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How Clickstream Tracking Helps Design Mobile Learning Content

Joey Chan[1], Rex Chiu[2], Grace Ng[3], Theresa Kwong[4]

Centre for Holistic Teaching and Learning, Hong Kong Baptist University
Kowloon Tong, Hong Kong S.A.R.
[1]*chancfj@hkbu.edu.hk*, [2]*rexcwp@hkbu.edu.hk*, [3]*msgng@hkbu.edu.hk*, [4]*theresa@hkbu.edu.hk*

Abstract: *A clickstream is the recording of what a computer user clicks on while web browsing or using a software application. In e-learning activities in which decision-making by the learner is required, clickstream data become especially useful for educators to visualise how learners go through the learning process. By applying clickstream tracking, educators also have the opportunity to examine the effectiveness of the e-learning activity design.*

This paper discusses how clickstream tracking is being applied in an ethical-induction learning trail project, in which students visit various locations around a university campus, make use of their mobile devices to retrieve different location-specific information, consider different ethical scenarios, and produce responses under different circumstances. The clickstream data reveal how some learning activities are more effective in engaging students in the exploration of ethical choices. The analysis of the collected data can assist educators in designing or redesigning the learning activities in order to enhance student learning.

Keywords: *clickstream, action tracking, e-learning, mobile learning, learning trail, learning process, content design.*

1. Introduction

Learning is a product of interactions between learners, educators and the learning contents (Elias, 2011). Traditionally, analysis of learning is performed through student evaluations, instructors' perceptions, the content of student work and the analysis of grades. Owing to the emergence of clickstream tracking technology, instructors are able to seamlessly track learning activities during a course and get prompt feedback for course content enhancement. With the recent surge of mobile learning in the higher education sector (Ally & Khan, 2015), capturing details of the interaction between learners and learning contents in mobile devices can be done through the application of clickstream tracking technology.

Clickstream tracking refers to the recording of what a computer user clicks on while web browsing or using a software application. Any action done by the users within the webpage or application is logged (Roebuck, 2011). In the field of business and marketing, clickstream tracking has been widely used as an analytics tool for tracking online consumer behaviour (e.g. Montgomery, 2001; Moe & Fader, 2004). Firms usually employ clickstream tracking technology to examine the quantity and profile of visitors to their websites and to analyse detailed clickstream data for revealing visitors' page viewing patterns, which serve as valuable inputs for optimising website contents and product offerings. In the education domain, application of clickstream tracking on mobile learning contents and the analysis of these data is known as learning analytics, which deal with the development of methods that harness educational datasets to support the learning process (Chatti, Dyckhoff, Schroeder, & Thus, 2012). However, research in the area of learning analytics using clickstream data through mobile devices is relatively new and the number of studies in this area is still limited.

Our paper describes the application of clickstream tracking on a web-based mobile learning project, entitled 'Reinforcing the Importance of Academic Integrity and Ethics in Students through Blended Learning – A Deployment of Augmented Reality Applications'. The project involves the design of Trails of Integrity and Ethics (TIEs), and is led by the Centre of Holistic Teaching and Learning (CHTL) at the Hong Kong Baptist University (HKBU). This paper describes the application of clickstream in the very first pilot trail, codename TIE-1, and how it enhanced the content design of the next trail, codename TIE-2. By applying clickstream tracking and learning analysis, the researchers were able to examine students' interactions and exploration patterns within the mobile learning activities, the tracked data in turn, became valuable inputs for enhancing future learning trail designs.

1.1. Clickstream Tracking for an Ethical Learning Trail

Through the design of various TIEs, the project aims to develop a learning environment that is supported by digital technologies (e.g. learning management systems, mobile devices and augmented reality), whereby students will be motivated to learn, engage more in learning activities and share their experiences in relation to making ethical decisions.

Specifically, our pilot learning trail, TIE-1, consists of four physical locations within the campus of HKBU. Each location is referred to as a *checkpoint*. Students activate learning activities at each checkpoint using their mobile phones.

Each learning activity describes a scenario based on fictitious student characters acting in the physical environment of the checkpoint location. The scenarios centre on these characters confronting issues related to academic integrity and ethics. Each learning activity therefore involves a digital overlay of information on top of the real-world setting, which is the essence of the conceptual definition of augmented reality, tailored to stimulate students to think about ethical scenarios in terms of physical objects to which they might relate and/or the physical settings in which they might occur. This situated learning approach (Lave & Wenger, 1990) should help students link their learning with their everyday lives, with the learning being better embedded as transfer distance is reduced.

After going through a scenario, students are presented with different ethical choices on issues addressed within the scenario, and are asked to make a decision between these choices. The consequences of their decisions are then presented and described in detail. By creating and simulating experiences through the envisioned scenarios, the learning trail could allow students to effectively learn about rules of academic integrity and ethics by exploring ethical choices without actually violating any rules or regulations in reality. To facilitate the exploration of different ethical choices, each learning activity gives students the option to go back and make a different decision upon selecting a non-optimal choice.

The contents of TIE-1 are stored and can be retrieved via an application (with server and mobile capabilities) called Mobxz. Mobxz is designed specifically for the deployment of learning trails using mobile devices and has been used to successfully deploy a number of heritage learning trails in Singapore. The contents used in TIE-1 are stored on a dedicated server in HTML5 format, which ensures visual consistency across the display on Android smartphones and iOS devices.

TIE-1 was conducted with two groups of students in the first semester of the 2014/15 academic year. The first round was conducted with 29 postgraduate students. After this round, three sets of data were collected for evaluation: qualitative feedback, a user experience survey and pre-trail/post-trail questions (Chow, Pegrum, Thadani & Wong, 2015), for learning analytics and content design revision. However, the result of the first round of TIE-1 revealed that the current data and technologies were unable to reflect the following:

- What choices had the students made when they were facing the scenario described in the learning content?
- Did the students engage in the learning activities? Observation showed that there were students skipped the learning contents by pressing the 'Next' button rapidly to process the screens. How many students actually did this?
- Which mobile platform had the student used? Detailed explanations are listed in the *Results and Discussion* section.

By taking reference of business websites, where clickstream tracking data are used to track which links a user clicked, how long a user stayed on a particular web page and the type of browser users used for viewing that particular website, we applied clickstream tracking to capture data that helps us answer these three questions. Thus, in the second round of TIE-1 conducted with 16 undergraduate students, by applying clickstream tracking, JavaScript snippets were inserted into the HTML5 mobile content files to record three sets of tracking data within each learning activity accordingly:

- *Decision on Ethical Choice* – each decision is measured by recording all button-press (or tab) events that occur within the learning activities when students make the ethical-related decision in the given scenario.
- *Time on Task* – the duration between the moment when an HTML page is loaded, and when the 'Got It!' button is pressed (this marks the completion of the learning activity). This is done by timestamping and useful in tracking the time which students spent on each learning activity.
- *Mobile Type* – records of the brand and model of smartphones the student's uses for the learning trail.

These records were then used for the consideration of content design in TIE-2. This paper also discusses the data collected from the undergraduates of TIE-2 and how clickstream data enhance the content design of TIEs. TIE-2 shares the same structure as TIE-1 but with revised contents; details are discussed later in the Results and Discussion section.

2. METHODS

The activities in TIE-1 and TIE-2 were conducted during two separate classes on academic integrity and ethics. For this paper, the clickstream data were collected from two groups of participants:

- TIE-1, conducted in the first semester of academic year 2014/15, with 16 undergraduate students
- TIE-2, conducted in the second semester of academic year of 2014/15, with 69 undergraduate students

The instructor first explained to students about setting up a wireless Internet connection and the appropriate mobile application for their smartphones. Then students were introduced to the learning trail and the steps to activate the various learning activities. Finally, the instructor led the students on the learning trail to visit the four checkpoints.

Table 1 summarises the scenario descriptions, issues explored and ethical choices of the four learning activities for TIE-1.

Table1. *Summary of learning activities for TIE-1*

Issue Explored	Scenario Description	Question	Ethical Choices
Plagiarism	A student in the classroom discovers that she has insufficient time to complete an assignment, and is considering copying from a classmate.	Should the student plagiarise?	1. Yes 2. No
Ethical Use of Library Resources	A student is considering hiding a sought-after textbook in the library on another shelf, so that he can use it for as long as he wants without letting other students access the book.	What should you tell this student?	1. 'Don't do that, …' 2. 'It's okay to put the book on the original shelf later' 3. 'It's a clever idea'
Citation and Common Knowledge	A student is considering using a famous Chinese phrase (inscribed on a statue) in her assignment, and ponders whether citation is required.	Is a citation needed for this Chinese phrase?	1. Yes 2. No 3. Unsure
Data Falsification	A student is conducting a survey about recycling habits of HKBU students. However, the student cannot collect enough data and is considering calling up relatives and friends to answer the survey without reporting this change of data collection method in his final report.	Should the student report the change of data collection method?	1. 'It should be OK not to mention it in the report…' 2. 'It's completely unacceptable…' 3. 'It's important to state how the data are collected…' 4. 'Consult his teacher…'

Students accessed the learning contents through their own mobile device. The learning contents were published in HTML5. To apply clickstream tracking, JavaScript snippets were inserted within the

HTML code to store certain states of user behaviours and then sent to a remote server for data logging. A server side script receives client logging requests and logs the data into a database file. The data can be downloaded upon request, and exported to an Excel file for analytics processing. Fig.1 shows the schematic diagram that summarises data transfer, storage and processing between the mobile application and the remote server. Note that all clickstream tracking data are recorded anonymously without collecting any personal information of the students (e.g. smart phone serial number, student name, student identification number).

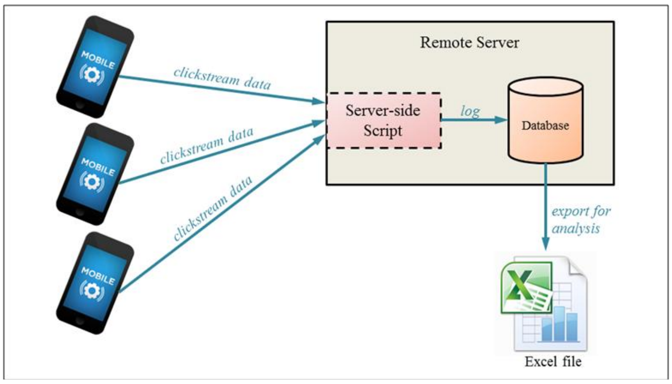

Fig1. *Schematic Diagram of Clickstream Tracking for TIE-1 and TIE-2*

3. Results and Discussion

According to each target of the clickstream tracking data in the TIEs, the results will now be discussed in the following three sections:

- Decision on Ethical Choice
- Time on Task
- Mobile Type

3.1. Decision on Ethical Choice

Figure 2 illustrates an example of the choices made by students in each branch of decision checkpoint – 'Ethical Use of Library Resources' of TIE-1.

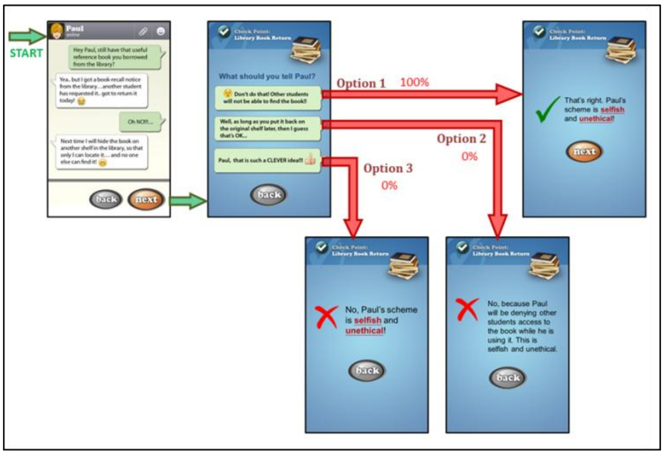

Fig2. *Clickstream Result of the 'Ethical Use of Library Resources' Checkpoint*

Tables 2 to 5 show the 'Decision on Ethical Choice' of the all checkpoints in TIE-1 and TIE-2.

Table2. *Decision on' Plagiarism'*

Option	**TIE-1**	**TIE-2**
Yes *(only in TIE-1)*	0%	*N/A*
No *(only in TIE-1)*	100%	*N/A*
Option 1 *(only in TIE-2)*	*N/A*	50%
Option 2 *(only in TIE-2)*	*N/A*	12%
Option 3 *(only in TIE-2)*	*N/A*	20%
Option 4 *(only in TIE-2)*	*N/A*	18%

Table3. *Decision on 'Ethical Use of Library Resources'*

Option	TIE-1	TIE-2
Option 1	100%	67%
Option 2	0	16%
Option 3	0	17%

Table4. *Decision on' Citation and Common Knowledge'*

Option	TIE-1	TIE-2
Yes	81%	72%
No	6%	20%
Unsure	13%	7%

Table5. *Decision on' Data Falsification'*

Option	TIE-1	TIE-2
Option 1	8%	5%
Option 2	30 %	25%
Option 3	31 %	19%
Option 4	31%	51%

From Table 2, it can be noted that for the 'Plagiarism' learning activity in TIE-1, when asked if plagiarism is acceptable and will be forgiven for first-time offenders at HKBU, all students had chosen 'No', i.e. the correct answer. Similarly, for the 'Ethical Use of Library Resources' learning activity in TIE-1, students had also unanimously chosen the optimal answer, 'Students should not deny other students' access to library resources by hiding library books' (see Fig.2). On the other hand, decision choices by students in the 'Citation and Common Knowledge' and 'Data Falsification' learning activities were not so straightforward, leading to a split in ethical decisions.

For the TIE-1 pilot, a clear pattern emerges upon examining the choices made by students at the decision point of each learning activity: if the questions and choices being presented have veryclear and obvious ethical divides (e.g. definitely right or definitely wrong), then students would unanimously choose the most ethical choice. In other words, students simply do not choose the unethical choices in the learning activities and hence cannot learn about their consequences. One motivation of the learning trail is to enable students to learn effectively about rules of academic integrity and ethics by exploring unethical choices through simulated 'realistic' experiences of envisioned scenarios, without actually violating them in reality. Our TIE-1 clickstream data show that two of the four learning activities failed to provide the opportunity for students to experiment with different choices and learn about the consequences. Thus, on the next design iteration of the learning trail of TIE-2, the questions and ethical choices presented in the learning activities were revised to make the correct choice less obvious, inducing students to consider and explore all the choices available, to review their consequences and arrive at well-thought-out decisions.

Tables 2 and 3 show the students' decision after the content had been revised in TIE-2. Both scenarios remain the same. In the 'Plagiarism'learning content (see Table 2), the question and the ethical choices were redesigned. Instead of giving 'Yes' or 'No' options to the question 'Should the student plagiarise?', the revised question in the same scenario became 'If you were the student, what would you do?' and provided with the options listed in Table 6.

Table6. *Summary of Learning Activities for TIE-2*

Issue Explored	Scenario Description	Question	Ethical Choices
Plagiarism	A student in the classroom discovers that she has insufficient time to complete an assignment, and is considering copying from a classmate.	If you were the student, what would you do?	1. Borrow classmate's assignment for 'quick reference' 2. Borrow and combine parts of the assignments from different classmates 3. Borrow somebody's assignment from past years and make a few changes 4. Re-use another similar assignment from a previous course

Each revised ethical choice describes a kind of plagiarism which the students may overlook. Since none of them are the ‘correct’ answer, by considering the scenario and choosing one of the answers, the students could learn more about the consequence of their choice (Table 2).

Similarly, this was applied to the ‘Ethical Use of Library Resources’ learning content. With exactly the same scenario, instead of asking ‘What should you tell the student about hiding a library book?’ the revised question in TIE-2 became ‘What do you think will happen to the people?’ and the decision options changed to ‘other students’, ‘librarian’ and ‘yourself’ for students exploring the consequences to these stakeholders.

Clickstream tracking data analysis on Decision to Ethical Choice extracts only the data of the first choice in the current stage. It could be more powerful if further attempts could be tracked to provide a more complete map to design forthcoming trails.

3.2. Time on Task

Table 7 summarises the time on task for the learning activities at each checkpoint in TIE-1.

Table7. *Time on Task for each Learning Activity in TIE-1*

Option	Number of Students	Number of Screens	Time on Task (in seconds)		
			Mean	Min	Max
Plagiarism	16	7	56	11	126
Ethical Use of Library Resources	15*	8	35	10	62
Citation and Common Knowledge	16	8	36	8	72
Data Falsification	13*	12	73	33	137

**Loss of some data due to temporary server failure*

The above table shows the mean, minimum and maximum time on task (in seconds) for each learning activity. These are the durations students spent on the learning activities. The table also shows the length of each learning activity by the number of screens students must view on their mobile devices to complete a particular activity.

It is interesting to note that even though the length of the three learning activities (Plagiarism, Ethical Use of Library Resources, and Citation and Common Knowledge) are similar (7 or 8 screens of content), the variation of the mean time on task was large. For instance, the Plagiarism learning activity has a longer time on task than the Citation and Common Knowledge one. One possible reason could be due to the varying number of words and the level of word difficulty in the learning activities. Given that English is a second language for most of the students who participated in this pilot, words and phrases such as ‘plagiarism’, ‘no leniency’ or ‘zero tolerance’ found in the Plagiarism learning activity are not everyday English, the students might then require relatively more time to comprehend the contents. In view of this, in future learning trail designs, the choice of words in the learning activity content should be tailored to match students’ level of English. Furthermore, mobile devices are not ideal for reading long passages, hence, more graphics or animations could be incorporated for trail designs and the number of words kept to a minimum. The maximum time on task was also relatively longer. Time on task can act as a proxy measure of students’ level of engagement with the mobile content (Stovall, 2003). Therefore, in the next learning trail design, if the level of English is kept at relatively the same level across different learning activities, then time on task could be a good indication of students’ level of engagement.

We also noticed that the time on task for the Data Falsification learning activity was the longest among the four learning activities. We cannot conclude whether the extra time spent was the result of a high level of engagement, or because students required more time to read through an increasing number of screens to complete this particular learning activity, or both. Thus, in our next learning trail design, if we were to use time on task to measure engagement level, contents for each learning activity need to be tailored to roughly the same length as the others.

Referring to Table 7 again, the minimum time on task among the activities is 8 seconds (Citation and Common Knowledge), while the maximum is 137 seconds (Data Falsification). Hence there is a huge difference between the minimum time on task and the maximum, or even between the mean times on task for the learning activities. It is not difficult to deduce that students who spent only 10 seconds to complete a learning activity have not thoroughly read all the content, or have not given much consideration to the different ethical choices in the learning activity. Although our data suggest that only a few students had exhibited this behaviour, it is still useful to be mindful to design engaging contents in future learning trails to motivate as many students as possible in this form of learning. For example, the use of multimedia content such as videos to replace textual explanations of concepts related to academic integrity may help to improve students' engagement in the learning activities. On the other hand, some students took twice as much time to complete a learning activity than the mean time on task for each learning activity. This could be caused by the long loading time of the mobile content due to an unstable Wi-Fi signal, which was observed when this pilot was being conducted. Therefore, in the future design of learning a trail, the selection of checkpoint locations must take the strength and stability of Wi-Fi reception into consideration.

With the analysis above, the learning content in TIE-2 was greatly revised: text scenarios were modified to photo-storyboards for case illustration and ethical concepts were explained in animated videos to produce more engaging content. Thus the number of screens in TIE-2 had increased. To overcome the Wi-Fi connection issue, certain physical locations were tested under the help of information technology officers, and students were guided to stand at good connecting locations ensuring the connection would be stable for the learning activities.

Table 8 summarises the time on task for the learning activities at each checkpoint in TIE-2.

Table8.*Time on Task for each Learning Activity in TIE-2*

Option	**Number of Students**	**Number of Screens**	**Time on Task (in seconds)**		
			Mean	**Min**	**Max**
Plagiarism	66*	20	227	63	825
Ethical Use of Library Resources	69	10	60	25	198
Citation and Common Knowledge	69	13 (with 100 seconds video)	91	27	332
Data Falsification	64*	18 (with 71 seconds video)	113	36	289

** Loss of some data due to temporary server failure*

Again, the above table shows the mean, minimum and maximum time on task for each learning activity together with the number of screens students view on their mobile devices and the number of students participating in each learning activity.

In TIE-2, although the stability of the Wi-Fi connection had improved a lot, nevertheless the Wi-Fi failed at some points when there was a large number of devices connecting to the same access point retrieving the same learning content at the same time, especially when the Plagiarism learning activity was conducted in a classroom. This alone resulted in large mean and maximum times on such tasks.

Generally, the mean, minimum and maximum time had increased in TIE-2 due to the reformatting of scenario illustrations and explanations and with a more stable Wi-Fi connection the students spent more time on each learning activity. It could be an indication of success having revised the plain text content into multimedia content.

Note that the mean time shown in the Citation and Common Knowledge activity in Table 8 is 91 seconds, despite the learning content including a 100 second video. This indicates that the student was not interested in the video content, which contains a piece of learning material important to the subject. In fact, the raw data shows that only 24% of students accessed this learning content for more than 100 seconds.

In contrast, the mean time of learning content for Data Falsification is 113 seconds; this content contains a 71 second video. The raw data shows that about 80% of students spent more than 71 seconds and half of the students spent more than 100 seconds on this learning activity. Although we cannot conclude that the students did watch the video in its entirely, nevertheless this indicates that the majority spent a reasonable time on this activity.

At this stage, it is hard to evaluate the success of the video content. Observation shows that some students found it hard to hear the sound (the narration) of the video since the activity was conducted outdoors. This may hinder student interest in learning from such material. Therefore, in the next iteration of TIE, several tasks could be incorporated, such as a subtitle may be added, increasing the sound volume of the video and/or asking the students to bring their own earphones, a mini game or quiz could be added after the video to encourage the students watch it carefully. Shortening the video length may also be considered. Further studies and observation should be done in this area with the help of tracking the time spent on video pages.

3.3. Mobile Type

After TIE-1, the researchers found that the mobile devices of some students were incapable of adopting a particular technology to activate the learning activities. For example, the GPS trigger works well on iOS devices but not on some Android devices, whereas Android phones have better performance on image recognition when triggering learning activity. Therefore data on students' mobile platform usage would be useful for selecting the content triggering method in our learning trail design.

In the second round of TIE-1, since clickstream tracking was employed, JavaScript codes were inserted to keep track on the User Agent string of the mobile browser. The following are sample values captured from two mobile phones from TIE-1:

> *Mozilla/5.0 (iPhone; CPU iPhone OS 6_1_4 like Mac OS X) AppleWebKit/536.26 (KHTML, like Gecko) Mobile/10B350*
>
> *Mozilla/5.0 (Linux; U; Android 4.2.2; zh-tw; GT-S7582 Build/JDQ39) AppleWebKit/534.36 (KHTML, like Gecko) Version/4.0 Mobile Safari/534.30*

The first record indicates the mobile device is an iPhone using an iOS operating system version 6.1.4, and the second line indicates the mobile device is a Samsung Galaxy S Duos 2 (model no. GT-S7582) using the Android operating system version 4.2.2.

The results for Mobile Type show the proportion of smart phone operating systems used by students in both TIE-1 and TIE-2 are the same: 75% Android vs 25% iOS devices. There are a larger number of Android smart phone users compared with iOS users among our students. This is in line with the current global smart phone market share, in which Android smart phone users outnumber iPhone users (Global Smartphone Market, 2014); the ratio was 80% Android vs 20% iOS as of the third quarter of 2014.

Being aware of this trend after TIE-1, the researchers prepared an alternative trigger for supporting both platforms to activate the learning content in TIE-2. For example, Quick Response (QR) code stickers were put at the checkpoint location, provided that the QR code scanner could work well on both Android and iOS devices. For those devices in which GPS was not functioning properly, students could still access to the same learning content through scanning the QR code. Although various technologies can engage students in the trail better, it was important that all participants were able to access the learning content equally and had the opportunity to learn from the activity.

The results from TIE-2 also showed the same proportion of mobile platforms, 75% Android vs 25% iOS, with the larger group of undergraduate students. To overcome the stability of various technologies on different platforms, we could consider the experience of other similar trails, such as the learning trails conducted in Singapore. In those trails, organisations distributed the same model of mobile device to a group of students, ensuring the user experience is under a certain level of control. This could reduce the effort involved in work concerned with the incompatibility of different types of devices. However, as Bring Your Own Device (BYOD) mobile learning is a growing trend and suits the learning atmosphere of universities, it is worth exploring the most feasible way of working on several platforms at this stage.

Considering that there are always iPhone users among our student population, however small in number, the choice of the learning trail mobile application must be compatible with both iPhone and Android smartphones. This may prove difficult as we observe that some learning trail mobile application developers tend to focus on making their product compatible with either the Android smartphones or iPhones but not both. Therefore, we conclude that our current choice of the Mobxz application is suitable for deploying learning trails on our university campus as it is equally compatible with both iPhone and Android smartphones.

4. CONCLUSION

In the context of mobile learning, clickstream data can provide valuable insights into students' interactions and behavioural patterns in response to various learning activities. These insights can shed light on how mobile learning content can be optimised and whether the general design of the learning trail can be improved.

In summary, clickstream tracking data can reflect, to a certain extent, how students engage with web-based mobile learning activities. They also provide good guidance in order to improve the content design of future learning activities to be more engaging. However, clickstream data cannot accurately reflect how much students have learnt from the activities. Therefore, collecting additional data, such as survey and qualitative feedback from students, or comparing pre-learning and post-learning knowledge and attitudes, will also help enhance the quality of mobile learning activities to become an effective learning tool.

It is worthy to note that the application of clickstream tracking in this project is not yet fully utilised and has great potential in learning analytics for mobile learning. As clickstream tracking on commercial websites allows the administrators to analyse user behaviours, in terms of click steps and time spent on each step, it could also be used for tracking whether a student goes back to explore another choice and its consequences, or how long a student remains on a certain page. These would help in revising the learning content in depth and will be considered in the development plan in the forthcoming phases of the project.

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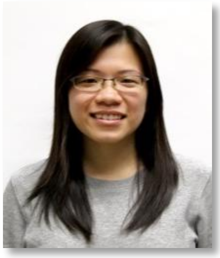
AUTHORS' BIOGRAPHIES

Mr Joey Chan is a Technical Officer at the Centre for Holistic Teaching and Learning (CHTL), Hong Kong Baptist University. His work focuses on digital content development and learning analytics for e-learning and mobile learning applications.

Mr Rex Chiu is a Technical Assistant at the Centre for Holistic Teaching and Learning (CHTL), Hong Kong Baptist University. His work focuses on digital content development for e-learning and mobile learning applications.



Miss Grace Ng is a Technical Officer at the Centre for Holistic Teaching and Learning (CHTL), Hong Kong Baptist University. Her work focuses on learning management system administration, web application and digital content development for e-learning.

Dr Theresa Kwong is the Assistant Director of the Centre for Holistic Teaching and Learning (CHTL), Hong Kong Baptist University. Her research interests include faculty development, service learning and academic integrity.