2012

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ABSTRACT

This research explores the effect of the use of laptop computers on students' learning experiences during lectures. Our methodology involves embedding laptops with visualization software as a learning aid during lectures. We then employ a framework of seven principles of good practice in higher education to evaluate the impact of the use of laptop computers on the learning experience of computer programming students. Overall, we found that students were highly motivated and supportive of this innovative use of laptop computers with lectures.

Keywords

Laptop computers, Lectures, Programming, Enhancement learning experience.

INTRODUCTION

For many subjects taught at university, it is crucial that students gain conceptual understanding and practical skills to become good practitioners with hands-on experience as well as theoretical knowledge of the subject. An appropriate learning environment for novices must give them an in-depth knowledge of the principles of their discipline as well as practical skills of using the course content (Hwang et al. 2009). However, there is a gap between the delivery of lectures in tertiary education and the learning potential of many students. In particular, learning computer programming includes understanding static concepts, codes, algorithms and data, none of which are visual in form. They require extensive understanding and memorization, which can pose a challenge to novice programmers.

This paper evaluates the potential of a teaching approach that delivers theoretical and practical components together in a lecture environment using laptop computers where students can simultaneously practice the subject being taught in the lecture. With the rapid advances in mobile learning, there is also a need to redesign introductory computing courses to meet the expectations of a new student generation in higher education. Although a few studies have considered the use of mobile learning in the context of computer programming education (Sheard et al. 2009), there is a lack of research investigating the connection between classroom technology and student learning (McCabe and Meuter 2011) and introducing the use of laptops in areas of higher education that currently do not support it (Robin and Lauricella 2011).

This research aims to identify pedagogical issues regarding the use of laptop computers in computer programming lectures. It uses seven principles developed by Chickering and Gamson (1987) as a framework for evaluating a novel method of course delivery that combines lectures with laptop computers. The authors of this paper reviewed several software technologies that combine visualization, programming platforms, as well as some management tools, and chose a software program with visualization environment called VILLE (Rajala et al. 2008). Thus, the following research questions are under investigation in this research:

(a) How can the seven principles of good practice in tertiary education developed by Chickering and Gamson (1987) be applied effectively to align the use of laptop computers in lectures?

(b) How do students perceive the use of laptop computers during lectures in terms of their satisfaction and motivation?

LITERATURE REVIEW

A constructivist-learning environment is a philosophy of learning whereby the individual, based on experience, ‘constructs’ an internalised understanding of the environment. Learning, therefore, is the process of adjusting those internal models to accommodate new experiences. Wang (2009) explains that the learning process in this paradigm comprises curriculum, social and technological perspectives. On the basis of these three perspectives, Wang conducted a study on a group of trainee teachers, using a specifically-designed computer-based learning environment. The researcher found that of the three aspects, technology was crucial to this form of learning environment, as the majority of the learning activities depended on skills in applying the technology and "the technological aspect provided a solid base for the pedagogical and social design" (ibid. p. 11).

Pedagogical practices and learning environments undergo continual change with shifts in technology, culture and demand. A current example of the breadth of this continual change is the use of mobile devices in educational practices, which has also grown into a topic of extensive research in the last decade (Hwang and Tasi 2011). Each cohort of students entering and graduating from university brings its varying attitudes and expectations. Roberts (2005) discovered that the so-called ‘net generation’ students who were raised in the last decade or so with prolific availability of internet seem to bring this technology-centric view to education and relate their learning expectations with the faculty member's knowledge and skills in the use of technology. More importantly, as computer-based technology changes and proliferates, education also does not remain immune from technological change.

The Seven Principles

This research uses the seven principles for good practice in undergraduate education developed by Chickering and Gamson (1987) as a framework to evaluate the effectiveness of the use of laptop computers in introductory programming courses. Although these principles have been developed to evaluate learning in traditional settings (Batts et al. 2006 and Chickering and Gamson 1996), they have now been extended to examine technology-based learning models (McCabe and Meuter 2011; Cromack 2008). The following paragraphs give a brief description of each principle and how they relate to expectations about the potential of laptop computers in enhancing learning programming experience.

P1: Good practice encourages student and faculty contact: Frequent contact between faculty and students amplifies student motivation and involvement (Astin 1996). With the widespread use of mobile technology in the educational environment, studies are beginning to show evidence of the value of incorporating such devices to enhance communication between the student and teacher (Sharples, Taylor and Vavoula 2010). With the use of laptop computers during the lecture, the software used could give the students immediate feedback, which not only saved time but also helped the students become more confident to discuss their work.

P2: Good practice develops reciprocity and cooperation among students: Cooperative work is proven to facilitate engagement and motivation among students (Hatfield and Hatfield 1995). During the trial lecture, students were asked to work in pairs on their laptops because sharing ideas and solutions may increase their involvement (Tan et al. 2010).

P3: Good practice encourages active learning: Active learning engages students to not just passively receive information from the lecturer but participate in constructing knowledge and solving problems (Barak et al. 2006; Dyson et al. 2009). The use of laptop computers during lectures may help facilitate active learning as students immediately apply the knowledge imparted to them by the lecturer. This could support better understanding of abstract theoretical content.

P4: Good practice gives prompt feedback: Feedback improves students’ learning as it gives them an idea of their achievements as well as the areas they are lacking in (Epstein et al. 2002). In our hybrid lecture environment, students can receive immediate feedback from the software on their laptop computers.

P5: Good practice emphasizes time on task: Students’ time management skills and the organization of content are crucial for curriculum development (Vorkin 1995). ViLLE has a facility of measuring the amount of time spent on a task and ensure that curriculum content is completed within allocated time. Programming activities in our hybrid environment were designed after considering the time expected for each activity. Although time-management mechanisms cannot guarantee that all students will finish their work on time, such a timed work-environment imposes a mental constraint on students and they become trained to become conscious of time when working on assignments.

P6: Good practice communicates high expectations: There is a proven relationship between student achievement expectancy and academic performance (Chickering and Gamson 1987). Although the lecturer may verbally communicate the expectations associated with a task, this may be easily forgotten by the students during the course of the lecture and the activity. In our hybrid-learning environment, all activities are structured with specific objectives to achieve and accompanied with explicit information of the expectations to be met by the student during the task. Lecturers can inform the students generally about the expectations for an activity, but seeing the objective explicitly and specifically outlined for each task imprints this more clearly on students' minds when they are doing the activity.

P7: Good practice respects diverse talents and ways of learning: Different individuals are comfortable with different learning styles. According to Richardson (2010), the approach and style of learning of students differs with their views and learning concepts. Using diverse teaching and learning activities and techniques in the hybrid-learning environment can help cater to a wider range of learning styles among students.

METHODOLOGY

The research was conducted at the school of Computer Science and Information Technology department at our university where the use of laptops in lecture theatres is not compulsory and infrastructure in the lecture theatres does not support the use of mobile devices. The research targeted students enrolled in novice Java programming subject, with a total of 250 enrolled students. A hybrid-learning programming environment was organized for a trial using laptop computers with ViLLE visualization software during the lecture. Both quantitative and qualitative data were collected in the research. The primary researcher took observational notes during the trial lecture, but was not involved in the teaching of the course. Paper-and-pencil surveys were designed and distributed to students. The research used three surveys to gain understanding on students' learning experience. A pre-trial survey was distributed to all students one week before the trial. Subsequently, two versions of a post-trial survey were distributed, one to be completed by students who participated in the trial (denoted PS1) and the other one to be completed by students who did not participate in the trial (denoted PS2) at the end of the trial lecture session. The three surveys are available online (ResS 2011). The pre-trial survey and PS1 were developed based on Chickering and Gamson's work that identified the seven key instructional practices found to influence teaching and learning environments. The main part of the survey is related to those seven principles and had 14 statements with two statements relating to each principle.

ViLLE is a program visualization tool with all the concepts necessary for teaching programming to novice learners, and there have been many successful studies that verify its effectiveness (Rajala 2008). There are predefined sets of exercises in ViLLE and teachers can also easily add new examples. In addition, teachers and students can trace executions and compare editing of code between the original preset program and the edited program in ViLLE. ViLLE's examples are structured in a manner that allows students to pay more attention to the programming concepts rather focusing on the syntactical issues like coding spelling mistakes. User interaction is a critical advantage in ViLLE as it triggers the students to respond at certain stages of the program execution and gives automatic evaluation of answers with immediate feedback with correct answers and final grade (Laakso 2010). Teachers can also access the results of their students and interpret the strengths and weaknesses of their students' understanding.

In traditional lectures, the lecturer uses power point slides for presentation and the document camera for discussion, he might stop drawing things, talking to students or explaining a program output. The lecturer sometimes uses examples, where he gives a program to the students and actively shows them how to compile, run or debug it; but such active teaching using practical examples only happens three or four times during the whole semester. In most traditional lectures, students follow the lecturer's presentation with their lecture notes, which has one set of exercises for every lecture to assist them in the tutorials. Students write their answers on their lecture notes during the break time assigned for exercises then have a discussion about their answers.

However, during the trial, the lecture format was designed to fit the new learning environment and exercises were drawn up on ViLLE to accommodate the different groups of students, some with laptops and some without. Different types of exercises were designed, such as tracing, coding, sorting and multiple-choice questions. The main aim in designing the content for the trial lecture was mixing theory and practice together where students were not merely taking down to lecture notes but also allowed to practice their lessons on actual programs. Therefore, after the lecturer explained a new concept, students worked on an exercise assigned to that particular concept. Students who used laptops were able to compile, run and debug programs and get feedback immediately form the software.

Due to the limited availability of the Internet in the theatre, an offline application version of ViLLE was arranged. An email was sent to the students with instructions to download the application before attending the lecture. As a backup measure (for those who did not act on the e-mail), a set of CDs and USBs was prepared. Furthermore, a set of printed papers with the same exercises available via ViLLE was organized for students who did not participate in the research but for whom the activity was intended to be part of their learning. During the trial lecture, there were three groups of students: 1) students working alone on their laptops, 2) students working in groups of two on one laptop and 3) students who did not participate in the trial but were given the printed copy of the exercises to work on.

DATA ANALYSIS

The data analysis will be explained in three stages for the pre-trial survey, the two post-trial surveys and a comparison between the pre- and post-surveys. SPSS version 19 was used for quantitative data entry and analysis. Moreover, the qualitative data from the open-ended questions were analyzed to extract themes relating to perceived benefits and challenges reported by the students.

The first part of the surveys contains some questions relating to the demographic profile of the students' study load, gender, age, laptop ownership, programming skill background and preparation to take laptop to university. We present the data relating to the background of the student cohort in Table 1.

Table 1. Students Demographics and Traits for 150 Students (Percentage %)

Gender		Age	Own laptop			Prepared to take laptop to University			Programming skills		
M	F	Average	Yes	No	Willing	Often	Occasionally	Seldom	High	Medium	Low
87.3	12.7	21Yrs	87.3	8	4.7	44.7	22	28.6	15.4	39.3	45.3

In the cohort, 98.7% of the respondents were studying full time and 1.3% part time, while 87.3% were male and 12.7% female. The average respondent was 21 years old. The majority of students, 87.3% owned a laptop and 8% did not have laptop but 4.7% would be willing to buy one if it were necessary for classes. Students were also asked if they were prepared to take their own laptops to university, only 143 students from 150 who answered this question. Our data shows that 66.7% of respondents always or occasionally brought their laptops to university or would be prepared to bring them. The targeted students were novice programmers and this is indicated by their responses on the programming skill background. This was also evidenced by their enrolment in the introductory programming course, which assumes no prior programming expertise. 45.3% students rated their programming background as very low to medium and only 15.4% students chose the high and very high rate.

Reliability Testing

A reliability analysis was run on the pre- and post-trial surveys data to determine the internal consistency of the survey instrument. The initial reliability was calculated for each principle of the survey with Cronbach's Alpha to determine the internal consistency of the two statements within each principle and the reliability coefficient across all the statements within the principles. Cronbach's Alpha for internal consistency is acceptable when its value is greater than .60 (Nunnally 1967). However, the number of items within a category affects the value of Cronbach's Alpha, for example, in a minimal scale with less than ten items, Cronbach values can be commonly quite low. In this case, it may be more appropriate to report the mean inter-item correlation (I-iC) for the items (Pallant 2007) and an optimal range for the inter-item correlation recommended being between .2 and .4 (Briggs and Cheek 1986). The Cronbach's Alpha values (shown in Table 2 below) ranged from .68 to .92, which are in the acceptable range. However, principles 3, 6 and 7 (before) and 3 and 7 (after) had Cronbach's Alpha value less than .60. Thus, the inter-item correlation was calculated on only those principles. It shows that the values are also within the recommended range, both demonstrating good reliability of internal consistency.

Table 2. Seven Principles' Reliability Analysis

Principles	Cronbach's Alpha (Before)	I-iC	Cronbach's Alpha (After)	I-iC
1	.79	-	.87	-
2	.82	-	.90	-
3	.43	.27	.57	.40
4	.70	-	.92	-
5	.69	-	.68	-
6	.57	.40	.75	-
7	.54	.38	.47	.31
Total	.74		.73	

Pre-trial Survey

150 students completed the pre-trial survey one week before the trial. The second part of the survey is related to the seven principles for good practice in higher education. It had 14 statements made up of 7 pairs of statements to represent each principle. For these statements, the students were asked to indicate their level of agreement on a Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree". The median response of 3 was considered neutral. At the end of the survey, the students were asked if they would be willing to participate in the trial of laptop use. They were also asked to give their thoughts on the use of laptops during programming lectures.

After combining each pair of statements on a principle, the mean values of student responses ranged from 1 to 10 and are presented in Table 3. Mean values higher than 6 were considered relatively positive, mean values lower than 4 were considered relatively negative and mean values between 4 and 6 were considered relatively neutral.

Table 3. Mean for Each Principle Pre and Post the Trial

	Principles	Pre-trial		Post-trial	
		Mean	SD	Mean	SD
1	Encourages student faculty contact	5.68	1.90	5.29	1.87
2	Encourages cooperation among students	6.78	1.95	6.69	1.84
3	Encourages active learning	6.88	1.52	7.37	1.34
4	Gives prompt feedback	6.76	1.63	7.15	1.89
5	Emphasizes time on task	7.03	1.53	6.89	1.54
6	Communicates high expectations	6.88	1.48	7.19	1.51
7	Respects diverse talents and ways of learning	6.52	1.68	6.83	1.38

As shown in the Table 3, the students' responses expressed a moderately positive view of the traditional lecture environment based on the seven principles. The respondents had the most positive perception for P5, which emphasizes time on task (M = 7.03) while P1, which encourages student faculty contact, received the least positive perceptions (M = 5.68) before the trial.

The survey asked students if they were willing to participate in the trial and more than half of the students (63.3%) replied in the affirmative. This high rate of willingness is due to high rate of laptop ownership, as 70.2% of students who had a laptop were willing to participate in the trial. Some of the students who were not willing to participate in the trial gave many reasons, such as preferring to listen to the lecture at all times, concern about laptop battery life, preferring paper and pen, distraction of laptop, lack of internet and the trouble of carrying about the laptop. The second factor was preparedness to take laptop to university, which meant bringing the laptop to university and using it during lectures. The students' responses indicate that the percentage of students willing to participate in the trial increases as the preparedness moves from Never to Always.

Post-trial Survey (PS1)

This survey was distributed to the students who participated in the trial, and either brought their own laptop or shared one. 54 students completed it at the end of the trial lecture. The same 14 statements in the pre-trial survey were asked again and another 11 statements were added to ask the students about their motivation and satisfaction in using mobile devices for learning.

Table 4. Student Responses to General Statements (Percentage %)

Statement	Agree	Neutral	Disagree
Using laptops during a programming lecture is a good idea	75.0	13.0	12.0
Using a laptop worked well with the way I like to learn in the lecture	64.8	14.8	20.4
I believe using a laptop enhanced my learning of programming during the lecture	63.0	24.0	13.0
I prefer the laptop classes to traditional classes	57.4	20.4	22.2
I felt that the laptop was a distraction during the lecture	31.5	27.7	40.8
The use of laptop to practice programming concepts during the lecture motivated me	72.3	18.5	9.20
I got more feedback from my instructor in the lecture because I used a laptop	29.6	38.9	31.5
I got prompt feedback from my instructor in the lecture because I used a laptop	26.0	37.0	37.0
Using the laptop in the lecture helped me to understand the material in a more interesting way	75.9	22.2	1.90
The lecture style was well organized for the use of laptops	51.9	25.9	22.2
I liked working on ViLLE during the lecture	66.7	24.0	9.30

As shown in Table 4, generally, students expressed a moderately high level of agreement about satisfaction and motivation asked by the 11 new statements. The highest level of agreement at 75% was for the statements "Using laptops during a programming lecture is a good idea", and "Using the laptop in the lecture helped me to understand the material in a more interesting way". However, statements that were given the least score were about receiving prompt and detailed feedback from the instructor at 29.6 % and 26 % respectively.

Respondents were satisfied with trial environment as it suited their learning style and was well organized, at 64.8 % and 51.9 % respectively. Moreover, students were motivated during the lecture as 72.3 % of them were motivated in practicing the concepts and 63 % believed that the use of laptop computers had enhanced their learning during lecture. The visualization software ViLLE worked well in the environment as 66.7 % of the students liked working on it during lecture. An additional question asked them if they shared someone else's laptop or used their own. The majority of the students, almost 88.3%, used their own laptops during the lecture; although they were asked to be in groups of two and only 16.7 % of the students shared someone else's laptop.

As shown in Table 3, in the last two columns for the stage after the trial, the respondents expressed a moderately positive view of the hybrid-learning environment in terms of the seven principles. The respondents had the most positive perception for principle P3: encourages active learning (M = 7.37). On the other hand, principle P1: encourages student faculty contact received the least positive perception (M = 5.29).

From the analysis of the open-ended questions three themes are identified in the positive and negative perceptions of students towards the use of laptop computers during lectures to highlight the advantages and problems of this method.

Positive perceptions

- *Practicing*: One of the key areas of improvement in learning brought about by the visualization software ViLLE was the fact that it enabled students practice their knowledge immediately. Students really appreciated the opportunity for compiling, running, checking, tracing, demonstrating and testing the code that were being taught in lecture. A comment from one student said that the main advantage of this learning method was "being able to see the program running as we were discussing it", while another added that it allowed her to "try and learn the best method for a certain code by myself."
- *Understanding*: Another key intervention of this method of hybrid learning was that it helped in increasing the students' understanding of concepts being taught in the lecture. Some students stated that "this allowed me to see holes in my understanding" and "it allowed me to test my knowledge immediately".
- *Enjoying*: The students also liked working in such an environment using hands-on computer-based technology to invigorate the lectures given by the instructors. Some students said that the incorporation of laptop computers with lectures "makes it more interesting and allows me to work at my own pace" and another said that it was "more interactive and enabled faster learning".

Negative perceptions

- *Software*: A few problems were raised by the students about the version of ViLLE used during the trial as the actual web-based application could not be used due to the lack of Internet access in the lecture hall. Some student's encountered issues during the compilation of codes, "setting up the program was an issue as everyone had different computers and it was difficult to compile".
- *Physical issues*: The students mentioned some common concerns about the physical equipment needed for such a hybrid lecture environment, such as laptop battery life and lack of power points, Internet connection and appropriate tables. A student said, "Battery, need power points and need wireless Internet to be really effective".
- *Distraction*: Distraction is often cited as a common concern in such learning environments where the focus is not entirely upon the instructor and student are allowed to be more active and work with devices. However, very few students mentioned this in answering the open-ended questions.

Post-trial Survey (PS2)

Students who did not participate in the trial were asked to fill in the PS2 survey. 50 students completed it at the end of the trial lecture. Overall, they did not have any objection to attending the lecture with other students who were using laptops. They felt that they were in an ordinary lecture hall. As shown in Table 5, more than half of the students (52%) did not feel that the laptops being used by the other students were distracting them from their lecture. Not having access to the greater functionality and information available through the laptop computers, these students may feel left out of the loop in these hybrid lectures. Here, 48% felt that they did not miss out on information due to the lack of a laptop, while 52% did not feel that the laptops were distracting. Notably, 58% of them would have preferred to have a laptop during the lecture. The students were also asked about the reasons behind their refusal to participate in the trial. They gave a lot of different answers but this was all relating to the laptop, they did not have laptop, they did not bring it to university, forgot to bring it, it was broken or too heavy and was not due to aversion to the hybrid learning method.

Table 5. Responses from Students who did not have Laptop During the Trial (Percentage %)

Statement	Agree	Neutral	Disagree
I felt that the laptops were distracting during the lecture	30	16	52
I felt that I missed some of the information given during the lecture because I did not have a laptop	32	18	48
I would preferred to have had a laptop	58	20	20

Comparison between Pre-trial Survey and Post-trial Survey (PS1)

An independent-sample *t-test* was conducted to compare the means for the seven principles to describe the significant differences in student perceptions of the hybrid lecture between before and after the trial, see Table 6.

Table 6: The Differences between Pre and Post the trial for each Principle

P	T	Df	2-tailed (P-Value)	Improved learning Experience through Seven Principles
3	-2.09	202	0.04	✓
4	-1.43	202	0.15	✓
6	-1.29	201	0.19	✓
7	-1.23	202	0.22	✓
1	1.27	202	0.20	▯
2	0.31	198	0.76	▯
5	0.59	202	0.55	▯

Statistically significant differences were found at the .05 level between before and after the trial for principle P3: encourages active learning, t (202) = -2.09, p= 0.04. This indicates that there was a strong perception among students after the lecture that active learning had been improved during the trial. Although mean differences were found in principle P4: gives prompt feedback, P6: communicates high expectations and P7: respects diverse talents and ways of learning, no statistically significant differences were found between before and after the trial. With regard to the main research question, Table 5 shows that this new method of hybrid-learning combining lectures with laptop computers is in alignment with the seven principles for good practice in undergraduate education. It shows that there is an alignment with four principles P3, P4, P6, and P7 disregarding the significance.

DISCUSSION

Considerable research has been done on evaluating the advantages and disadvantages of the use of laptop computers in lectures (Bruhn and Burton 2003; Barak et al. 2006; Robin and Lauricella 2011; Fried 2008). Our work is focused on the use of laptops and support software in lectures to enhance introductory programming learning experiences on the basis of the seven principles for good practice in undergraduate education. Our findings are discussed in relation two issues, namely, the students' satisfaction and motivation, and the seven principles of good practice in education.

Students' Satisfaction and Motivation

The pre-trial survey indicated that more than half of the students were willing to participate in the trial and 87.3% of them owned laptops, of which 64.7% either brought the laptops to their classes or were prepared to do so. This shows that the use of technology in lecture theatres is rapidly becoming the norm.

In the post-trial survey students were asked some questions about their experience during the trial, and their feedback shows that the students were satisfied and highly motivated to practice ViLLE-based activities on their laptops during the lecture. Their replies to the questionnaire rated a 'highly agree' on the Likert scale for questions regarding improvement in learning and better delivery of course material. Furthermore, the students' answers to the open-ended questions showed even more positive views on hybrid-learning environment. They made comments appreciating the role of this new learning method in improving their learning and understanding. However, feedback from lecturer got the least level of agreement compared with the other general statements. This difficulty may be related to the presence of only one lecturer for 104 students. In such a case, the opportunity for feedback from the lecturer on an individual basis is very limited.

Apart from these active participants in the research, a significant number of students who did not participate in the trial did not feel that the laptops used by the counterparts were distracting them or causing them to miss out any information given during the lecture. In fact, many indicated that they would prefer to have had a laptop during the lecture. However, in a large lecture hall distraction is still an issue (Fried 2008) and in this study around a third of the respondents expressed concern about it. Also, it may be argued that while the price of laptops appears to have reached a point where almost any higher education student can afford to purchase one ("Laptop," n.d., Wilen-Daugenti, 2008), there would be many higher education students for whom even a cheap laptop represents a significant financial hurdle. Therefore, such hybrid lectures should not be introduced with a blind assumption that all students own or can afford to own a laptop.

Alignment with the Seven Principles

With regard to the alignment of this new learning method with the seven principles of good education, the most significant result of this research was that the use of laptop computers during introductory programming lecture improves active learning (Principle P3) (Barak et al. 2006; Dyson et al. 2009). This was the significant evidence at the high level of .05, which showed in Table 5. Moreover, students greatly appreciated the opportunity of practically implementing their knowledge by writing, compiling and running codes.

Principle P4 ("gives prompt feedback") has been enhanced through the use of mobile technology (Kift and Moody 2009). The ViLLE-based activities provided students with prompt feedback during their interaction with the system. The feedback helped the students to have a clear road map of what they were doing correctly and how they could improve their work.

Principle P6 ("communicates high expectations) and principle P7 ("respects diverse talents and ways of learning") showed improvement. The respondents indicated that their quality of work and understanding of the topic being taught have been enhanced by actively practicing ViLLE-based activities on their laptops. In addition, producing diverse ways of learning by using the software and hybrid-learning environment helped students learn in a style they were comfortable in. A considerable number of students noted that the lecture style was well-organised, which suggests that the use of laptops and ViLLE fits in with the students' perception of good educational practice.

However, it has to be recognized that this particular mode of using laptop computers in a learning environment may not be adequate to address all the seven principles. The findings show that Principle P1 regarding student and faculty contact had the lowest mean when compared with the other principles. In fact, the score for the principle actually decreased after the trial showing that the students felt that student-faculty contact had diminished in the hybrid learning method. There are some interesting insights on this issue from other studies. A study found that lecturers negatively rated this principle when using laptops in the classroom (Bin-taleb 2005). Yet considering the context of a very large class size and class time, this is still an issue to be covered.

The average mean for Principle P5 (“emphasizes time on task”) decreased after the trial. Although activities were well designed and prepared, students noted that they were not able to complete the given tasks properly or manage their time efficiently. Moreover, during the lecture the researcher observed that some students were not following the lecturer and jumping ahead, either answering or skipping questions. Thus, it is important to not only engage students in such a learning environment but also in the task being addressed. Moreover, students may need training in time management for this approach to be successful.

In addition, although working together in pairs has many benefits when compared to solo workers in programming (Braught 2011), we observe that that Principle P2 (“cooperation among students”) has not been improved with the hybrid-learning environment as expected. This is perhaps due to the nature of the ViLLE-based activities used. As the majority of the students worked alone, one possibility for further work is to design collaborative exercises for the hybrid-learning environment. Using software that helps collaboration between students in lectures may assist in better fulfillment of this principle.

CONCLUSION AND FUTURE WORK

This research aimed to identify the effectiveness of the use of laptop computers to enhance the learning experience of novices in lectures using the framework of the Seven Principles of Good Practice in Higher Education. The findings showed that the participants reported improvement in four principles: active learning gives prompt feedback, communicates high expectations, and respect for diverse talents and ways of learning. Moreover, students were highly motivated by the opportunity of instantaneously trying out the lessons on their laptops and satisfied with the immediate feedback they received. They appreciated the fact that they could learn the theoretical component of the lecture while simultaneously practicing it, and this two-pronged approach gave them a better understanding of their course materials. Providing greater opportunities for active learning in lectures may assist in improving students’ motivation and enhancing their learning.

One of the contributions of this research is to facilitate the application of such innovative pedagogical tools as laptop computers in learning environments in higher education that currently do not support the use of mobile devices in lectures or only use it as an optional choice. This is a challenging task, and all the ramifications for the issue cannot be drawn from a single research on one lecture session, therefore, future work is needed on a larger scale to support the validity of the results. Moreover, for this research the results was analysed based on the reported students’ perceptions. However, further research needs to be conducted on students’ scores and assessment results. Furthermore, there are some areas for improvement. It would be valuable for future research to further evaluate the effectiveness of different types of visualization software and mobile devices used in programming lectures. It would also be important to develop a design for the activities within any hybrid-learning environment that is in alignment with all of the seven principles of good practice in higher education.

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