Analysis of Students Engagement and Learning Performance in a Social Community Supported Computer Programming Course

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ABSTRACT

In Taiwan, the social community, Facebook has been more and more powerful ever since being launched, and it serves as if a strong magnet, attracting teachers and students to share and discuss on such platform, and also to search for films, pictures, and messages of their specific interests. Some researchers have probed into the learning interaction and efficacy of a computer programming course, and the results show that not only could the learning interactions between teachers and students enhance, but also between students themselves under this environment supported by Facebook. We propose four steps of learning analytics to study students' behaviors and learning performances in a social community supporting computer programming course. Furthermore, our learning analytics method could decrease the time and energy consuming process, which includes collecting, correlating and organizing students' participative patterns. A reported case, focuses on students' engagement behaviors and its influence on students' learning outcomes, is carried out with 43 freshmen at a university in northern Taiwan. The results show that our learning analytics method benefits students' participative behaviors, which are related to students' learning achievements in the computer programming course supported by social community, since students could obtain better understanding under such learning mode.

Keywords: social community, engagement, learning analytics, computer programming

INTRODUCTION

After Facebook, a social community site, has been launched, it has become more and more powerful since many people could reach the educational purpose of creating, sharing, and discussing knowledge by using it as a multifunctional medium (Garrison, Anderson, & Archer, 2001; Sherry, Michael, & Jason, 2011). Having the feature of being limited by neither time nor location, users can share knowledge, seek for certain answers or share the after-class feedbacks by posting questions on such learning community anytime and anywhere. Meanwhile, the teacher may also respond to students' questions at any time, and the students can also see all the contents posted by others. Therefore, this social community becomes more and more efficient for learning computer programming due to the fact that users are not restricted by a particular time or location. Since the students do not speak directly in front of their fellows in class or after class, therefore those who are shy or introverted are also able to participate in Facebook

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State of the literature

- According to past literature, we found that learning computer programming courses has become more efficient due to the social community, Facebook, since this type of medium is helpful for learning in the field of computer programming education, and so, it turns out to be a social learning space for computer programming course discussions and feedback sharing among the students.
- Some literatures point out that it is a must to integrate the social community Facebook technology with learning computer programming to find patterns in students' participative and interactive behaviors.
- The use of educational data mining technologies can be utilized to sustain four steps of learning analytics. Previous studies, which had been published in this decade, have predicted that learning analytics would gradually turn into an integral part of the computer programming course.

Contribution of this paper to the literature

- In this paper, we propose the learning analytics method in four steps, namely data collection, data storage, data analysis, and data visualization.
- We propose four steps of learning analytics to explore the influence of students' engagement and interaction behaviors on students' learning performance. Moreover, we examine whether students' engagement behaviors are different in terms of students' learning performance.
- In the social community which supports the computer programming course, we discuss the relationships between students' engagement behaviors and learning performances. The proposed learning analytics is hoped to discover the participative and interactive behaviors of the students so as to promote students' learning effectiveness.

discussions enthusiastically, and so does expressing their thoughts and opinions well (Jeong, 2003; Hou, Chang, & Sung, 2010; Sherry, Michael, & Jason, 2011).

Some studies indicate the benefits of learning computer programming from such learning community as Facebook (Kabilan, Ahmad, & Abidin, 2010; Mazer, Murphy, & Simonds, 2007; Mazman & Usluel, 2010). Not only the communicating chances between the teacher and the students could be increased, but also the interactions among the students. Compared to traditional forums, students tend to devote themselves to Facebook discussions with higher participation and concentration (Hou, Chang, & Sung, 2010; Kabilan, Ahmad, & Abidin, 2010; Su, Huang, Wu, & Su, 2016). Facebook has such characteristics as achieving knowledge sharing, interactive cooperation, mutual communication, recording students learning progress and building up personal relationships. And thus, Facebook is helpful for a learning community which is set in the environment of a college classroom because a learning community like this could become a virtual learning space for community discussions, and exercising feedback sharing would be much easier for teachers and students.

In this paper, we propose four steps for learning analytics in order to study students' engagement behaviors and learning performances in the social community enabled computer-programming course. The proposed learning analytics method consists of four steps, namely data collection, data storage, data analysis, and data visualization. Moreover, we would adapt social community Facebook and education data mining techniques in this study to carry out the learning computer programming activity with least effort, and then we could grasp and analyze students' learning behaviors. Both the teacher and students can discuss, inquire, and share on such platform in order to allow the students to gain more associated information and knowledge, and also deeper learning and thinking in the learning computer programming activity could be achieved. This experiment is set up at a university in northern Taiwan, which involves 43 freshmen. The whole learning activity lasts for 12 weeks. Two research problems would be raised as the following.

Question 1: How do students attend the Facebook learning community in the computer programming course?

Question 2: Are students' participative and interactive behaviors related to their learning outcomes?

LITERATURE REVIEW

Social Community Supporting Computer Programming

In Taiwan, it is pretty usual to apply social networking websites to the educational environment of social community. By explaining "social" and "community" individually, "social" would be like a group gathering people with common hobbies, interests, or purposes while "community" means that any users who knows the basics of computer functions, are able to communicate, exchange, and share information with different communities at the networking space by utilizing a virtual space which is connected to the Internet via computer hardware. Thanks to the highly informal environment on such social networking website as Facebook, the users can interact, cooperate, participate, share information, and place themselves to possible critical thinking extendedly during after school hours (Boulos & Wheelert, 2007; Mazman & Usluel, 2010). According to its informal environment, applying social networking websites for supporting the computer-programming course could allow the students to learn inadvertently and happily. Mazman and Usluel (2010) found out that the social networking websites in daily lives is closely related to the educational environment. Social networking websites could connect users, time, locations, and object contents easily in everyday life. Boulos and Wheelert (2007) have successfully applied the social software to the social community learning activity. The researchers point out that high opportunities would students share and respond to problems in the social community learning activity under the environment of actual social community combined with useful learning information techniques. By this means, students can handle problems easily in extracurricular time by making use of their past experience, in other words, they are able to analogize the old questions and solutions to the problems they encounter at present.

In recent years, many benefits could be seen from research probes applying the social community, Facebook, to the environments of learning computer programming (Cheung, Chiu, & Lee, 2010; Sherry, Michael, & Jason, 2011; Wang, Li, Feng, Jiang, & Liu, 2012; Lin, Hou, Wu, & Chang, 2014; Su, Yang, Hwang, Huang, & Tern, 2014; Su, Huang, & Yang, 2015). Sherry, Michael, and Jason (2011) indicate that Facebook has been identified as a potential educational tool because many university students widely use it. Applying Facebook to the activities of learning computer programming may increase not only its utilization but also students' interests. Cheung, Chiu, & Lee (2010) mention that Facebook is a student-friendly and student-focused environment which trains students how to self-control, also, friends' invitations are sent socially without any coercion. Su, Huang, & Yang (2015) find out that Facebook can not only encourage students to discuss and answer related problems, but also promote students' learning motivation by utilizing the computer programming courses supported by Facebook. Wang, Li, Feng, Jiang, & Liu (2012) find that once the learning activities are adequately designed in the computer-programming courses, it can increase students' willingness of interaction. By doing so, it not only helps satisfy students' needs of growing the knowledge and skills of computer programming, but also raises the effectiveness of computer programming.

As for the benefits of adapting social community for supporting computer programming, we found that the social community, Facebook, has provided a multifunctional platform since sharing network information can be clicked into or discussed via the hyperlinks of any audios, videos, and words etc. The advantage of Facebook lies in the power of collective wisdom, and further encouraging students by "establishing relationships for the route of gaining knowledge" with the interactive knowledge creation and digital contents. Kabilan, Ahmad, and Abidin (2010) raise that the characteristics of Facebook are that students can construct individual knowledge sharing and supporting group interactions through participating in the social community which supports computer programming activity. Besides, it can produce and format specific feelings and knowledge for students. Because learning computer programming is getting more and more popular around the world, all students can contribute one's own professional knowledge, or obtain resources shared by others via Facebook. The experimental results found out that supporting computer programming with Facebook increases the speed that the students obtain their computer programming knowledge and skills.

In this study, we apply the social community-based learning method demonstrated by Lin, Hou, Wu, and Chang (2013) to a real computer programming activity. In addition to that, this kind of learning method is designed

into two phases, namely the social community-based notification and discussion. The reason why using Facebook for supporting computer programming activities is because such medium has little restrictions on time and place compared to the traditional face-to-face discussion. Moreover, Facebook provides learners with opportunities to prepare, reflect, think, and search for additional information before participating in the social community discussion. The teacher delivers notification messages by Facebook and decides whether to arrange the Facebook discussion or not after the students respond to the Facebook messages.

Learning Analytics

With the wide adoption of learning analytics in recent decades, some studies have applied education data mining techniques for studying the unknown and unrevealed modes in e-learning environments (Bakeman & Gottman, 1997; Jeong, 2003; Hou, Chang & Sung, 2010; Wang, Li, Feng, Jiang, & Liu, 2012; Lonn, Aguilar, & Teasley, 2015.) Hou, Chang, and Sung (2010), and Lonn, Aguilar, and Teasley (2015) propose learning analysis methods, which is based on educational data mining techniques, to make researches into the association mode and the degree of information literacy and students' participative behaviors. By testing every participations and interactions among the relationships of behaviors and using continuous behavior association, we would come up with a conversion chart. The proposed learning analysis methods try to understand the students' participative and interactive behaviors in the social community supporting computer programming activity.

Based on the learning analysis methods propose by Hou, Chang, and Sung (2010) and Lonn, Aguilar, and Teasley (2015), we apply the learning analysis method to propose four steps for learning analytics so as to study out students' participative and interactive behaviors in the computer programming environments supported by Facebook. The proposed method shows how the users engage themselves into the unknown association and unrevealed modes while utilizing it on Facebook to show learning objects, and also to analyse how learning objects affect students' participations and interactions. Since the social community could promote the effectiveness in the computer programming activity, students could not only gain the appropriate information by teacher's immediate recommendations, but also the response from their fellows on Facebook discussions, and therefore, the students could boost their learning motivations and confidences (Hou, Chang & Sung, 2010; Wang, Li, Feng, Jiang, & Liu, 2012; Lonn, Aguilar, & Teasley, 2015).

As stated in the proposed method for the computer programming supported by social community, we would collect students' learning data at first by recording students' clicking events and accessing time during in the whole activity. When the students encounter problems in the computer programming assignment, the teacher would try to help out in students' computer programming trouble spots by providing important hints on Facebook. The proposed method can analyze and generate useful information for the teachers to improve their instructional design on Facebook-supported computer programming activity. Some studies have illustrated that the system logs adapt education data mining techniques for studying the relationships between online participative behaviors and learning performances (Wang, Li, Feng, Jiang, & Liu, 2012; Lonn, Aguilar, & Teasley, 2015). Because students' participations and interactions might turn out to be different from the behavior patterns when applying the Facebook-supported computer programming course, and may result in affecting their learning performances. However, after the teacher provides help, students should learn to refine their computer programming quality by adjusting their learning result. Finally, understanding how students' participative and interactive behaviors in the social community influence the way computer programming course affects their learning performances is crucial.

FOUR STEPS FOR LEARNING ANALYTICS

In this paper, we propose four steps for learning analytics to explore students' participative and interactive behaviors in the computer programming activity supported by social community Facebook. The four steps for learning analytics includes data collection, data storage, data analysis, and data visualization, shown as **Figure 1**.

Using social community Facebook as the basis and let the teacher conducts the social community-based learning method in the real computer programming course (Su, Huang, & Ding, 2016; Huang, Yang, Chiang, & Su,
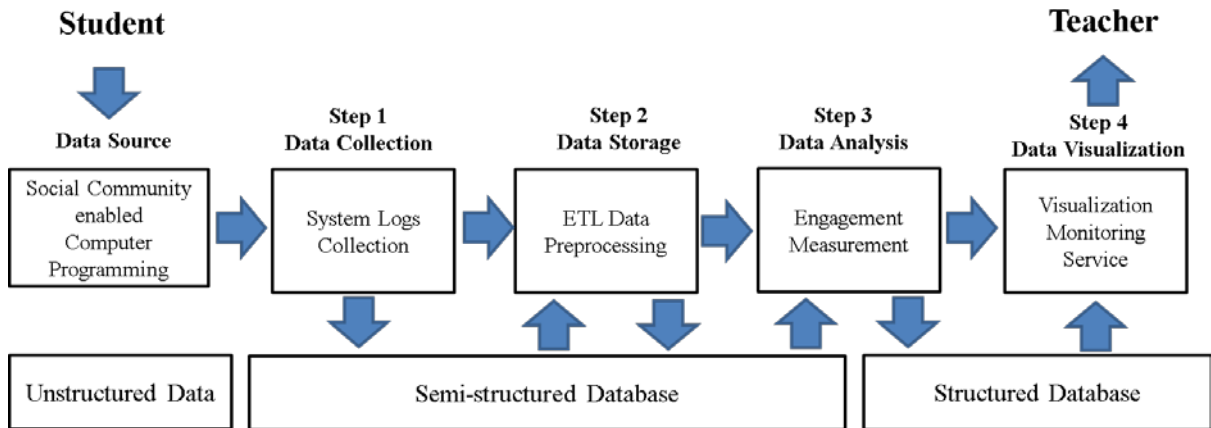
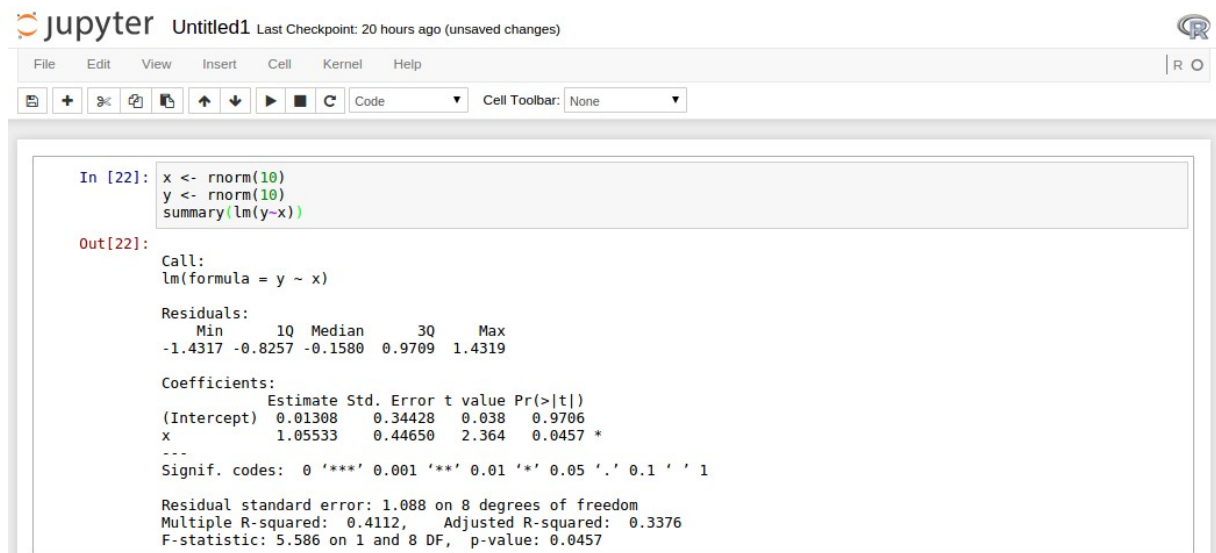**Figure 1.** Four steps for learning analytics

Figure 2. The user interface of the web-based computer programming IDE

2016). The teacher assigns computer programming assignments to students, and students use the web-based computer programming IDE to complete their assignments, as shown in **Figure 2**. The menu list enables students to manage their project life cycle. Furthermore, we implement a computer programming code development panel on which students developed and tested their computer program and managed code life cycle. In the social community, Facebook, the teacher guides students to share knowledge and cooperative to discuss the computer programming problems. Students read course materials and post issues by the social community Facebook. After the computer programming course supported by social community Facebook, the system logs are a tracking log that records students' detailed engagements and interactions, such as the student read a lecture material, and the student posts a Facebook message.

And then, we apply the learning analysis method to obtain and deal with gigantic social community information, just like how we use the system logs collection function on social community Facebook obtaining semi-structured information such as the context, results, environment, time, and so on. Through data collection, data storage, and data analysis steps turn unstructured raw data into semi-structured database. After data aggregating and analyzing the structured information saves at the structured database. After that, the final step of the data

visualization with the integrated structured database on the visualization and monitoring service, and carries out the engagement measurement function in the step 3 of data analysis.

At last, we use the visualization monitoring service in connecting with both long and short terms of data for analysis and comparison. Through visualization and monitoring service, they understand the frequency of immediate use on the computer programming course by students, and so is students' participative and interactive behaviors.

Data Collection

We found that the learning activity appears on the social community Facebook is mainly displayed in the concept of timeline. As time passes or if there are too many posts in Facebook, the topics discuss naturally descend quicker. The popular posts do not remain at the top of classification window or discussion area. The students' degree of interaction and information attainment are difficult to measure is because the existence of knowledge is hard to be expressed as numeral data.

In this step, we use the system logs collection module to record users' clicking and accessing event logs in the social community Facebook discussion board and the web-based computer programming IDE. Each recorded raw data comprises four information events, namely who caused the event, what the event was, when the event occurred, and the computer programming assignment when the event occurred. The system logs collection module not only recorded the events of opening and closing the social community Facebook discussion board and the web-based computer programming IDE, but also recorded the event of the mouse focusing in and out of the web-based computer-programming IDE.

By recording these events, we could understand how long a student spent accessing the learning activity and how long he/she focused his/her mouse on the computer programming assignment. The module fetches the clicking events and accessing time data sets from unstructured raw data and stores it in the semi-structured database. Moreover, we convert unstructured raw data into semi-structured database, and the semi-structured information metadata includes contents, authors, time, replied messages, likes, shares, fan page / group name, fan page / number of people, fan page / group link, and picture hyperlink icons etc. After aggregation, the semi-structured information saves at the semi-structured database.

Data Storage

We found that not all semi-structured data is useful for educational data analysis. In this step, we apply the ETL(Extract-Transform-Load) data preprocessing module to extract, transform, and load useful semi-structured information. For example, the semi-structured information contains lecture materials accessed, programming assignments accessed, Facebook posted messages accessed, and programming refinements accessed.

Data Analysis

After formation into columns, we apply the engagement measurement function (Lonn, Aguilar, & Teasley, 2015) to evaluate students' participative and interactive behaviors from lecture materials accessed, programming assignments accessed, Facebook posted messages accessed, and programming refinements accessed. Students' engagement in accessing lecture materials are evaluated when a student clicks lecture materials in the social community Facebook to read a learning material. Students' engagement in accessing Facebook posted messages are measured when a student posts a Facebook message to the learning computer programming activity for replied a posted message. Finally, students' engagement measurement values in the computer programming activity are measured from students' clicking and accessing events. We store the analytics results in the structured database for data visualization in the next step.
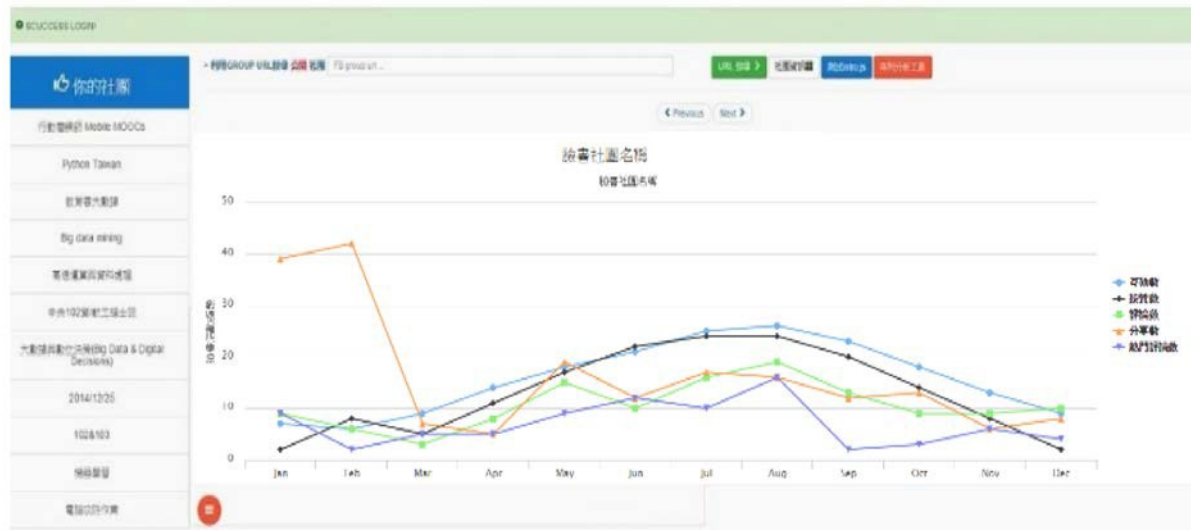
Figure 3. A weekly learning computer programming report in the visualization and monitoring user interface

Data Visualization

To both the long-term and short-term information, comparisons and analyses are made. In final step, our system generates a weekly learning computer programming report for the teacher that includes human-readable information, shown as **Figure 3**. The visualization and monitoring service presents the figures and tables through a web-based interface, which allows the teacher access to the information at any time and from any location. Therefore, the teacher understands the frequency of students' immediate uses, analysis summaries, and action changes in the learning computer-programming activity.

METHODOLOGY

Participants

In this experiment, students attend a case study of the computer-programming course supported by the social community Facebook in a university in northern Taiwan. 43 freshmen students from a class (36 males and 7 females) with an average age of 19 participate in the course entitled 'Introduction to Computer Programming'. The experiment is conducted from October to December in 2016.

In this course, the teacher has teaching experience of computer programming exceeding 6 years. The course unit contents are the data structure units of computer programming. Teaching contents and schedules of the course are according to the teacher. The goal of the course is to develop students learn the concepts of computer programming and related computer programming skills. The students use a certain level of familiarity of using the social community Facebook to undergo computer programming lessons. The social community Facebook supported computer-programming course has all coordinated teaching contents, guiding messages, and expanded teaching materials.

Procedures

In the experimental procedure, we plan 12 weeks to conduct the computer-programming activity supported by social community Facebook. The class time is 150 minutes for each week. In the first 4 weeks, the students learn the basic concept of computer programming. The teacher assigns computer programming

assignments for the students to practice after class. The students can refer to the learning materials published on social community Facebook to learn computer programming knowledge.

This experimental activity had lasted for about 7 weeks. During the activity, students read lecture materials previously provided in the social community Facebook. Students can work jointly on learning computer programming and participate in the Web-based computer-programming IDE to develop their computer programming skills. The teacher and classmates then provide suggestions for refined computer programming assignments in the social community Facebook. When students encounter problems in doing computer programming assignments, the teacher apply the social community-based learning method to intervene in the student' learning activity. After the teacher provides assistance, students learn to refine their computer programming assignment quality by developing their computer programming skills.

The teacher gives feedbacks to students and evaluated the results and the efficiency of the whole learning activity. It likes students would review contents and commented each other on social community Facebook. The students entered Facebook every week at the topic section. They would be able to see the headings of opinions posted with their names with all the students of the course and the teacher who instructed. In addition, the refinement of computer programming assignments is to improve students' learning effectiveness. Moreover, students' computer programming skills are promoted by modifying their computer programming assignment according to the suggestions from social community Facebook.

At the end of the learning activity, we collect students' learning data by recording students' clicking events and accessing time. In the final week, a computer programming test is conducted to obtain students' learning performance.

Instruments

The computer programming test used in this research is designed by the computer programming teacher who had 6 years of teaching experience. This test is conducted to obtain students' learning performance, and it consists of two parts, namely a paper-based test and a computer programming test. The paper-based test evaluates the students' cognitive levels of remembering and understanding. The students are required to answer 15 true/false questions (each correct answer = 2 points) and 10 single selection questions (each correct answer = 2 points). The total score is 50. In the computer programming test, students have to complete two computer programming assignments. The test evaluates students' cognitive levels of applying, analyzing, and integrating. The students are awarded 25 points for each correctly completed computer programming assignments. The total score of the computer programming test is 50. The computer programming test score equals the sum of the scores of the paper-based test and the computer programming test. The Kuder-Richardson Formula 20 (KR-20) reliability test is used to estimate the computer programming test data (Wang, Feng, Jiang, & Liu, 2012). The Cronbach's α value is 0.78, indicating high reliability.

Data Collection and Analysis

There are three kinds of data collected, namely web-based computer-programming IDE system logs, social community Facebook system logs, and students' learning performances. To analyze the data, we apply the clustering method to generate three clusters based on the data analysis step for learning analytics. To compare the students' participative and interactive behaviors and students' learning performances among the three clusters, we use the IBM SPSS software to analyze students' participative behavior data. Before analysis, the dependent variables are checked for normal distribution and homogeneity of variance. All variables violated the assumption of normality, as assessed by a Shapiro-Wilk's test ($p < .05$). To address these violations, and for the sake of consistency, the Kruskal-Wallis nonparametric test is used. The post-hoc test is performed using the Mann-Whitney U test.

The system logs and data provide statistical information for each student on the quantity of lecture materials accessed, the time spent of lecture materials accessed, the quantity of computer programming

Table 1. Descriptive statistics of students' engagement behavioral variables

No.	Variables	Mean	S.D.
1	Time spent accessing lecture materials (second)	5376.36	4698.94
2	Number of lecture materials accessed	36.32	15.32
3	Time spent accessing computer programming assignments (second)	1358.39	1123.68
4	Number of computer programming assignments accessed	20.19	16.86
5	Time spent accessing Facebook posted messages (second)	342.64	467.32
6	Number of Facebook posted messages accessed	18.52	13.82
7	Time spent accessing computer programming refinements (second)	9225.85	6797.75
8	Number of computer programming refinements accessed	36.43	15.68

assignments accessed, the time spent of computer programming assignments accessed, the quantity of Facebook posted messages accessed, the time spent of Facebook posted messages accessed, the quantity of computer programming refinements accessed, and the time spent of computer programming refinements accessed.

1. The quantity of lecture materials accessed is defined that the number of times that a student accesses the lecture materials.
2. The time spent of lecture materials accessed is defined that the amount of time a student spends to access lecture materials.
3. The quantity of computer programming assignments accessed is defined that a student accesses the computer programming assignments to complete it.
4. The time spent of computer programming assignments accessed is defined that the amount of time a student spends to complete computer programming assignments.
5. The quantity of Facebook posted messages accessed is defined that a student posts a Facebook message to the Facebook discussion for replied a posted message.
6. The time spent of Facebook posted messages accessed is defined that the amount of time a student spends to access Facebook messages and reply posted messages.
7. The quantity of computer programming refinements accessed is defined that a student accesses the computer programming assignments to improve it.
8. The time spent of computer programming refinements accessed is defined that the amount of time a student spends to refine computer programming assignments.

The statistical information helps us to understand students' participative and interactive behaviors and the learning performance data contributions of each student.

RESULTS

Descriptive Statistics of Students' Participative Behaviors

During the 12-weeks experimental activity, all students accessed lecture materials, accessed computer programming assignments, accessed Facebook posted messages, and accessed computer programming refinements. **Table 1** shows the means and standard deviations of the variables related to students' participative behaviors in the computer-programming activity supported by social community Facebook. As the descriptions in **Table 1** indicate, the students spend most of their time accessing computer programming refinements, followed by read lecture materials, understood programming assignments, and posted Facebook messages.

The Differences in Participative Behaviors and Learning Performance

We classify the students with similar participative behavioral variables into a homogeneous group, the clustering method for learning analytics is performed on four variables, namely time spent accessing lecture materials, time spent accessing programming assignments, time spent accessing Facebook posted messages, and time spent accessing programming refinements. Before using the clustering method, four variables are transformed

Table 2. Students' participative behaviors and learning achievements among three clusters

	Intensive Use		Short Use		Regular Use		Kruskal-Wallis Test	Post-hoc Test
	Mean	S.D.	Mean	S.D.	Mean	S.D.	p	
Number of lecture materials accessed	43.13	14.32	17.86	14.23	33.32	14.12	0.000**	cluster1>cluster2** cluster1>cluster3* cluster3>cluster2**
Number of computer programming assignments accessed	31.21	16.86	6.91	6.27	17.48	11.32	0.000**	cluster1>cluster2** cluster1>cluster3** cluster3>cluster2**
Number of Facebook posted messages accessed	28.32	15.82	7.68	10.28	11.31	11.23	0.000**	cluster1>cluster2** cluster1>cluster3** cluster3>cluster2*
Number of computer programming refinements	42.32	13.74	44.83	8.13	35.62	12.56	0.000**	cluster1>cluster2** cluster3>cluster2**
Learning performance	53.12	20.13	36.42	27.67	56.29	19.40	0.036*	cluster1>cluster2* cluster3>cluster2*

*p<0.05, **p<0.01

in order to reduce the bias in the proposed learning analytics method (Lust, Vandewaetere, Ceulemans, Elen, & Clarebout, 2011).

The 33.33% lowest, intermediate, and highest time durations are allocated a value of 1, 2, and 3, respectively, indicating low, moderate, and high accessing time. After using the clustering method, the three clusters are generated. 15 students in the "intensive use" cluster spend more time accessing lecture materials, programming assignments, and Facebook posted messages than the students in the other clusters. 14 students in the "regular use" cluster spend more time accessing programming refinements than students in the other clusters. However, 14 students in the "short use" cluster spend less time accessing any lecture materials, programming assignments and programming refinements than the students in the other clusters.

Because the "short use" cluster accesses computer programming assignments and Facebook posted messages significantly fewer times and spends a shorter time accessed lecture materials, computer programming assignments, and posted messages than the students of the "intensive use" cluster and the "regular use" cluster. Moreover, the "regular use" cluster spends significantly longer average time on each access of students' participative behaviors, and spends marginally significantly longer students' participative behaviors and students' learning performances than the "short use" cluster. In addition, the "intensive use" cluster accesses significantly more times and spends longer accessed lecture materials, computer programming assignments, Facebook posted messages, and computer programming refinements than the "short use" cluster. In **Table 2**, the result gives us a clearer understanding of students' participative behaviors among the three clusters.

In order to explore students' participative behavioral variables and learning performances among the three clusters, we apply the Kruskal-Wallis test to compare the three clusters in terms of the quantity of students' participative behaviors and the average time spent on each student's participative behaviors. **Table 2** indicated that students in the three clusters significantly demonstrate different participative behaviors and learning performances in the learning activity. After using Kruskal-Wallis test, we apply the post-hoc test to demonstrate statistical significances existed in all comparisons except in the following cases, namely the quantity of lecture materials accessed, the quantity of computer programming assignments accessed, the quantity of Facebook posted messages accessed, the quantity of computer programming refinements accessed, and students' learning performance, as shown in **Table 2**. When Kruskal-Wallis test is conducted, we examine whether the three clusters are different in terms of students' engagement behaviors and learning performance. The result shows significant effects of the three clusters on students' learning performance (χ^2 (2, N=43) =32.231, p=0.036). After using post-hoc test, we reveal statistically significant differences in all comparisons.

CONCLUSIONS AND DISCUSSIONS

In this paper, we propose four steps for learning analytics to explore the influence of students' engagement behaviors on students' learning performances. A 12-weeks case study observes students to attend the computer-programming course supported by social community Facebook. We examine whether students' participative behaviors are different in terms of students' learning performances. Therefore, we address two research questions.

For the research question 1, students attend the computer programming course supported by social community Facebook to find several interesting results based on **Table 1**. The experimental result indicates that students access computer programming refinement processes more often and, on average, spend more time on each access than they do for the other participative behaviors. This result may represent that the students more frequently improve computer programming errors that are directly associated with students' background knowledge. These findings are also consistent with the results of previous studies (Hou, Chang & Sung, 2010; Wang, Li, Feng, Jiang, & Liu, 2012; Lonn, Aguilar, & Teasley, 2015), which found that students' participative behaviors can be promoted through the proposed social community-based learning method. Moreover, students do computer programming assignments more often than other computer programming IDE tools (Lust, Vandewaetere, Ceulemans, Elen, & Clarebout, 2011; Wang, Li, Feng, Jiang, & Liu, 2012; Lonn, Aguilar, & Teasley, 2015). Students can post messages in the Facebook discussion. However, the number of Facebook posted messages accessed is lower than the number of other participative behaviors that are accessed. The reason for the fewer times accessing Facebook posted messages may be that Facebook provided the notification page and discussion function where students could access how many posts they had not viewed. Therefore, the teacher delivers posted messages by Facebook. However, students only respond to teachers' messages, and they do not check other students' questions and new posts.

For the research question 2, we found that students' participative behaviors are related to students' learning performances. We apply the clustering method for learning analytics based on students' engagement behavioral variables to classify the students with similar participative behaviors into distinct groups. **Table 2** shows three clusters, namely the "intensive use" cluster, the "short use" cluster, and the "regular use" cluster are generated. The "short use" cluster performs fewer times and spends a shorter amount of time accessing any of the four kinds of students' participative behaviors compared with the two clusters "intensive use" and "regular use". The two clusters "intensive use" and "regular use" spend the same total amount of time accessing the four types of students' participative behaviors. However, the "intensive use" cluster significantly performs more times and spends more time accessing the lecture materials, computer programming assignments, and Facebook posted messages than the "regular use" cluster, who in turn spend significantly longer on each access and spend marginally significantly longer total time accessing computer programming refinements than the "intensive use" cluster. The results indicated that the students actually demonstrated very different behavior patterns and learning outcomes in the computer-programming activity.

In addition, we found several interesting results in **Table 2**. First, 28% of the students in this study are labeled as "short use" as they infrequently accessed lecture materials, computer programming assignments, and Facebook posted messages. We found that there is a high percentage of students who do not access or who infrequently accessed the online learning tools and resources. Second, we found that the students who had intensively engaged in accessing learning tools and resources could be divided into two types: intensively using all learning tools and resources ("intensive use") and selectively intensively using some learning tools and resources ("regular use"). When Kruskal-Wallis test and post-hoc test are conducted, we found that students' participative behaviors and learning performances among the three clusters are significantly different. The result indicates that the participative behaviors of students are associated with learning performances. In particular, the "intensive use" cluster and the "regular use" cluster obtain significantly higher achievement scores than the "short use" cluster. The result indicates that the students who invest more time and effort in the computer programming activity had better learning effectiveness.

According to our findings, we provide several suggestions for teachers, researchers, and system designers based on our findings. Students' participative behaviors actually affect their learning performances. In particular, the "short use" cluster is lower learning effectiveness. The results suggest that instructional and system designers should devise strategies for motivating students to engage in the computer programming activity supported by social community Facebook. For example, the teacher can send Facebook messages or emails to remind students which doing computer programming assignments they have not accessed, or to recommend Facebook posted messages that can help them complete their computer programming assignments or achieve a higher score in the computer programming outcomes. In addition, the teacher can embed interactive tasks, such as answering questions, in the computer programming course supported by social community Facebook to engage students in accessing them.

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