The Impact of Mobile Learning on Academic Achievement and Learning Experience Using a Tailor-made Mobile App

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Abstract
With the rapid growth of mobile technologies, mobile learning becomes more and more popular where students can learn at any time and any place using their own mobile devices. A lot of researches have proven that mobile learning is feasible with various advantages such as diversifying learning activities and synchronizing learning experience. However, its impact on academic achievement is still controversy where contradictory conclusions were made in the literature. In this study, the effectiveness of mobile learning is further investigated. According to the teaching materials and schedule of a technical subject, a tailor-made mobile app was developed to assist students' learning along with regular lecture and tutorial classes. By deploying the mobile app at different stages of teaching, a 4-year experiment was conducted where 3 cohorts of students were involved. Students' subject results and mobile learning experience were statistically analyzed. Results showed that the use of mobile app has immediate effect on improving academic performance, but the effect becomes minimal when the mobile app is used for a longer period of time. Nevertheless, positive mobile learning experience was demonstrated, such as enhanced engagement and higher motivation of learning. These significant observations provide further information on how mobile learning could be effectively incorporated with pedagogical strategies.

Keywords: Mobile learning; academic achievement; learning experience; tailor-made mobile app.

Introduction

Mobile learning has been proven feasible with various benefits, such as diversifying learning activities; supporting learning process; and synchronizing learning experience (Crescente and Lee, 2011; Savil-Smith et al., 2006; and Elias, 2011). Learners can also schedule their learning at any time and any place as long as they are covered by mobile signal (Crescente and Lee, 2011). In addition to big data analysis, students' learning patterns, progress, weaknesses, etc. can be easily obtained (Bienkowski et al., 2012).

However, concerning the impact of mobile learning on students' academic achievement, contradictory conclusions were observed in the literature. For examples, Lu (2008) stated that the mobile learning group achieved higher score in an immediate quiz on vocabulary knowledge. Kattayat et al. (2017) also concluded that students performed better with mobile learning in a 4-day physics course. On the other hand, Miller and Cuevas (2017) argued that mobile learning played no significant effect on their 3-week learning setting. Similarly, Males et al. (2017) investigated the national test result in Australia for years and concluded that the impact of mobile learning on academic performance is minimal. More research is definitely required in this area of study.

In this paper, the effect of mobile learning on students' academic achievement and learning experience was studied. Instead of just simply digitizing the teaching materials, a tailor-made mobile app was developed for students to use as an additional learning tool along with normal classroom teaching. Since there were conflicting research on the correlation between mobile learning and academic achievement, the findings and conclusion in this paper would provide more insight and evidence on the effect of mobile learning.

Research Context

This research was conducted in the Hong Kong Community College in Hong Kong. The college offers both associate-degree and higher diploma programmes in various major fields, such as engineering, information technology, social sciences, business, and arts. Although Hong Kong is a city of China, apart from those subjects teaching Chinese language, the college adopts English as the major medium of instruction.

Since technical competence is a key success factor of mobile learning (Alrasheedi and Capretz, 2015), a compulsory technical subject Computer Programming was used for investigation and three cohorts of students from technical-related sub-degree programmes were involved. The same set of teaching materials was used for all cohorts. While the assessments were different, they were designed to have the same level of difficulty. The subject consisted of six assessment components, among them individual assignment 1, group project and participation exercises were take-home assessments, while individual assignment 2, mid-term test and examination were immediate on-site assessments.

The three cohorts of students took the subject in years 2015 to 2018. A total of 1376 students who had attempted all assessment components of the subject were considered in the data analysis. Among them, 706 students were from Associate in Engineering

(AENG), 526 students were from Associate in Information and Technology (AIT) and 144 students were from Higher Diploma in Mechanical Engineering (HDME).

Tailor-made Mobile App

In addition to normal classroom teaching, a mobile app was designed as an additional learning tool. Unlike other similar mobile apps about computer programming in the market, this tailor-made mobile app adopted the lecture and tutorial notes of the subject, and the content was arranged to follow the teaching sequence of the subject. It also included illustration and explanation of basic programming techniques, simple programming exercises for students' revision and practice, and small quizzes for checking their level of understanding.

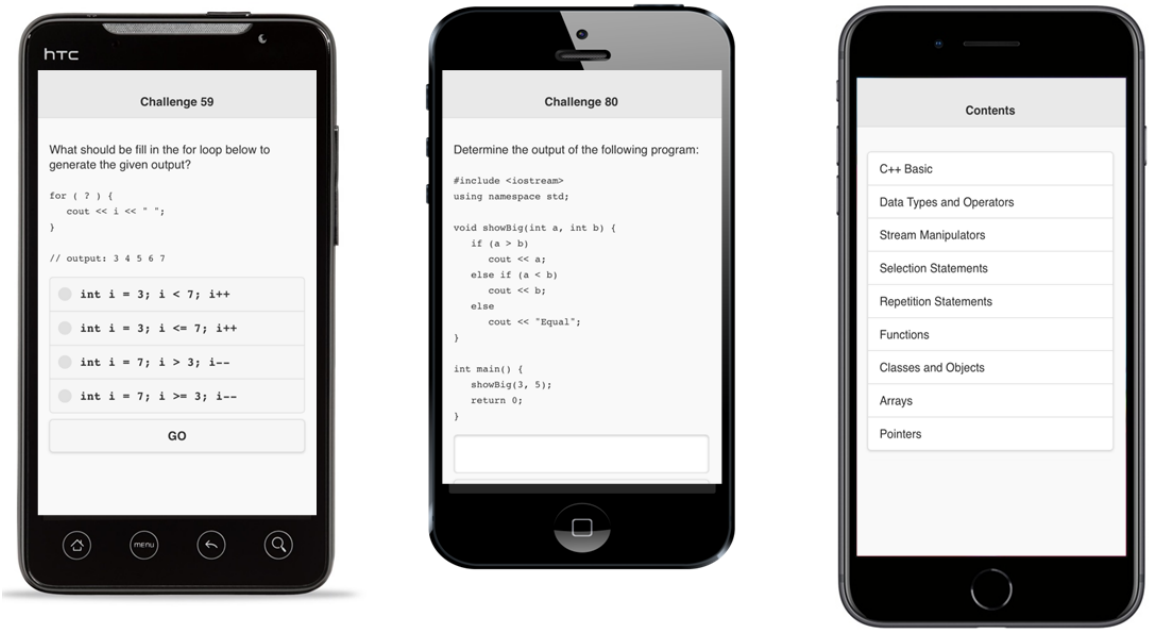

Figure 1: Demonstration of the tailor-made mobile app.

It was suggested that elements of competition could increase students' motivation and engagement (Ciampa, 2014). Therefore, to further improve the effectiveness of the tailor-made mobile app, the quizzes were divided into more than 150 levels, where students had to complete a quiz correctly to unlock the quiz in the next level. Students were encouraged to compete with their friends to achieve as high level as possible.

Experiment Design

The subject Computer Programming was a compulsory subject in the curriculum. Students were required to attend lecture and tutorial classes regularly throughout the semester. The same teaching schedule was adopted for all the three cohorts. This ensured that students in different cohorts had the same amount of time in preparing and completing the assessments.

For the three cohorts, the mobile app was released and used at different stages. Cohort 2015 was the control group, where mobile app was not used. Students learned the subject in a traditional way by normal classroom teaching.

For cohort 2016, mobile app was used throughout the semester. In every lesson, teachers reminded students to use the mobile app as an additional tool for learning and revision.

For cohort 2017, the mobile app was released after all classes had been conducted. Students were suggested to use the mobile app for revision of the examination.

Measures

This research aimed at evaluating the effectiveness of mobile learning on academic achievement and learning experience. The former was measured by statistically analyzing the scores of all assessment components. For the latter, students' feedback was collected where a 5-point Likert Scale questionnaire was used. Since students in cohort 2015 did not use the mobile app in their learning, the feedback was collected from students in cohorts 2016 and 2017 only.

Results

Figure 2 presents the mean scores of the assessment components of the three cohorts. Students in general performed better in take-home assessments, i.e. individual assignment 1, group project and participation exercises. This observation was expected as students had more time in preparation and checking. Students might also collaborate with each other to complete the assessments. As a result, the effect of mobile app on these assessment components was minimal.

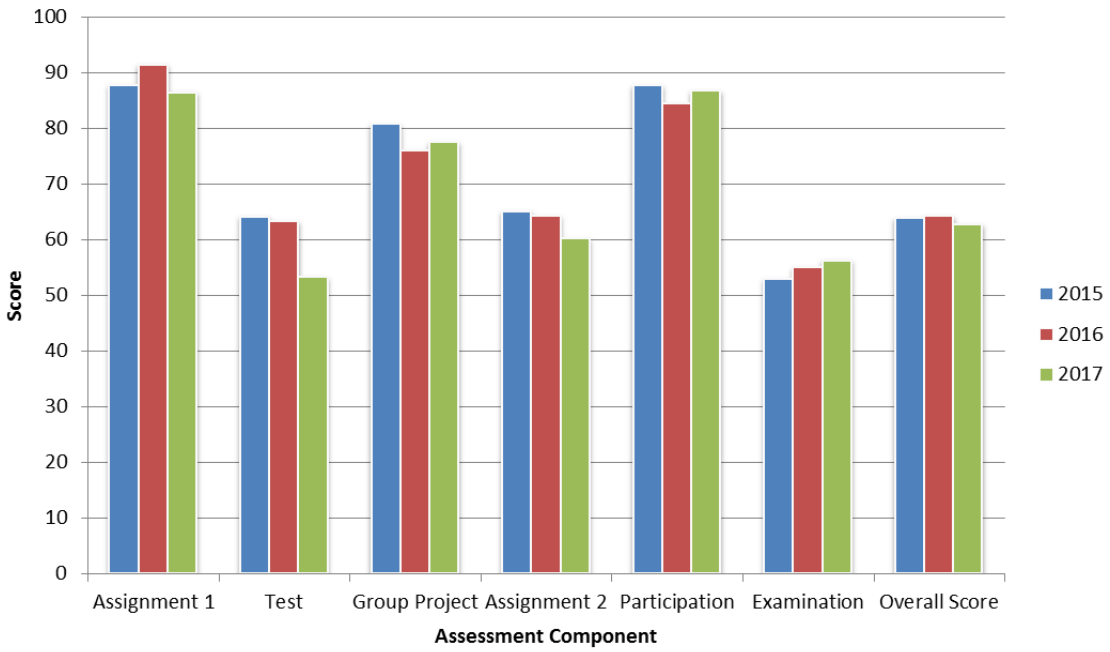

Figure 2: Mean scores of assessment components

On the other hand, immediate on-site assessment required students to have deeper understanding of the subject knowledge. Students needed to complete the tasks in short time. The scores of these assessments directly reflected the students' ability in the subject. The mean scores of these assessment components, i.e. mid-term test,

individual assignment 2 and examination, were further analyzed statistically by one-way ANOVA with Turkey HSD post-hoc test. The result was summarized by Table 1.

Dependent Variable	(I) Cohort	(J) Cohort	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Test	2015	2016	.848	1.221	.767	-2.02	3.71
		2017	11.252*	1.082	.000	8.71	13.79
	2016	2015	-.848	1.221	.767	-3.71	2.02
		2017	10.404*	1.077	.000	7.88	12.93
	2017	2015	-11.252*	1.082	.000	-13.79	-8.71
		2016	-10.404*	1.077	.000	-12.93	-7.88
Assignment 2	2015	2016	.842	1.146	.743	-1.85	3.53
		2017	4.974*	1.016	.000	2.59	7.36
	2016	2015	-.842	1.146	.743	-3.53	1.85
		2017	4.132*	1.011	.000	1.76	6.50
	2017	2015	-4.974*	1.016	.000	-7.36	-2.59
		2016	-4.132*	1.011	.000	-6.50	-1.76
Examination	2015	2016	-2.051	1.349	.282	-5.22	1.11
		2017	-3.180*	1.196	.022	-5.99	-.38
	2016	2015	2.051	1.349	.282	-1.11	5.22
		2017	-1.130	1.190	.609	-3.92	1.66
	2017	2015	3.180*	1.196	.022	.38	5.99
		2016	1.130	1.190	.609	-1.66	3.92

*. The mean difference is significant at the 0.05 level.

Table 1: Analysis using one-way ANOVA with Turkey HSD post-hoc test

When comparing cohorts 2015 and 2016, the performance of mid-term test, assignment 2 and examination were comparable and had no statistically difference at a 0.05 significance level. In other words, using the mobile app throughout the entire learning period does not affect the students' academic achievement.

Taking cohort 2017 into consideration, the performance of students in this cohort was different from other cohorts. The difference was statistically significant with $p < 0.05$. To look into the performance difference in more detail, students in cohort 2017 had the poorest performance in mid-term test and assignment 2. This may due to the fact that students in cohort 2017 were admitted with a lower mean admission score. However, the mean examination score was the highest in cohort 2017, and hence the students in cohort 2017 had the largest improvement. Hence, using the mobile app before examination as a revision tool had positive impact to the examination performance.

These observations aligned with the literature that mobile learning is effective in short courses, such as the English vocabulary workshop by Lu (2008) and the 4-day physics course by Kattayal et al. (2017). The effect of mobile learning becomes minimal if the mobile learning tool is used for a longer period of time (Miller and Cuevas, 2017 and Males et al., 2017). Even for the same subject as in the current research, using the mobile app in different stages affects the effectiveness of mobile learning. To be more specific, strategically using the mobile app before the examination allowed students to have better performance; but prolonged use of mobile app throughout the semester did not have the positive impact as expected.

#	Question	Mean	Rate ≥ 3
1	I would find mobile apps useful in my learning.	4.31	97.72%
2	Using mobile apps enables me to accomplish learning activities more quickly.	4.24	97.34%
3	Using mobile apps increases my learning productivity.	4.19	97.72%
4	If I use mobile apps for learning, I will increase my chances of getting a better grade.	4.05	97.72%
5	My classmates would suggest me to use mobile apps for learning.	3.79	89.73%
6	My teachers would suggest me to use mobile apps for learning.	4.17	96.96%
7	I had experience in using mobile apps for learning in other subjects.	3.41	73.00%
8	I would prefer using mobile apps for learning in other subjects as well.	4.14	97.72%
9	The app is easy to use.	4.13	97.34%
10	It would be easy for me to pick up subject content by using the app.	4.15	97.72%
11	I can learn the subject content by using the app.	4.19	97.34%
12	I can evaluate my subject knowledge by using the app.	4.21	97.34%
13	I can find out my misunderstanding of subject content by using the app.	4.16	96.96%
14	Using the app will give enjoyment to me for my learning.	4.00	95.82%
15	Using the app will stimulate my curiosity.	3.98	96.20%
16	Using the app will lead to my exploration.	4.07	97.34%
17	Using the app will encourage discussion among classmates.	3.87	93.16%
18	The app is useful to my learning.	4.22	99.24%
19	I would recommend the app to my fellow classmates.	4.18	98.48%

Table 2: Students' feedback on mobile learning experience.

For the mobile learning experience, students' feedback was collected using a 5-point Likert Scale questionnaire. The ratings ranged from 1: "strongly disagree" to 5: "strong agree". The survey result was summarized by Table 2.

As shown in Table 2, almost all items were rated with mean score above 4 points. The lowest mean score of 3.41 was observed in item 7: "I had experience in using mobile apps for learning in other subjects". This revealed that mobile learning was not common in other subjects. However, students would prefer to have mobile learning implemented, which was supported by the high rating of 4.14 in item 8: "I would prefer using mobile apps for learning in other subjects as well".

This positive survey result showed that students welcome mobile learning and enjoyed their mobile learning experience. In general, students agreed that the mobile

app was useful in their study. Students also found that their learning productivity was improved and they had higher confidence in getting a better grade in the subject.

Conclusion

This research studied the impact of mobile learning on students' academic achievement and learning experience. Mobile learning allows learners to learn using mobile devices. The 4-year experiment evaluated the impact of mobile learning by implementing the tailor-made mobile app in different stages of the learning process. The results revealed that mobile learning has its short-term effect on academic achievement. By using the mobile app as an additional tool for revision before examination, students' performance was largely improved. However, the impact was minimal if mobile learning is implemented for a longer period of time.

Regardless to the impact on academic performance, students welcome mobile learning. It was interesting to know that mobile learning was not common in other subjects. Nevertheless, students expressed their positive mobile learning experience. They could learn faster and pick up the subject content easier. The learning productivity was increased and hence improving their self-confidence. They also found the app useful to their learning and could use the app as an additional tool for revision.

A strategic use of mobile learning is important, such that learner can benefit from its short-term impact to improve their academic performance. Educators should consider incorporating mobile learning into their pedagogical plan so as to enhance the learning experience of the learners, which in turns improve their interest and concentration to the class.

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