Educ Inf Technol (2017) 22:2565–2581
DOI 10.1007/s10639-016-9561-2

The comparison of students' satisfaction between ubiquitous and web-based learning environments

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Published online: 1 December 2016

Abstract Higher education is moving towards digitalized learning. The rapid development of technological resources, devices and wireless networks enables more flexible opportunities to study and learn in innovative learning environments. New technologies enable combining of authentic and virtual learning spaces and digital resources as multifunctional learning platforms. In the development process it is important to ensure that the quality of environment and the pedagogical suitability are high in relation to the intended learning outcome. The quality of the learning environment can be assessed, for example, from students' levels of satisfaction. In this study a satisfaction is proposed by following aspects: instruction and feedback, pedagogical and technological methods, perceived enjoyment and self-motivation. The aim of this study

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was to compare the students' satisfaction with a ubiquitous learning environment based on 360°–technology and a traditional web-based online learning environment. A comparative, quasi-experimental study design was used. 115 students assigned on clinical histology and histotechnology course and voluntarily to the study, 61 students were assigned to an experimental group and 54 to a control group. The experimental group studied via a 360°–ubiquitous learning environment (ULE) and the control group via a web-based online course (WLE). Satisfaction was assessed at the end of studies by using an instrument developed for this study. The instrument measured aspects affecting the perceived satisfaction by 25 items (Likert 1–5) and 2 open-ended questions. The data was analysed by using the Mann Whitney U-test and with an inductive content analysis. Students in both groups were highly satisfied in the use of the learning environments. Used pedagogical and technological methods were assessed as high. The environments were assessed as easy to use and re-use. Diverse, interesting and clear learning content was seen as highly positive. Statistically significant difference between groups were seen in aspect concerning instruction and feedback. Other significant differences were not seen between groups. Developmental needs were seen in instruction and feedback aspect. More structured course planning, more supportive supervision and technical support were pointed out. The results suggest that ubiquitous learning environments should be used as supportive in histology and histotechnology studies. The results also indicated that the further development and optimisation of the learning environment should be done.

Keywords Ubiquitous learning · U-learning · Learning environments · 360°–technology · Student's satisfaction · Histotechnology · Higher education

1 Introduction

During last decades learning and teaching trends have rapidly moved from electronic learning (e-learning) towards mobile (m-learning) and to ubiquitous learning (u-learning) (Yang et al. 2008; Hwang et al. 2008; Liu and Hwang 2009). Electronic learning (e-learning) is defined as the use of electronic technology in learning, mobile learning (m-learning) is based on mobility and ubiquitous learning (u-learning) on ubiquitous computing and technology supported environments which can be used in all places and at all times. In all fields of education computer- and web-based learning strategies and various types of technology supported learning have come prevalent. Ubiquitous learning environments (ULE) support interactivity between the student and the used environment by sensing the situation of the student by utilising embedded functional objects, sensors or tags (Hwang et al. 2008; Marinagi et al. 2013; Hwang et al. 2009). Ubiquitous environments fuse together authentic learning spaces, virtual environments, digital resources, wireless mobile devices, networks and embedded functional objects.

When developing new learning environments, it is crucial to evaluate and ensure the quality of the developed environments, components, contents, objectives and outcomes. Quality can be defined in many ways and in educational contexts it can be seen as availability, usability, effectiveness, interactivity and satisfaction. One of the most significant aspects in the evaluation of learning environments is satisfaction assessed by students (Jung 2014). Previous studies have reported evaluation of satisfaction mostly in blended or e-learning contexts. Only a few have focused on mobile or ubiquitous environments. In these studies, satisfaction and meeting students' expectations are one of most desirable outcomes when assessing the success of used technologies (Jung 2014). In Rahman, Wu and Liu (2013) study satisfaction was described as a crucial factor affecting learning effectiveness. The importance of satisfaction has also been noted in other studies (Jung 2014; Naaj et al. 2012).

Great educational potential can be seen in ubiquitous, virtual and technologically supported learning environments. New and innovative teaching and learning methods could prove useful in all fields of education. But there is still a lack of published information concerning the development and evaluation of ubiquitous learning environments. In health sciences education, there is not any published material concerning ubiquitous learning or learning environments in biomedical laboratory science or histology contexts when Science Direct, PubMed, EBSCOHost and ProQuest databases were used for systematic literature search.

2 Review of literature

2.1 Ubiquitous learning

Ubiquitous learning is based on information technology and ubiquitous computing by providing an interactive learning architecture, where students can seamlessly and interactively immerse themselves in the learning process by using smart devices, such as phones, mobile devices or computers (Weiser 1991; Yaya et al. 2010; Huang et al. 2008; Ogata et al. 2008; Huang et al. 2011; Jones and Jo 2004). Ubiquitous technology enables learning anywhere, anytime and for anyone (Sakamura and Koshizuka 2005; Hwang et al. 2008). Ubiquitous learning environments can provide relevant learning material according to the learners' situation through badges, tags and sensors to the smart device being used. (Sakamura and Koshizuka 2005; Hwang, Wu, Tseng & Huang 2011; Marinagi et al. 2013). U-learning and u-learning environments provide self-directed learning possibilities without time or location constraints facilitating ubiquity, mobility, accessibility, personalisation and context customisation (Jung 2014). Based on the previous literature, ubiquitous learning environments can vary from interactive virtual learning environments to use of ubiquitous social media (Liu 2010).

In the health sciences context, ubiquitous environments have not been reported but the development and use of different types of virtual environments have been described, for example in proteomics and in chemistry studies (Ray et al. 2012; Tatli and Auas 2013). The used environments have simulated authentic laboratories virtually where students can safely practice complex, hazardous and expensive laboratory processes. Previous studies have suggested the use of virtual environments can be used in facilitating theory association between texts and practice but not for replacing practical hands-on training (Ray et al. 2012; Tatli and Auas 2013). Previous studies have focused on virtual laboratories and have concluded advantages on possibility to organize high-quality laboratory work virtually. (Potkonjak et al. 2016; Ray et al. 2012.) Virtual environments mimicking actual laboratory conditions have found to be most effective. One main criteria is that operating in virtual laboratory should feel like working in real authentic space with real authentic devices. The real experience makes students more serious and responsible. Visualization should be provided so that the students feel like they are looking authentic real-life thing. Behaviour should be equivalent to physical system. Virtual space must allow communication and collaboration as in real life situations. Main problems in virtual environment development are costs, complexicity of modelling and time-consuming configuration. (Potkonjak et al. 2016.)

According to previous studies, the meaningfulness of learning increases if used environments reflects authentic real-life situations as well as possible (Ogata and Yano 2004; Vygotsky 1978). In this study the best possible correspondence between the real-life and virtual environment was pursued by using 360°- technology based on spherical panorama images. In the 360°–environment users can take a virtual tour of a laboratory by using a smart device screen as a navigation tool. It allows the user to move around the laboratory and view and zoom in on interesting targets in all directions of the virtual space. A 360°–panorama image can be used as a learning management system with relevant learning resources, such as webinars, video lectures, literature, e-books, audio files, virtual microscopes and community-based tools.

In educational contexts just a few learning environments based on 360°–technology have been reported (Kurtulus 2013; Bastanlar 2007). It is more familiar in virtual tours in museums (Louvre Museum 2007). In a biomedical laboratory science context, the development or use of 360°–technology based virtual laboratories or ubiquitous learning environments has not been reported. The developmental need for this study arose from the perspective of pedagogical and technological diversity in learning environments with high real-life correspondence. Future environments should support various types of learning and teaching online, in real-time and with versatile multimedia learning content creation and delivery. It also should enable personalised content management and instant collaboration online.

2.2 Students' satisfaction

Satisfaction can be defined in many ways and it can mean different things to different people. (Giese and Cote 2002; Parker and Mathews 2001). In general satisfaction can be viewed as an outcome of experience (Henning-Thurau and Klee 1997) Satisfaction is one of the most desirable outcomes when implementing new technologies and services (Jung 2014). Previous studies have examined satisfaction in various educational settings including e-, m- and u-learning as a key outcome of technology use (Ramayah and Lee 2012; Sun et al. 2008). Regarding these studies, satisfaction can be defined from many perspectives, such as learner, instructor, technological or environmental which might affect the perceived satisfaction (Sun et al. 2008). It can also be defined regarding the teacher's expertise, environment and classroom facilities (Butt and Rehman 2010), instructions and feedback (Jones and Chen 2008), flexibility, efficiency and convenience (Looney et al. 2004), self-directed learning opportunities, customized contexts, high degree of interactivity and enjoyment (Jung 2014), self-motivation, learning climate and learning style (Eom et al. 2006). Several studies have reported the importance of ease of use and student satisfaction (Arbauch 2000; Arbauch and Duray 2002; Rahman et al. 2015; Lim et al. 2007). In previous literature the main factors affecting satisfaction have been complex and have strongly varied between studies. Main aspects can be summarized as technological satisfaction (including course delivery, ease of use, flexibility, technological comfort, quality), pedagogical satisfaction (including aspects as group work, interaction, course design), satisfaction on instructions and feedback, perceived enjoyment (including availability, reliability, usefulness,perceived value, overall satisfaction) and self-motivation (control, attitude, self-directed learning opportunities). Based on the related references (Table 1) and researchers´ previous knowledge, this study focuses on factors affecting student's satisfaction as technological and pedagogical satisfaction, instructions and feedback, perceived enjoyment and self-motivation. Insufficient satisfaction has been shown as an obstacle when implementing environments (So and Brush 2008). Technological quality have seen as important factor in Piccoli et al. (2011) study. Challenges in previous studies have been experienced in the following areas: problems with computers and internet access, learner ability, use of technology, course design, interaction and integration (Bonk et al. 2002; Wu et al. 2010).

In previous studies satisfaction has been assessed by using different types of questionnaires, surveys and interviews (Jung 2014; Novo-Corti et al. 2013; Sun et al. 2008). Several studies have focused on comparisons of traditional face-to-face methods and e-learning or web-based or blended learning strategies and have reported positive effects (Chu et al. 2010; Hwang et al. 2011a, b; Owston et al. 2013). Consequently, it has become important to re-examine if effective web-based strategies can also benefit mobile or ubiquitous learning (Chu 2014).

3 Aim of the study

The aim of this study was to compare students' satisfaction with a ubiquitous learning environment based on 360^{o}–technology and a traditional web-based online learning environment. The study answered the following research questions: 1) What is the

Table 1 Related references about factors affecting satisfaction

Author (Year)	Factors
Piccoli et al. (2011)	Technology comfort, control and attitudes, self-efficacy, availability, reliability, quality, procedural and conceptual knowledge
Arbauch (2000)	Perceived flexibility, usefulness and ease of use, virtual immediacy, media, instructor experience, interaction
Arbauch and Duray (2002)	Perceived flexibility, usefulness and ease of use
Eom et al. (2006)	Course structure, feedback, self-motivation, interaction, learning style
Jones and Chen (2008)	Instruction, interaction, feedback, group work, technology, course design, multimedia, course delivery
So and Brush (2008)	Course structure, emotional support, communication
Sun et al. (2008)	Course quality, usefulness, ease of use, diverse assessment
Butt and Rehman (2010)	Teachers expertise, course offered, learning environment, classroom facilities
Wu et al. (2010)	Learning climate, ease of use, perceived value, system functionality. Social interaction, computer self-efficacy
Naaj et al. (2012)	Instructor, technology, class management, interaction instruction
Ramayah and Lee (2012)	Service quality, information quality, information quality
Owston et al. (2013)	Overall satisfaction, convenience, sense of engagement, learning outcomes
Jung (2014)	Self-directed learning opportunities, context customization, interactivity, enjoyment
Rahman et al. (2015)	Ease of use, perceived value, learning climate, student-instructor interaction

students' level of satisfaction with ubiquitous and web-based online learning environments? 2) Are there differences between the students' satisfaction with ubiquitous learning environment and web-based online learning environment? 3) What the students' liked and disliked on ubiquitous learning environment?

4 Methods

4.1 Study design and setting

A comparative quasi-experimental study design with experimental and control groups was used. A Ubiquitous Learning Environment (ULE) was used with the experimental group and a web-based online learning environment (WBE) was used with the control group. The study was undertaken as a part of a larger study implemented in the largest University of Applied Sciences in Finland. The students (n = 115) studying clinical histology and histotechnology studies as part of a biomedical laboratory science degree were assigned to an experimental group (n = 61) and to a control group (n = 54) based on the semester when the histology studies were carried out. The eligibility criteria for the participants were as follows: studies must have progressed as planned in the curriculum. 82% of the participants were women and 18% men (n = 95/20). The average age of the participants was 27 years. 28% of the participants had a previous degree (vocational or university). 93% indicated their current status as full-time students.

4.2 Procedure

The anticipated and targeted learning outcomes for the five-week studies were to identify the importance of histological and histotechnological processes as a part of diagnosis and patient treatment, in theory. The objects also included the recognition of the most common pathological changes in theory. After completing the course students were capable to perform histotechnological tissue sample processes. The experimental group studied in a ubiquitous learning environment (ULE) which fused together an

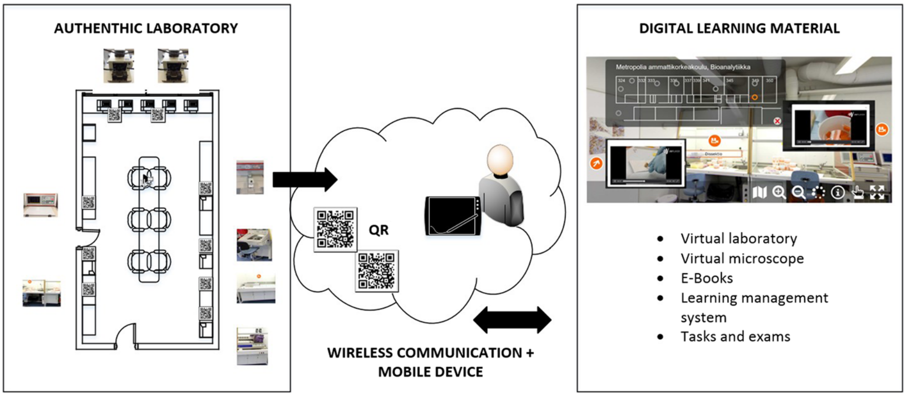

Fig. 1 The ubiquitous learning environment

authentic learning space, virtual laboratory and digital learning (Fig. 1.) and where pedagogy of collaborative and self-directed learning was used. In this study the ULE combined a 360°–virtual laboratory, virtual microscope, online webinars, recorded video lectures, demos and tutorials, electronic books, tasks, assignments and exams and quick response barcodes in an authentic practical training laboratory. Mobile devices were used during the study period. The studies were entirely guided and learning material distributed in ULE.

In the web-based learning environment (WLE), learning material was entirely distributed online in a learning management system (Moodle 2.7). Same pedagogical strategies were used than in ULE. Differences between ULE and WLE were that ubiquitous 360° environment, virtual laboratory, virtual microscope, quick response barcodes, mobile device or communicative tools were not available for the WLE group.

4.3 Learning environment

The 360°–virtual laboratory was developed by using Adobe Lightroom, Adobe Photoshop, GardenGnome, Pano2VR, Kolor Autopano and PTGui software programmes. The user interface, icons and control buttons were customised and produced by using HTML5, CSS and JavaScript techniques. All the used learning material was attached or linked to the 360°–virtual laboratory which was used as a learning management system (Fig. 2).

For online webinars and recorded video lectures the Adobe Connect web conference system was used. Tutorials and practical training demonstrations were recorded and edited by using Apple iPad, iMovie and Explain Everything applications. All material in video file format was distributed on YouTube.

A virtual microscope was developed by scanning and digitizing tissue slides, processed at the university, using a Pannoramic 250 Flash scanner, 20× lens and bright light. The scanned image files were compressed and uploaded to WebMicroscope® (Fimmic Ltd). A virtual slide viewer was used for microscopy (Fig. 3).

All the used assignments, tasks and exams were provided electronically in Moodle (version 2.7). Electronic books from the university's library were used. Community-

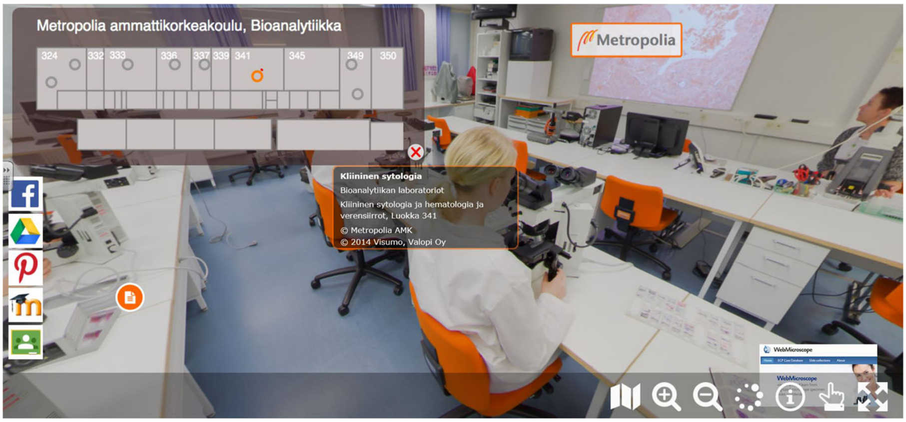

Fig. 2 Virtual laboratory for microscopy

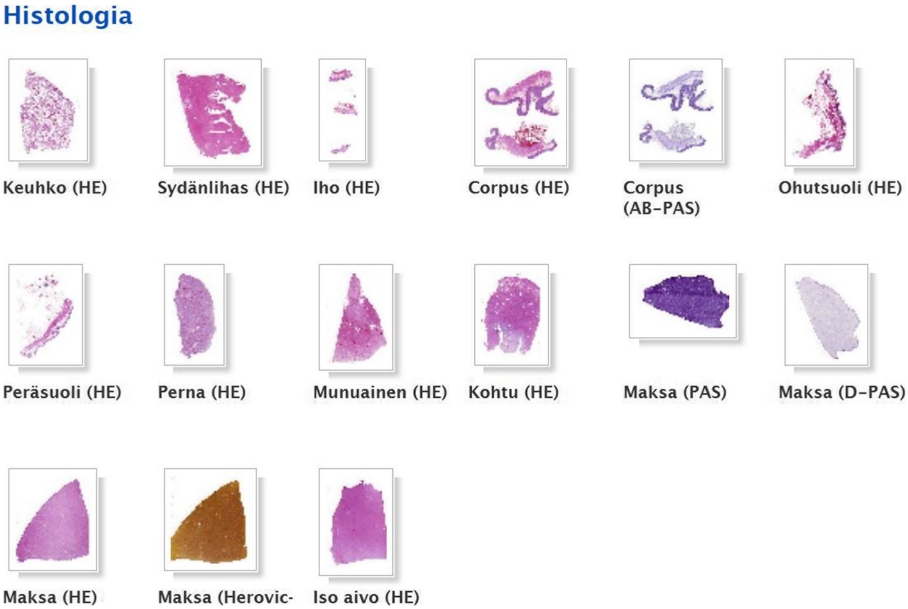

Fig. 3 Virtual microscope for histology

based tools as Google Drive were used to perform collaborative learning tasks and to enable interactive communication.

Quick response barcodes were attached to the authentic laboratory to offer relevant multimedia learning content at relevant places linked to the learning process and based on the students' demands. The quick response barcodes were generated by using free online software (Fig. 4). The ULE was accessed using Apple iPads but can be used with all smart devices, such as phones, tablets and computers whenever there is internet access.

4.4 Instrument

The instrument measuring the satisfaction of the learners was developed by the researcher based on the literature (Eom et al. 2006; Butt and Rehman 2010; Navarro et al. 2005; Small et al. 2012; Rahman et al. 2015; Novo-Corti et al. 2013; Jung 2014). An existing instrument was not found which would adequately address the research questions. A number of items for the instrument were formed to meet the criteria of satisfaction and were focused on instruction and feedback ($n = 7$), pedagogical methods used ($n = 6$), technological methods

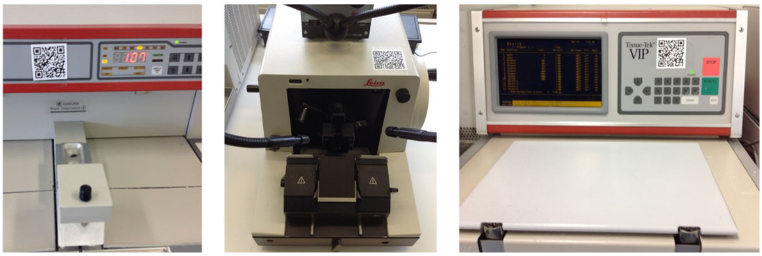

Fig. 4 Quick response barcodes in the laboratory

used ($n = 3$), enjoyment ($n = 5$) and self-motivation ($n = 3$). Sum variables were formed from these aspects. All individual items were rated on a 5-Likert scale, from strongly agree (scored as 5) to strongly disagree (scored as 1). The instrument contained background information, such as age, gender, previous level of education and current study status (full-time/ part-time). In addition, two open-ended questions were included to indicate positive effects and developmental needs. The internal reliability of the instrument was evaluated by using Cronbach's alpha for both groups separately and for the whole instrument. The alpha for whole instrument was .955 in ULE group and .944 in WLE group. The values indicate the good internal reliability.

4.5 Data collection and analysis

The data was collected at the end of the course using Eduix software (version 3.1) in 2015 and in 2016 by an instrument developed for this study. The study was carried out and data was collected in three Universities of Applied Sciences in Finland with the permission of directors of health and nursing science departments. The data was analysed using descriptive statistics with the IBM SPSS statistical software version 21 (SPSS, Chicago, IL). Differences between the experimental and control group in subscales and independent items were identified by using independent samples Mann-Whitney U-test. The level of statistically significant difference was set at p- value <0.05. Descriptive statistics were used to characterise the participants.

The open-ended questions were analysed using inductive content analysis. The analysis was performed in three phases: preparation, organisation and reporting. Preparation for data analysis was determined by research objectives, multiple readings and interpretations of the raw data where the findings were outlined by researcher. In the preparation phase the analysis unit was defined. In the organising phase raw data was open coded and formalised categories were defined by capturing key themes of important processes from multiple interpretations. After the categories were grouped, final categories were defined and listed under higher categories. Sub-categories, categories and main categories were formed. The trustworthiness of the findings was assessed by using expert evaluations (Elo and Kyngäs 2008).

4.6 Ethical considerations

The study was carried out with the permission of Universities of Applied Sciences. Students participated voluntarily in the experiment and participation was confirmed by informed consent. The students were informed about the objectives, contents and data collection. The collected data was treated and stored confidentially and password-protected. Identification of the individuals who participated in the study was not possible.

5 Results

5.1 Aspects affecting on students' satisfaction

The satisfaction was assessed rather high in both groups, mean in ULE group was 3.82 (Likert 1–5) and in WLE group 3.95. The mean scores of satisfaction ranged between

2.08 and 5.00 in ULE group and between 1.87–4.88 in WLE group. Standard deviations ranged between 0.00 and 1.58 in ULE and between 0.33–1.50 in WLE group. In ULE group the students were the most satisfied with the used pedagogical and technological methods and most dissatisfied with instructions and feedback. In WLE group instruction and feedback and technological methods were assessed high. Statistically significant difference between groups were seen in variable concerning instructions and feedback ($p > 0.001$) (Table 2).

When the items were compared individually the students were the most satisfied with following items in ULE group: the methods used provided challenges (4.49) and the used methods were innovative (4.48). Multiple pedagogical methods were used (4.26) and the studied contents were practical (4.11). The students were most dissatisfied with the supportive role of teacher (3.11) and on technical easy to use (3.23). The biggest deviations emerged in items: role of teacher was supportive (1.28) and ULE was technically easy to use (1.26). Statistical differences between experimental and control groups were revealed in items technically easy to use, the learning material was clear and the use of LE was supportive. In all these items assessments were higher in WLE group. Multiple items were assessed higher in WLE group (Table 3).

5.2 Students´ satisfaction on ubiquitous learning environment

Based on data from the open-ended questions two main categories were formed. The students' perceived positive aspects of learning environment was described in terms of active and technology-supported learning methods and environment. Developmental needs were seen in combining the used teaching methods to support independent learning. Sub-categories, categories and main categories are shown in Figs. 5 and 6.

The main category, "Importance of active and technology-supported learning environment" contained supportive material for independent learning and efficient use of technology and active learning methods. The students were satisfied with motivational, diverse, clear and supportive learning material which enabled flexible timetables and schedules. Also easy to use and re-usable learning content was described as supportive. The use of the virtual laboratory was efficient and helpful by clarifying laboratory processes and orientation into practical laboratory work. The use of mobile devices and a selection of usable apps and a wireless network connection were seen as a

Table 2 Comparisons of sum variables between groups

Sum variables	ULE (n = 61) Mean (Std. Dev.)	WLE (n = 54) Mean (Std. Dev.)	Difference (ULE-WLE)	p*	Cronbach alpha
Instruction and feedback (n = 7)	3.62 (1.20)	4.06 (1.00)	-0.44	<.001**	.842
Pedagogical methods (n = 6)	4.01 (1.01)	3.94 (0.96)	0.07	.944	.829
Technological methods (n = 3)	4.15 (0.99)	4.11 (1.06)	0.04	.967	.607
Enjoyment (n = 6)	3.71 (1.06)	3.80 (1.12)	-0.09	.314	.835
Self-motivation (n = 3)	3.77 (1.05)	3.83 (1.20)	-0.06	.390	.641
ALL (n = 25)	3.82 (1.09)	3.95 (1.06)	-0.13	.096	.942

* Mann Whitney U-test, ** $p < .05$

Table 3 Comparisons of individual items between groups

	ULE (n = 61) Mean (St. Dev.)	WLE (n = 54) Mean (St. Dev.)	Difference (ULE-WLE)	p*
Instructions and feedback				
Technically easy to use	3.23 (1.26)	4.17 (0.94)	-0.94	<.001**
The learning material was clear	3.21 (1.24)	4.11 (1.01)	-0.90	<.001**
The learning material was interesting	4.43 (0.67)	4.43 (0.64)	.	.907
The learning material was supportive	4.05 (1.11)	4.26 (0.81)	-0.21	.517
The instructions were clear	3.72 (1.14)	3.94 (1.01)	-0.22	.348
The role of teacher was supportive	3.13 (1.28)	3.58 (1.15)	-0.45	.056
The use of LE was supportive	3.60 (1.03)	3.94 (1.12)	-0.34	.027**
Pedagogical methods				
The methods used allowed deep understanding	3.30 (1.19)	3.50 (1.06)	-0.20	.333
The methods used provided challenges	4.49 (0.60)	4.22 (0.84)	0.27	.089
The methods used gained learning	3.85 (0.98)	3.74 (1.08)	0.12	.697
The assignments used supported learning	4.03 (1.05)	4.09 (0.86)	-0.06	.855
The contents were practical	4.11 (0.90)	4.11 (0.93)	.	.908
Multiple teaching methods were used	4.26 (0.85)	3.98 (0.87)	0.28	.053
Technological methods				
The used methods were innovative	4.48 (0.85)	4.28 (0.96)	0.20	.435
The used methods were up-to-date	4.35 (0.67)	4.42 (0.75)	-0.07	.967
The used devices were supportive	3.62 (1.13)	3.63 (1.28)	-0.01	.751
Perceived enjoyment				
Satisfaction with implementation	3.40 (1.12)	3.66 (1.24)	-0.26	.170
Satisfaction with studies in general	3.98 (0.92)	4.02 (0.94)	-0.03	.800
Expectations fulfilled	3.65 (1.09)	3.98 (0.87)	-0.33	.111
LE was useful	3.89 (1.09)	3.68 (1.17)	0.21	.605
LE eased my studying	3.50 (1.11)	3.81 (1.28)	-0.31	.102
Use of LE suggested to other courses	3.82 (1.10)	3.63 (1.28)	0.19	.521
Self-motivation				
LE motivated learning	3.31 (1.10)	3.20 (1.31)	0.11	.521
I was actively responsible of my studies	4.10 (0.93)	4.25 (0.94)	-0.15	.761
Interest towards occupation increased	3.92 (0.94)	4.06 (1.09)	-014	.312

* Mann Whitney U-test, ** $p < .05$

positive contribution allowing studies at any time and place. Continuous use in the future and also for other courses were recommended.

> "*Video Lectures and other material supported my learning. I was able to use my mobile phone while traveling in the bus and read issues related to histology.*"

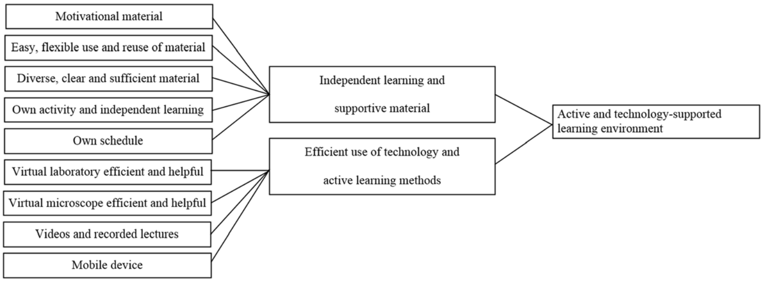

Fig. 5 Positive aspects of ubiquitous learning environment

"*I was satisfied to have better opportunities for independent study.*"

"*Virtual environments were really good.*"

"*The iPad was easy to use while travelling by train and elsewhere. Definitely motivated to study more.* "

"*The course was interesting and well implemented ... it brought a good variation to studies.*"

"*I experienced different activation methods as positive: assignments, video lectures, project, lab work…*"

The main category, "Needs to improve combination of used teaching methods to support of independent learning" included more course planning, supervision and technical support, more detailed instructions and more traditional teaching and practical training. Students asked more guidance, interactivity between teacher and student, detailed instructions and scheduling to facilitate punctuality. Also a more detailed and clear structure of the course was needed as well as solving technical and internet connection problems. A few of the students pointed out personal needs for "traditional" lectures. Plenty of student's requested more time for practical hands-on training in the histotechnology laboratory.

"*... Maybe more guidance by teacher.*"

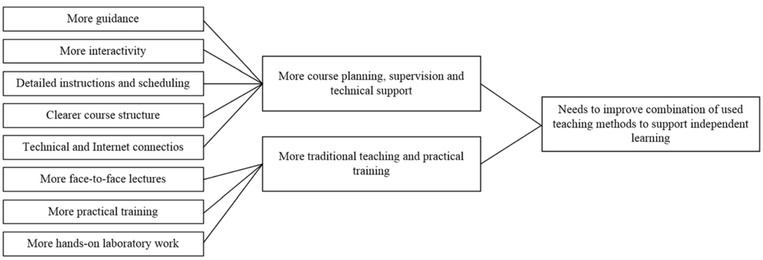

Fig. 6 Developmental needs of ubiquitous learning environment

"*... Bit more guidance on the timing of self-study materials.*"

"*A more detailed and clear schedule would nice to facilitate learning assignments. Now everything was done in the last minute.* "
"*Mobile access to iPad. So it really would work everywhere.*"

"*More traditional lectures. I can't learn effectively just by watching video lectures alone.*"

"*More time for practical laboratory work.*"

6 Discussion

Effects of learning environments on students´ satisfaction have not been widely studied or reported in health science context. Also use of 360^o technology in learning environment development have not previously reported in any educational context. Based on arguments of virtual learning environment development (Potkonjak et al. 2016; Ray et al. 2012) in this study ULE was developed by using innovative 360^o technology instead of virtual worlds or 3D modelling. Developed ULE mimics real-life situations, authentic laboratory and laboratory devices. Visually ubiquitous learning environment and authentic laboratory environment were equal. Development was cost-effective and contents were easy and fast to product. Method is suitable for any educational context and can be used in multiple designs. This study presents a new method for a higher education use and answers questions concerning students' satisfaction in different digital learning environments. This study provides an empirical investigation on satisfaction focusing on instructions and feedback, pedagogical and technological methods, perceived enjoyment and self-motivation.

In this study web-based learning environment, used with control group, was evaluated as technically easier, more clear and supportive than ULE which was used with experimental group. In ULE group students were satisfied with used pedagogical and technological method but preferred clearer instructions and more support from teacher. Previous studies have also shown that instructors´ feedback and timely response influences significantly on satisfaction (Arbauch 2000; Sun et al. 2008.) This was also seen in this study and was one of the main outcome. Interesting point in this study was that WLE group has assessed satisfaction higher than ULE group in almost every subscale. This might be argued with increased cognitive load when new technological methods have implemented. Hwang, Wu, Zhuang and Huang (2011) and Wu et al. (2012) have also focused in their studies on student's cognitive load while studying in mobile and context-aware environments. They have shown less cognitive load when new methods have used.

Students were also satisfied with the possibility to decide the place, time and duration and the possibility to plan their own schedules. Owston et al. (2013) have also reported positive effects on learning process regulation. Studying in digital learning environments requires more of the students' own activity to achieve goals, manage tasks and create timetables. Several studies have shown time management as a problem when using digitally supported learning environments. Poor time management can be a greater problem than technological obstacles (So and Brush 2008; Aycock et al. 2002). Time management was pointed out also in this study when more detailed schedules and deadlines were requested.

Developmental needs were seen especially in technology use. Several studies indicate that technological quality affects significantly on satisfaction (Piccoli et al. 2011; Sun et al. 2008). Also learner attitude towards computers or information technology have mentioned as satisfaction aspect (Arbauch 2000; Arbauch and Duray 2002) In this study mobile devices were seen as a positive contribution allowing flexible possibilities to study at all times and in any place. Positive effects of mobile device use have reported also in Davies (2014) and Martin and Ertzberger (2013) studies.

Students on the web-based learning environment perceived satisfaction more positively than students in the ubiquitous group. This illustrated the fact that web-based environments have been used in teaching for some years and can be seen as a traditional method. Margaryan et al. (2011) have shown in their study that students' conform to fairly traditional teaching methods with minor uses of technology. This was also seen in this study. Wishes regarding traditional lecture-based methods (with web-based content delivery) were present. The ubiquitous learning environment was evaluated as being more challenging to use and there were stronger needs for personal guidance, detailed information and support than in web-based learning alone. However, the differences between the groups were very small and detailed conclusions based on this data cannot been made.

In the future 360°–ubiquitous learning environments can be used in all fields of education. They can support any learning situation at any level of education, in work places, in continuous education and in patient education and can easily be focused on any educational context. 360°–panorama images can set as a background for any learning situation in health sciences, for example, in dental clinics, maternity clinics or clinical laboratories. These implementations are already under development. 360°–ubiquitous learning environments creates a new opportunity to achieve high degrees of student satisfaction enabling online and real-time support for various types of learning and can be seen an innovative method for learning environment development. The use of ULE can support collaborative learning and offer more possibilities. The developed material can be used flexible and easily in multiple universities and degree programs to support learning. All developed modules can be easily shared between collaborators.

Several limitations narrow the scope of the conclusions. The small number of participants were only related to a health science histology and histotechnology context and findings reflect limited aspects of user experience. This research is exploratory and conclusions are tentative because development of ULE is still in early stage. These leads to limited generalizability. The selection of participants and contents were based on the context of biomedical laboratory science which has been the focal point for the researcher for several years.

Instrument development was based on a few factors instead of adopting a multidimensional perspective. Developmental decisions were made by keeping the main focus on the students' satisfaction in general. The developed instrument can be used or developed further in other contexts when assessing satisfaction in health education purposes. Limitations concerning data collection or analysis were not defined.

7 Conclusions

The results of this study support that ubiquitous and traditional web-based environments can gain equal satisfaction assessed by students. In this study ubiquitous 360° learning environment has shown its pedagogical potential and significant benefits for students. The results also provide an understanding of why students may or may not be satisfied with the implementation. The ubiquitous 360° learning environment supports seamless interaction between the authentic and virtual environment and can be used as supportive environment in histology and histotechnology studies. Based on this study, further development, optimisation and interventions will be done. Design, development and implementation of ULE in other contexts of health sciences will be done based on these results. Improvements as detailed instructions, instant feedback and one-line support system will be made. Structure and components of learning environment and learning materials will be clarified. All learning materials will be updated. In the future attention will be paid on interactivity and on the structural and technical reliability of the environment.

Compliance with ethical standards

Conflict of interest During this development and evaluation process no conflict of interest has been declared by the authors. No ethical issues were related to the selection of the participants, data collection or data analysis.

Contribution MV, MK, EH was responsible for the study design. MV was responsible for learning environment production. MV performed the intervention, data collection and data analysis. MV was responsible for drafting the manuscript. MK, EL and EH made critical and intellectual revisions.

References

Arbauch, J. B. (2000). Virtual classroom characteristics and student satisfaction with internet-based MBA courses. *Journal of Management Education, 24*(1), 32–54.

Arbauch, J. B., & Duray, R. (2002). Technological and structural characteristics, student learning and satisfaction with web-based courses. An exploratory study of two on-line MBA programs. *Management Learning, 33*(3), 331–347.

Aycock, A., Garnham, C. & Kaleta, R. (2002). Lessons learned from the hybrid course project. Teaching with Technology Today, 8.

Bastanlar, Y. (2007). User Behaviour in Web-Based Interactive Virtual Tours. In Proceedings of 29th International Conference on Information Technology Interfaces, doi:10.1109/ITI.2007.4283774

Bonk, C. J., Olson, T. M., Wisher, R. A. & Orvis, K. L. (2002). Learning from focus groups: An examination of blended learning. *Journal of Distance Education, 17*(3), 97–118.

Butt, B., & Rehman, K. (2010). A study examining the student's satisfaction in higher education. *Procedia Social and Behavioral Sciences*. doi:10.1016/j.sbspro.2010.03.888.

Chu, H.C. (2014). Potential negative effects of mobile learning on student's learning achievement and cognitive load - A format assessment perspective. Educational Technology and Society, http://www.jstor.org/stable/jeductechsoci.17.1.332.

Chu, H. C., Hwang, G. J., & Tsai, C. C. (2010). A knowledge engineering approach to developing mindtools for context-aware ubiquitous learning. *Computers & Education*. doi:10.1016/j.compedu.2009.08.023.

Davies, M. (2014). Using the apple iPad to facilitate student-led group work and seminar presentation. *Nurse Education in Practice*. doi:10.1016/j.nepr.2014.01.006.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*. doi:10.1111/j.1365-2648.2007.04569.x.

Eom, S., Wen, J., & Ashill, N. (2006). The determinants of students perceived learning outcomes and satisfaction in university online education: An empirical investigation. *Decision Sciences Journal of Innovative Education*. doi:10.1111/j.1540-4609.2006.00114.x.

Giese, J. L., & Cote, J. A. (2002). Defining consumer satisfaction. *Academy of Marketing Science Review, 2000*(1), 1–24.

Henning-Thurau, T., & Klee, A. (1997). The impact of customer satisfaction and relationship quality on customer retention: A critical reassessment and model development. *Psychology & Marketing, 14*(8), 737–764.

Huang, Y-M., Huang, T-C., & Hsieh, M-Y. (2008). Using annotation services in a ubiquitous Jigsaw cooperative learning environment. Educational Technology & Society, http://www.jstor.org/stable/jeductechsoci.11.2.3

Huang, Y.-M., Chiu, P.-S., Liu, T.-C., & Chen, T.-S. (2011). The design and implementation of a meaningful learning-based evaluation method for ubiquitous learning. *Computers & Education*. doi:10.1016/j.compedu.2011.05.023.

Hwang, G.J., Tsai, C.C. & Yang, S.J.H. (2008). Criteria, Strategies and Research Issues of Context-Aware Ubiquitous Learning. Educational Technology & Society, http://www.jstor.org/stable/jeductechsoci.11.2.81

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*. doi:10.1016/j.compedu.2009.02.016.

Hwang, G., Wu, P., Zhuang, Y., & Huang, Y. (2011a). Effects of the inquiry-based mobile learning model on the cognitive load and learning achievement of students. *Interactive Learning Environments*. doi:10.1080/10494820.2011.575789.

Hwang, G. J., Wu, C. H., Tseng, J. C. R., & Huang, I. W. (2011b). Development of a ubiquitous learning platform based on a real-time help-seeking mechanism. *British Journal of Educational Technology*. doi:10.1111/j.1467-8535.2010.01123.x.

Jones, K., & Chen, C. (2008). Blended learning in a graduate accounting course: Student satisfaction and course design issue. *The Accounting Educators Journal, XVIII*, 15–28.

Jones, V. & Jo, J.H. (2004). Ubiquitous learning Environment: An adaptive teaching system using ubiquitous technology. In Atkinson, R., McBeath, C., Jonas-Dwyer, D. & Phillips, R. (Eds), Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference, pp. 468–474. Perth.

Jung, H. (2014). Ubiquitous learning: Determinants impacting learners' satisfaction and performance with smartphones. *Language Learning & Technology, 18*(3), 97–119 EISSN-1094-3501.

Kurtulus, A. (2013). The effects of web-based interactive virtual tours on the development of prospective mathematics teachers´ spatial skills. *Computers & Education*. doi:10.1016/j.compedu.2012.11.009.

Lim, H., Lee, S.-G., & Nam, K. (2007). Validating e-learning factors affecting training effectiveness. *International Journal of Information Management*. doi:10.1016/j.ijinfomgt.2006.08.002.

Liu, Y. (2010). Social media tools as a learning resource. *Journal of Educational Technology Development and Exchange, 3*(1), 101–114.

Liu, G. Z., & Hwang, G. J. (2009). A key step to understanding paradigm shifts in e-learning. *British Journal of Education Technology*. doi:10.1111/j.1467-8535.2009.00976.x.

Looney, C. A., Jessup, L. M., & Valacich, J. S. (2004). Emerging business models for mobile brokerage services. *Communications of the ACM*. doi:10.1145/990680.990683.

Louvre Museum. (2007). Virtual tour. http://musee.louvre.fr/visite-louvre/index.html?defaultView=entresol.s489.p01&lang=ENG

Margaryan, A., Littlejohn, A., & Vojt, G. (2011). Are digital natives a myth or reality? University students´ use of digital technologies. *Computers & Education*. doi:10.1016/j.compedu.2010.09.004.

Marinagi, C., Skourlas, C., & Belsis, P. (2013). Employing ubiquitous computing devices and Technologies in the Higher Education Classroom of the future. *Procedia-Social and Behavioral Sciences*. doi:10.1016/j.sbspro.2013.02.081.

Martin, F., & Ertzberger, J. (2013). Here and now mobile learning: An experimental study on the use of mobile technology. *Computers & Education*. doi:10.1016/j.compedu.2013.04.021.

Naaj, M. A., Nachouki, M., & Ankit, A. (2012). Evaluating student satisfaction with blended learning in a gender-segregated environment. Journal of Information Technology Education: Research, 11. ISSN-1547-9714.

Navarro, M. M., Iglesias, M. P., & Torres, P. R. (2005). A new management element for universities: satisfaction with the offered courses. *International Journal of Educational Management, 19*(6), 505–526.

Novo-Corti, I., Varela-Candamio, L., & Rami-Diaz, M. (2013). E-learning and face to face mixed methodology: Evaluating effectiveness of e-learning and perceived satisfaction for microeconomic course using the Moodle platform. *Computers in Human Behaviour*. doi:10.1016/j.chb.2012.06.006.

Ogata, H., & Yano, Y. (2004). Knowledge awareness map for computer-supported ubiquitous language-learning. *Proceedings of the International Workshop on Wireless and Mobile Technologies in Education*. doi:10.1109/WMTE.2004.1281328.

Ogata, H., Paredes, J. R. G., Saito, N. A., San Martin, G. A., & Yano, Y. (2008). Supporting classroom activities with the BSUL system. *Educational Technology & Society*. doi:10.1109/WMTE.2005.61.

Owston, R., York, D., & Murtha, S. (2013). Student perceptions and achievement in a university blended learning strategic initiative. *Internet and Higher Education*. doi:10.1016/j.iheduc.2012.12.003.

Parker, C., & Mathews, B. P. (2001). Customer satisfaction: contrasting academic and consumers' interpretations. *Marketing Intelligence & Planning, 19*(1), 38–44.

Piccoli, G., Ahmad, R., & Ives, B. (2011). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skill training. *MIS Quarterly, 25*(4), 401–426.

Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrovic, V. M., & Jovanovic, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers and Education*. doi:10.1016/j.compedu.2016.02.002.

Rahman, N., Hussein, N., & Aluwi, A. (2015). Satisfaction on blended learning in a public higher education institution: What factors matter? *Procedia- Social and Behavioral Sciences*. doi:10.1016/j.sbspro.2015.11.107.

Ramayah, T., & Lee, J. (2012). System characteristics, satisfaction and E-learning usage: A structural equation model (SEM). *TOJET: The Turkish Online Journal of Educational Technology, 11*(2), 197–206.

Ray, S., Koshy, N., Reddy, P., & Srivastava, S. (2012). Virtual labs in proteomics: New E-learning tools. *Journal of Proteomics*. doi:10.1016/j.jprot.2012.03.014.

Sakamura, K., & Koshizuka, N. (2005). *Ubiquitous computing Technologies for Ubiquitous Learning, proceedings of the 2005 I.E. international workshop on wireless and mobile Technologies in Education (WMTE '05)*. doi:10.1109/WMTE.2005.67.

Small, F., Dowell, D. & Simmons, P. (2012). Teacher communication preferred over peer interaction: student satisfaction with different tools in a virtual learning environment. *Journal of International Education in Business, 5*(2), 114–128.

So, H.-J., & Brush, T. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment. *Relationships and critical factors. Computers & Education*. doi:10.1016/j.compedu.2007.05.009.

Sun, P.-C., Tsai, R. J., Finger, G., Chen, Y.-Y., & Yeh, D. (2008). What drives a successful e-learning? *An empirical investigation of the critical factors influencing learner satisfaction. Computers & Education*. doi:10.1016/j.compedu.2006.11.007.

Tatli, Z. & Auas, A. (2013). Effect of a Virtual Chemistry Laboratory on Student's achievements. Educational technology & Society, http://www.jstor.org/stable/jeductechsoci.16.1.159

Vygotsky, L. (1978). Interaction between learning and development. In Gauvain & Cole (Eds.), *Readings on the development of children* (pp. 34–40). New York: Scientific American Books.

Weiser, M. (1991). The computer of the twenty-first century. *Scientific American, 265*(3), 66–75.

Wu, J., & Liu, W. (2013). An empirical investigation of the critical factors affecting students´ satisfaction in EFL blended learning. *Journal of Language Teaching and Research, 4*(1), 176–185.

Wu, H., Tennyson, R. D., & Hsia, T. (2010). A study of student satisfaction in a blended e-learning system environment. *Computers & Education*. doi:10.1016/j.compedu.2009.12.012.

Wu, P-H., Hwang, G-J., Su, L-H & Huang, Y-M. (2012). A Context-Aware Mobile Learning System for Supporting Cognitive Apprenticeships in Nursing Skills Training. Journal of Educational Technology & Society, http://www.jstor.org/stable/jeductechsoci.15.1.223.

Yang, S.J.H., Okamoto, T. & Tseng, S.S. (2008). Context-aware and ubiquitous learning (Guest editorial). Educational Technology and Society, http://www.jstor.org/stable/jeductechsoci.11.2.1.

Yaya, S., Ahmad, E., & Jalil, A. (2010). The definition and characteristics of ubiquitous learning. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2010, 6*(1), 117–127.