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Yan Chang Chen

Fiona Sng

Mohamed Ariffin Kawaja

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Yan Chang Chen, Nanyang Technological University, Singapore, ychen@e.ntu.edu.sg
Fiona Sng, Nanyang Technological University, Singapore, lsng001@e.ntu.edu.sg
Mohamed Ariffin Kawaja, Nanyang Technological University, Singapore, ariffin001@e.ntu.edu.sg

ABSTRACT

Businesses are adopting Bring Your Own Device (BYOD) policies in their organisations to allow employees to bring personal mobile devices to work. This approach can be adopted in education to address the educational divide between developing and developed nations. A BYOD approach to education could entail the use of cheap tablets to deliver educational content but would require an appropriate blended learning approach for learning to be effective. Consequently, the objective of this paper is to investigate the effectiveness of different blended learning approaches with tablets as an instructional medium. A conceptual model for blended learning was constructed from learning theories in the literature. Subsequently, experiments were conducted to investigate the impact of media richness, collaborative work and performance feedback on learner performance, engagement and satisfaction. The results have implications on educators who plan to design tablet-based blended learning arrangements.

Keywords: Education divide, blended learning, BYOD, learning theories, tablet device.

INTRODUCTION

There exists an educational divide between developing and developed countries which governments and non-governmental organizations have sought to address through the use of new technologies [1, 2]. In particular, the rural poor still lack easy access to education and skilled teachers despite the fact that the majority of applications deployed in these areas are created for education [3]. At the same time, the proliferation of cheaper mobile devices [4] has prompted organisations to adopt a Bring Your Own Device (BYOD) IT policy. Companies are allowing their employees to use their personal mobile devices to access work information [5] to raise productivity, lower IT costs and improve staff morale [6]. It has also been pointed out that the BYOD trend in business could be mirrored by a Bring Your Own Tablet trend in education as more students utilise cheap tablets for their school work [7].

The BYOD approach of using cheap tablets for education has the potential to close the educational divide in developing nations. For example, the use of cheap wireless and battery powered tablets could address the lack of wired technologies and power that plagues developing nations [3]. Moreover, by providing access to educational content online or offline on the tablets, the lack of teachers and poor accessibility to classrooms mentioned earlier can be mitigated.

However, tablets alone are insufficient to bridge the educational divide. For learning to be effective, new pedagogical models need to be designed [8]. Blended learning is a suitable pedagogical model that leverages on the use of technology to vary the amount of face-to-face (F2F) instruction with technological-mediated learning [9]. This makes it an ideal candidate for use in developing nations where the provision of F2F instruction is challenging. This is particularly since tablets are becoming cheaper and more widely available. With the availability of hardware, the challenge is to identify an appropriate blended learning approach that would successfully integrate tablets into the learning curriculum. With this in mind, the objective of this paper is to investigate the effectiveness of different blended learning approaches with tablets as the instructional medium.

To accomplish this we examined the different approaches to blended learning in the literature. We then formulated our conceptual model using the theories identified. Thereafter, a series of experiments were conducted to understand the factors that influence student performance, engagement and satisfaction when tablets are used in learning.

LITERATURE REVIEW

ICT Projects for Education in Developing Nations

The effectiveness of the BYOD approach to using laptops as an instructional medium in developing nations is mixed. While some studies have cited its effectiveness in improving academic performance [10], others have disagreed with this approach [8, 11]. Referring to the OLPC initiative, Tedre, et al. [8] pointed out that for one–to-one computing to be effective in improving mass education, the ICT programs will need to look beyond technical innovation than just the provision of cheap ICT equipment [12]. To be effective, the social, organisational and physical infrastructures will need to be available to integrate one-to-one computing technologies into the curriculum [13]. This highlights the need to focus on the formulation of appropriate tablet-based learning pedagogy. To do so, we examined the field of blended learning in the following sections.

Theories in Blended Learning

Blended learning is defined as a pedagogical method that uses a combination of conventional face-to-face (F2F) instruction

with technological-based learning to enhance learning effectiveness, accessibility and cost effectiveness [9, 14]. Graham [9] highlights that blending can be introduced at various levels by instructors to improve learning effectiveness or by administrators wanting to reduce cost. Several theories underpin blended learning approaches. These theories include the Media Richness Theory, the Constructivist Theory (also known as Constructivism) [15] and the Behaviourist Theory (also known as Behaviourism) [16].

Media Richness Theory (MRT) is the most frequently cited theory to explain how communication medium impacts the performance of tasks [17]. MRT classifies communication media within a spectrum of rich and lean media with face-to-face being the richest and numeric documents the leanest. Communications media that allow for feedback, have multiple communication cues, allow for expression of natural language and can be directed at individuals, are the richest. Rich media is suitable for scenarios which are uncertain and equivocal while lean media is applicable for settings which are routine [18].

Evidence that support the effects of media richness on learner performance in blended learning is mixed. While some researchers [19, 20] support MRT's proposition that better learner scores are associated with richer medium, other researchers have found little or only partial impact [17, 21]. In particular, Erik Timmerman & Kruepke [22] found that moderately rich audio media resulted in better scores than media rich videos. Moreover, lean textual content was associated with better scores than rich text with graphics [22]. This was also the case for impact of media richness on learner's engagement and satisfaction.

Another theory often applied in blended learning is constructivist theory. Constructivism is an instructional philosophy that presumes that learners are active processers of information who construct meaning by interacting with the surroundings including other people [23]. As part of the constructivist paradigm, blended learning arrangements may include opportunities for collaborative learning among fellow students. Blends implementing collaborative work will require students to work on group-based assignments to help them construct their own meanings as they interact among students and instructors [16].

Behaviourist theory is another theory that is applied in blended learning. The behaviourist paradigm presumes that learners are passive recipients of instruction. Unlike constructivism, students require feedback on their performance as soon as possible [16]. The emphasis is on repetitive activities rather than the formation of cognitive formation of mental models when learning [24]. Thus, the behaviourist approach would provide timely feedback on learner performance to help them gauge their learning progress.

Blended Learning Approaches

The typical approaches of blended learning include a mix of traditional and technology-mediated formats. Traditional formats include classroom instruction and paper-based books. Technology-mediated formats include interactive online learning, email discussions, self-paced content, online forums, collaboration software and online tests [14]. Higher institutions and K-12 schools have adopted a combination of different mixes to achieve their learning objectives [25].

Djenic, Krneta, & Mitic [26] formulated a blended learning approach for two programming courses in VISER, Serbia. The effectiveness of the blend was compared to F2F instruction. In traditional F2F instruction lessons were taught by instructors in classrooms with the use of paper textbooks and practices in computer laboratories. In their blend, approximately 50% of the sessions were held over the Internet through the use of online instructional content, books, exercises and discussions. The other 50% consisted of compulsory first and last meetings, colloquiums as well as the final examinations. Their evaluation of students' results and feedback found that this blend was able to give satisfactory results in tests, have a higher percentage of students participating in exams and a lower drop-out rate. The latter was because the blended mode was able to cater to the individual needs and learning dynamics of the students.

Hoic-Bozic, Mornar, & Boticki [16] applied blended learning to a university course. Their blend was a combination of F2F learning with independent learning of online material, online discussions as well as problem-based learning (PBL) through a group project. The group and instructor communication was done via emails, online forums and some F2F meetings. In this blend only the first introductory lecture, project presentation and final examinations are F2F. The other course requirements are done entirely online. Their blend takes a constructivist view of learning where students contextualise concepts in a practical situation when they participate in their group projects.

More extensively, Twigg [27] identified five different blends in thirty US universities as part of an instruction redesign project. They are the Supplemental Model, Replacement Model, Buffet Model, Emporium Model and the Fully Online Model. The Supplemental model is a blend which contains traditional lectures but with the provision of online materials and as well as online activities such as quizzes. The Replacement Model involves replacing F2F class time with activities that can be done online in a computer lab or at home. The Buffet Model is a blend where students are given the choice between online or F2F options for lectures, laboratories and projects that suit their individual needs. In the Emporium Model, a learning resource centre replaces a classroom with materials placed online and on-demand personal assistance. Lastly, the Fully Online Model is a blend which eliminates F2F class meetings altogether. Only in rare instances are there an option for F2F help.

3-C Model for Blended Learning

Having surveyed the different theories and approaches in blended learning, the challenge remains on how an appropriate blend can be formulated. The 3-C didactical model is a useful framework for this purpose [14]. The model specifies three didactical components - content, communication and construction that need to be considered when formulating a blend. Different weights are placed on each component depending on the learning objectives. The amount of time students spend on different components can vary and not all components are necessary.

The *content* component is the part of a learning arrangement that presents the learning information to the student. This component is essential when there is a need to transmit facts or rules that the user needs to recall. In designing this component,

the mode of delivery of the information and the choice of synchronous or asynchronous distribution will need to be considered.
The *communication* component refers to the interpersonal exchanges among students and between student and teacher. This component is essential when the knowledge is complex, depth of understanding is desired, there is a need for students to articulate their personal views and mutual feedback within a discussion is important. Communication can be one-to-one, one-to-many, F2F or virtual.
The *construction* component assists individual learners or groups to work on learning tasks of different complexity. These tasks may include individual assignments or projects to group projects such as problem-based learning. This component is essential when practice, application of concepts and self-discovery is needed.

Evaluation of Different Blends
To measure the effectiveness of different blends, we look to Drysdale, Graham, Spring, & Halverson [25] who summarised the factors used by different researchers to assess the effectiveness of blended learning programs. Factors useful for our study include the performance outcome, level of satisfaction and the level of engagement. We summarise the evaluation metrics in Table 1.
The most common factor was the performance scores. This was typically measured through the examination scores of the learners in a blended approach **compared** to traditional F2F courses. The scores and passing rates were compared to make a quantitative assessment. While these may measure the retention rate of the content learnt, the time taken to learn in different blends can also serve as an indicator of pedagogical effectiveness [16].
Another factor was the student **satisfaction** of blended programs. Survey responses were used to identify user satisfaction. Factors that affected satisfaction include the degree that the learner feels that learning needs are met, the perceived efficacy of learning, the quality of interactions and the whether the format was appropriate [28].
Finally, the level of **engagement** measures the learners' motivation and effort when participating in the learning activity. This can be measured by looking at the amount of time spent in online discussions and other learning activities [29].

Table 25. Evaluation metrics for blended learning.

Evaluation Metrics	**Measurement**
Performance outcome	Test scores
Satisfaction	Questionnaires
Engagement	Time spent on online/classroom discussions Time spent on learning materials

CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

To formulate the conceptual framework for experimental design, we analysed the different blended learning arrangements in literature using the 3C Didactical Model by Kerres & Witt [14] to identify similarities between the different approaches which can be adopted for our tablet learning approach.

Analysis of Blended Learning Approaches
Through the analysis (See Table 2), we make the following observations about the different blended learning approaches:

1) The replacement of classroom presentation of content with lesser **media rich content** was assumed to not impede learning performance.
2) Blends typically applied **constructivist** learning pedagogies in the form of **collaborative learning** to the communication and constructive components.
3) Blends also applied the **behaviourist** approach to learning by providing timely **performance support** in the form of online assignments. This gave learners timely feedback on their learning progress.
4)

Table 26. Analysis of Blended Learning Models.

Blends	**Theoretical Basis/Assumptions**	**Content**	**Communication**	**Construction**	**Performance Outcome**
Djenic et. al(2011)	-Traditional pedagogical principles must be retained. -Feasible to **replace** classroom learning components with technologically-mediated instruction.	-Online interactive textbook (lessons, animations) -CD ROM textbooks (self-study) -Some lesson reviews	-Async discussions forum -Sync online discussions	-Online exercises -Online knowledge assessment -Some lab reviews	-Better academic results -Lower drop out Rate -Satisfaction with medium
Hoic-Bozic et. al(2009)	-**Constructivism:** Independent learning of online lectures,	-Online lectures (audio, video, animation)	-Async discussion forum -Email	-Online quizzes -Group project -Seminar papers	-Better academic results -Lower drop out

	collaborative learning through discussion forum and PBL in group projects. -**Behaviourism:** Give learning feedback via online tests and use of adaptive hypermedia. -**Cognitivism:** Allow individuals to choose own project topic and provide map of lessons in online modules	-Only intro topics in classroom		-Classroom presentation	rate -Satisfaction with system
Supplement [27]	-**Active learning approach**: Have interactive technology to supplement classroom meetings	-Classroom lecture -CD ROM	-Group session in class with response posted online	-Online exercises -Online quizzes	-Better academic results -Lower drop out rate
Replacement Model [27]	- **Active learning approach:** Online activities are better replacements for the classroom whether they are done in groups or individually.	-Reduced classroom lecture -Online lesson (interactive module)	-Classroom discussion -Discussion board	-Online exercises with immediate feedback -Online quiz	-Better academic results
Buffet Model [27]	-**Cognitivist** approach: Assortment of interchangeable paths that match their individual learning styles, abilities, and tastes at each stage of the course.	-Classroom lectures -Recorded lectures -Text-based material -Videos -Online resources	Classroom discussions	Lab sessions	Better academic results
Emporium Model [27]	-**Active learning approach:** Direct students to resources instead of teaching. -Student's choice of suitable materials	-Online lectures -Online interactive textbook	-On-demand assistance -Group session for problems	-Online exercises -Online quizzes	Lower costs
Fully Online [27]	**Active learning approach:** Unsupervised learning based on learning schedule	-Online course content	Discussion forum	Online assignments	Raise number of students handled by one instructor

RESEARCH METHODOLOGY

Conceptual Framework

Based on the above analysis and literature review, we formulate the following conceptual framework for accessing tablet-based blended learning arrangements (See Figure 1). In this framework, the learning theories form the basis for designing the different blends. Each blend is made up of the components as specified in the 3-C Model. Finally, the effectiveness of each blend is measured with respect to the metrics in the learning quality.

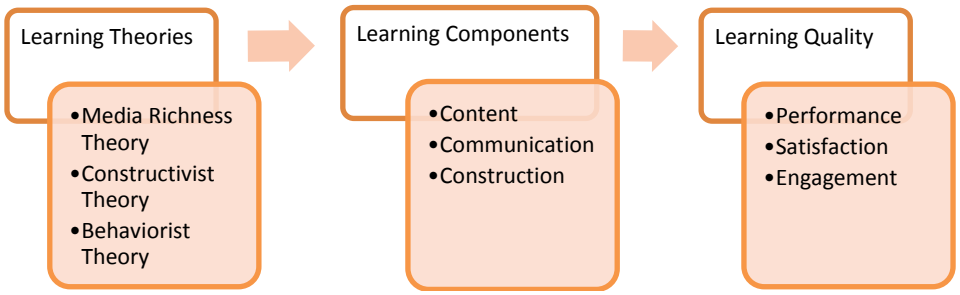

Figure 1. Conceptual framework adapted from 3-C didactical model [14].

Our framework proposes that media richness theory, constructivist theory and behaviourist theory have implications on learning quality. To elaborate, MRT proposes that the media richness of the content presented on the tablet will have an impact on the three indicators of learning quality. Similarly, one implication of subscribing to constructivism in blended learning would be an emphasis on collaborative work to improve learning quality because it facilitates active learning. Examples of implementing collaborative work would be the discussion forums or chat rooms. Finally, the implication of behaviourism would be the emphasis on providing timely performance feedback to enhance learning quality. This may involve the administering of online assignments with given answers for learners to apply what they have learnt and to assess their learning progress.

Research Hypotheses

Based on the conceptual framework, we raised three research questions about the impact of media richness, collaborative work and performance feedback on the effectiveness of tablet learning.

Media Richness

We first investigate the validity of the often cited MRT. Here we planned to investigate if media richness will impact the learning quality on the tablets. Based on MRT, we would expect that increasing the media richness of the learning content would result in better learning quality. Thus, the following research question (RQ) is asked:

RQ1: Does the media richness of content impact learning quality?
H_0: Media richness of content does not impact learning quality
H_{1a}: Media richness of content has a positive effect on performance.
H_{1b}: Media richness of content has a positive effect on engagement
H_{1c}: Media richness of content has a positive effect on learner satisfaction

Collaborative Learning

Constructivism presumes that the introduction of collaborative learning would positively impact learning quality on tablets. Consequently, we asked the following research question:

RQ2: Does collaborative learning impact learning quality?
H_0: Collaborative learning has no impact on learning quality
H_{2a}: Collaborative learning has a positive effect on performance.
H_{2b}: Collaborative learning has a positive effect on engagement
H_{2c}: Collaborative learning has a positive effect on learner satisfaction

Performance Feedback

Finally, we investigate the impact of the behaviourist's assertion that performance feedback can positively impact the learning quality. We pose the corresponding research question as:

RQ3: Does performance feedback impact learning quality?
H_0: Performance feedback has no impact on learning quality
H_{3a}: Performance feedback has a positive effect on performance.
H_{3b}: Performance feedback has a positive effect on engagement
H_{3c}: Performance feedback has a positive effect on learner satisfaction

EXPERIMENTAL RESULTS

Experimental Conditions

We recruited 30 volunteers from the Masters of Science in Information Systems programme at Nanyang Technological University to participate in these experiments. This group was chosen because of their reasonable proficiency with IT equipment and to eliminate the need for extensive training on how to use the tablets. Groups of 5 students from the volunteer pool were randomly selected to perform each experiment to ensure that variations in learning ability would be spread out against the different groups.

To investigate the hypotheses, we designed 6 learning experiments using the 3C Model framework (See Table 5). They consist of 5 different blended learning approaches (B1 – B5) and a control group C0. With exception to C0, participants were given a maximum of 11 minutes to consume the content that was administered via a tablet. Thereafter they were given a maximum of 10 minutes to complete an online assignment on the tablet that consists of 4 open ended questions about the content. With exception to B5, answers where provided immediately once they submitted their own responses.

Table 27. Experimental blends and their corresponding Content and Communication/Construction components.

ID	Blend Description	Content	Communication	Construction
B1	Learning content presented in hypertext. Individual assignment with answers provided after response is submitted for participant to review.	Hypertext	None	Online Individual Assignment (4 Open-ended Questions with answers)
B2	Learning content in audio format with textual transcript. Individual assignment with answers provided after response is submitted for participant to review.	Audio & Hypertext	None	Online Individual Assignment (4 Open-ended Questions with answers)
B3	Learning content in video format. Individual assignment with answers provided after response is submitted for participant to review.	Videos	None	Online Individual Assignment (4 Open-ended Questions with answers)
B4	Learning content in hypertext format. Group assignment via online discussions. Assignment answers are provided after response is submitted for participant to review.	Hypertext	Online Group Assignment (4 Open-ended Questions with answers)	
B5	Learning content in hypertext format. Individual assignment without answers after response submitted.	Hypertext	None	Online Individual Assignment (4 Open-ended Questions with no answers)

The subject of Gamification was chosen for the content since it was a topic that is relatively new and participants were less likely to have prior knowledge. A YouTube video about this subject was adapted and transcribed into hypertext and converted into audio-only format to vary the media richness for B1, B2 and B3 [30, 31]. Steps were also taken to ensure that the experimental conditions were consistent. Participants were instructed not to interact with each other except for B4 where the interactions in the group online assignment were encouraged through the use of Google Chat. To ensure external reliability, Apple iPad2 tablets were used for all activities in B1-B5 and C0 to eliminate differing tablet performances during the experiment.

Experimental Procedure

In each experiment, the participant will first consume the content component as presented in their respective blends for up to a maximum of 11 minutes, since that is the length of the video component. Participants are allowed to stop the consumption at their own preference, at any time before or at the end of 11 minutes. The participant's time spent on consuming the content will then be recorded as the "content engagement time".

This will be followed by a 4-question, open-ended online assignment based on the content learnt earlier. This was completed by the participant individually in the experiment blends B1, B2, B3 and B5. For the experiment testing of the blend B4, participants will complete the online assignment as a group through a facilitated online chat discussion using Google Chat. Upon each individual submission ofthe completed assignment, the answers were provided to the participants for their own review of their performance. The exception was B5 in which participants were not given any performance feedback. Participants were allowed to stop doing any part of the assignment or review at their own preference, at any time before or at the end of a maximum of 10 minutes. The participant's time spent on this portion of the experiment will then be recorded as the "assignment engagement time".

As mentioned, the times recorded for "content engagement" and "assignment engagement" is summed up and the "engagement percentile" metric is then obtained by taking the sum as a percentage of 21 minutes. After completing the assignments, participants were tasked to complete the quiz of 10 questions within ten minutes to test how well they have learnt the content. The number of correct answers is recorded as the "performance result" of the participant of that blend. The survey questions were then administered after the quiz without time limit.

To analyse the data collected, we planned to compare the mean performance, engagement and satisfaction scores across the appropriate experimental groups in Table 6. To investigate hypotheses H1a – H1c about media richness, we examine the effects of varying media richness of content by comparing the results of B1, B2 and B3. To examine the impact of collaborative work for hypotheses H2a – H2c, we looked at the impact of individual and group assignments on learning quality in B1 and B4

respectively. Finally, to test hypotheses H3a – H3c about the impact of performance support, we examined the difference between B1 and B5 where assignment answers were provided in B1 and absent in B5.

Table 28. Research Question and Blend Comparisons.

Research Question	Blends to be compared
RQ1: Does the media richness of content impact learning quality?	B1,B2,B3
RQ2: Does collaborative learning impact learning quality?	B1,B4
RQ3: Does performance feedback impact learning quality?	B1, B5

EXPERIMENTAL RESULTS

The data collected from the experiments were collected and the summarised means scores is displayed in Table 7.

Table 29. Mean values for performance, engagement percentile and satisfaction score of different blends.

Blends	C0	B1	B2	B3	B4	B5
Mean Performance (p-value of T-test with mean of C0)	2.0	5.6 (0.006)	6.6 (0.002)	7.2 (<0.000)	8.0 (<0.000)	5.2 (0.006)
Mean Engagement Percentile	-	86.76	93.08	83.83	79.13	81.56
Mean Satisfaction Score	-	22.2	23.2	25.2	22.2	23.4

Mean Performance

Participants from the control group C0 scored an average of 2 out of a possible 10, while those in B1, B2, B3, B4 and B5 scored an average of 5.6, 6.6, 7.2, 8.0 and 5.2 respectively. In an independent t-test between the means of C0 and each of the blends B1-B5, the p-values are all significant (α=0.05). The mean values for performance, engagement percentile and satisfaction score for each blend are summarised in Table 6, as well as in Figures 3, 4 and 5 respectively.

We observed a linear increase in performance from B1 to B2 to B3, as the media richness of the content increases in each blend. When comparing between B1 and B4 to test the effect of collaborative learning, B4 has posted a higher mean content proficiency score of 8.0 than B1's score of 5.6, and is the only comparison between blends that is statistically significant (p-value=0.035, α=0.05). To assess the effect of performance feedback, we compare performance scores for B1 and B5 and find that the mean content proficiency score of B5 (5.2) is lower than that of B1 (5.6).

Mean Engagement Percentile

In testing for the effect of media richness of content on learner engagement, we observed that participants who were given content of moderate media richness in B2 (93.08) had a higher mean engagement percentile than participants given the leanest media in B1 (86.78). Participants given the most media rich content in B3 had the lowest mean engagement percentile (83.83) compared to B1 and B2.

To test the effect of collaborative learning on engagement we compare results of B1 and B4. Here we observed that participants who were given group assignments in B4 had a lower mean engagement percentile (79.13) than participants in B1. To test the effect of performance feedback we compared B1 and B5 and we observed that the participants in B5 had a lower mean engagement percentile (81.56) than those in B1.

Mean Satisfaction Score

To test for internal reliability of the items used in the satisfaction survey Cronbach's alpha was found to be at acceptable value of 0.982. To test the effect of media richness on satisfactions, we compared the blends B1, B2 and B3. We note that there was a slight linear increase in the mean satisfaction scores of B1 (22.2), B2 (23.2) and B3 (25.2) as the media richness varies from hypertext (B1) to audio and text (B2), and then to video (B3). When comparing the blends B1 and B4 to test the effect of collaborative learning, participants who were given the group assignment in B4 (22.2) had the same mean satisfaction score as those in B1 who were given individual assignments. Finally, we compared B5 and B1 to test the impact of performance feedback and the results revealed that participants in B5 (23.4) had a slightly higher mean satisfaction score than those in B1.

We summarise the results of the hypotheses that were tested and show whether the experiments supported them in Table 8.

Table 30. Summary of hypotheses that were supported or not supported by the experimental results.

Research Questions	Hypotheses	Results
Does media richness of content have any impact on learning quality?	H_{1a}: Media richness of content has a positive effect on performance.	**Supported**
	H_{1b}: Media richness of content has a positive effect on engagement.	Not supported
	H_{1c}: Media richness of content has a positive effect on learner satisfaction.	**Supported**
Does collaborative learning have any impact on learning quality?	H_{2a}: Collaborative learning has a positive effect on performance.	**Supported**
	H_{2b}: Collaborative learning has a positive effect on engagement.	Not supported
	H_{2c}: Collaborative learning has a positive effect on learner satisfaction.	Not supported
Does performance feedback impact learning quality?	H_{3a}: Performance feedback has a positive effect on performance.	**Supported**
	H_{3b}: Performance feedback has a positive effect on engagement.	**Supported**
	H_{3c}: Performance feedback has a positive effect on learner satisfaction.	Not supported

ANALYSIS AND DISCUSSION

Effect of Media Richness on Tablet Learning Quality

The linear increase in the performance results as media richness varies from hypertext (B1) to audio and text (B2) and finally to video (B3) provides support for our hypothesis H1a that media richness has a positive effect on the learner performance. This trend was also observed in the mean satisfaction scores of the participants in B1, B2 and B3 respectively, although only slightly. Thus, it also provides support for our hypothesis H1c that media richness of content has a positive effect on learner satisfaction.

However, the trend was not repeated entirely in the mean engagement percentiles of B1, B2 and B3. There was an increase in the mean engagement percentile from B1 to B2, but not from B2 to B3. Therefore, it only partially supports the hypothesis H1b that the media richness of content has a positive effect on learner engagement. This illustrates how learner performance is not directly related to his level of engagement in the content during the learning process.

Effect of Collaborative Learning on Tablet Learning Quality

Our hypothesis H2a is supported by the great increase in the learning performance of B4 participants in contrast to that by B1 participants. The earlier observation that learner performance is not directly related to engagement is also repeated here, as B4 posted a lower mean engagement percentile than B1. The mean satisfaction scores are the same for both B1 and B4. Collectively, these results seem to suggest that the positive effects of collaborative learning on the quality of learning are fairly limited. In particular, the positive effects pertain only to the learner's performance.

There are a few possible reasons why the B4 participants do not feel more engaged or more satisfaction than those in B1. Firstly, there might have been dissatisfaction with the chat module in the experimental tablet learning system. Secondly, some participants who are not particularly vocal in a group setting might have experienced less personal engagement. An examination of the details of the recorded chat history of the discussion for the online assignment revealed that there were mainly two participants who were dominant.

Given the above observations, it should be noted that in designing learning blends where there is a collaborative learning element, educators may want to consider integrating complementary elements in the blend that could assist learners to be more engaged, and/or derive greater satisfaction from the learning process.

Effect of Performance Feedback on Tablet Learning Quality

There are increases in both the learner performance and the engagement of participants of B1 when compared to those of B5, in which performance feedback is absent. This supports our hypotheses H3a and H3b that performance feedback has a positive effect on learner performance and engagement respectively. However, since the mean satisfaction score observed in B5 compared to B1 is only slightly greater, the difference is considered as insignificant. Thus, H3c is unsupported.

What was unexpected in the results is the slightly higher mean engagement percentile and mean satisfaction score observed in B5, as compared to B4, which had performance feedback. This may shed further light on how performance feedback may not be the sole factor in determining the level of learner engagement and satisfaction. It also shows how the combination of collaborative work with performance feedback in a learning blend can have a negative effect on learner engagement and satisfaction. This relationship was first observed when we compared B1 with B4, and is observed again when we compare B4 with B5.

Further Discussion

Among the survey comments received, we noted that some participants in the blend B2 and B5 reflected similar sentiments about the presentation of the content. Two participants in blend B2 and a participant in blend B5 felt that the inclusion of

images and videos would have been useful to the learning experience. The summary of the comments provided by these participants is shown in Table 9 below. We postulate that these participants may be more visual learners and raised these comments because of the lack of visual tools such as images and/or video in the learning content of their respective blends.
Another possible reason is that as seasoned learners in a graduate program, they are generally more informed of the types of tools available that can aid learning. As such, their expectations of more visual-oriented learning tools might have contributed to their survey comments.

Table 31. Summary of the comments by participants relating to suggestions of the provision of more images/video.

Experiment Participant	Comment given in response to "Do you have any feedback on how this system can be improved?"
Participant A from B2	*"Incorporate images/videos"*
Participant B from B2	*"Adding some picture or mind map"*
Participant C from B5	*"Pictures may be helpful for readers to understand the content of the report"*

CONCLUSION

Limitations

One limitation of the experiments was the small sample size of 30 graduate students. While the results were consistent with some of the learning theories, a larger sample size may further augment the validity of our results [32]. Another limitation is the short amount of time participants are expected to learn the content. While this may allow us to observe the immediate impact of the different treatments, the authors are aware that a typical educational curriculum has more content and take place over longer durations which could produce different results.
Finally, our study comprises IT savvy students who are comfortable and proficient with tablets. With only a small minority of learners in developing nations having access to computers [1], the lack of IT skills may result in differences in learning quality when conducted in developing nations.

Future work

Apart from repeating the experiment with a larger sample size within a developing nation context, the authors also note that the usability of the learning interface on the tablet can also impact learning quality. Hence, future research should include investigations on how usability factors and design guidelines that have been proposed for tablet-based mobile learning [33, 34] can impact the learning quality.
Further research on tablet-based blends could also investigate: the relationship between other types of learning content and learning quality; the differences in the resultant learning quality between students of high and low achieving students when using a tablet-based learning system; and the implementation costs of adopting the BYOD approach in education [35].

Concluding Remarks

In our investigation of the effectiveness of different blended learning approaches using tablets, we defined learning quality in terms of learner performance, engagement and satisfaction. The results of the experiments provided support for the impact of media richness theory, constructivist theory and behaviourist theory on performance outcome only. More specifically, the amount of media richness, collaborative work and performance feedback had a positive relationship with learner performance scores. In addition, only performance feedback had a positive effect on learner engagement. In terms of learner satisfaction, only the impact of media richness was supported while collaborative work and performance feedback had negligible effect. We also discovered that collaborative work when combined with performance feedback resulted in lower learner engagement and satisfaction.
An implication of these results on the BYOD approach for developing nations is that curriculum planners and educators should consider focusing more on how best to provide learning content that is media rich to maximise learning quality. As tablets become cheaper and Internet video streaming become more ubiquitous, the BYOD approach proposed in this study has the potential to further narrow the educational divide between developed and developing nations [36].

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