Analysis of learning behavior in a flipped programing classroom adopting problem-solving strategies

Tosti Hsu-Cheng Chiang

To cite this article: Tosti Hsu-Cheng Chiang (2017) Analysis of learning behavior in a flipped programing classroom adopting problem-solving strategies, Interactive Learning Environments, 25:2, 189-202, DOI: 10.1080/10494820.2016.1276084

To link to this article: http://dx.doi.org/10.1080/10494820.2016.1276084

Published online: 19 Feb 2017.

Article views: 33

View related articles

View Crossmark data
Analysis of learning behavior in a flipped programming classroom adopting problem-solving strategies

Tosti Hsu-Cheng Chiang
Graduate Institute of Mass Communication, National Taiwan Normal University, Taipei, Taiwan

ABSTRACT
Programing is difficult for beginners because they need to learn the new language of computers. Developing software, especially complex software, is bound to result in problems, frustration, and the need to think in new ways. Identifying the learning behavior behind programing by way of empirical studies can help beginners learn more easily. In this study, a flipped classroom combined with the blended learning mode was adopted by switching the in-class instructional time and the out-of-class edX lecture time. The research laboratory developed a system that collected the teacher and students discussion activities when adopting problem-solving strategies in online discussion. The participants were 44 third-year college students from the computer science course of a university in northern Taiwan. The experiment was from 30th March to 4th May in 2015. A total of 120 initial comments were collected, along with 401 responding comments. These 521 comments were coded according to the problem-solving steps as posing questions, offering solutions, discussion, and sharing conclusions. The inter-rater reliability of the two coders reached a kappa value of 0.81. The results indicated that the flipped classroom combined with the problem-solving strategy was more effective than the previous problem-solving behavior sequence.

ARTICLE HISTORY
Received 24 March 2016
Accepted 1 August 2016

KEYWORDS
Problem-solving strategy; lag sequence analysis; flipped classroom; content analysis; edX online learning

Introduction
What is the learning behavior which underlies programing learning? How can learning programing be improved and made easier? There is no denying that, along with many other facets of modern life, the use of technology has become common throughout the world. Developing technology needs programmers. However, programing is difficult for beginners because they need to learn the new language of computers, including the vocabulary, grammar, logical operators, methods for solving errors, etc. Developing software, especially complex software, is bound to result in problems, frustration, and the need to think in new ways. Identifying the learning behavior that underlies programing via empirical studies can help beginners learn more easily.

In the traditional discussion method, students sought the instructor after class to discuss the topics covered in class, or groups of two or more students shared their thoughts through small collaborative interactions in oral discussions in order to solve problems (Sung & Hwang, 2013). In such collaborative learning, the students needed to have mutual trust and to feel a certain degree of warmth and belonging so that they would feel connected with each other. Only then would they feel that collaboration was a worthy educational experience (Kreijns, Kirschner, & Jochems, 2003).

As technology has developed, however, students have started to use discussion boards, similar to social network groups or BBS, to search for problem-solving methods or to engage in conversations.
Because these conversations take place in cyberspace, the students tend not to have so many reservations about interacting due to feelings of unfamiliarity, strangeness, or lack of communication. Therefore, those students who are shy or independent are more able to communicate with others via discussion boards. Although there is no real-life interaction, the students can develop mutual support and learning through online discussion boards, leading to a valuable educational experience (Reynolds & Anderson, 2015). Hence, this research provides an analysis method for Computer-Supported Collaborative Learning (CSCL).

In recent years, it has become common for problem-solving strategies to be applied to learning, and these strategies have become a popular topic in educational research. Through problem-solving strategies, students are able to raise questions, collect information, discuss their findings, and share their conclusions. This improves and develops their ability to solve problems (Krawec, Huang, Montague, Kressler, & Melia de Alba, 2013). Because of technology development, many instructors now require that students use a discussion board and commonly apply it to their practical learning (Venkatesh, Croteau, & Rabah, 2014). Many studies have also examined the benefits of discussion boards in education (Oztok, Zingaro, Brett, & Hewitt, 2013). Based on these benefits, the combination of online discussion and problem-solving strategies is able to establish a basis for online problem-solving learning activities. During class, instructors define the problem scope and allow the students to raise related questions. Subsequently, the students are able to use the Internet to collect information, and use online discussion to find possible solution proposals and share solution plans. This encourages the students to solve various problems and develop their knowledge; moreover, through this process, the instructors provide appropriate guidance to improve the quality of the student discussions.

Massive Open Online Courses (MOOCs) are large-scale free online courses. These courses are separated into numerous 5–10-minute video segments between written paragraphs, and provide instant online discussion and feedback, online peer cooperative learning and discussion, and online virtual test exercises and assessment. Many researchers have examined the educational benefits of MOOC learning activities (Cruz-Benito, Borrás-Gené, García-Peñalvo, Blanco, & Therón, 2015; Fidalgo-Blanco, Sein-Echaluce, García-Peñalvo, & Escaño, 2014).

Lai and Hwang (2016) emphasized that a self-regulated flipped classroom approach can improve students’ learning performance. Moreover, the problem-solving and personalized interaction that take place face-to-face sets these classes apart, making them more effective than MOOCs (Margaryan, Bianco, & Littlejohn, 2015). edX is a MOOCs provider. The edX offers free online courses and classes. Find the latest MOOCs from the world’s best universities including MIT, Harvard, Berkeley, UT, and others. In this study, a flipped classroom combined with the blended learning mode was adopted by switching the in-class instructional time and the out-of-class edX lecture time. The teacher encouraged the students to contribute to the collective knowledge of their classmates.

This research infers the timing point for the instructors’ interactive discussions and directive strategies, allowing the behavior model to increases its analysis value. However, in comparison with other research methods, lag sequential analysis has detected more student online discussion sequential models in this context (Wu, Chen, & Hou, 2015). This method is able to examine every discussion behavior related to a sequence, and whether or not it has significance. This approach is now increasingly being used to analyze online discussions (Hou, Chang, & Sung, 2007).

In this research, students’ collaborative learning processes were observed through discussion boards, and according to some research and analysis dissertations, the discussion content becomes encoding format for encoding (Yang, Chen, & Hwang, 2015), and through lag sequential analysis (Hou & Wang, 2015). It is possible to infer the entire student online discussion sequence, and it detects the highest behavior model frequency.

The tools used in this research are a self-developed online discussion board and a chat room. The students were able to discuss the course content on the discussion board and chat room simultaneously after participating in the edX classes. Through instant online chat, the students could
immediately solve the problems they encountered in the class. This model is similar to a small reading group, and the instant discussions helped the students to solve their problems or exchange information.

The first problem that appeared in this designated system was how to conduct it with the edX class at the same time. If, after the edX class, the students went to the system and could not find any class-related discussion, or could not open any class-related discussion group, they would not feel connected to the discussion group and would feel discouraged. Therefore, the edX class information needed to be regularly transferred from the edX system platform to our own platform. This would thus become a heterogeneous platform and create a different database problem. In order to solve this problem, it was necessary to write a Java Quartz and use Jsoup to retrieve the edX class information through HTML and transfer it to the database. This information retrieval process happened at 12:00 am every day, so that the students could find the related class material and use the discussion room.

To enable the students to more easily log into the system, a direct Facebook SDK communication function was developed, and, with the RestFul technology, it retrieved student account information, a photo URL, and imported them into the database. Therefore, the students did not have to be registered members of this development platform. Directly through Facebook, they could easily enter into the system to use the discussion board and chat room. In addition, there was a text editor for posting comments, so there needed to be an applied editing tool (WYSIWYG text editor), like a text editor in Microsoft Word that allowed the use of a variety of fonts, boldface, indentation, tables, an insert picture function, etc. which was easy for the users to use.

The discussion board displays also required some attention. The discussion threads needed to be displayed as a jQuery Treeview, or else the screens would be mixed with a main screen and a sub-screen.

The benefits of selecting Java as a development tool are: (1) the Java web application has been available for many years, and using Java shortens the development time and reduces the learning time; (2) the setup of the operating system is Linux, and Java is a cross-platform programing language. Regardless of which operating system is installed, Java Virtual Machine (JVM) will be able to translate the Java language into any operating system’s applicable machine language; and (3) because Java is based on object-oriented (OO) language, it can use object properties, polymorphism, inheritance technology, coupled with the Java Web framework which provides many useful Application Programming Interfaces. It makes it easier to design and develop systems, follow the framework structure, and write compliant systems.

This experiment used Model-View-Controller (MVC) as the infrastructure, because MVC is currently the most popular technology in the industry. Whether it is Java, PHP, ASP.net, Rails, etc., each programming language uses MVC as one of the most basic frameworks. The main advantages of MVC is its separate interface logic, program control logic, and database logic. The traditional approach was to put the program logic of the system picture and of the database into the same program, which would cause maintenance problems that could easily destroy the entire system. This was the reason for the birth of the MVC framework, the purpose of which is to clearly partition the program logic. M is the Model, the primary store information from a database; V is View, mainly to show the system screen; and, C is the Controller, that is, the program logic controller. Through the MVC framework, it is easier to plan how to partition the system. Java web application programs of the most popular MVC framework apply Struts and Spring. This research chose the Spring Web Framework as the web application system framework. Other than the fact that Spring is the most popular framework, it also provides other services such as transaction management, web application development, data access, JUnit tests, Tiles, Upload file, etc., which makes the development system more productive.

The research questions of this study are as follows:
Perform online problem-solving learning activities and observe students’ online problem-solving processes. During the discussion, provide no instructor intervention or guidance.

Combining lag sequential analysis and content analysis, analyze the sequence model of the students’ problem-solving discussions.

Observe the limitations of the students’ discussions, and, according to the results and strategy recommendations, provide the instructor with instructions on when to intervene.

Literature review

Collaborative learning

Collaborative learning refers to a group of two or more people interactively learning from each other (Barkley, Cross, & Major, 2014). Studies have shown that the most effective way of learning is when students in pairs or small groups learn from each other, verbalize each other’s ideas, challenge other people’s ideas, or through interactive collaborative learning, solve problems (Herrington, Reeves, & Oliver, 2014). Through working together in small groups to interact, learn, and motivate each other, students can develop a higher level of academic achievement and the skills required for a successful career (Joseph & Payne, 2003).

CSCL includes distance education, collection of messages, and the sharing of messages (Jacko, 2012). From educational learning and developers’ perspectives, the collaborative learning method tends to encourage the establishment of knowledge, a deep understanding, and a development of the future career technology in the learning process (Jara et al., 2009). Based on the relevant research, collaborative learning has been successfully implanted in the traditional teaching environment.

Collaborative learning can be divided into five approaches: discussion with each other, teaching each other, problem solving, the information through graphic organizers, and shared authorship (Huang, Liao, Huang, & Chen, 2014). According to the above, these approaches can be used independently of each other, but can also be used together. According to this theory, students’ knowledge is developed through a given topic and through teaching others (Sung & Hwang, 2013). The benefits include listening, encouragement, participation, and expressing empathy. Team members must work together as a team to accomplish a common goal. Each student needs to rely on others for assistance, as no student can do it alone. This design facilitates interaction among all students in the class and guides them to value each other’s contributions in a common task. The goal of this technology is to make students familiar with the problem structure and characteristics, resulting in in-depth discussion. In a debate environment, by observing the student group activities, one can get the necessary skills and increase one’s knowledge. The students, through their relationships with others, exchange experiences, ideas, and theories. By these means, they can identify multiple dimensions of the issues to debate, or think of different opinions and thus strengthen their thinking skills. Therefore, they can develop their problem-solving skills and get better at helping others.

The experiment in this study used collaborative learning theory applied to problem-solving strategies in an online discussion. Students used writing to express each other’s ideas and to challenge each other or other people’s thoughts. Through collaborative interactive learning to solve problems, students share knowledge and encourage mutual knowledge establishment, and can therefore interact and exchange ideas with each other as teachers to practice problem-solving strategies.

Problem-solving strategy

Problem solving is often used in collaborative learning as a teaching strategy. Different scholars define problem-solving methods in different ways, leading to different approaches (Savery, 2015). Gagné (1980) argued that the problem-solving process combines past knowledge and experience
to solve new problems, while Mayer (1985) believed that problem-solving was a process of an initial state transferring to the goal state, and proposed that it was a cognitive process combined with the behavior of an individual to find a solution using past experience. Hatch (1988) defined the problem-solving process as finding a suitable solution to a problem, while Rowe and Lester (2015) considered problem-solving as a process of finding a conclusion in time of removing difficult points.

Through problem-solving strategy learning, the students can ask questions, gather information, discuss with each other, come up with a solution, and share conclusions. This further develops the students’ abilities to solve problems using discussion boards and problem-solving strategies to form online problem-solving strategies (Demiraslan Çevik, 2015).

Since the development of this learning technology, it has been widely used in actual learning environments by instructors who ask the students to engage in asynchronous online discussions. Many researchers have also found the benefits of asynchronous discussion, whereby combining online discussion and problem-solving behavior can form an online problem-solving learning activity (Gao, Zhang, & Franklin, 2013; Nandi, Hamilton, & Harland, 2012). In such learning activities, the instructors can define the scope of the problem and allow students to ask each other questions. Then the students can collect information from the Internet to discuss possible solutions to the problem, and can then share their solutions to come to a conclusion. This process encourages the students to solve problems and build their knowledge.

In order to design a more appropriate online problem-solving discussion activity, the key is for the instructors to appropriately lead and strategically intervene (Wise, Zhao, & Hausknecht, 2013). The instructor should know how to diagnose the condition of the learners’ discussion and whether to issue appropriate comments to guide the students properly in order to solve the problem. This is an important issue worth studying. In order to solve this problem, one needs to observe the learners’ discussion process to understand the limitations of the discussion, and to develop a systematic instructional strategy.

Lag sequential analysis applications can better infer the sequential patterns in students’ online discussions, and can be used to individually examine and observe whether each discussion behavior in a sequential pattern is significant (Chiang, Yang, & Hwang, 2014). In this study, lag sequential analysis was adopted to analyze the students’ problem-solving sequence patterns once the students’ online discussion content had been coded. The encoded information was processed for content analysis and then sorted into chronological order. Then, according to the topic order, patterns of behavior were inferred via lag sequential analysis. A sequence pattern diagram was produced to serve as a basis for inferences after some verification, and was useful for explaining the students’ problem-solving strategies, as every action sequence identified by the statistical analysis could be used as a reference for subsequent discussion and recommendation.

**Instrument**

**Platform structure design and implementation**

According to the experimental system structure as shown in Figure 1, when the students had questions in class and needed to seek help regarding their online learning on edX, they could log into the system developed in this study to use the discussion board and chat room for discussion with their classmates. The system was synchronized with the new classes from edX so that the users would see the latest course discussion board when they signed in. The focus of this paper is experimental online tutorials for edX’s Introduction to Programming with Java course.

The students could instantly chat in the chat room, and discussions could also be held on the asynchronous discussion boards. The operating system of this structure is Linux; the server is Tomcat; the database is MySQL; Object-relational mapping’s database object is DBTool; the framework is Spring; the template is Tiles; and the application layer part is Quartz; FB SDK, Log4j, Session Interceptor,
JsoupJUnit Test, Ckeditor, jQuery Treeview (Figure 1). The MVC structure was used to partition the web page from the program logic using DBTool to turn it into data structure objects inside of DB.

This experiment used Spring as the Framework structure. Tiles separate the web graphic design from the program design. Session intercept managed abnormal user procedures when logging in and out. The system used Java Quartz via a web analysis tool (Jsoup) to retrieve the edX course material and upload it to the experimental database each day. The sign-in modes used FB SDK, and the students did not need to register an account but could use their FB account login. jQuery Treeview allows a discussion thread in a tree structure. Log4j records system logs or error messages. JUnit Test Case is the unit test element. Ckeditor is a Chinese webpage processing tool. Jsoup retrieves and deposits a complete database of class courses through the web page modus to save the list of classes.

The tool used for the experiment is a self-developed online discussion board. After taking the MOOC classes, the students could use the discussion board for after-class discussion or use the chat room to synchronize the discussion. Online instant discussion allows the students to resolve any problems they face in class. This model is like a small reading club, and the small group uses instant discussion to solve problems or to exchange information.

Methodology

The participants of this analysis were 44 third-year students from the Computer Science and Information Engineering Department of a university who were studying OO analysis and design. There were 31 males and 13 females aged between 21 and 22 years. The experiment was conducted from 20th April to 29th May, 2015, a total of six weeks. The edX online course was: Introduction to Programming with Java Part 1. The tool used as the discussion board was developed specifically for this study. The students learned from edX before the class. The three hours of the class were then used for solving problems that they encountered with edX, and there was no lecture lesson.

In this study, the coding program was modified from Hou, based on the problem-solving strategies applied to an online discussion board encoding program. This is a reference to Hou’s problem-solving encoding program in 2009, as shown in Table 1, and is divided into five phases (Hou, Chang, & Sung, 2008). In P1, when the students watch the edX course videos they can ask or clarify questions on the forum. In P2, the students provide information or possible solutions to the problem (part of the problem or all of the problem). In P3, the students compare, analyze, and discuss answers given by others. In P4, the students conclude everyone’s answers to come to a
general conclusion. In P5, the students post some unrelated comments. These five phases were analyzed and researched using coding principles to encode the discussed content. Sorted by time sequence according to the discussion threads generated by the lag sequential analysis, we could identify the significant sequences from the statistical data. After a certain deduced coding, the result is usually accompanied by a code based on the observation of the more significant behavior patterns of the students' problem-solving strategies.

When the course started, the teacher used 30 minutes to introduce the edX course, “Introduction to Programing with Java Part 1” and then asked the students to watch the course videos. The teacher encouraged the students that if they had learning problems, they could use the discussion board to ask questions, and discuss and share their solutions. The teacher's assistants showed the students the web forum, the operating instructions, and the functions of the forum. They also taught the students how to register accounts and post comments or reply to them. This helped the students to clearly understand how to use the system. They could use the discussion board to ask questions, propose answers, discuss, and generate conclusions. Then, every week the students would spend three hours on the edX class and use the discussion board to discuss confusing materials, and the teacher would use the class time to solve their problems on the forum and give them new problems to discuss and solve. The experimental flowchart is given in Figure 2.

After five weeks, the total number of comments collected that related to the topic was 120, while there was a total of 401 responding comments. The comments on the discussion board were placed in sequence based on the topics, such as a discussion topic “Question about hascode and equals problems” (Figure 3, discussion thread), for which there were six responding comments. Therefore, there were a total of seven comments for this topic including one question and six responses. The comments were sorted according to the time when a question was asked and coded according to the comment content. The coding rules for each article are listed in Table 1, behavior mode coding. The coding sequence formed a p1p2p3p1p2p2p3 series of sequence encoding, and then the sequence analysis tool GSEQ was used to calculate the number of the encoding, an event transcoding frequency table and the $z$-score value.

Table 1. Problem-solving strategy coding principles.

<table>
<thead>
<tr>
<th>Code</th>
<th>Phase</th>
<th>Description</th>
<th>Discussed example</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Asking questions</td>
<td>Asking questions or clarify questions</td>
<td>I want to use for each() to display the maximum value of various data types, but the result is the sum of the string in the case?</td>
</tr>
<tr>
<td>P2</td>
<td>Provide solutions and information</td>
<td>Provide information or possible solutions to the problem (part of the problem or all of the problem)</td>
<td>The direction I can think of is “reflect”. Just write two or three lines on it</td>
</tr>
<tr>
<td>P3</td>
<td>Compare, analyze, and discuss answers made by others</td>
<td>Compare and analyze answers from others, or comment on answers made by others</td>
<td>Reflect (java.lang.reflect method, array, class, constructor, etc.) Anything plus String would be addstring (like calling these types of toString(), if the value of calling the function class “toString()” is none, then return the memory address). I am not sure the function of “reflect”, but it seems that many things are commonly used with reflect (java.lang.reflect includes method, array, class, constructor, etc.)</td>
</tr>
<tr>
<td>P4</td>
<td>Result in a conclusion</td>
<td>Conclude with everyone's answers and a result in a conclusion</td>
<td>It is correct that your (Dada's) method can print out the maximum value of all data types. But if you just want to print all, it does not seem to need to be used for &amp; with the switch approach.</td>
</tr>
<tr>
<td>P5</td>
<td>Other</td>
<td>Other unrelated comments</td>
<td>Thank you for your answer!</td>
</tr>
</tbody>
</table>
Results and discussion

Coded discussion

In this study, two experts performed the coding (Figure 4) using GSEQ version 5.1. The kappa value of their inter-rater reliability was equal to 0.81, which is acceptable since it is greater than 0.7.

According to the results of Figure 4, distribution of the quantitative content analysis, it was found that P1 constituted 32.44% of the total comments while P2 constituted 46.26%, a combined total of
nearly 75.1%; it can therefore be seen that P1 and P2 constituted the majority of the discussion behavior. This shows that most students liked to pose questions and share their opinions and possible solutions. From the pie chart in Figure 4, it can be seen that P2 constitutes the greatest proportion of the comments, with a total of 241 (refer to Figure 4, encoded number). In comparison, P3 constitutes only 8.83% of the entire pie chart. This means that only 8.83% of the comments in the online forum tended to discuss ideas, opinions, and information related to the issues. As for P4, 5.57% of the comments generated conclusions, which is higher than that recorded by Hou, Chang, and Sung (2008). This is because, during the observation, the students who asked questions mostly used others’ responses to generate their own conclusions, while some students took the initiative to integrate and continue seeking to understand the problem thoroughly.

In the present study, it was found that some of the students who asked questions, in the end, would respond to others to thank them. In this experiment this behavior was classified as P5, which had a total of 36 comments (refer to Figure 4, encoded number) or 6.91% of the total, most of which were comments of appreciation, such as “Thank you for your answer!” while the others were irrelevant remarks in the discussion thread.

**Event transcoding frequency table**

In Table 2, the event transcoding frequency table, the leftmost vertical column P1, P2, P3, P4, P5 is the sequence starting action, while the first horizontal row P1, P2, P3, P4, P5 is the sequence ending action.

<table>
<thead>
<tr>
<th>Times</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>z-score</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>5</td>
<td>137</td>
<td>6</td>
<td>2</td>
<td>13</td>
<td>-6.03</td>
<td>10.89*</td>
<td>-1.62</td>
<td>-1.95</td>
<td>1.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>27</td>
<td>87</td>
<td>27</td>
<td>21</td>
<td>14</td>
<td>-4.6</td>
<td>0.24</td>
<td>2.73*</td>
<td>3.41*</td>
<td>0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>3</td>
<td>10</td>
<td>15</td>
<td>3</td>
<td>5</td>
<td>-2.52</td>
<td>-1.58</td>
<td>6.79*</td>
<td>0.75</td>
<td>1.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>-2.33</td>
<td>-1.98</td>
<td>-0.68</td>
<td>0.69</td>
<td>1.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>5</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>-1.33</td>
<td>-1.63</td>
<td>-1.56</td>
<td>0.38</td>
<td>-0.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 4. Distribution of the quantitative content analysis.*
action. For example, from P1 (left column first code) to P2 (the first row second code), there is a total of 137 sequence codes represented as $P1 \rightarrow P2$.

From Table 2, we can see what kind of behavior led to what kind of behavior with a higher frequency. The table indicates that $P1 \rightarrow P2$ (“ask questions” to “provide solutions, information, opinion”) has the highest frequency with a total of 137 times. $P2 \rightarrow P2$ also has a very high frequency of 87 times. From the above two results, it was found that the students liked to offer their opinions, information, and possible solutions in response to their classmates’ questions or problems, which is consistent with the findings of Hou, Chang, and Sung (2008).

Through $P1 \rightarrow P2$ or $P2 \rightarrow P2$, the students could promote the issues discussed and then produce a $P3$ and $P4$. $P2 \rightarrow P1$ has a frequency of 27 times. After careful analysis, we found that most of the students who asked questions would pose other questions, or would continue to clarify the issue when they found gaps between others’ answered contents and their own thoughts after receiving others’ responses.

$P2 \rightarrow P3$ has a frequency of only 27 times. This tells us that the students did not usually challenge, refute, analyze, or compare with other people’s views during the online discussions. $P2 \rightarrow P4$ has a frequency of 21 times. In addition to the students summarizing a question in the conversation, others may also conclude with problems. In this experiment, there is not necessarily a limit in which the author of the original question concludes the conversation. As for $P3 \rightarrow P2$ (“puzzled by others responses” to “provide information and answers”), it has a frequency of 10 times.

**Behavior transition diagram**

For behavior transition, a value of 1.96 or more is needed to achieve significance. The values for the identified transitions, as shown in Table 2, are as follows:

- $P1$ (ask questions) -> $P2$ (provide a solution): 10.89
- $P2$ -> $P3$ (discuss, analyze, and compare the views of others): 2.73
- $P2$ -> $P4$ (generate conclusions): 3.41
- $P3$ -> $P3$: 6.79

Based on the above significant values, a behavior transition diagram was drawn, as shown in Figure 5, which shows those sequences which reached a significant effect; the thicker the lines, the higher the significance value. The $z$-value on the line is calculated according to the adjusted residuals table, and each arrow is pointing to an event.

According to Table 2, the adjusted residuals table, and Figure 5, we can draw the significant behavior modes as: $P1 \rightarrow P2$, $P2 \rightarrow P3$, and $P2 \rightarrow P4$, $P3 \rightarrow P3$. We can use the above results to observe the most common behavioral transfer sequences on the online discussion board.

**Figure 5.** Behavior transition diagram.
From the results of Figure 5, we can see that P1 → P2 is the most significant pattern, meaning that almost all of the “ask question” behaviors led to “provide solutions, provide opinion” behaviors.

P2 → P3 represents the respondents’ “provide solutions”, and the next response is often “discuss respondents’ views and opinions given”. P2 → P4 is also listed as one of the significant patterns, which can be observed in the behavior of the discussion board. Students used all methods and responses provided by everyone to select and generate a better response for their conclusions.

P3 → P3 results in high significance. The reason for this is because, when a student responded to another’s answer, the next student would respond to the previous respondent’s answer with doubts and so offered his/her own thoughts. This could mean that everyone enjoyed the heated debate and might focus on the discussion (P3), but they did not come to a definitive conclusion (P4) at the end of the discussion.

We also found that some of those who asked questions did not take the initiative to do the final organization and come to conclusions. Even when the original questioner responded to the content of the original question, it was usually toward others’ responses with doubts. Then the discussion thread was too long, and the original questioner kept extending the question with further questions which would cause a lack of conclusion or lack of interest in responding. A frequent sequence is: ask question P1 → provide solution P2 → provide solution P2 → analyze and discuss others’ opinions P3 → provide solution P2 → analyze and discuss others’ opinions P3.

We also found that most of the respondents did not express opinions on others’ responses, but only provided answers to the original question, and they finally generated conclusions from the answers provided. Therefore, the sequence showed P1 ask question → P2 provide solution → P2 provide solution → P4 generate conclusion. According to this sequence, it is found that if the respondents had no opinion regarding others’ answers, then the resulting sequence would not include P3.

If a respondent’s solution was a unanimously recognized one, or if there was no better solution, or no need for further discussion, then it was difficult to extend from P3 → P4. The reason is that the question had an obvious answer from the beginning.

Often after the conclusion had been reached, the author still wanted the original problem to be extended to other questions. Then P1 regenerated questions → P2 provide solution → P3 analyze, compare, and discuss would follow P4 generate conclusion. Then the sequence would be P1 ask question → P2 provide solution → P3 analyze, compare, and discuss other people’s opinions → P4 generate conclusion → P1 regenerate questions.

P5 being insignificant is a good sign, as it means that the students were seriously discussing the problems raised, and tended not to make irrelevant remarks.

Conclusion

P1, P2 represented most of the comments

Most of the discussion consisted of P1 (ask questions) and P2 (provide answer, opinion, and information), where P2 accounted for most of the comments. Compared with the findings of Hou, Chang, and Sung (2008), the students in this study liked to provide their own opinions and possible solutions to their classmates.

A flipped classroom needs empirical teachers

According to the findings from the behavior transition diagram (Figure 5), P3 discussion and analysis of other people’s response → P3. This is when a respondent responds to the other respondent’s answer, then the next respondent will respond to the previous respondent’s answer with doubts and so offer his/her own thoughts. This could mean that everyone enjoys a heated debate, but they do not reach a definitive conclusion. One possible reason could be the lack of students’
background knowledge, meaning that they could not select a best answer or suggestion from the responses. Another reason might be that the teacher had made conclusions in the class, so the students did not offer their own on the forum. This indicates that the flipped classroom needs teachers to finalize conclusions.

**Growth of knowledge**

Another finding is that the students began to respond to other people’s responses, P3 → P3, or made conclusions based on existing solutions, P2 → P4, and did not become stuck asking questions (P1), or answering questions (P2) in the two stages. Based on this conduct, the process of in-depth “comparison” and “discussion”, “analyzing other people comments”, and “generating conclusions” enhances students’ knowledge sharing; through this behavior, students gain more knowledge.

**This study is better than the old model**

From the results discussed above, we can see that the students’ problem-solving processes on the discussion board are similar to those of the models from the past proposed research (Hou, Sung, & Chang, 2009). Students use online discussion to “ask questions”, “provide solutions”, “compare, analyze, and discuss other people’s solutions”, and “generate conclusions”. However, due to the involvement of the instructor in the flipped classroom, the students’ learning behavior model is better than the problem-solving behavior sequence as more students were willing to offer their possible solutions (P2), share their discussions (P3), and generate conclusions (P4).

**Multiple internet resources**

There are some limitations to this approach which need to be noted. After the students raised questions, they used Google to find answers, but they often eliminated the need for analysis of the problem or comparing given solutions by the respondents. The resources on the web can provide answers, meaning that the discussion sequence was often P1 → P2 → P3, and it was difficult to move to the next stage, P4. This makes it impossible for the process of the discussion to go deeper, or to be organized into the proposed conclusions.

**The students were very serious in discussion and rarely raised irrelevant issues**

The behavior transition diagram (Figure 5) shows that there was no line connecting to P5. This is a positive phenomenon as it means that the students were serious about taking part in the discussion. Therefore, they did not raise unrelated questions to interrupt the consultation process. In Hou, Sung and Chang’s (2009) study, P5 was significant as the students would propose irrelevant issues, causing the following responses to circle around the irrelevant issue without ever completely discussing the question. However, P5 has no significance in this study, meaning that this experiment was very successful.

**Future work**

**Encouragement generates conclusions**

Based on the behavior transition diagram (Figure 5), we found P3 → P3, which means that the students enjoyed lively discussions but did not reach final conclusions. Therefore, it is suggested that the originator of the questions or other respondents be encouraged to proactively organize everyone’s thoughts and generate their own ideas or conclusions. This would be helpful in terms of leading to P4.
Instructor intervention

Because students lack background knowledge, it may be impossible to distinguish between those responses which can produce results and those that cannot. If the instructor could make timely interventions, it could lead the students to P4 to complete the ideal discussion sequence.

Use encouragement often

Because questions have been used often and were replied to quickly, they would not be forgotten. Thus, the discussion could continue. This study found that the average number of responses was four (response comments 401/120 questioning comments). If the average number of responses per comment is only four, then it could be difficult to achieve “ask questions”, “collect information”, “discuss with each other”, and “generate solutions and share the conclusion” in the problem-solving strategy. Of course, this low number of responses could also be related to the level of difficulties of the course.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes on contributor

Tosti Hsu-Cheng Chiang is an assistant professor of the Graduate Institute of Mass Communication, National Taiwan Normal University in Taiwan. His research interests include new media, learning analysis, problem-based learning, and augmented reality learning.

References


