Meaningful learning with mobile devices: pre-service class teachers' experiences of mobile learning in the outdoors

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The authors consider the use of mobile learning environment ActionTrack in teacher education. Pre-service class teachers' (*N* = 277) experiences of the mobile learning environment were measured with a 7-point Likert scale questionnaire based on seven attributes of meaningful learning. Students' ratings for different attributes were analysed quantitatively, and based on this analysis, we conclude that it is possible to create meaningful learning experiences using ActionTrack. All the measured attributes of meaningful learning obtained positive values. In the mobile learning events of this study, three attributes arose as the essential features: mobile learning in the outdoors was primarily considered collaborative, active and contextual.

Keywords: meaningful learning; mobile learning; outdoor learning; teacher education

Introduction

Mobile information technology is helping people learn in informal, everyday life situations wherever they go (Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez, & Vavoula, 2009). Traxler (2007) argued that mobile devices alter the nature of learning and enable new methods of teaching and instruction. Moreover, the new national curriculum in Finland (National core curriculum for basic education 2014, 2016) emphasises the use of information communications technology, varied learning environments and personally owned mobile devices. These foci thus highlight the need for the design and development of formal mobile learning applications and experiences. Teachers ought to be aware how to effectively integrate mobile technologies into their teaching; moreover, there is a call for investigations of mobile learning within teacher education programmes (Baran, 2014).

At the University of Turku, the mobile learning environment ActionTrack has been used for several teacher education study modules since 2013. ActionTrack is a software programme which enables learners to perform contextual tasks in the outdoors and receive and send information through wireless networks. Research has indicated that there is a link between student satisfaction and the effectiveness of teaching, and that students' ratings are a qualified source for examining the quality of learning (Theall & Franklin, 2001). In this study, we explored pre-service class teachers' experiences of mobile learning in the outdoors using the ActionTrack application in the framework of meaningful learning (Jonassen, 1995). Meaningful learning is described by the seven attributes depicted in Figure 1

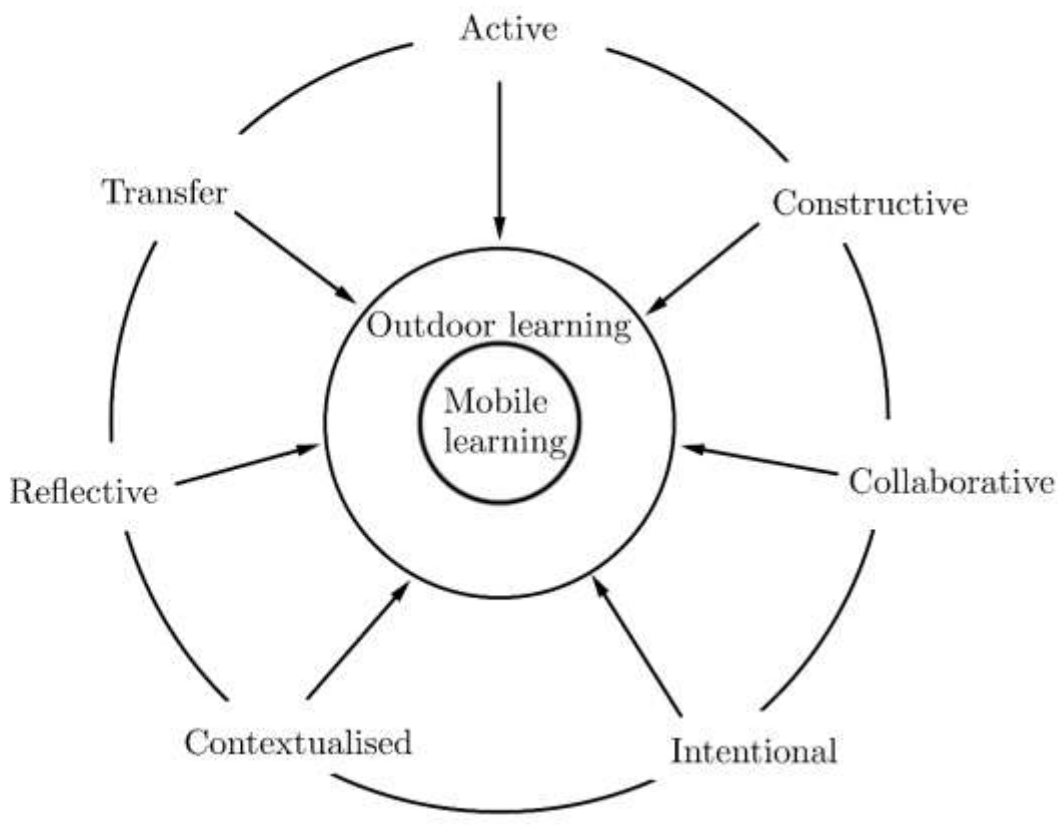

Figure 1. The seven attributes of meaningful learning.

Mobile learning outside the classroom

Mobile learning is a subcategory of e-learning (Attewell & Savill-Smith, 2004) defined by Crompton, Muilenburg and Berge (Crompton, 2013) as ‘learning across multiple contexts, through social and content interactions, using personal electronic devices’ (p. 4). Learners are supported by the features and functionality of laptops, e-book readers, mobile and smart phones and tablets, regardless of time and place (Veerappan, Wei, Wong, & Paramasivam, 2014). The definition of mobile learning covers formal, nonformal and informal learning, learning that is directed by others or by oneself, and learning that is spontaneous or designed to satisfy predetermined goals; the physical environment may or may not be involved in the learning experience (Crompton, 2013).

Mobile learning outside of the classroom can be considered an instance of outdoor learning. Outdoor learning is sometimes used interchangeably with outdoor education (Beames, Higgins, & Nicol, 2011); here it should be understood in a broad sense as experiential learning with an emphasis on active learner involvement in meaningful and challenging experiences (Knapp, 1996). Such learning involves being outside the classroom, either outdoors or indoors, in real-world situations, dealing with hands-on activities, and engaging in individual and group reflection and knowledge construction, as well as the application of knowledge to new situations (Knapp, 1996). Similar to Veletsianos et al. (2015) and Beames, Higgins and Nicol (2011), we do not focus on adventurous outdoor activities conducted by outdoor education professionals in remote locations for the purpose of personal and social development; instead, we refer to learning opportunities provided in local settings outside the classroom and arranged by teachers. Some examples of using technology for outdoor learning include mobile learning with QR codes (Lai, Chang, Li, Fan, & Wu, 2013) and technology-enhanced outdoor learning experiences introduced by Veletsianos et al. (2015).

Mobile technologies foster learning outside the classroom, in learners' own physical and virtual environment, making learning more situated, personal, collaborative and informal (Caballé, Xhafa, & Barolli, 2010). According to Ruchter, Klar and Geiger (2010), mobile devices include a variety of features that can help link the benefits of computer-mediated learning with the direct experience of the environment. Mobile devices permit the recording of aspects of the local environment via electronic notes and photos; they also provide access to digital resources. Rogers, Connelly, Hazlewood and Tedescoet (2010) showed that mobile devices can scaffold collaborative learning activities. With mobile devices, learners can switch between task-based and sense-making activities by altering actions in the physical environment and through abstract reasoning. At the same time, educators are able to guide learners and monitor their progress during activities (Abe et al., 2005).

The attributes of meaningful learning

Our basis for exploring pre-service class teachers' experiences in mobile learning events is the model of meaningful learning developed by Jonassen (1995) and further refined by Jonassen, Peck and Wilson (1999), Ruokamo and Pohjolainen (1999), Nevgi and Tirri (2003), Hakkarainen, Saarelainen and Ruokamo (2007), and Löfström, Kanerva, Tuuttila, Lehtinen and Nevgi (2010), among others. The concept of *meaningful learning* originated in Ausubel's (1968) subsumption theory, in which meaningfulness refers to the active process whereby learners form new meanings by integrating new information with their prior knowledge. New information is meaningfully linked to learners' existing knowledge base, creating relevant relationships between different concepts (Keengwe, Onchwari, & Wachira, 2008).

Meaningful learning occurs when learners are active, constructive, intentional, cooperative, and at work on authentic tasks (Jonassen, Howland, Moore, & Marra, 2003;

Jonassen & Strobel, 2006). Jonassen (1995) advised school and university educators to use technology to facilitate such learning events, where the interrelated, interactive and interdependent characteristics of meaningful learning can result in greater learning than if each of these qualities were approached individually. Jonassen's ideas were affected by the model of situated cognition, wherein the importance of context and conversation is emphasised (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Jonassen (1995, 2010) connected the efficient use of technology to twenty-first century skills and stressed knowledge construction, conversation, collaboration and reflection over knowledge re-production, reception and competition. In order to promote meaningful learning, Jonassen, Peck and Wilson (1999) found it important to help students regulate their learning by developing goal-setting skills, recognising and solving problems, and constructing mental models in new situations.

There are several ways of describing and naming the characteristics of meaningful learning (Hakkarainen, Saarelainen, & Ruokamo, 2007). In this article, we use seven attributes of meaningful learning in accordance with Ruokamo and Pohjolainen's (1999) model, where the original conversational component of Jonassen (1995) was included in the collaborative attribute. Hence, in our model, the attributes of meaningful learning are (1) *active,* (2) *constructive,* (3) *collaborative*, (4) *intentional*, (5) *contextualised*, (6) *reflective*, and (7) *transfer*. We share Hakkarainen, Saarelainen and Ruokamo's (2007) view that meaningful learning processes do not require all characteristics of meaningful learning to be met all the time, and we believe that these characteristics provide a reasonably wide perspective for assessing learning within different subject areas.

According to Petress (2008), in *active* learning, learners take a dynamic and energetic stance towards their own learning process. Active learning is usually enjoyable, motivational, personally satisfying and effective. It typically stimulates pride, increased self-confidence, and the desire for a broader and deeper understanding of future academic challenges. Active learning is commonly associated with experiential learning, learning by doing, service learning, peer tutoring, laboratory work, role-playing, and the use of case studies (Chi, 2009; Carr, Palmer, & Hagel, 2015). In active learning, technology is expected to be used productively (Laird & Kuh, 2005).

Learning is a *constructive* process in which learners are active sense-makers who seek to achieve coherence between new and prior knowledge (Mayer, 2014). Jonassen and colleagues (1999) stated that new experiences often create discrepancies between what learners observe and what they realise; these discrepancies lead to puzzlement, which in turn serves as the catalyst for individual meaning making. Learners construct their own mental models to explain the world and, with more experience and reflection, these models become increasingly complex. The active and constructive parts of the meaning-making process are symbiotic and both are needed for meaning making to occur.

According to Löfström and Nevgi (2007) and Jonassen (1995), learning is *collaborative* when learners form knowledge-building communities where they observe and utilise other members' skills and provide each other with social support and feedback. Collaboration is a dialogical process involving interactive group processes, such as negotiation and the sharing of meanings towards the construction and maintenance of shared conceptions of a task (Stahl, Koschmann, & Suthers, 2006). Successful collaboration that benefits individual learning requires collaborators to work closely; which means, for example, considering shared ideas as common resources, producing verbalisations which support reasoning, giving explanations not answers, and regulating each other's work (Taneva, Alterman, & Hickey, 2005).

Bereiter and Scardamalia (1989) defined *intentional* learning as 'cognitive processes that have learning as a goal rather than an incidental outcome' (p. 363). According to them, instead of simply trying to do well on school tasks, intentional learners in supportive environments have high levels of self-efficacy and use learning as a primary transformative force. Intentional learners are highly self-aware, motivated by the desire for expertise, enjoy making efforts to attain learning objectives, and responsibly monitor and develop their learning strategies (Cholbi, 2007). Essential to the attribute *intentional* is that learners are able to recognise their objectives for learning events, wilfully strive to accomplish these objectives, and monitor the process of achieving them (Nevgi & Tirri, 2003).

In its simplest form, *contextuality* in learning refers to the environment in which learning occurs as well as how it potentially affects what is learned. Apart from recognising the context-dependent nature of knowledge, Hager and Halliday (2006) highlighted the influential and complex role of context in learning as well. According to Hager and Smith (2004) and Hager and Halliday (2006), three views on the role of context can be considered: (a) The weakest role of context, *context as minimally influential*, occurs when context is seen as preventing learning. Hence, when negative contextual factors are minimised or removed, the context itself becomes irrelevant. (b) When viewed as *influential but controllable*, context has more relevance, although the content and outcomes of learning nonetheless remain independent of context; however, arrangements can still be made to optimise learning. (c) The third and strongest view is that context is *decisively influential*. This view recognises that both learning processes and learning outcomes are affected by context. In meaningful learning, the third view is emphasised, and therefore learning tasks are situated in real-world surroundings, including problem-solving in authentic situations and the use of authentic materials, or they are simulated tasks in problem-based learning environments (Jonassen, 1995; Löfström et al., 2010; Nevgi & Tirri, 2003).

According to Dewey (1910), a *reflective* thought entails ‘active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends' (p. 6). Learning requires reflective thinking, i.e., a process whereby learners create knowledge and personal meanings through the transformation of experience (Fullana, Pallisera, Colomer, Fernández Peña, & Pérez-Burriel, 2016; Kolb, 1984). Ryan (2013) viewed reflection as making sense of current experiences in relation to oneself, others and one's context; moreover, it includes the reimagining and planning of personally or socially beneficial future experiences. In meaningful learning, learners should identify their own learning processes, articulate what they have learned, and search for implications (Jonassen, 1995; Löfström & Nevgi, 2007).

Transfer refers to the ability of an individual or group to effectively apply the knowledge, skills and attitudes acquired in one learning environment to other similar or novel contexts (Haskell, 2001; Liu & Hsueh, 2016). Transfer may be positive or negative, since previous learning may promote or inhibit the learning of a new task (Ellis, 1965). *Near transfer* refers to executing learned skills in circumstances roughly similar to the original learning environment, whereas *far transfer* indicates the ability to decontextualise learning and apply the discovered common principles to new contexts and phenomena different from the past learning environment (Liu & Hsueh, 2016). For transfer to occur, learning should be repeatedly reinforced with multiple examples or similar concepts in multiple contexts and on different levels and orders of magnitude (Haskell, 2001). An authentic learning context may facilitate the adaptation of new skills to real-life situations, and general principles are more easily transferable than isolated matters (Ruokamo & Pohjolainen, 1999). The transfer of learning can be regarded as the ultimate goal of instruction (Bransford, Brown, & Cocking, 2000).

Methodology

The aim of this study was to explore pre-service class teachers' experiences of mobile learning with respect to the model of meaningful learning. The type of mobile learning considered in this study took place in short-term events in academic settings in relation to four different study modules offered by the Department of Teacher Education at the University of Turku during autumn 2015 (Table 1). Altogether, 277 pre-service class teachers participated in at least one of the events, each of which lasted from one to four hours, and in which students worked in groups of two to six students. Participation in the event was an obligatory assignment in each study module, but it did not have an effect on the student's grade. A common goal for all of the events was to inspire students to diversify their pedagogical approach, promote outdoor learning, and serve as an example of mobile learning for their future teaching as well as increase students' physical activity during lessons. Moreover, special emphasis was placed on linking the learning tasks with the authentic environment outside the classroom.

Table 1. The objectives and the number of participants of the mobile learning events. For each event, the number of participants (N), the number of respondents on the research questionnaire (n), and the number of respondents participating only in that event (n_1) are indicated.

Mobile learning event	No. of students	Objectives
Introductory Outdoor Adventure	$N = 109$, $n = 105$, $n_1 = 103$	to become acquainted with phenomenon-based learning and integration of subjects in basic education; to foster team spirit among students
Mathematics	$N = 112$, $n = 110$, $n_1 = 101$	to revise geometric topics and perform measurements in outdoor situations
Health Education	$N = 27$, $n = 26$, $n_1 = 18$	to notice health promoting and health-related issues in everyday life; to experience the ethos of the health education subject
Environment and Nature Studies in Primary Education	$N = 29$, $n = 23$, $n_1 = 20$	to observe and explore the daily environment and historical background of Turku from the education and outdoor learning perspective

The events were carried out using the ActionTrack application created by Team Action Zone. ActionTrack is an award-winning platform for location-based activities (Holm & Laurila, 2014). It enables the creation of various routes with activity checkpoints. Participants in ActionTrack events use mobile devices as guidance tools and employ their versatile properties for completing the checkpoint tasks. The application guides participants along routes using text or photographic clues, maps, or a guiding arrow showing the direction and distance to the next checkpoint. The routes may be different for each participant, as the order of the checkpoints can be randomised by the application or chosen freely by the participant. When a user reaches a checkpoint location, a task assignment is shown on a display screen of the mobile device. Versatile task assignments may include images, text, sound, videos, web links, multiple-choice and text-based questions, and numerical challenges. The numerical, textual and photographic answers, as well as performance in physical challenges and hands-on activities, can be scored automatically or by an event staff member at the checkpoint location or a controller using the online administration site to follow users in real time. The answers, movements and scoring of the participants are stored on a server and can be retrieved and reviewed afterwards. During the activity, the controller and the participants may exchange messages using the application's built-in chat function. In addition to checkpoint scores, ActionTrack contains game elements like time limitations, special keys granted for opening new routes and checkpoints, and extra points, which participants may earn by asking for on-demand tasks at any time during the activity. The ActionTrack Arrow Guidance Mode and an example of a checkpoint assignment with an answer are depicted in Figure 2.

Figure 2. The ActionTrack Arrow Guidance Mode with the distance and direction to the next checkpoint, and an example of a task assignment with a numerical and photographic answer about measuring and estimating the perimeter of a tree using fathoms and meters.

The attributes of meaningful learning were manifested in the events in several ways. The attribute *active* was emphasised when groups of students took responsibility of their learning while advancing in the track and in the various hands-on tasks, such as measuring the perimeter of a tree using fathoms or making kindlings for a camp fire. The attribute *constructive* arose in tasks that required applying prior knowledge to new situations. For example, knowledge of traffic regulations was needed in the task of observing traffic and considering the reasons behind people not obeying rules. The attribute *collaborative* appeared when students had to debate their answer, e.g., in analysing the landscape from a historical, architectural and geographical point of view. Since the tasks were solved in groups and required various skills, each group could benefit from the strengths of its members. The possibility to choose the degree of difficulty in a task and the extent and depth of an answer demonstrate the attribute *intentional* in our events. In order to foster intentionality, we used

ActionTrack's gamification elements such as scoring and online feedback. The majority of the tasks were *contextual* and closely related to specific geographic positions. For example, the students needed to be on-site to examine soundscapes, flora and fauna, art, social behaviour and health related aspects of particular locations. In some tasks the participants were instructed to reflect upon their learning processes and take notes on their experiences. Further, assessing the student performance in collective discussions at the end of the ActionTrack events exhibited the attribute *reflective*. Event data stored on a server was sometimes used to initiate the reflection. The attribute *transfer* was visible, for example, when applying prior mathematics skills in examining properties of concrete objects. From the teacher education perspective, the events repeatedly offered the pre-service teachers multiple examples of learning in authentic environments. This aspect was meant to be transferred to their teaching in the future.

The research questions posed for this study are:

(1) Does the ActionTrack learning environment enable meaningful learning according to students' experiences?

(2) To what extent are the attributes of meaningful learning apparent in the students' experiences of mobile learning in the outdoors?

For data collection, a quantitative questionnaire with 38 items rated on a 7-point Likert-scale was created on the basis of the seven attributes of meaningful learning. The operationalisation of the model was guided by the framework for pedagogical evaluation of learning environments developed by Hämäläinen, Korpi, Kähäri, Niemi, Ovaskainen, Pajunen, Piiksi, Posti, Ruokamo, Siekkinen and Taina (Ruokamo & Pohjolainen, 1999). The response options for each item were 1 = 'completely disagree', 2 = 'moderately disagree', 3 =

‘slightly disagree’, 4 = ‘I neither disagree nor agree’, 5 = ‘slightly agree’, 6 = ‘moderately agree’, and 7 = ‘completely agree’. The questionnaire was designed so that there were five items for each of the seven attributes of meaningful learning *(active, constructive, collaborative, intentional, contextualised, reflective* and *transfer*), and one item for each attribute was negatively worded. Examples of the items are given in Table 2. For the attribute *intentional*, one item was divided into four sub-items that considered the social, cognitive, attitudinal and game-related aspects of goal-setting, which resulted in a total of eight items for this attribute. Based on the pilot study (*N* = 137) outcome (Kärki et al., 2015), the items concerning the attribute *reflective* were rephrased in order to increase the reliability of the attribute.

Table 2. Examples of the items of the questionnaire related to different attributes of meaningful learning.

Attribute	Example of an item (English translation)
Active	Item 2: In the learning environment, I was able to be active and influence the learning event.
Constructive	Item 16: I was able to utilise my previous knowledge and skills in the ActionTrack event.
Collaborative	Item 35: In the ActionTrack event, it was beneficial to work in groups.
Intentional	Item 4: The learning environment inspired me to set goals.
Contextualised	Item 19: Operating in the learning environment was concrete and linked with the physical environment.
Reflective	Item 15: The ActionTrack event made me conscious of my strengths and weaknesses.
Transfer	Item 28: When learning something new, I have made good use of the knowledge and skills I learned in the learning environment.

Participants in the ActionTrack events answered the questionnaire anonymously online via Webropol between five and seven weeks after the event. For some rare cases (n = 9), the possibility of filling out the questionnaire by paper and pencil was offered. Reflecting on learning experiences of the mobile learning environment by answering the questionnaire was one of the students' course assignments, although participating in this research study was voluntary. Approximately 90% of the students answered the research questionnaire (n = 253). Following the typical gender distribution of Finnish teacher students, the majority of the respondents were females (n = 199). The age range was from 18 to 48 years (Mdn = 22, Mo = 20). All the participants had succeeded in a highly competitive selection process for a master's degree program in teacher education in Finland. The pedagogical content of the events can be considered novel for the participants, of which around 70% were first year students. Only 4% of the students (n = 11) participated in more than one ActionTrack event. Hence, for comparisons of different ActionTrack events, we excluded students who had experiences in several events, yet still obtained a large number of respondents (n = 242).

For the analysis of the data, IBM SPSS Statistics 22 software was used. First, the negatively worded items were reverse-coded, and the composite variables of the seven attributes of meaningful learning were formed by calculating the mean values of items related to the same attribute. These composite variables were named after the attributes with capital first letter: *Active, Constructive, Collaborative, Intentional, Contextualised, Reflective* and *Transfer*. We refer to the above composite variables as *attribute variables* in the following. We also calculated the composite variable *Meaningful Learning*, which is the mean value of the scores for all 38 items. It was used to describe students' overall impression of meaningful learning in the ActionTrack events. Forming composite variables was considered feasible, since the Cronbach's alpha values (Table 3) for the items of each attribute were between

0.640–0.838; and for all items of the questionnaire, the value was 0.940. These values are consistent with the pilot study.

Table 3. Internal consistency of the items for the attributes of meaningful learning.

Attribute	*Active*	*Constr.*	*Collab.*	*Intent.*	*Context.*	*Reflect.*	*Transf.*
No. of items	5	5	5	8	5	5	5
Cronbach's α (*n* = 253)	0.721	0.749	0.731	0.838	0.716	0.640	0.808
Cronbach's α, pilot (*n* = 137)	0.775	0.772	0.770	0.836	0.807	0.692	0.879

Results

In this study, respondents' (*n* = 253) overall impression of the ActionTrack mobile learning environment was positive. The values of the composite variable *Meaningful Learning* indicate that the students found the mobile learning events of our study to be quite meaningful (*M* = 5.11, *SD* = 0.745). Students' answers expressed affirmative perceptions towards each of the seven attributes of meaningful learning (Table 4). Among the attribute variables, *Transfer* had the lowest mean and the highest standard deviation, whereas *Collaborative* had the highest mean and the lowest standard deviation. According to a one-sample *t*-test, the mean values of the composite variables were statistically significantly higher ($t(252)$ varied from 7.644 to 38.706, $p < .001$) than the midpoint (4.00) of our scale. Hence, these mean values clearly indicate respondents' positive attitude towards the realisation of meaningful learning in our ActionTrack events. The variables *Collaborative, Contextualised* and *Active* stand out from the other attribute variables, with means and medians closer to 6.00 (moderately agree) than 5.00 (slightly agree). The maximum value 7.00 (completely agree) was obtained for all attribute variables except *Intentional*. The minimum values of the attribute variables varied between 1.00 and 2.80, indicating complete or slight disagreement

Table 4. Descriptive statistics for the composite variables (n = 253). *M.L.* denotes the composite variable *Meaningful Learning*.

Variable	*Active*	*Constr.*	*Collab.*	*Intent.*	*Context.*	*Reflect.*	*Transf.*	*M.L.*
M	5.44	4.94	5.88	4.87	5.48	4.81	4.52	5.11
SD	0.852	0.898	0.772	0.985	0.840	0.965	1.089	0.745
Min	2.00	1.20	2.80	1.63	2.80	1.80	1.00	2.39
Max	7.00	7.00	7.00	6.75	7.00	7.00	7.00	6.84
Mdn	5.60	5.00	6.00	5.00	5.60	5.00	4.60	5.24
Skewness	−0.70	−0.75	−0.79	−0.46	−0.62	−0.30	−0.42	−0.43
Kurtosis	0.71	1.06	0.47	0.05	0.15	−0.06	0.05	0.20

In order to compare the appearance of different attributes of meaningful learning, we examined the differences in means of the attribute variables. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean values differed statistically significantly between the attributes ($F(5.312, 1338.572) = 163.247$, $p < .001$). Post hoc tests using the Bonferroni correction revealed statistically significant differences ($p < .001$) between all pairs of attribute variables except for the pairs *Contextualised–Active*, *Constructive–Intentional*, *Intentional–Reflective*, and *Constructive–Reflective*. Based on this testing, we positioned the composite variables into four levels I–IV (Figure 3), where there are no statistically significant differences between the variables on the same level.

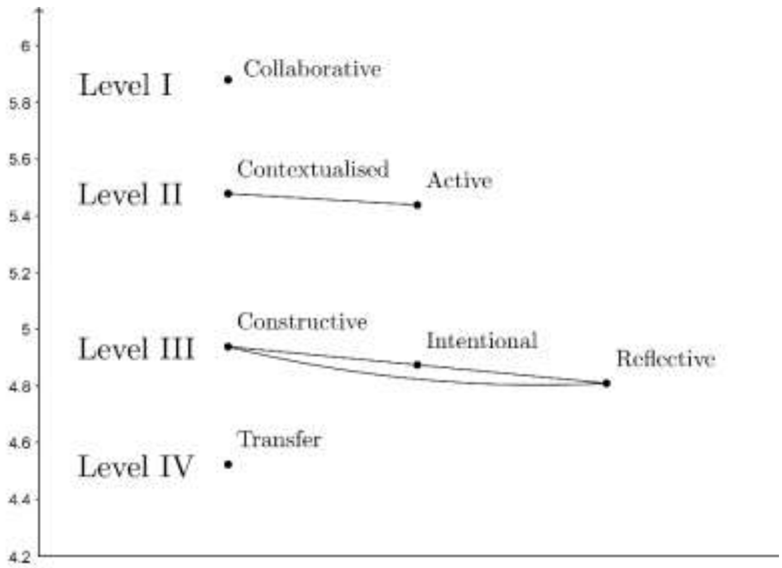

Figure 3. The attributes of meaningful learning divided into four levels based on their mean values. Statistically significant differences were found between all the mean values except those connected with a line.

The level structure of Figure 3 was partially supported by the mean values of the attribute variables in the ActionTrack events of the distinct study modules (Table 5). For Introductory Outdoor Adventure (n = 103) and Mathematics (n = 101), the post hoc tests with Bonferroni correction of the repeated measures ANOVA revealed the same level structure as in Figure 3 with the significance level $p < .01$. However, in Health Education (n = 18) and Environment and Nature Studies (n = 20), the order of the attributes based on the mean values differed from Figure 3. The levels I and II, and levels III and IV seemed to merge. Statistically significant differences were only found between some attributes of these two merged levels.

Owing to the skewness and kurtosis values of the attribute variables (Table 4), we performed nonparametric tests in order to confirm the level structure of Figure 3. Friedman test revealed statistically significant differences between the attribute variables ($\chi^2(6) = 625.637$, $p < .001$). Post hoc analysis with Wilcoxon signed-rank tests was conducted with a

Bonferroni correction applied, resulting in a significance level set at $p < 0.0024$. The test results were consistent with the previous parametric tests.

Table 5. Means and standard deviations of the attribute variables for different mobile learning events.

Event		*Active*	*Constr.*	*Collab.*	*Intent.*	*Context.*	*Reflect.*	*Transf.*
Outd. Adv.	*M*	5.64	5.25	6.02	5.18	5.61	5.22	4.90
(*n* = 103)	*SD*	0.759	0.774	0.687	0.807	0.769	0.816	0.932
Math.	*M*	5.34	4.75	5.87	4.61	5.29	4.52	4.16
(*n* = 101)	*SD*	0.828	0.872	0.769	1.025	0.861	0.950	1.058
Health Ed.	*M*	5.67	5.04	5.59	5.16	6.10	4.80	5.01
(*n* = 18)	*SD*	0.679	0.695	0.882	0.895	0.567	0.905	1.025
Env. and Nat.	*M*	4.82	4.16	5.53	4.34	5.08	4.13	3.84
(*n* = 20)	*SD*	1.062	1.041	0.941	1.043	0.806	1.018	1.254

When comparing the attribute variables between different study modules using one-way ANOVA, statistically significant differences were found in all attribute variables except *Collaborative* ($F(3) = 3.480$, $p = .017$). For all other attributes, the F-values were in the range 6.877–14.602 and $p < .001$. Post hoc tests revealed that statistically significant differences were mixed with different study modules; and for attribute variables other than *Collaborative*, Tukey HSD formed two or three homogenous subsets of study modules with a significance level of 0.05.

The highest and lowest scores of the separate positively worded or reverse-coded items are presented in Table 6. There were three items (1, 19 and 35) where the mean value exceeded 6. In addition to these three items, mode value 7 was obtained by Item 29. Items 1 and 35 were also the only items that obtained a median value of 7. The lowest scores were obtained by Item 28. In addition to Item 28, mean values indicating a neutral stance appeared only in Items 11b and 33, and the neutral mode value 4 only in the reverse-coded Item 34.

Table 6. The items with the highest and lowest descriptive values.

Item (no.)	*Attribute*	*M*	*SD*	*Mdn*	*Mo*
In the ActionTrack event, I worked together with other students. (1)	Collab.	6.45	0.847	7	7
In the ActionTrack event, it was beneficial to work in groups. (35)	Collab.	6.27	1.072	7	7
Operating in the learning environment was concrete and linked with the physical environment. (19)	Context.	6.05	1.049	6	7
I have discussed the experiences of the ActionTrack event with others during the event or afterwards. (29)	Reflect.	5.42	1.681	6	7
Reflecting on my own performance and learning was part of my ActionTrack experience. (34)	Reflect.	4.80	1.360	5	4
In the ActionTrack event, I set objectives concerning knowledge and skills. (11b)	Intent.	4.45	1.497	5	5
In the ActionTrack event, I acquired skills by means of which I can perform better in corresponding situations later on. (33)	Transf.	4.36	1.445	4	5
When learning something new, I have made good use of the knowledge and skills I learned in the learning environment. (28)	Transf.	3.69	1.423	4	4

Discussion and Conclusions

In this study, pre-service class teachers' experiences of mobile learning in the outdoors were studied. Based on our results, it is possible to create meaningful learning experiences in teacher education by using the mobile application ActionTrack. All of the seven attributes of meaningful learning obtained positive values in our events. Especially, the attributes *collaborative, contextualised* and *active* were perceived as the essential features of mobile learning in the outdoors. This is consistent with earlier results. Kärki, Keinänen, Hoikkala and Niinistö (2014) discovered that ActionTrack offers authentic and functional challenges and requires peer collaboration. Direct experience of the environment and alternating actions between physical reality and abstract reasoning indicate contextuality as a benefit of mobile learning (Rogers et al., 2010; Ruchter et al., 2010). Mobile learning has been found to support collaborativeness (Rogers et al., 2010) and enhance active, experiential learning (Dyson, Litchfield, Lawrence, Raban, & Leijdekkers, 2009). Caballé, Xhafa and Barolli's (2010) vision about mobile technology that can enhance social interaction and context awareness was demonstrated in our study.

In order to confirm the validity of our questionnaire, the items were formulated based on an earlier study concerning meaningful learning by Hämäläinen et al. (Ruokamo & Pohjolainen, 1999), and the formulations of the items were contemplated from the perspective of several research articles describing the attributes of meaningful learning (Hakkarainen et al., 2007; Jonassen, 1995; Nevgi & Tirri, 2003; Löfström et al., 2010). Nevertheless, respondents may not interpret the items as intended. In our pilot study (Kärki et al., 2015), the students agreed on many aspects of meaningful learning in the ActionTrack events and emphasised the same three attributes as in this study, indicating an admissible reliability of the questionnaire. The reported Cronbach's alpha values signify feasible internal consistency of the items related to each attribute of meaningful learning. We recognise that quantitative methods and statistical analysis give a limited view of the phenomenon; they deal with measurable aspects, are confined to the items of the questionnaire and neglect the respondents' individual views. We are aware that the characteristics of the pre-service class teacher students may have influenced the measured values of the attributes. For example, social interaction and collaboration are essential in Finnish class teacher education, which might in turn increase the values of the attribute variable Collaborative. Certainly, there are several factors affecting the subjective experience of meaningful learning, such as existing conditions and students' prerequisites for attending the events. In order to increase the validity of our results in this respect, we have examined four events of a different type. Furthermore, delayed data collection might have caused effects on our results.

The students experienced high collaborativity regardless of the event. More precisely, the attribute variable *Collaborative* demonstrated no statistically significant differences between different study modules. Hence, mobile learning with ActionTrack seems to support the collaborative attribute of meaningful learning. We assume that the students not only worked in groups sharing one mobile device but, as a group, experienced peer support and feedback and utilised the various strengths of the group members. Each group had to take responsibility for their own performance and problem solving, and the critical reflection of peers may have challenged the group members for better performance.

Mobile learning outside the classroom enables learning in authentic environments. In this study, the students experienced contextuality in all ActionTrack events. They agreed that ActionTrack tasks were concrete and connected to the physical environment and real-world phenomena. In Health Education, the attribute variable *Contextualised* attained the highest mean value of all attributes of all study modules. We presume that this is due to the fact that the tasks concerning health, safety and well-being issues of public space were more focused on observing the environment than in other ActionTrack events.

In ActionTrack events, the attribute *active* was also emphasised. Naturally, ActionTrack enables substantial physical activity while participants walk from one checkpoint to another. Moreover, the tasks not only contained discussions and written answers, but also required concrete actions like handicrafts and physical exercises. However, the items on our questionnaire concerning the attribute variable *Active* were formulated to measure mental activity especially, as well as participants' responsibility for their active role in the learning process. Students also found the ActionTrack events to be active in this regard.

We argue that students' impressions of the attributes of meaningful learning strongly depend on the nature of the tasks of the mobile learning events. Based on our study, ActionTrack enables collaborative, contextualised and active learning inherently, since these attributes were strongly expressed in all independently designed events. On the other hand, our results also suggest that it is possible to underline specific attributes of meaningful learning by using a suitable task design. For example, Introductory Outdoor Adventure was purposely designed to contain several tasks fostering reflection during and after the event. In this case, the value of the attribute variable *Reflective* was higher than in other events. Similarly, the attribute variable *Contextualised* was highlighted in Health Education, as described above.

In our opinion, the attributes of meaningful learning form a relevant theoretical framework for pedagogical design of mobile learning events, but learning can be meaningful even though all the attributes of meaningful learning are not strongly present in the learning event at the same time. However, teachers should endeavour to provide the attributes of meaningful learning extensively in their teaching. We recommend ActionTrack for familiarising pre-service teachers with technology-enhanced learning environments where the features of meaningful learning are supported. We suggest that the benefits of long-term frequent use of mobile learning in teacher education as well as in basic education should be further examined. It would be especially interesting to study the mechanisms which promote constructivity, intentionality, reflectivity and transfer in mobile learning.

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References

Abe, M., Yoshimura, T., Yasukawa, N., Koba, K., Moriya, K., & Sakai, T. (2005). Development and evaluation of a support system for forest education. *Journal of Forest Research, 10*(1), 43–50.

Attewell, J., & Savill-Smith, C. (2004). Mobile learning and social inclusion: Focusing on learners and learning. In J. Attewell & C. Savill-Smith (Eds.), *Learning with mobile devices: Research and development* (pp. 3–12). London: Learning and Skills Development Agency.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart & Winston.

Baran, E. (2014). A review of research on mobile learning in teacher education. *Educational Technology & Society*, *17*(4), 17–32.

Beames, S., Higgins, P., & Nicol, R. (2011). *Learning outside the classroom: Theory and guidelines for practice*. New York, NY: Routledge.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 361–392). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18,* 32–42.

Caballé, S., Xhafa, F., & Barolli, L. (2010). Using mobile devices to support online collaborative learning. *Mobile Information Systems, 6*(1), 27–47.

Carr, R., Palmer, S., & Hagel, P. (2015). Active learning: The importance of developing a comprehensive measure. *Active Learning in Higher Education, 16*, 173–186.

Chi, M. T. H. (2009). Active-Constructive-Interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*, 73–105.

Cholbi, M. (2007). Intentional learning as a model for philosophical pedagogy. *Teaching Philosophy, 30*(1), 35–58.

Crompton, H. (2013). A historical overview of mobile learning: Toward learner-centered education. In Z. L. Berge & L. Y. Muilenburg (Eds.), *Handbook of mobile learning* (pp. 3–14). New York, NY: Routledge.

Dewey, J. (1910). *How we think*. New York, NY: D.C. Heath & Co.

Dyson, L. E., Litchfield, A., Lawrence, E., Raban, R., & Leijdekkers, P. (2009). Advancing the m-learning research agenda for active, experiential learning: Four case studies. *Australasian Journal of Educational Technology, 25*(2), 250–267.

Ellis, H. (1965). *The transfer of learning*. New York, NY: The Macmillan Company.

Fullana, J., Pallisera, M., Colomer, J., Fernández Peña, R., & Pérez-Burriel, M. (2016). Reflective learning in higher education: A qualitative study on students' perceptions. *Studies in Higher Education, 41*(6), 1008–1022.

Hager, P., & Halliday, J. (2006). *The importance of contextuality for learning. Recovering informal learning. Wisdom, judgement and community*. Dorthrecht, Netherlands: Springer.

Hager, P., & Smith, E. (2004). The inescapability of significant contextual learning in work performance. *London Review of Education, 1*(2), 33–46.

Hakkarainen, P., Saarelainen, T., & Ruokamo, H. (2007). Towards meaningful learning through digital video supported, case based teaching. *Australasian Journal of Educational Technology, 23*(1), 87–109.

Haskell, R. E. (2001). *Transfer of learning: Cognition, instruction, and reasoning*. San Diego, CA: Academic Press.

Holm, J., & Laurila, K. (2014). Designing ActionTrack: A state-of-the-art authoring tool for location-based games and other activities. In E. Banissi, M. W. McK. Bannatyne, F. T. Marchese, M. Sarfraz, A. Ursyn, G. Venturini, T. G. Wyeld, U. Cvek, M. Trutschl, G. Grinstein, V. Geroimenko, S. Kenderdine, & F. Bouali (Eds.), *2014 18th*

International Conference on Information Visualisation (pp. 402–407). Piscataway, NJ: IEEE Computer Society Conference Publishing Services.

Jonassen, D. H. (1995). Supporting communities of learners with technology: A vision for integrating technology with learning in schools. *Educational Technology, 35*(4), 60–63.

Jonassen, D. H. (2010). *Research issues in problem solving*. Paper presented at the 11th International Conference on Education Research (ICER), New Educational Paradigm for Learning and Instruction, Seoul, South Korea. Retrieved from http://www.aect.org/publications/whitepapers/2010/JonassenICER.pdf

Jonassen, D. H., Howland, J., Moore, J., & Marra, M. (2003). *Learning to solve problems with technology: A constructivist perspective* (2nd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology. A constructivist perspective*. Upper Saddle River, NJ: Prentice Hall.

Jonassen, D. H., & Strobel, J. (2006). Modeling for meaningful learning. In D. Hung & M. S. Khine (Eds.), *Engaged learning with emerging technologies* (pp. 1–27). Dorthrecht, Netherlands: Springer.

Keengwe, J., Onchwari, G., & Wachira, P. (2008). The use of computer tools to support meaningful learning. *AACE Journal, 16*(1), 77–92.

Kolb, D. A. (1984). *Experiential learning. Experience as the source of learning and development*. Englewood Cliffs, NJ: Practice-Hall.

Kukulska-Hulme, A., Sharples, M., Milrad, M., Arnedillo-Sánchez, I., & Vavoula, G. (2009). Innovation in mobile learning: A European perspective. *International Journal of Mobile and Blended Learning, 1*(1), 13–35.

Knapp, C. E. (1996). *Just beyond the classroom: Community adventures for interdisciplinary learning*. Charleston, SC: Appalachia Educational Laboratory.

Kärki, T., Hoikkala, M., Keinänen, H., Maijala, H., Matikainen, E., Niinistö, H., & Tuominen, A. (2015). Students’ opinions on out-of-classroom learning with mobile devices in class teacher education. In *NoFa5, 27–29 May 2015, Nordic Conference on Subject Education. Book of abstracts* (pp. 27–28). Retrieved from http://blogs.helsinki.fi/nofa5-2015/programme-2/

Kärki, T., Keinänen, H., Hoikkala, M., & Niinistö, H. (2014). Enhancing collaboration and a holistic approach in teacher training education with tablet-assisted experiential outdoor adventure education. In H. L. T. Heikkinen, J. Moate, & M-K. Lerkkanen (Eds.), *Research in Educational Sciences: Vol. 66. Enabling Education. Proceedings of the Annual Conference of Finnish Education Research Association FERA 2013* (pp. 165–84). Jyväskylä: Finnish Educational Research Association.

Lai, H-C., Chang, C-Y., Li, W-S., Fan, Y-L., & Wu, Y-T. (2013). The implementation of mobile learning in outdoor education: Application of QR codes. *British Journal of Educational Technology, 44*(2), E57–E62.

Laird, T. F. N., & Kuh, G. D. (2005). Student experiences with information technology and their relationship to other aspects of student engagement. *Research in Higher Education, 46*(2), 211–233.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge, UK: Cambridge University Press.

Liu, K. S., & Hsueh, S-L. (2016). Effects of digital teaching on the thinking styles and the transfer of learning of the students in department of interior design. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(6), 1697–1706.

Löfström, E., Kanerva, K., Tuuttila, L., Lehtinen, A., & Nevgi, A. (2010). *Laadukkaasti verkossa: Verkko-opetuksen käsikirja yliopisto-opettajalle* [Quality teaching in Web-based environments: Handbook for university teachers]. (Helsingin yliopiston hallinnon julkaisuja 71, Raportit ja selvitykset). Helsinki: University of Helsinki.

Löfström, E., & Nevgi, A. (2007). From strategic planning to meaningful learning: Diverse perspective on the development of web-based teaching and learning in higher education. *British Journal of Educational Technology, 38*(2), 312–324.

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed.) (pp. 1–24). New York, NY: Cambridge University Press.

Nevgi, A., & Tirri, K. (2003). *Research in Educational Sciences: Vol. 15. Hyvää verkko-opetusta etsimässä* [In search of good virtual learning]. Turku: Finnish Educational Research Association.

National core curriculum for basic education 2014. (2016). Helsinki: Finnish National Board of Education.

Petress, K. (2008). What is meant by ‘active learning’?. *Education, 128*(4), 566–569.

Rogers, Y., Connelly, K., Hazlewood, W., & Tedesco, L. (2010). Enhancing learning: A study of how mobile devices can facilitate sensemaking. *Personal and Ubiquitous Computing, 14*(2), 1–14.

Ruokamo, H., & Pohjolainen, S. (Eds.). (1999). *Etäopetus multimediaverkoissa* [Distance learning in multimedia networks]. (Digitaalisen median raportti 1/99). Helsinki: TEKES.

Ruchter, M., Klar, B., & Geiger, W. (2010). Comparing the effects of mobile computers and traditional approaches in environmental education. *Computers & Education, 54*(4), 1054–1067.

Ryan, M. (2013). The pedagogical balancing act: Teaching reflection in higher education. *Teaching in Higher Education, 18*(2), 144–155.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 409–426). Cambridge, UK: Cambridge University Press.

Taneva, S., Alterman, R., & Hickey, T. (2005). Collaborative learning; Collaborative depth. In B. G. Bara, L. Barsalou, & M. Bucciarelli (Eds.), *Proceedings of the XXVII Annual Conference of the Cognitive Science Society* (pp. 2156–2161). Mahwah, NJ: Lawrence Erlbaum.

Theall, M., & Franklin, J. (2001). Looking for bias in all the wrong places: A search for truth or a witch hunt in student ratings of instruction. *New Directions for Institutional Research, 109*, 45–56.

Traxler, J. (2007). Defining, discussing and evaluating mobile learning: The moving finger writes and having writ…. *International Review of Open and Distance Learning, 8*, 1–12.

Veerappan, V., Wei, H. S., Wong, S. P., & Paramasivam, S. (2014). Mobile assisted teaching and learning in an institute of higher education. *International Review of Social Sciences and Humanities, 8*(1), 68–79.

Veletsianos, G., Miller, B. G., Bradley Eitel, K., Eitel, J. U. H., Hougham, R. J., & Hansen, D. (2015). Lessons learned from the design and development of technology-enhanced outdoor learning experiences. *TechTrends: Linking Research & Practice to Improve Learning, 59*(4), 78–86.