Development and evaluation of an interactive learning module on summation notation using comics
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Introduction
With the advancement of technology in recent times, different approaches to facilitate teaching and learning are needed in order to adapt to the trend and the pace of cognitive development of the new generation of learners. One such approach is via the use of interactive learning modules (ILM).

Reeves and Hedberg (2003) described interactive learning “as a way of acquiring information or learning through hands-on means.” It sometimes can be interchanged with what is called electronic learning (e-learning) and according to Pollard and Hillage (2001) it is the “delivery and administration of learning opportunities to help individual performance and development.” Roffe (2002) and Schank (2002) referred to e-learning as “communication and learning activities through computers and via electronic means.”

Some related studies
There have been different studies that focused on the facilitation of e-learning. Bleimann (2004) stated that “e-learning is a self-directed learning based on web-based technology” and that “e-learning is a form of collaborative learning,” while Kearsley (2001) mentioned that “e-learning provides autonomy to learn,” but the learners should have “initiative and self-discipline to study and complete assignments.” Schott, et.al. (2003) noted that the success rate of e-learning was very dependent on students’ abilities to be “self-directed and internally motivated.” On the other hand, Rivera and Rice (2002) commented that “learners, who are not self-motivated, will find web-based learning an unsatisfactory experience.”

Rosenberg, Grad and Matear (2003) found that e-learning is “at least as effective as traditional instructional strategies” and that students performed academically in the same way “between traditional and technology-oriented modes of instruction.” However, Young-Ju, Bong and Choi (2000) noted that a disadvantage of e-learning since it is learner-centered, was that learners may tend to “postpone or delay their coursework.” This means that the level of maturity of the learners plays a vital role, for them to finish the task at hand even without supervision.

Objectives
This study focused on developing and evaluating the effectiveness of the ILM in studying summation notation and some of its properties, using CourseLab 2.4. Specifically, this study aimed to:
1. create a 45-minute ILM on studying summation properties;
2. conduct a pretest and post-test on the students about the summation properties;
3. conduct a survey concerning the design and operability of the ILM;
4. determine if there is significant increase in scores on the post-test compared to the pre-test; and,
5. interpret the student’s feedback in evaluating the effectiveness of the module.

Methods

The development of the ILM

The ILM was created using CourseLab 2.4. Definitions, properties, theorems and an application of the summation notation were included in the module. The module is in comic form, which was done so that different graphic illustrations will aid in engaging the user. Also, cartoon characters, based on an existing anime series, were introduced. The approach of the module was made similar to interactive graphic stories that included Flash Games created in Adobe Flash®, Javascripts developed through Java™, animations and images in .GIF (Graphics Interchange Format). Also, considered were suggestions from previous studies on ILM such as: (1) the addition of games (Bolivar, 2013) and (2) the characters used should be of the same age as user (Obias, 2012).

Administration of the ILM

The designed ILM was pilot-tested to three college students, a Grade 8 student, and a high school instructor, and based on their initial comments was revised accordingly. The revised ILM was then used on a class of fifty-one Grade 8 students from Los Baños Integrated School-LBCNHS Annex. These students who participated had no background in summation notation. The class was divided into two batches and was transported to the Interactive Learning Center (ILC) of UPLB for the testing of the module. The students were given a 15-item multiple-choice pre-test about summation notation for twenty minutes. Two such questions that were included in the pretest and post-test were: “Which of the following is the correct expansion of ∑6k=1 2k?” and “What is the sigma notation for the given series: 2^0 + 2^1 + 2^2 + 2^3 + 2^4 ?”.

The students of the first batch were given forty-five minutes to use the ILM. After using the module, they were given the post-test and were asked to answer the provided evaluation sheet. Immediately after the first batch finished, the same procedure was administered to the second batch of students.

Evaluation of the ILM

The students were asked to answer a devised evaluation sheet, which was composed of questions about: (1) the module’s appearance, operability, and student learning, (2) the module as an aid for understanding; and, (3) the students’ use and recommendations for improvements. The results of the evaluation were tallied and scored as follows:

- Strongly Agree = 5 (highest)
- Agree = 4
- Neither Agree or Disagree = 3
- Disagree = 2
- Strongly Disagree = 1 (lowest)

The weighted average (WA) of the students’ response for each criterion was calculated using the following formula:

$$ WA = \frac{5(f_{SA}) + 4(f_A) + 3(f_{NAD}) + 2(f_D) + 1(f_{SD})}{n} $$

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where
\[ f_{SA} = \text{frequency of the strongly agree (SA) responses} \]
\[ f_A = \text{frequency of the agree (A) responses} \]
\[ f_{NAD} = \text{frequency of the neither agree or disagree (NAD) responses} \]
\[ f_D = \text{frequency of the disagree (D) responses} \]
\[ f_{SD} = \text{frequency of the strongly disagree (SD) responses} \]
\[ n = \text{total number of students} \]

The average scores were then ranked from highest to lowest for each criterion. These responses, as well as the students’ feedbacks were then used to determine what aspect of the ILM was good and which aspects still need improvement.

**Results and discussion**

**The development of the ILM**
The module was entitled “SIGMATORIA: The Summation Adventure” (see Figure 1). A brief narration and Luffy were introduced to build up the story in a friendly environment, with finding Luffy’s friends as the main goal of the user.

![Figure 1. The title slide and introduction slide of the ILM](image)

![Figure 2. The map of Sigmatoria, together with the objectives slide of the ILM](image)

The goal can be achieved by using the map of Sigmatoria (see Figure 2), which indicated the names of the stations the student needs to visit. The objectives of the module, which were (a) to write a finite sum using sigma notation, (b) to recognize properties and (c) to evaluate a sum, appeared next in order to orient the student on what the program was all about, what they would be doing, and the expectations after finishing the module.
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Figure 3. The Slide of General Instructions of the ILM, with a Definition Slide

Figures 3 and 4 show slides consisting of the (1) General Instructions on how to use the navigation buttons as well as the time allotted for the ILM, (2) an example of a definition slide, (3) a slide showing a guided example, and (4) the response slide when after a question testing the student’s understanding of the concept is discussed. The example in the given slide was presented using the multiple-select option. Also, the character Dr. Chopper was introduced to guide the user in answering the next examples in order to provide a more interactive approach.

Figure 4. An example slide, with a response to a question

A slide containing the second property of summation with a ‘map’ to inform students of their current location can be seen in Figure 5. At least three questions were presented after each property has been discussed in order to assess the student’s understanding of the concept. At the end of the discussion of all the properties, a drag-and-drop puzzle, developed through the use of Adobe Flash®, would have been completed by the user. Questions on the board have corresponding answers on the puzzle pieces. The puzzle was designed in such a way that when the puzzle pieces were placed on the correct position, they will lock. However, this evaluation scheme may not have met its goal since most students tended to complete the image instead of solving for the problems as given.
Some theorems were also introduced (see Figure 6). Conversations between Luffy and Dr. Chopper allow the restatement of concepts in order to aid the understanding process of the learner. Optional additional examples were provided. However, it was observed that users commonly skip them. If the user chose to go to this station, they will be directed to a different route, where a puzzle game, multiple-choice questions, and a new game entitled “Who wants to be a Sigmathionaire?” (developed in Adobe Flash®) appear.

Area approximation provided an illustration of application of the topic (see Figure 6). The end slide for the ILM shows a congratulatory message to the user for finding Luffy’s crew.

The evaluation of the ILM
As shown in Table 1, the criterion with the highest average was “I find the elements (text, images, and animations) well-organized” with a score of 4.63 and the lowest average gathered was 3.86 for the criterion “I find the textual contents not wordy and boring to read.” Other criteria which concern the design of the ILM also gathered relatively high average. The use of a comic approach in designing the ILM may have improved the aesthetic aspect of the ILM since more illustrations and animations were used. However, due to this kind of approach, more conversations from the characters were involved. There were also many narrations and texts, which caused the ILM to look “wordy” and “boring” based on the low average it obtained.
The frequency and average score of the students' responses on the operability and appearance of the ILM evaluation.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>Average Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not encounter problems on navigation.</td>
<td>17</td>
<td>24</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>4.06</td>
</tr>
<tr>
<td>I find the background color appropriate for the material.</td>
<td>29</td>
<td>19</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4.51</td>
</tr>
<tr>
<td>I find the background image appropriate for the material.</td>
<td>32</td>
<td>18</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4.61</td>
</tr>
<tr>
<td>I find the elements (text, images, and animations) well-organized.</td>
<td>34</td>
<td>15</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>4.63</td>
</tr>
<tr>
<td>Text size and colors do not hinder on the readability of texts.</td>
<td>30</td>
<td>11</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>4.35</td>
</tr>
<tr>
<td>I find the textual contents not wordy and boring to read.</td>
<td>14</td>
<td>24</td>
<td>5</td>
<td>8</td>
<td>0</td>
<td>3.86</td>
</tr>
<tr>
<td>I can easily understand the statements presented in each frame.</td>
<td>27</td>
<td>16</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>4.33</td>
</tr>
<tr>
<td>The texts and images go along with each other.</td>
<td>28</td>
<td>17</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>4.39</td>
</tr>
<tr>
<td>The module is easy to use.</td>
<td>36</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>4.57</td>
</tr>
</tbody>
</table>

The frequency and average score of the students' responses on the criteria to evaluate the ILM as a learning tool can be found in Table 2. The criterion “I enjoyed using the interactive learning medium” got the highest average of 4.67. The use of comic approach in the design of the module made it enjoyable for the users. The lowest average score obtained in terms of the ILM as a learning tool was 3.88 under “Concepts and ideas presented are sufficient for the topic.”

In general, the ILM rated relatively good, since all of the weighted averages were between 3.86 and 4.67 inclusive. It seems that the students appreciated the design more than the concepts discussed in the module. However, since the approach of the module was in comic form, having lots of narrations and conversations might have bored some of the respondents.

**Students' response as to which part of the ILM they liked the most**

Majority (31 of 51 respondents) chose animations as their favorite in the ILM, followed by games (27 of 51). Others cited were pictures (23), quiz (15), examples (12) and discussion (19). Twelve students chose “others” and some of their specifications were the anime characters and the illustration of the map at the start of the ILM.
Table 2. Frequency and average score of the students' responses on the understanding portion of the ILM evaluation.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Average Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animations are easy to understand.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>15</td>
<td>33</td>
<td>4.59</td>
</tr>
<tr>
<td>Animations simplify the concept being presented.</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>21</td>
<td>24</td>
<td>4.33</td>
</tr>
<tr>
<td>Concepts and ideas presented are sufficient for the topic.</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>24</td>
<td>14</td>
<td>3.88</td>
</tr>
<tr>
<td>I can easily remember the concepts and ideas being emphasized in the medium.</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>19</td>
<td>23</td>
<td>4.25</td>
</tr>
<tr>
<td>I am enlightened on the concepts that confused me before.</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>20</td>
<td>20</td>
<td>4.14</td>
</tr>
<tr>
<td>I enjoyed using the interactive learning medium</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>38</td>
<td>4.67</td>
</tr>
</tbody>
</table>

On the ILM's usefulness in delivering new information to the user
The results of the pre-test and post-test were gathered, tabulated and analyzed using one-tailed t-test for paired samples/scores, with the following hypotheses:

\[ H_0: \text{The mean post-test scores and the mean pre-test scores of the students are equal.} \]

\[ H_1: \text{The mean post-test scores of the students is significantly higher than the mean pre-test scores} \]

The computed value of \( t \) is 11.5759, which was higher than the \( t_{\text{tab}} = 1.645 \). This meant that the mean post-test scores of the students were significantly higher than the mean pre-test scores, and somehow indicated that the ILM was able to teach the students about summation notation and its properties.

Students' response as to adapt the use of ILM in other subjects and/or topics
Majority (38 of 51) preferred the kind of material to be adapted for other subjects or topics, which suggests that the students in the sample were willing to be engaged in such kinds of materials as learning enhancements. Foremost reasons mentioned in adapting the material were: fun, accessibility, and interactivity. However, those who chose “no” (11 out of 51) reasoned out that it will be better if there is someone they can immediately ask if the concepts were not clear.

Conclusions and recommendations
The results showed a “good” mark on the appearance, operability and aid in understanding. There were some suggestions, though, to decrease the amount of
conversation in the ILM as they found it wordy and boring. Also, since most of the students’ interests in the use of ILM rely on its ability to provide interactivity, the students also recommended the addition of more quiz or games. Furthermore, it was recommended that Filipino be used as the medium of instruction, and an audio should be incorporated. However, since Filipino cannot be always adopted; improvements could be on the use of language on a level, which can be easily comprehended by the target students. As such, it is safe to say that the developed ILM somehow may be used to supplement student learning about summation notation and its properties.

References

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