Because of commonly-shared views on preferred LEs, it appears logical to create partnerships and benchmarks nationally and cross-nationally for learning environments that seem to finely accomplish common objectives. This too is a step towards developing shared LE solutions and deepening knowledge transfer to respond better to internationally-shared societal and educational challenges.

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Appendix: Material package for the learning environment design workshops

Description

Objectives: The aim of the learning environment (LE) design workshops is to invite learners from Finland and Spain to express their views of environments that they think improve their learning and wellbeing. The workshops will provide learners cross-curricular learning experiences for practicing the skills needed for participatory 21st century citizenship. For teachers facilitating the organization of workshops, they will provide professional development opportunities and new ideas for their work. The ideas that emerge during the workshops can also be used posteriorly in the actual LE design.

Structure: Before starting the workshop, learners are assisted in understanding the concept of learning environments. It will be explained to them that learning can take place anywhere (= ubiquitous learning experiences), also outside the classroom or school building. In these workshops, designing LEs is not only about buildings, furniture, and equipment, but is also about designing personally, socially, physically and virtually ideal spaces for learning and wellbeing. This will be followed by three types of activities:

Part 1. Web questionnaire on Students' Perceptions of Good Learning Environments: Collaborative reflection will be fostered by filling out of the web questionnaire in pairs (preferably with girls and boys grouped separately so as to be able to analyse the differences between genders).

Part 2. Scale modelling of learning environments: The group will be divided into at least five or more different groups with 3 to 5 pupils each (girls and boys mixed if possible). These groups will construct LEs for different learning situations.

Part 3. Group discussions: The researcher will conduct group discussions with each group. During these discussions, participants have a chance to describe orally the main characteristics of their scale models. In addition to this, a structure for the group discussions will be used to guide the discussion on good LEs. Discussions will be recorded for future analysis.

Preparations: Parental consent for using research data should be obtained before the workshop (a separate form will be provided for this purpose). For the scale modelling activity, participants should be asked to collect and bring recyclable material (e.g. ice cream sticks, washed milk cartons, yoghurt pots, candy wrappers and boxes, egg cartons, toilet paper rolls, pieces of fabrics...). Recyclable material can be combined with other craft materials and supplies (e.g. cartons and papers of different colours, plasticine, foil, tissue paper, stickers, fabric, cotton wool, glue, stapler, paints, and scissors).

Duration: It is possible to conduct all the activities in two lessons, but if participant teachers wish so, the time required for the scale model design can be extended. The material and the complexity of the workshop need to be adapted to the time used for the project.

Thank you for participating in the research and in organizing the workshop!

Part 1. Web Questionnaire on Students' Perceptions of Good Learning Environments

A) Background information

Name of the school:

Participant 1	**Participant 2**
Gender: female/male	*Gender:* female/male
Class and age:	*Class and age:*
Mother tongue/tongues:	*Mother tongue/tongues:*

B) Views related to schooling

1. Why do you think we go to school?

2. What is the most important thing for you at school?

C) Positive effects of the learning environment items on learning and wellbeing
How much, in your opinion, can the following items improve and make learning more enjoyable? (scale: 1 = very little, 2 = a little, 3 = some, 4 = much, 5 = very much)

I Overall wellbeing
- 1.1. safety
- 1.2. fresh indoor air which is not too hot or cold
- 1.3. spaces that are not too noisy
- 1.4. tasty and healthy school meals
- 1.5. good relations with all pupils
- 1.6. that there are no trouble makers at school
- 1.7. good relations with teachers and other staff members
- 1.8. good relations between school and parents

II Learning situation
- 2.1. nice teachers
- 2.2. teachers who teach well
- 2.3. interesting and different types of classes
- 2.4. working in groups
- 2.5. working in pairs
- 2.6. studying quietly alone
- 2.7. learning in peace at your own rhythm
- 2.8. that we can use what we have learned in our own life
- 2.9. doing exams and getting grades

III Learning tools and space design
- 1.1. functionality and practicality
- 1.2. easy to modify
- 1.3. environmental friendliness
- 1.4. tidiness and order
- 1.5. aesthetics and beauty
- 1.6. lots of light
- 1.7. lots of space
- 1.8. lots of different learning materials
- 1.9. use of technology
- 1.10. interesting school books
- 1.11. well-stocked pen case

1.9. a sufficient amount of pauses and breaks
1.10. sufficient sleep
1.11. not too long school days
2.10. opportunities for creativity and self-expression
2.11. opportunities for designing own learning and learning environments
1.12. good library

D) Learning companions

Select from the list below all the persons with whom it is nice to learn: (a) Principal, (b) Teacher, (c) Classmates, (d) Your best friend, (e) Pupils younger than yourself, (f) Pupils older that yourself, (g) Mother, (h) Father, (i) Siblings (brothers and sisters), (j) Grandparents, (k) Other elderly people, (l) Neighbours, (m) Pupils living in other countries, (n) Other:

Who should not come to your learning environments?

E) Spaces for learning

Select from the list all the places where you think it is good to learn: (a) Indoors, (b) Outdoors, (c) At school, (d) At home, (e) In a café/bakery, (f) At parent's workplace, (g) In a library, (h) In a museum, (i) In the shopping centre, (j) In a recycling centre, (k) On the street, (l) In the forest, (m) In a park, (n) Other:

What is there that should not be in your LE??

Where do you think it is impossible to learn?

F) Additional information. *Thank you for your participation! Feel free to write down any other remarks considering learning and ideal learning environments here:*

Part 2. Learning situations types for learning environment scale modelling

Group 1. Learning by studying (e.g. classroom, spaces for group work; spaces where it is possible to study with the teacher and a whole group, work in groups or in pairs, discuss, plan, concentrate on difficult issues, do exams, give feedback and evaluate tasks...)

Group 2. Learning by doing (e.g. workshops, kitchen, laboratories, gym; spaces where it is possible to move, dance, cook, play music, do arts and crafts, paint, act....)

Group 3. Learning by socializing (e.g. vestibule, dining room, lobbies, school yard; spaces where it is possible to spend time during the breaks, where you can have lunch, different celebrations...)

Group 4. Learning by reflecting (e.g. computer room, library, corners for reading and studying; spaces where is possible to search, read and evaluate information, study for the exam, write notes, meditate, calm down...)

Group 5. Learning by exploring the world (e.g. nature, park, museum, shopping mall, recycling centre; spaces where it is possible to learn things about the neighbourhood, nature, local environment...)

Examples are given only to show what types of spaces each group designs. Participants can design any kind of spaces they like (e.g. learning by doing in an amusement park) with the stipulation that they must justify how these spaces provide good conditions for the assigned learning situation.

Part 3. Structure for the group discussions

Name of the school: **Group number:** **Type of learning space the group has been assigned to design:**

Questions to guide the discussion:

1. Describe the learning environment you have been designing. Why did you choose to design that specific space for learning?

2. In which positions do you think people would learn there/is good to learn (e.g. lying on the floor, lying on the bed or on the couch, sitting on the couch, sitting at a desk, standing, walking)?

3. Where would the teacher be in your learning environment (e.g. Would he or she have a corner/space for himself/herself?)?

4. What kind of colours, shapes, and surface materials (e.g. wood, plastic, glass, tile) would you like to have there?

5. Would you prefer technological (e.g. video conferencing equipment, smart board, computers, tablet computers, mobiles, stereo, game consoles, e-books) or traditional (e.g. chalkboard, wall clock, textbooks, notebooks, calendar, drawing instruments, craft supplies, music instruments, sports equipment) work and communication equipment?

6. Would the learning space and its interior design be antique and traditional (e.g. desk in rows, chairs, teacher's desk) or new and modern (e.g. couch, bean bags chairs, swing, pillows, carpets)?

7. Would the learning spaces of your dreams be very different to the spaces you currently study in?

References

Aldridge, J., & Fraser, B. J. (2000). A cross-cultural study of classroom learning environments in Australia and Taiwan. *Learning Environments Research, 3*, 101–134.

Awartani, M., Whitman, C. V., & Jean Gordon, J. (2008). Developing instruments to capture young people's perceptions of how school as a learning environment affects of their well-being. *European Journal of Education, 43*(1), 51–70.

Bagot, K. L. (2004). Perceived restorative components: A scale for children. *Children, Youth and Environments, 14*(1), 120–140.

Barrett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2013). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning. *Building and Environment, 59*, 678–689.

Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge, MA: Harvard University Press.

Cleveland, B., & Fisher, K. (2014). The evaluation of physical learning environments: A critical review of the literature. *Learning Environments Research, 17*, 1–28.

Crespo, J., & Pino, M. (2007). Description of environmental factors in schools: Lessons from a study in North-west Spain. *Review of Education, 53*, 205–218.

Creswell, J. W. (2003). *Research design. Qualitative, quantitative and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Dewey, J. (1907). *The school and society*. Chicago: University of Chicago Press.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education,* (Electronic version by the University of Virginia American Studies Program 2003). Available from http://xroads.virginia.edu/~hyper2/Dewey/TOC.html. Retrieved 30 May 2015

Elen, J., Clarebout, G., Léonard, R., & Lowyck, J. (2007). Student-centered and teacher-centered learning environments: What students think. *Teaching in Higher Education, 12*(1), 105–117.

Engeström, Y. (2009). From learning environments and implementation to activity systems and expansive learning. *An International Journal of Human Activity Theory, 2*, 17–33.

Fraser, B. J. (1998). Classroom environment instruments: Development, validity and applications. *Learning Environments Research, 1*, 7–33.

Gee, L. (2006). Human-centered design guidelines. In D. G. Oblinger (Ed.), *Learning spaces* (pp. 128-140). Educause. (www.educause.edu)

Ghaziani, R. (2010). School design: Researching children's views. *Childhoods Today, 4*(1), 1–27.

Gislason, N. (2010). Architectural design and the learning environment: A framework for school design research. *Learning Environments Research, 13*, 127–145.

Higgins, S., Hall, E., Wall, K., Woolner, P., & McCaughey, C. (2005). *The impact of school environments: A literature review*. Newcastle: The Centre for Learning and Teaching. School of Education, Communication and Language Science, University of Newcastle.

Horne Martin, S. (2002). The classroom environment and its effects on the practice of teachers. *Journal of Environmental Psychology, 22*, 139–156.

Kangas, M. (2010). Finnish children's views on the ideal school and learning environment. *Learning Environments Research, 13*, 205–223.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*, 169–182.

Kostenius, C. (2011). Picture this—our dream school! Swedish schoolchildren sharing their visions of School. *Childhood, 18*(4), 509–525.

Kuuskorpi, M., & Cabellos, N. (2011). *The future of the physical learning environment: School facilities that support the user (CELE Exchange, Centre for Effective Learning Environments, 2011/11)*. Paris: OECD Publishing.

Linnankylä, P., & Malin, A. (2008). Finnish students' school engagement in the light of PISA 2003. *Scandinavian Journal of Educational Research, 52*, 583–602.

Liu, C. J., Zandvliet, D. B., & Hou, L.-L. (2012). The learning environment associated with information technology education in Taiwan: Combining psychosocial and physical aspects. *Learning Environments Research, 15*, 379–402.

Mäkelä, T., Kankaanranta, M., & Helfenstein, S. (2014). Considering learners' perceptions in designing effective 21st century learning environments for basic education in Finland. *The International Journal of Educational Organization and Leadership, 20*(3), 1–13.

Marchand, G. C., Nardi, N. M., Reynolds, D., & Pamoukov, S. (2014). The impact of the classroom built environment on student perceptions and learning. *Journal of Environmental Psychology, 40*, 187–197.

Papatheodorou, T. (2002). How we like our school to be… Pupils' voices. *European Educational Research Journal, 1*, 445–467.

Pieters, J. M. (2004). Designing artefacts for inquiry and collaboration when the learner takes the lead. *European Educational Research Journal, 3*(1), 77–100.

Piispanen, M. (2008). *Good learning environment: Perceptions of good quality in comprehensive school by pupils, parents and teachers.* Jyväskylä: University of Jyväskylä.

Plomp, T. (2007). Education design research: An introduction. In T. Plomp & N. Nieveen (Eds.), *An introduction to educational design research* (pp. 9–35). Enschede: SLO.

Sanoff, H., Pasalar, C., & Hashas, M. (2001). *School building assessment methods*. Raleigh, NC: School of Architecture, College of Design, North Carolina State University.

Scardamalia, M., Bransford, J., Kozma, B., & Quellmalz, E. E. (2012). New assessment and environments for knowledge building. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 231–300). Dordrecht: Springer.

Schrittesser, I., Gerhartz-Reiter, S., & Paseka, A. (2014). Innovative learning environments: About traditional and new patterns of learning. *European Educational Research Journal, 13*(2), 143–154.

Staffans, A., Teräväinen, H., Meskanen, S., & Mäkitalo, A. (2008, April). *Collaborative planning and design and students' epistemic agency*. In Paper presented at Architectural Inquiries conference, Göteborg, Sweden.

Sulonen, J., & Sulonen, K. (2014). The grammar of a modern school building: A comparative study on schools and the changing ways of learning. In M. Kuuskorpi (Ed.), *Perspectives from Finland—Towards new learning environments*. Tampere: Finnish National Board of Education.

UNESCO. (2012). *A place to learn: Lessons from research on learning environments* (Technical paper No. 9). Montreal: United Nations Educational, Scientific and Cultural Organization, Institute for Statistics.

van den Akker, J. (2007). Curriculum design research. In T. Plomp & N. Nieveen (Eds.), *An introduction to educational design research* (pp. 37–50). Enschede: SLO.

Vygotsky, L. S. (1978). *Mind in society. The development of higher psychological processes.* In M. Cole (Ed.). Cambridge, MA: Harvard University Press.

Wang, M.-T., & Holcombe, R. (2010). Adolescents' perceptions of school environment, engagement, and academic achievement in middle school. *American Educational Research Journal, 47*, 633–662.

Wolff, S. J. (2002). *Design features for project-based learning*. Corvallis, OR: Oregon State University.

Woolner, P., Clark, J., Hall, E., Tiplady, L., Thomas, U., & Wall, K. (2010). Pictures are necessary but not sufficient: Using a range of visual methods to engage users about school design. *Learning Environments Research, 10*, 1–22.

Zandvliet, D. B., & Fraser, B. J. (2005). Physical and psychosocial environments associated with networked classrooms. *Learning Environments Research, 8*, 1–17.

III

STUDENT PARTICIPATION IN LEARNING ENVIRONMENT IMPROVEMENT: ANALYSIS OF A CO-DESIGN PROJECT IN A FINNISH UPPER SECONDARY SCHOOL

by

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ORIGINAL PAPER

Student participation in learning environment improvement: analysis of a co-design project in a Finnish upper secondary school

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Abstract The present educational design research involved analysing Finnish upper secondary school students' participation in the improvement of their psychosocial and technology-enhanced physical learning environment (LE). It examined which LE characteristics students considered important when redesigning their LE, and whether they felt that their ideas for improvement had been taken into account in the LE change process and if there was an improvement in these characteristics. A Learning Environment Design (LED) framework balancing the various LE dimensions, namely, communality and individuality, comfort and health, novelty and conventionality, was utilised in the analysis for four sets of data collected for four cycles: (a) co-design activities (students, $n = 11$) and (b) student feedback ($n = 175$); (c) professional design evaluation (students, $n = 2$); and (d) student satisfaction survey ($n = 83$). Students considered all LE dimensions important. In addition, they felt that their wishes were generally taken into account in the redesign and also they perceived an improvement in most of the LE characteristics. Student involvement helped to avoid overly radical changes, fostered a participatory culture, and contributed to understanding what students view as important to their learning and wellbeing. The study demonstrated the usefulness of the LED-framework for LE design and suggests content-related design principles to serve as a starting point in LE improvement projects involving learners.

Keywords Educational design research · Participatory design · Physical learning environment · Psychosocial learning environment · School improvement · Student participation

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Introduction and background

Increased understanding of the complex synergetic influence of psychosocial and physical learning environments (LEs) on learning and wellbeing has drawn attention to their design (e.g. Higgins et al. 2005). Contemporary learner-centred educational paradigms, reflected in school curricula and policies, advocate the importance of considering each learner's individual needs, experiences and preferences and empowering them by giving them responsibility and autonomy in learning) i.e. in constructing personally meaningful knowledge and skills in collaboration with others) (APA Work Group 1997; Cornelius-White 2007; Land et al. 2012; ÓNeill and McMahon 2005). Learners' active agency as designers of their learning and LEs is emphasised (Scardamalia et al. 2012). Students are also more frequently seen as change agents or partners in change in improving their educational environments (Hargreaves and Shirley 2009; Simmons et al. 2015).

The literature discusses various expected benefits of involving students in the LE design and change process. As a first benefit type, student involvement is anticipated to improve the design quality and lead to more adequate and desirable LE designs for students (Flutter 2006; Woolner 2009). Students' contributions have been considered practical and realistic (Flutter 2006; Lievonen et al. 2014) or innovative and visionary (Kostenius 2011; Newman and Thomas 2008). Second, a participatory design that involves students is anticipated to foster a participatory culture. It can, for example, be used to empower and engage students in decision-making in the schools (Hargreaves and Shirley 2009; Parnell et al. 2008). It also provides students with opportunities to express their views and have a voice on issues directly affecting them (den Besten et al. 2008; Frost and Holden 2008).

Finally, student participation in design and change processes is expected to positively influence both student learning processes and their wellbeing. The design process itself can already be considered an authentic learning experience in which students practise a wide range of cross-curricular life and citizenship skills (Flutter 2006; Frost and Holden 2008). During the design process, participants gain an understanding of the interrelationships between psychosocial and physical environments, learning and wellbeing (Flutter 2006; Simmons et al. 2015), which they can apply later. Increased ownership and dominance of the co-designed solutions can lead to their more efficient use in support of learning (Newman and Thomas 2008; Woolner 2009). Having the opportunity to influence one's own LEs and being taken seriously as a responsible member of the school community can also increase students' overall wellbeing, sense of community, engagement, motivation, positive attitudes and morale, and reduce absenteeism and vandalism in school (Flutter 2006; Parnell et al. 2008; Simmons et al. 2015).

However, various challenges must be overcome before the expected benefits convert into actual benefits. First, in relation to improving design quality, young people's competence and maturity to contribute to the design in insightful ways has been questioned (den Besten et al. 2008; Robinson and Taylor 2012). Their contributions have been judged as impractical and not deliverable (Newman and Thomas 2008; Woolner et al. 2007), not innovative but predictable, superficial (den Besten et al. 2008) and even reactionary and conservative (Woolner 2009). The effect of student participation on design has also been reported to be minor or difficult to identify (Parnell et al. 2008; Woolner 2009). Second, it is arguably evident that student consultation does not automatically foster a participatory culture. A lack of commitment or inadequate mechanisms for student participation can lead to raised expectations, but then not meeting them, or failure to successfully take students' views into account, can cause disappointment and frustration, instead of empowerment

(Simmons et al. 2015). Adults also can intentionally or unintentionally interpret students' views as support for their own interests (Fielding 2004; Robinson and Taylor 2012). Furthermore, recruiting a representative group of students in the design is challenging because more-forthcoming students often are selected (Fielding 2004; Woolner 2009), while disaffected and unengaged students are omitted (Lodge 2005). Emphasising students' perspectives also could lead to marginalising the views of other important stakeholders such as teachers (Woolner 2009).

Third, realising student learning and wellbeing benefits during the design process can be hampered by both teachers' and students' concerns about the loss of teaching and learning time with other subjects (Parnell et al. 2008; Woolner et al. 2007). Positive outcomes can be limited to only those students who are directly involved (Flutter 2006), and little is known about maintaining the positive effects in the longer term or scaling them up (Woolner 2009; see also Hargreaves and Shirley 2009). In some cases, the participating students do not benefit from the new design themselves, because they will have moved on during the implementation phase (den Besten et al. 2008).

This article addresses the need to better understand the actual benefits of student participation in the improvement of their school LE. The study context involved Finnish upper secondary school students in an LE redesign aimed at converting a terraced-floored (tiered) natural science classroom and its adjacent hallway (see Fig. 1) into an inspiring technology-enhanced space that fosters 21st century ideas of learning and wellbeing (Mäkelä et al. 2014b, 2015).

Student participation in the LE improvement is evaluated on the basis of the responses to the following research questions:

1. What LE characteristics did the participating students consider important for their learning and wellbeing?
2. What were the students' perceptions of (a) the extent to which their ideas had been taken into account in the design and (b) the extent to which there were improvements in these LE characteristics after the redesign?

The case study presented in this article is part of a long-term educational design research initiative aimed at developing a research-based toolkit including both substantive (i.e. content-related) and procedural (i.e. process- or method-related) design principles or guidelines for the participatory co-design of psychosocial and (technology-enhanced) physical LEs involving learners (Mäkelä et al. 2014a). This article focuses on content-related design principles. As is typical for educational design research, this study: (1) involved various stakeholders; (2) was conducted in real-life settings; (3) consisted of iterative semi-

Fig. 1 The natural science classroom (*left*) and the hallway corner (*right*) before the changes

independent research cycles; (4) mixed qualitative and quantitative research methods; and (5) aimed at both practical and theoretical contributions (Plomp 2007; van den Akker 2007).

The concepts of 'participatory design' and 'co-design' are used here in a broad sense to refer to knowledge sharing and creation (in relation to the past, present and future) between participants representing various backgrounds (Kujala 2008; Sanders and Stappers 2008). For considerations related to learner involvement, the study has sought inspiration from the students as the (co)researchers approach, emphasising doing research with, rather than on, students (Fielding 2004), and the student voice approach, which gives students an active agency and values their expertise and genuine partnership in improving educational provisions (Frost and Holden 2008; Lodge 2005; Robinson and Taylor 2012; Simmons et al. 2015).

The Learning Environment Design (LED) framework Version 2.1 (Fig. 2) employed in this study merges various theoretical and empirical considerations related to learning,

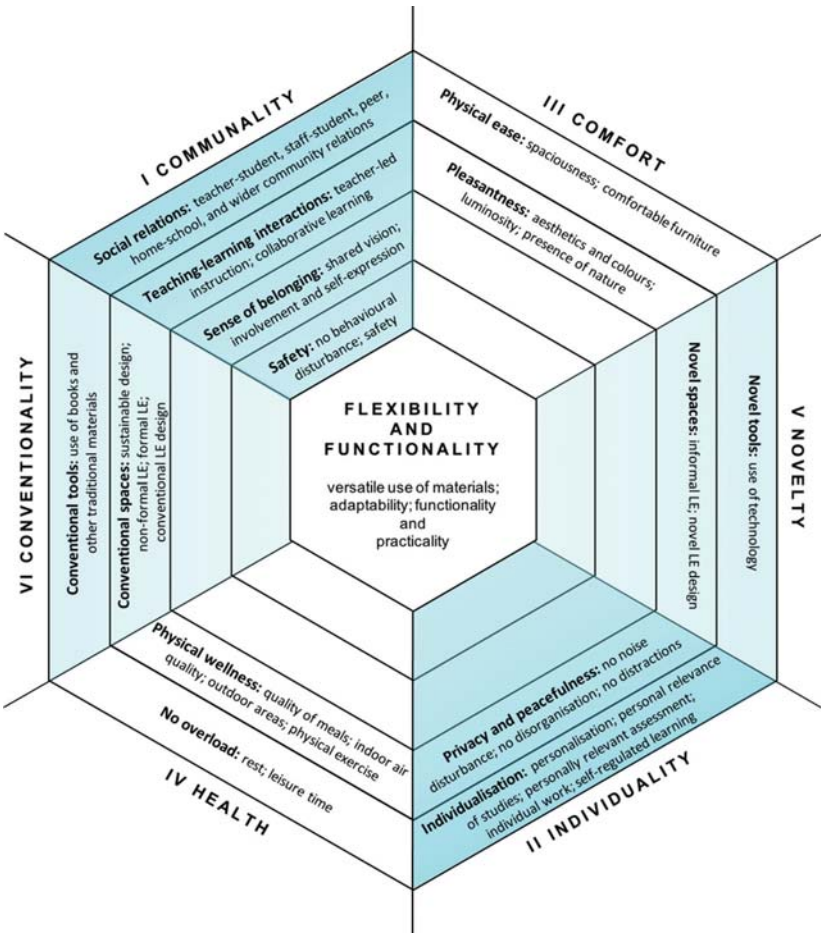

Fig. 2 LED-framework (V2.1) for guiding the co-design of LEs (Mäkelä and Helfenstein, 2016)

wellbeing and psychosocial and physical LEs. Its theoretical underpinnings go back to Dewey's (1907, 1916) educational philosophy on cognitive, affective, social and physical dimensions of learning and views of learning as student-centred, active, experiential and reflective activity (ÓNeill and McMahon 2005; Veloso et al. 2014). In line with Dewey's thinking (1916), dynamic interaction is assumed between individuals and their social and physical environments; while these environments can promote or hinder an individual's action and development, individuals can also actively influence them. The framework also draws insights from sociocultural and socio-constructivist theories (e.g. Vygotsky 1978), highlighting the importance of social environment and the mediating artefacts for human development and learning. The LED-framework combines these theoretical considerations with contemporary educational (Kangas 2010; Zandvliet and Fraser 2005) and architectural (e.g. Barret et al. 2013) studies of the LE design, as well as pilot studies conducted with primary and lower secondary school students in Finland and Spain (Mäkelä and Helfenstein 2016).

The LED framework is divided into three pairs of concepts that provide equilibrium between needs and wishes related to communality and individuality, comfort and health, and novelty and conventionality. The main constructs are further divided into thematic sub-blocks consisting of various LE characteristics. In addition, a construct named flexibility and functionality is integrated in the framework as a centric enabler for considering the school community's varying needs and preferences. The framework draws attention to complex interrelationships between its components, instead of seeking rigid categorisations or a fixed list of characteristics (see Cleveland and Fisher 2014). LE characteristics can vary between individual LE co-design projects, for example, depending on the project aims and the specific context in which the project takes place.

Methods

Participants

The LE co-design project described in this article was carried out in a teacher training school (a comprehensive and upper secondary school where the teacher students carry out their teaching practice) with approximately 1000 students located in Central Finland. The school follows the Finnish National core curriculum that emphasises the importance of learner-centred approaches, students' active agency, self-regulation, collaborative learning, versatile working methods, and both formative and summative evaluation such as self- and peer-evaluation, projects, assignments and examinations (Finnish National Board of Education 2003).Various internal (school administration, teachers, teacher students, students) and external (researchers, professional designers, constructors, companies) stakeholders contributed to the final design. This article, however, focuses on the students' participation in the LE co-design project on the school's premises at the upper secondary school level. Three hundred (300) upper secondary students (students between 16 and 19 years of age) were invited to participate in the LE redesign process. The number of participants for each design cycle was as follows:

1. *Co-design activities* 11 students (females $n = 8$, males $n = 3$)
2. *Student feedback* 175 students (females $n = 104$, males $n = 61$, no info on gender $n = 10$),

3. *Professional design evaluation* 2 male student co-designers
4. *Student satisfaction survey* 83 students (females $n = 45$, males $n = 37$).

Procedure and measures

Varying participatory design methods and numeric, verbal and visual data, both quantitative and qualitative, were collected to provide a rich understanding of the students' perspectives (Frost and Holden 2008; Simmons et al. 2015; Woolner et al. 2012). The following paragraphs describe the procedures and measures employed in each design cycle involving students.

1. *Co-design activities* (Autumn term 2012) An invitation to participate in the elective co-design project course (38 h) was sent to all students by email using the school's general mailing list. Because only a few students enrolled, more students were recruited from those aiming to take a visual arts course entitled Environment, Place and Space (Finnish National Board of Education 2003) by offering them the possibility to study the course as a co-design project with the researchers. The co-design project course involved, for example, visiting recently (re)designed nearby schools, meeting with an interior designer, and using a blog for sharing and co-creating ideas. As their final coursework, the 11 students created (in groups) LE designs consisting of 3D-models/sketches and colour, furniture and technology plans (see Fig. 3).
2 *Student feedback* (November 2012) The project course culminated in an exhibition that displayed the students' designs and which gave other upper secondary school students an opportunity to comment on the redesign plans using a structured feedback form. Students could visit the exhibition during their weekly tutorial. In addition to gathering background information (age and gender), the student feedback form consisted of:

   - giving feedback regarding (a) advantages and (b) disadvantages of each student design
   - voting for one's favourite design and justifying the choice
   - recording which physical, virtual, social and personal aspects (a) enhance learning and wellbeing and (b) inhibit learning and wellbeing.

   Student designs and summarised student feedback were then presented to teachers and student teachers who, first, evaluated students' ideas and, subsequently, gave their own suggestions. Because of a delay in acquiring official permissions, professional space

Fig. 3 Examples of student designs (virtual 3D sketches)

designers could not be invited into the initial co-design but student designs and feedback from each participant group were delivered afterwards to professional designers.

3 *Professional design evaluation* (May 2013) Before implementing the changes, the researchers invited participants of the co-design project course to evaluate the extent to which students' contributions were integrated into the professional design (Fig. 4). The interior designer in charge of the redesign was also invited to this session, but was obliged to cancel the meeting at the last minute. Summarised feedback was thus sent to her by email. After some final revisions to the professional design, changes were initiated in the summer of 2013 and completed during the first months of the 2013–2014 school year (see Fig. 5).

4 *Student satisfaction survey* (December 2013–January 2014) After some months of appropriating the redesigned environments, approximately 100 students employing the remodelled spaces were invited to take part in the post-reform evaluation. A student satisfaction survey (a web questionnaire) including both numeric ratings and open-ended questions was constructed. Survey items were based on the LE characteristics

Fig. 4 Professional interior design, general view (with the permission of the interior designer, Liisa Lundell, Architects LPV Jyväskylä Oy)

Fig. 5 The natural science classroom (*left*) seen from the sliding glass doors and one hallway corner (*right*) after the redesign

highlighted in the student designs and the written feedback. The analysis focused on one section of the survey which had the following instruction: "Please rate the following 38 items depending on whether you think that, after the redesign, they have (a) improved (+1 or +2), (b) remained the same (0), or (c) worsened (−1 or −2)". In the present analysis, responses to the open-ended questions (e.g. "What do you think is the best aspect of the redesigned LE?" and "What could still be improved?") were used as support data. "Appendix" contains more information about the instrument and the survey questions and items, and provides some clarifications in parenthesis (translated into English). Survey items are also presented in the Results section in Tables 1, 2, 3, 4, 5, 6, 7.

Data analysis

Data analysis was theory-driven in the sense that an a priori LED framework (see Fig. 2) was used to structure the data collected during each design cycle that involved students. However, adjustments were made based on participants' views (Woolner et al. 2012). The following paragraphs summarise the phases of data analysis:

1. *Student designs* A thematic analysis was conducted to identify and classify the LE design characteristics present in the student designs (3D-models/sketches and colour, furniture and technology plans). Field notes from the co-design project course were used to support the analysis.
2. *Student feedback* Content analysis techniques were used to analyse, code and classify LE characteristics identified in the written student feedback using the Atlas.ti program. For the purpose of this analysis, the frequencies of each LE characteristic were calculated for each individual respondents' overall responses, not for each question type (see Procedures and measures section).
3. *Professional design evaluation* A thematic analysis of the transcription of the evaluation session with the students was conducted (supported by a copy of the professional design; see Fig. 4).
4. *Student satisfaction survey* Descriptive statistics (means, standard deviation and frequencies) from the student satisfaction survey items were calculated using the SPSS program. In the calculation of frequencies, negative (−2, −1), neutral (0) and positive (+ 1, + 2) ratings were grouped into three categories: 'negative changes', 'no changes' and 'positive changes'. Responses to open-ended questions were utilised to support interpretation of the findings based on the quantitative data. While deepening understanding of students' perceptions on the LE items, they also helped to identify issues that were left out in the structured ratings, but which the students raised as important concerns.

An overview of student perceptions was finally constructed by synthesising the results of the various data sources and design cycles (Frost and Holden 2008; Simmons et al. 2015; Woolner et al. 2012) and by visualising the overall results with respect to the prior LED framework structure (Fig. 2) by making adaptations to the framework to reflect the findings of the empirical data collected in this study (Fig. 6).

Results

Reporting of results is organised using seven section subheadings, with each presenting one construct of the framework (see Fig. 2). The first two cycles (i.e. the student designs and written feedback) are seen as providing information about students' wishes and ideas about the desired LE characteristics. The latter two cycles (i.e. the professional design evaluation and student satisfaction survey) are seen as indicating whether students perceived that their wishes had been considered in the professional design and whether they viewed an improvement in these LE characteristics after the redesign (see Tables 1–7). Student satisfaction survey results are summarised using means and standard deviation. Examples of distributions of responses (negative, neutral and positive ratings) are given in the text.

Communality

Social relations As can be seen in Table 1, the importance of areas for socialising (i.e. supporting *peer relations*) was the only 'social relations'-related LE characteristic explicitly advocated in the student designs and student feedback (cf. Figure 2). Students evaluating the professional design felt that these wishes were taken into account. Also, the results of the student satisfaction survey indicate that, after the redesign, students had generally experienced an improvement in support for peer relations.

Table 1 Communality in student designs, feedback, professional design and satisfaction survey

1.1. Student designs ($n = 11$)	1.2. Student feedback ($n = 175$): Frequency(f)[a]	1.3. Professional design evaluation ($n = 2$)	1.4. Student satisfaction survey[b] ($n = 83$) M (SD)
(a) Social relations			
Bar stools and tables Sofas and easy chairs	Peer relations/Areas for socialising: f = 70	Bar stools and tables Low sofa area	Areas for socialising: 0.7 (0.7)
(b) Teaching–learning interaction			
The tiered floor maintained	Teacher visibility: f = 22 Teacher-led instruction: f = 17	The tiered floor removed	Teacher visibility: −0.1 (1.0) Teacher-led instruct.: 0.2 (0.7)
Group working tables	Collaborative learning: f = 13	Triangular-shaped desktops allowing group configurations	Group work: 0.7 (0.9) Pair work: 0.5 (0.8)
(c) Sense of belonging			
Homelike environment	Homelike environment: f = 32	Pleasant and comfortable spaces	Cosiness and comfort: 0.8 (0.8)
(d) Safety			
Transparent glass walls Separate laboratory tables	No behav. disturbance: f = 10 Transparency: f = 10 Physical safety: f = 4	Large sliding glass doors Separate laboratory tables	No disturbance or distractions: 0.1 (0.8) Safety: 0.3 (0.7)

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: −2, −1, 0, 1, 2

Teaching–learning interaction Students' wishes to maintain the tiered classroom floor (see Fig. 1) to ensure *teacher visibility* indicated that they did not want to completely abandon *teacher-led instruction*. The tiered floor was removed, however, to better enable group configurations of the novel triangular-shaped desktops and to promote *collaborative learning* that also was valued by the students. Group working possibilities were also augmented in the hallway (see Fig. 4 and 5). In the survey, the percentage of students experiencing a negative change in teacher visibility (35%) was the highest of all items, resulting in a very low mean for this item. On the other hand, the survey results indicated that students had experienced an improvement in opportunities for collaborative learning.

Sense of belonging The importance of *homelike environments* emerged in this project's context (cf Fig. 2 and Table 1). The results of the student satisfaction survey indicated that students perceived the redesigned spaces as being cosier than before.

Safety Students' comments referring to wishes for *no behavioural disturbance* and an emerging characteristic named *transparency* were taken into account by increasing transparency by opening up the classroom to the hallway using the large sliding glass doors. Based on both students' and teachers' requests, *physical safety* was taken into consideration by creating a separate laboratory area (Fig. 4 and 5). However, the survey results indicated that that the improvements related to disturbance or safety were not noticed or positively perceived by the students.

Individuality

Privacy and peacefulness In addition to the LE characteristics of *no noise disturbance*, *no disorganisation* and *no distractions*, a new characteristic named *private spaces* was formulated based on students' wishes (cf Fig. 2 and Table 2). Students evaluating the

Table 2 Individuality in student designs, feedback, professional design and satisfaction survey

2.1. Student designs ($n = 11$)	2.2. Student feedback ($n = 175$): Frequency (f)[a]	2.3. Professional design evaluation ($n = 2$)	2.4. Student satisfaction survey[b] ($n = 83$) M (SD)
(a) Privacy and peacefulness			
Textiles to diminish echo Acoustically isolating box lounger	No noise disturbance/good soundproofing: f = 37	Acoustic panels and textiles No acoustically isolating box lounger	Good soundproofing: 0.4 (0.8)
Increased storage spaces	No disorganisation: f = 29	Increased storage spaces	No disorganisation: 0.0 (0.8)
Dimming curtains Private lounge	No distractions: f = 38 Private spaces: f = 17	No dimming curtains Private science booth	No disturbance or distractions: 0.1 (0.8) Private spaces: 0.1 (0.8)
(b) Individualisation			
Varying smaller-scale learning stations	Personalisation: f = 11	Varying smaller-scale learning stations	Personalisation: 0.3 (0.6)
Individual desktops	Individual work: f = 5	Individual desktops	Individual work: 0.1 (0.7)
Working tablets to put on laps in the hallway	Self-regulated learning: f = 21 Study during the breaks: f = 9	Learning stations in the hallway	Self-regulated learning: 0.2 (0.7) Study during the breaks: 0.5 (0.8)

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: −2, −1, 0, 1

professional design were pleased to hear that soundproofing would be improved, especially in the hallway, because noise coming from downstairs had been making it difficult to study there. Students noticed, however, that the large sliding doors separating the classroom and the hallway did not include dimming curtains (see Fig. 5), which they anticipated causing distractions. On the other hand, the design entailed a private acoustically and visually isolated 'science booth' in the hallway extension (Fig. 4). This private space, however, was left out of the final design because of the elevated costs of structural changes that it would have required. In the survey, 45% of the respondents viewed that the redesign had improved soundproofing. For other items related to privacy and peacefulness, no changes were generally reported to have been experienced.

Individualisation Students expressed valuing *personalisation*, *individual work* and *self-regulated learning*. Also, comfortable places for doing homework or *studying during the breaks* were desired. These aspects were considered by creating varying smaller-scale 'learning stations' both in the classroom and in the hallway and by the triangular-shaped individual desktops. The survey results indicated that most students had not experienced a change in the possibilities for individual work (68% no change), personalised learning (63% no change) or self-regulated learning (68% no change). Only possibilities for studying during the breaks were considered to have been improved by 48% of the respondents, resulting in the highest item mean for this construct.

Comfort

Physical ease In addition to *spaciousness*, students gave importance to having *enough seats, seating and table space* (cf Fig. 2 and Table 3). In the professional design, there were more seats and tables both in the classroom and the hallways which, however, could increase the feeling of being cramped. In the survey, respondents generally reported a positive change in spaciousness but, in relation to having enough seating space, 34% of respondents reported a negative change and 35% reported no change at all. Further, in the open-ended questions, 22 students criticised the triangular-shaped desktops because they had less table space than traditional desks.

Students' numerous wishes for *comfortable furniture and spaces* were considered by using soft sofas and additional cushions with the classroom chairs. However, instead of the soft arc-shaped sofa advocated by the students, hard two-tiered seating was selected (Fig. 4) because it fitted better in the hallway corner. In the survey, 63% of the respondents reported a positive change in space comfort. In the responses to the open-ended questions, however, some students complained about hard two-tiered seating.

Pleasantness Students paid lots of attention to *aesthetics*. *Colour* was the most commented LE characteristic of all. In response to different tastes in colours, colour-changing lamps to create different ambiances were suggested, something that teachers additionally considered as a tool to teach colour theory. In the survey, a very high percentage of respondents (75%) believed that the aesthetic pleasantness of the redesign spaces had improved. Most of the respondents also viewed changes in colours positively.

Students also gave importance to *luminosity*, which was increased by large sliding glass doors (see Fig. 5) and improved lighting. In the survey, 70% of the respondents considered that renovations had a positive effect on luminosity. On the other hand, students evaluating the professional design were disappointed that their ideas of having plenty of interior plants (*the presence of nature*) had not been considered, because their watering during vacations was deemed to be too complicated. In the survey, 67% of respondents reported not to have

Table 3 Comfort in student designs, feedback, professional design and satisfaction survey

3.1. Student designs ($n = 11$)	3.2. Student feedback ($n = 175$): Frequency (f)[a]	3.3. Professional design evaluation ($n = 2$)	3.4. Student satisfaction survey[b] ($n = 83$) M (SD)
(a) Physical ease			
Reduced amount of tables and seats in the classroom	Spaciousness: f = 52	A high number of desks may increase cramped conditions	Spaciousness: 0.4 (1.1)
Maximum amount of desks in the classroom	Enough seats, seating and table space: f = 70	Increased number of seats and tables	Enough seating space: 0.0 (1.1)
Soft carpets and cushions A modular arc-shaped sofa	Comfortable furniture and spaces: f = 115	Additional cushions for chairs Hard two-tiered seating	Cosiness and comfort: 0.8 (0.8)
(b) Pleasantness			
Calming colours combined with special effect colours Colour-changing lamps	Aesthetics: f = 64 Pleasant colours: f = 134 Calming colours: f = 21	White walls combined with colourful design elements Colour changing lamps	Aesthetic pleasantness: 1 (0.8) Pleasant colours: 0.8 (1) Calming colours: 0.5 (0.9)
A glass wall Additional lamps	Luminosity: f = 30	Large sliding glass doors Improved lighting	Luminosity: 0.9 (0.7)
Interior plants	Presence of nature/ interior plants: f = 12	No interior plants	Interior plants: −0.1 (0.8)

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: -2, -1, 0, 1, 2

experienced changes in this aspect, and its mean was also amongst the lowest for all items. It is worth mentioning, however, that a hydroponic green wall was installed in the renovated space after the student satisfaction survey had been conducted.

Health

Physical wellness In addition to good *indoor air quality*, the importance of optimal *air temperature* emerged. Students also gave attention to good *ergonomics* (cf Fig. 2 and Table 4). Despite the renewed ventilation system, students responding to the survey did not generally report a positive change in indoor air quality. On the other hand, 73% of the respondents reported a positive change in relation to ergonomics.

No overload Students desired opportunities for both *rest* and *leisure time* or, in the context of this project, spaces for relaxing. In the professional design, the redesigned hallway offered opportunities to rest and relax. Survey results indicated that these changes had also been positively experienced by most of the participating students.

Table 4 Health in student designs, feedback, professional design and satisfaction survey

4.1. Student designs ($n = 11$)	4.2. Student feedback ($n = 175$): Frequency (f)[a]	4.3. Professional design evaluation ($n = 2$)	4.4. Student satisfaction survey[b] ($n = 83$) M (SD)
(a) Physical wellness			
Interior plants to purify the air	Indoor air quality: f = 20 Air temperature: f = 4	Renewed ventilation system No interior plants	Indoor air quality: 0.5 (0.8) Air temperature: 0.3 (0.8)
Adjustable desks and chairs	Ergonomics: f = 28	Ergonomic chairs	Ergonomics: 0.8 (0.9)
(b) No overload			
Floor-wide mattress Spaces to relax in the hallway	Rest: f = 55 Leisure time/ Spaces to relax: f = 50	Spaces to relax in the hallway	Spaces to rest: 0.8 (0.9) Spaces to relax: 0.8 (0.8)

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: −2, −1, 0, 1, 2

Novelty

Novel tools The LE characteristic, *use of technology*, was clearly present in all student designs and also praised in many student feedback forms. Students evaluating the professional design were generally pleased with the technological choices. In the survey, 71% of the respondents reported that there was a positive change in relation to the use of technology. In open-ended questions, for instance, students explained that technology was used more frequently and in more varied ways.

In the context of this project, an LE characteristic named *educative design elements* emerged (cf Fig. 2 and Table 5) because of certain design elements, such as the planetarium ceiling suggested by the students, which was converted into a solar system model in the professional design, as suggested by the teachers. Despite the lack of interior plants, which according to the students evaluating the professional design could also serve

Table 5 Novelty in student designs, feedback, professional design and satisfaction survey

5.1. Student designs ($n = 11$)	5.2. Student feedback ($n = 175$): Frequency (f)[a]	5.3. Professional design evaluation ($n = 2$)	5.4. Student satisfaction survey[b] ($n = 83$) M (SD)
(a) Novel tools			
Interactive whiteboards Tablets Stereos	Use of technology: f = 36	Interactive whiteboards/ walls Tablets No stereos	Use of technology: 0.8 (0.8)
Planetarium ceiling Interior plants	Educative design elements: f = 8	Solar system model No interior plants	Educative design elements: 0.7 (0.8)
(b) Novel spaces			
Novel design elements	Novel LE design: f = 57 Inspiring and motivating spaces: f = 54	Novel design elements	Novel LE design: 1.2 (0.7) Inspiring and motivating spaces: 0.7 (0.8)

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: −2, −1, 0, 1, 2

educative purposes and include information of the vegetation and their origins, this aspect received quite high satisfaction ratings overall.

Novel spaces The students wanted a *novel* rather than a school-like, hospital-like or institutionalised *LE design*. In addition, an LE characteristic named *inspiring and motivating spaces* was formulated based on students' wishes (cf Fig. 2 and Table 5). Students evaluating the professional design explained that almost nobody spent breaks in the actual hallway. They thought that the renovation would make spaces more inspiring and inviting. The survey responses indicated that students generally had experienced an improvement in survey items related to novel spaces. Novel LE design was rated positively by 85% of the respondents and had the highest mean of all items.

Conventionality

Conventional tools The students' designs combined the use of technology with *the use of books and other traditional materials* (see Table 6). In the student feedback forms, the use of traditional materials was not directly discussed, but there were some negative comments related to the use of technology (e.g. that teachers do not know how to use it or that students get distracted by the technology). In the survey, 77% of the respondents reported that the LE redesign had not led to a change in the use of traditional materials.

Conventional spaces In relation to the *conventional LE design*, all student designs kept the border between the classroom and the hallway and, in the student feedback forms, many students wanted to keep traditional school furniture (see also Fig. 3). In the professional design, as a compromise between desires to open up the classroom completely to the hallway and to keep the space division, which was discussed both with the students and the teaching staff, the distinction between the classroom and the hallway was only partially removed by the glass sliding doors. In the student satisfaction survey, 46% of the respondents reported not having experienced a change in relation to the *conventional LE design*, and 28% of the respondents reported a negative change. In the responses to the open-ended questions, the most frequently criticised aspect was the triangular-shaped desktops because of their reduced table space.

Table 6 Conventionality in student designs, feedback, professional design and satisfaction survey

6.1. Student designs ($n = 11$)	6.2. Student feedback ($n = 175$): Frequency (f)[a]	6.3. Professional design evaluation ($n = 2$)	6.4. Student satisfaction survey[b] ($n = 83$) M (SD)
(a) Conventional tools			
Use of textbooks and other traditional materials	Criticising the use of technology: f = 4	Use of textbooks	Use of books and other traditional materials: 0.0 (0.6)
(b) Conventional spaces			
Division between the classroom and hallway	Conventional LE design: f = 30	Division between the classroom and hallway partly kept	Conventional LE design: −0.1 (0.9)
Desks in rows		Individual desktops	

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: −2, −1, 0, 1, 2

Flexibility and functionality

LE characteristics named as *versatile tools, materials and methods* and *adaptability* were present both in the student designs and feedback (see Table 7). Students evaluating the professional design viewed positively the possibilities for multiple furniture configurations. Also, the responses to the survey indicated that changes related to these aspects were mainly viewed positively.

Students also gave value to *practicality*. Students evaluating the professional design showed an understanding that some expensive or impractical furniture solutions, such as box loungers that can only be used by one or two people at a time, were not included in the design. Based on the survey results, students generally thought that the redesign contained improvements in the practical aspects.

Discussion

Summary

The main LE characteristics identified in the overall analysis of the student data based on the LED framework V2.1 (see Fig. 2) are illustrated in Fig. 6 (LED framework V2.2). The LE characteristics missing in this study in comparison with previous research (Mäkelä and Helfenstein 2016) are in parenthesis. The features that emerged in the present study, in turn, are highlighted in italics.

The results for the first research question concerning LE characteristics that students considered important for their learning and wellbeing were generally in line with our pilot studies (Mäkelä and Helfenstein 2016) and other studies (e.g. Barret et al. 2013; Kangas 2010; Kostenius 2011; Simmons et al. 2015). Students participating in this project stressed the importance of *communality*-related LE characteristics, but also paid attention to *individuality*. They viewed *comfort* as particularly important, but neither neglected issues related to *health*. The participants also hoped to combine *novelty* with *conventionality*.

Table 7 Flexibility and functionality in student designs, feedback, professional design and satisfaction survey

7.1. Student designs ($n = 11$)	7.2. Student feedback ($n = 175$): Frequency (f)[a]	7.3. Professional design evaluation ($n = 2$)	7.4. Student satisfaction survey[b] ($n = 83$) M (SD)
Removing the tiered classroom floor Varying learning stations	Versatile tools, materials and methods: f = 15	Varying learning stations	Versatile tools and materials: 0.6 (0.7) Versatile teaching methods: 0.8 (0.7)
Modular tables and sofas	Adaptability: f = 8	Design solutions allowing multiple configurations	Adaptability: 0.8 (0.9)
Stools which can be hung on the wall	Practicality: f = 65	No stools which can be hung on the wall Practical design solutions	Practicality: 0.5 (0.9)

[a] Frequency = frequency of persons advocating this aspect; [b] Scale: −2, −1, 0, 1, 2

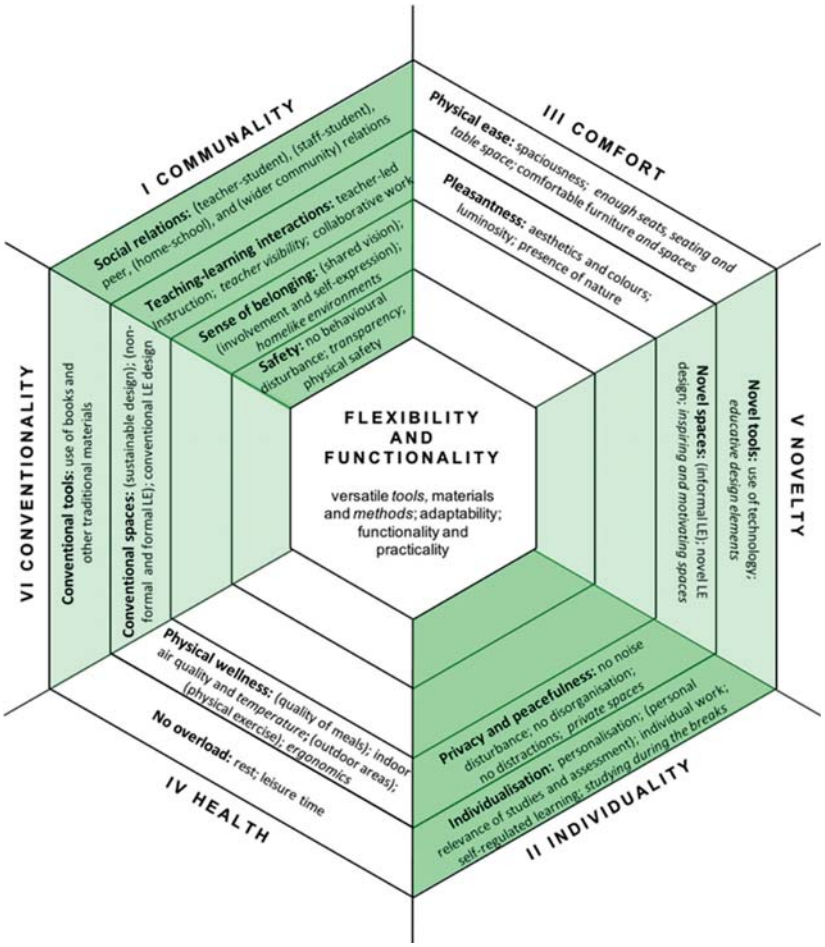

Fig. 6 Visualisation of the results (LED framework V2.2) (Non-replicated LE characteristics are in *parenthesis* and emerged characteristics are in *italics*.)

In comparison with our previous research (Mäkelä and Helfenstein 2016), the participants seemed to pay more attention to LE characteristics related to *flexibility and functionality*. This, as well as the presence of some emerging comfort- and health-related characteristics (e.g. enough seats, seating and table space or ergonomics), could be explained by the older age of students in comparison with our pilot studies. Moreover, it is possible that characteristics such as flexibility, ergonomics and functionality were considered as relevant because of the particular requirements for science classrooms (see also Duarte et al. 2015). The absence of some LE characteristics (e.g. wider community relations and outdoor areas) is understandable because they were clearly beyond the scope of

this project which focused on specific indoor environments. These differences point out the importance of adapting the LE design in accordance with age-, subject- and other context-specific requirements.

In response to the second research question, students generally perceived their wishes had been considered. Students perceived an improvement in most of the communality-, comfort-, health- and novelty-related LE characteristics, as well as in flexibility and functionality. No changes were commonly experienced in relation to individuality. In relation to conventionality, students reported no changes or negative changes.

The results shed light on the influence of student participation on design quality, participatory culture, and student learning and wellbeing. First, upper secondary school students' mature and insightful contributions (cf den Besten et al. 2008; Newman and Thomas 2008) led to designing a more adequate (e.g. *good ergonomics*) and desirable (e.g. *inspiring and motivating spaces*) LE for students (Flutter 2006; Parnell et al. 2008). Student participation deepened understanding of the interrelatedness of psychosocial and physical LE dimensions, such as *good peer relations* supported by *areas for socialising*, and *teacher-led instruction* supported by good *teacher visibility*. Student participation also revealed possible contradictions between various wishes, such as *spaciousness* versus *enough seats*, *teacher visibility* vs. spaces for *collaborative learning*, and *transparency* versus *no distractions*. In this redesign project, the final decisions regarding issues for which there were contradicting wishes were based on pedagogical and wellbeing-related goals as well as on practical requirements. For practical reasons, having enough seats was considered more important than spaciousness, and removing the tiered classroom floor (to better enable group configurations) reduced teacher visibility but was pedagogically justified (Dewey 1907, 1916; Land et al. 2012; Scardamalia et al. 2012). In some cases, a compromise was possible: the dilemma of providing transparency, while at the same time minimising distractions in the space, was solved by opening up only half of the wall to the hallway.

In this study, students' contributions were more realistic and pragmatic (Flutter 2006; Lievonen et al. 2014) than revolutionary and highly innovative (Kostenius 2011; Newman and Thomas 2008). In our view, student participation improved the design quality, particularly by helping to avoid the design of overly radical changes. In this sense, students' views seemed to be in harmony with the Finnish educational change, which connects renewal with traditions without completely abandoning them (Hargreaves and Shirley 2009; Sahlberg 2011).

Second, the project provided plenty of opportunities for students to participate in the change process without marginalising teachers (Woolner 2009). Balancing co-design activities with a smaller number of students with collecting anonymously-written data from a more representative group of students (den Besten et al. 2008; Newman and Thomas 2008) supported considering a variety of wishes and more silent and contradictory voices in the design (Fielding 2004; Robinson and Taylor 2012).

Finally, the participatory design project offered plenty of authentic learning experiences (Flutter 2006; Frost and Holden 2008; Parnell et al. 2008) and, when matched with curricular content and the school's everyday practices, was not perceived as lost time from other subjects (cf Parnell et al. 2008; Woolner et al. 2007). While the students played an important role in designing spaces that foster physical and psychosocial wellbeing (e.g. good ergonomics, spaces for socialising), teachers' participation was fundamental, especially for gaining detailed pedagogical knowledge. Some students' ideas, such as colour-changing lamps and a planetarium ceiling, were also further developed by the teachers from the pedagogical perspective.

The participating students seemed to value teacher-led instruction. This can be explained both by its familiarity and perceived relevance for students. We anticipate, however, that the decision to create less favourable conditions for predominantly teacher-led instruction promotes a transition towards more learner-centred collaborative forms of learning supported both by earlier (Dewey 1907, 1916) and contemporary (APA Work Group of the Board of Educational Affairs 1997; Land et al. 2012; Scardamalia et al. 2012) theoretical considerations. This transition is also justified by the associations found between positive learner-centred teacher–student relations (e.g. honouring students' voice, nondirectivity, encouraging learning) and cognitive, affective and behavioural student outcomes (Cornelius-White 2007). In our view, however, stimulating and interactive teacher-led instruction, particularly when dealing with topics new for learners and content such as sciences which require a strong knowledge base, also is needed as long as it is balanced with other ways of learning (see also ÓNeill and McMahon 2005). The need for more direct instructional guidance can also be justified by Vygotsky's (1978) conceptualisation of the zone of proximal development that indicates that direct guidance can be gradually loosened according to factors such as learner's maturity, skill level and self-regulation skills. Further, based on the results of the student satisfaction survey, it seems that the LE redesign had not fostered changes in teaching practices related to individualisation. Thus more effort could be needed to support students' self-regulated learning and to provide choices and personalised learning opportunities also advocated in the educational literature (Cornelius-White 2007; Dewey 1907; ÓNeill and McMahon 2005; Simmons et al. 2015; Zandvliet and Fraser 2005).

Limitations and future directions

Despite the several strengths of this study, it also had limitations. First, there was relatively little time between design cycles to analyse the data and consider the results before developing the research design for the following cycles. For example, a need to improve some student satisfaction survey items was identified only in a retrospective analysis: instead of single items, 'no disturbance or distractions' and 'cosiness and comfort', it would have been better to formulate distinct items for each LE characteristic. Furthermore, some aspects such as 'having enough table space' had not been included in the survey items, but surfaced as an important concern in the open-ended questions.

The framework for synthesising a wide range of psychosocial and physical LE characteristics conducive to learning and wellbeing is limited in its capacity to consider each characteristic individually. However, it is important that pedagogical principles include a comprehensive range of teaching and learning ecologies guide the LE design. While the empirical data used to develop the framework reflect mainly student perceptions and wishes regarding their wellbeing needs, in the future cycles of the framework development, more emphasis could be given to teachers' views, thereby possibly further enriching the framework from pedagogical perspectives.

Although careful follow-up in the form of professional design evaluation and student satisfaction survey supported identifying the influence of student participation on the design (cf Parnell et al. 2008; Woolner 2009), it is challenging to point out the direct impacts of student involvement. This is because many ideas that were chosen for action, such as renewing the ventilation system or increasing collaborative learning opportunities, were consistent with the intentions of staff (Newman and Thomas 2008; Simmons et al. 2015).

Student participation rates were somewhat low. For example, we achieved enough student co-designers only after embedding the co-design in the obligatory visual arts

course (Parnell et al. 2008; Woolner et al. 2007). Low participation rates might be explained by the students' tight schedules but, as relatively temporary occupants of the school, they also might have been less committed to the change process than the staff (Veloso et al. 2014; Woolner et al. 2007). It is also possible that some students chose not to participate because they did not believe that their views would be taken into account (Lodge 2005; Newman and Thomas 2008). While more unengaged students were not purposefully omitted, the challenge of how to get them involved and their voices heard remains. In the future, more effort could also be exerted on communicating to students how their views had been taken into account and why some of their ideas had not been implemented (Mäkelä et al. 2014b). Justifying design choices based on clear criteria is likely to decrease experiences of disappointment (cf Simmons et al. 2015).

Finally, more time is needed to evaluate the impact of student participation on their learning and wellbeing in the long run and on a wider scale (Flutter 2006). For example, the duration of the motivational and inspirational effect of the novel design solutions or durable changes in the ways of teaching and learning (e.g. towards more collaborative, self-regulated and less teacher-led practices), or improvements in the overall wellbeing, remains to be discovered (Woolner 2009). As discussed in other studies (e.g. Veloso et al. 2014), providing conditions, spaces and tools for change does not necessarily lead to change in pedagogy. While re-designed spaces and equipment can facilitate active, student-centred learning, they also can be used in passive, more teacher-centred ways. In this study, students' comments about challenges in the use of ICT suggest a need to support more efficient use of ICT in teaching and learning. Further, only in time will we see whether the participatory LE design involving students endures and becomes an institutionalised practice, scales up and diffuses both within the school and to other schools (Hargreaves and Shirley 2009). At best, the participatory design of LEs would be an iterative process (Woolner et al. 2007) in schools consisting not only of 'the design for use', but also of 'the design in use' and 'the redesign in use' (Bjögvinsson et al. 2012), thus giving continuous possibilities for the whole school community to participate in the LE design.

Conclusion

The present study shows how student participation in the LE design can increase understanding of the complex synergetic influence of psychosocial and technology-enhanced physical LEs on learning and wellbeing, as well as contribute significantly to improving educational environments. In light of the findings, we elaborated the following substantive design principles to support the LE design:

- Balance needs for communality and individuality by combining:
  - cosy areas for socialising with private spaces and good soundproofing
  - teacher-led and collaborative learning with individual, personalised and self-regulated learning
  - transparent surfaces with dimming curtains and safety working areas with good storage spaces.
- Balance comfort wishes with health needs by providing:
  - spacious areas with enough seats, seating and table space that have optimal air quality and temperature

  - comfortable and soft furniture for resting and relaxing and ergonomic furniture for working
  - aesthetically pleasing design and colours, luminous spaces and interior plants.
- Balance novelty with conventionality by blending:
  - use of technology and innovative educative design elements together with books and other traditional materials
  - novel and inspiring design with conventional school design.
- Assure that tools, spaces and ways of working are flexible and functional so that they allow versatile ways of working and the balancing of shared and individual needs and wishes concerning learning and wellbeing.

The findings of this particular study can serve as a point of departure in similar participatory LE efforts. We anticipate that both conceptual and methodological tools developed in this research not only will facilitate planning, conducting and evaluating individual co-design projects in schools, but also support comparing and generalising their findings to generate shared knowledge of the design of LEs conducive to learning and wellbeing.

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Appendix

Survey questions used in the analysis presented in this article. (To see the complete survey, please contact the first author.)

Survey items were formulated guided by the conceptual framework (Mäkelä and Helfenstein 2016) but the final selection of items was based on the LE characteristics highlighted in the student designs and written feedback.

Student satisfaction survey:

Natural science classroom and hallway change as experienced by students

Background information

Group: ____ Age: ____ Gender: ____

I have spent time in the classroom before the redesign: Yes____ No ____

I have spent time in the hallway before the redesign: Yes ____ No ____

Compare your experiences of redesigned classroom and hallway to how you experienced them before. If you do not have previous experience in these spaces, you can compare them to your experiences of other classrooms and hallways at school. Evaluate the classroom and the hallway as a conjunct.

Survey items

Please rate the following 38 items depending on whether you think that, after the redesign, they have (a) improved (+ 1 or +2), (b) remained the same (0), or (c) worsened (−1, −2).

Areas for socialising	Luminosity
Teacher visibility	Interior plants
Teacher-led instruction	Indoor air quality
Possibilities for group work	Indoor air temperature
Possibilities for pair work	Ergonomics (*furniture, working positions, etc.)*
Cosiness and comfort	Spaces to rest
No disturbance or distractions (*peaceful ambient*)	Spaces to relax
Safety aspects	Use of technology
Good soundproofing (*e.g. less echo*)	Educative design elements supporting learning natural sciences
No disorganisation	Novel LE design (*e.g. cushions and sofas*)
Private spaces (*where you can be by yourself*)	Inspiring and motivating spaces
Personalisation (*possibilities to choose personally preferred ways of working*)	Use of books and other traditional materials
Possibilities for individual work	Conventional LE design (*e.g. traditional desks, teacher's desk*)
Self-regulated learning (*autonomous study*)	Versatile tools and materials
Study during the breaks	Versatile teaching methods
Spaciousness	Adaptability (*e.g. furniture allowing multiple configurations*)
Enough seating space (*no cramped*)	Practical and functional equipment and spaces
Aesthetic pleasantness	
Pleasant colour choices	
Calming colours	

Open-ended questions

What do you think is the best aspect of the redesigned learning environment? What could still be improved? How redesign has influenced the use of spaces during the breaks? How redesign has influenced teachers' ways of working? How redesign has influenced students' ways of working? In your opinion, what new ways of teaching and learning can redesigned spaces and equipment offer?

References

APA Work Group of the Board of Educational Affairs. (1997). *Learner-centered psychological principles: A framework for school reform and redesign*. Washington: American Psychological Association.

Barret, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2013). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning. *Building and Environment, 59,* 678–689.

Bjögvinsson, E., Ehn, P., & Hillgren, P.-A. (2012). Design things and design thinking: Contemporary participatory design challenges. *Design Issues, 28*(3), 101–116.

Cleveland, B., & Fisher, K. (2014). The evaluation of physical learning environments: A critical review of the literature. *Learning Environments Research, 17,* 1–28.

Cornelius-White, J. D. (2007). Learner-centered teacher-student relationships are effective: A meta-analysis. *Review of Educational Research, 77,* 113–143.

den Besten, O., Horton, J., & Kraftl, P. (2008). Pupil involvement in school (re)design: Participation in policy and practice. *CoDesign: International Journal of CoCreation in Design and the Arts, 4*(4), 197–210.

Dewey, J. (1907). *The school and society*. Chicago: University of Chicago Press.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education.* Electronic version by the University of Virginia American Studies Program 2003.

Duarte, A., Veloso, L., Marques, J., & Sebastiao, J. (2015). Site-specific focus groups: Analysing learning spaces in situ. *International Journal of Social Research Methodology, 18*(4), 381–389.
Fielding, M. (2004). Transformative approaches to student voice: Theoretical underpinnings, recalcitrant realities. *British Educational Research Journal, 30*(2), 295–311.
Finnish National Board of Education. (2003). *National core curriculum for general upper secondary intended for young people*. Vammala: Opetusministeriön julkaisuja.
Flutter, J. (2006). 'This place could help you learn': Student participation in creating better school environments. *Educational Review, 58,* 183–193.
Frost, R., & Holden, G. (2008). Student voice and future schools: Building partnerships for student participation. *Improving Schools, 11*(1), 83–95.
Hargreaves, A., & Shirley, D. (2009). *The fourth way: The inspiring future for educational change*. Thousand Oaks: Corwin.
Higgins, S., Hall, E., Wall, K., Woolner, P., & McCaughey, C. (2005). *The impact of school environments: A literature review*. Newcastle: The Centre for Learning and Teaching: School of Education, Communication and Language Science, University of Newcastle.
Kangas, M. (2010). Finnish children's views on the ideal school and learning environment. *Learning Environments Research, 13,* 205–223.
Kostenius, C. (2011). Picture this—Our dream school! Swedish schoolchildren sharing their visions of school. *Childhood, 18*(4), 509–525.
Kujala, S. (2008). Effective user involvement in product development by improving the analysis of user needs. *Behaviour and Information Technology, 27*(6), 457–473.
Land, S. M., Hannafin, M. J., & Oliver, K. (2012). Student-centered learning environments: Foundations, assumptions, and design. In D. Jonassen & S. Land (Eds.), *Theoretical foundations of learning environments* (pp. 3–25). New York: Routledge.
Lievonen, M., Kinnunen, P., & Kankaanranta, M. (2014). Student views on ideal learning space: A case from upper secondary education. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* 2014 (pp. 511–514). Chesapeake: AACE.
Lodge, C. (2005). From hearing voices to engaging in dialogue: Problematising student participation in school improvement. *Journal of Educational Change, 6,* 125–146.
Mäkelä, T., & Helfenstein, S. (2016). Developing a conceptual framework for participatory design of psychosocial and physical learning environments. *Learning Environments Research, 19*(3), 411–440.
Mäkelä, T., Kankaanranta, M., & Helfenstein, S. (2014a). Considering learners' perceptions in designing effective 21st century learning environments for basic education in Finland. *The International Journal of Educational Organization and Leadership, 20*(3), 1–13.
Mäkelä, T., Kankaanranta, M., & Gallagher, C. (2014b). Involving students in the redesign of learning environments conducive to learning and wellbeing. In *Proceedings of the 6th Architectural Research Symposium in Finland 2014: Designing and Planning the Built Environments for Human Well-Being* (pp. 268–282). Oulu, Finland.
Mäkelä, T., Lundström, A., & Mikkonen, I. (2015). Co-designing learning spaces: Why, with whom, and how? In S. Nenonen, S. Kärnä, J. Junnonen, S. Tähtinen, N. Sandström, K. Airo, & O. Niemi (Eds.), *How to co-create campus?* (pp. 197–211). Tampere: Suomen Yliopistokiinteistöt.
Newman, M., & Thomas, P. (2008). Student participation in school design: One school's approach to student engagement in the BSF process. *CoDesign: International Journal of CoCreation in Design and the Arts, 4*(4), 237–251.
ÓNeill, G., & McMahon, T. (2005). Student-centred learning: What does it mean for students and lecturers? In G. O'Neill, G. Moore, & B. McMullin (Eds.), *Emerging issues in the practice of university learning and teaching*. AISHE: Dublin.
Parnell, R., Cave, V., & Torrington, J. (2008). School design: Opportunities through collaboration. *CoDesign: International Journal of CoCreation in Design and the Arts, 4*(4), 211–224.
Plomp, T. (2007). Education design research: An introduction. In T. Plomp & N. Nieveen (Eds.), *An introduction to educational design research* (pp. 9–35). Enschede: SLO.
Robinson, C., & Taylor, C. (2012). Student voice as a contested practice: Power and participation in two student voice projects. *Improving Schools, 16*(1), 32–46.
Sahlberg, P. (2011). The fourth way of Finland. *Journal of Educational Change, 12,* 173–185.
Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign: International Journal of CoCreation in Design and the Arts, 4*(1), 5–18.
Scardamalia, M., Bransford, J., Kozma, B., & Quellmalz, E. E. (2012). New assessment and environments for knowledge building. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 231–300). Dordrecht: Springer.

Simmons, C., Graham, A., & Thomas, N. (2015). Imagining an ideal school for wellbeing: Locating student voice. *Journal of Educational Change, 16,* 129–144.

van den Akker, J. (2007). Curriculum design research. In T. Plomp & N. Nieveen (Eds.), *An introduction to educational design research* (pp. 37–50). Enschede: SLO.

Veloso, L., Marques, J. S., & Duarte, A. (2014). Changing education through learning spaces: Impacts of the Portuguese school buildings' renovation programme. *Cambridge Journal of Education, 44*(3), 401–423.

Vygotsky, L. S. (1978). In M. Cole, V. John-Steiner, S. Scrimbner & E. Souberman (Eds.), *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

Woolner, P. (2009). Building schools for the future through a participatory design process: Exploring the issues and investigating ways forward. In *Proceedings of BERA.* Manchester.

Woolner, P., Hall, E., Wall, K., & Dennison, D. (2007). Getting together to improve the school environment: User consultation, participatory design and student voice. *Improving Schools, 10,* 233–248.

Woolner, P., McCarter, S., Wall, K., & Higgins, S. (2012). Changed learning through changed space: When can a participatory approach to the learning environment challenge preconceptions and alter practice? *Improving Schools, 15*(1), 45–60.

Zandvliet, D. B., & Fraser, B. J. (2005). Physical and psychosocial environments associated with networked classrooms. *Learning Environments Research, 8,* 1–17.