Development of digital interactive math comics (DIMaC) for senior high school students in general mathematics

Leo A. Mamolo

Abstract: Supporting the 21st-century learners’ instructional needs is a trend of today’s educational system. This educational design research aimed to develop a Digital Interactive Math Comics (DIMaC) as an instructional material envisioned to meet these learners’ needs to a better understanding of Mathematics concepts. This employed the ADDIE framework for instructional material development design. There were 425 randomly chosen students who took the validated and acceptable with 0.7888 Cronbach’s alpha researcher-made General Mathematics Competency Test. This was done to identify the least learned skills and be the basis for design and development. The initial storyline with the Mathematics contents integrated were validated by the set of experts before the electronic illustrations and coding took place. The initial outputs of the DIMaC were revalidated for comments and suggestions before distribution for classroom use. These experts also evaluated the final version of DIMaC as very acceptable. The DIMaC was then implemented in a classroom and found to have high usability as rated by the students. Also, the app draws positive feedback for classroom use because of its interesting nature and
uniqueness. Thus, this study adds to the body of literature on helpful instructional materials for utilization to these tech-savvy learners.

Subjects: Development Studies, Environment, Social Work, Urban Studies; Education - Social Sciences; Secondary Education; By Subject; ICT

Keywords: developmental studies; ADDIE model; general mathematics; least learned skills; interactive comics

1. Introduction
The use of any instructional material aims to support the teachers in the teaching process and to engage the students towards concepts acquisition towards a meaningful teaching-learning process. Instructional materials are tools that include both visual and audio-visual aids that could either be concrete or non-concrete with the main aim of supporting teaching and learning (Koko, 2016; Tuimur & Chemwei, 2015). In the Philippines, the development of ICT integrated IMs is encouraged with the advent of the K-12 program. These materials are envisioned to cater to the needs of 21st-century learners who are considered digital natives. As Kristanto, Mustaji, and Mariano (2017) highlighted, there are already many institutions using e-learning today for it is becoming the global issue. Stoič (2015) also emphasized that having educational technology in the classroom is growing and the students today are ready to work with these new technologies. Moreover, the use of new technology aid in an explosion of learning and receiving new information, especially on mobile devices.

In the senior high school program, one of its salient features is on the provision and utilization of Information and Communication Technology (ICT) as a strategy to improve the access to quality of education (Department of Education, 2013). But as per DepEd memo as of 10 June 2016, having only one material for the teacher and one for the students in General Mathematics may not be enough to achieve those goals. General Mathematics is one of the core subjects with aims to offer students an understanding of how to solve problems involving rational, exponential and logarithmic functions; to solve business-related problems, and to apply logic to real-life situations. However, to successfully impart its learning competencies may pose a challenge for educators most especially that it is only taught for 80 hours and there is only one learner material provided. Thus, contributing to having a new set of instructional materials for General Mathematics is essential. As Mamolo (2019) highlighted, teachers may find other ways in dealing with students in a more engaging manner. One of these ways is by means of development of instructional materials that would best fit to the 21st-century learners.

One kind of instructional material that might be contributed is the utilization of comics that will be upgraded to be digital and that can be interactive. Comics are “juxtaposed pictorial and other images in deliberate sequence, intended to convey information and/or produce an aesthetic response in the viewer” (McCloud, 1993, p. 9). For Hayman and Pratt, “it is a comic if and only if it is a sequence of discrete, juxtaposed pictures that comprise a narrative, either in their own right or when combined with text” (Hayman & Pratt, 2005, p. 423). On the survey made by the National Book Development Board in 2012 on what Non-School Books (NSB) Filipinos read, it was found out that comic books are one of the top five most-read and garnered 31% readership for some high school and college students (National Book Development Board, 2012), hence; to consider the use of comics as an Instructional Material could be a help in the teaching-learning process.

Several comics have been already developed that are concerned with different subjects, educational levels and diverse educational purposes (Lazarinis, Mazaraki, Verykios, & Panagiotakopoulos, 2015). As Yang (2003) emphasized, these have been done because the use of comics in the teaching-learning process can motivate students. Cleaver (2008) emphasized that teachers viewed comics as a potential educational tool arousing students’ interest in an academic subject. Versaci (2001) highlighted that analytical and critical thinking skills can be developed through comics. With students'
interest in comics, using those to students’ activities to classroom material might make a unique contribution to mathematical discourse in the classroom (Kessler, 2009). Present in comics are cartoons. In the study of Sexton (2010) in a 7th-grade classroom, it has found that cartoons can be a successful tool for increasing student and teacher insight in mathematics instruction. Brandenburg, Gervasoni, and Sexton (2009) have reported that cartoons encouraged students to discuss the advantages and disadvantages of their preferred strategies for solving addition problems and to find out how students approach calculations. While Toh (2009) stressed that teachers who used cartoons suggest that employing them in Algebra lessons increased students’ motivation to learn. A decrease in terms of mathematics anxiety has also been reported using cartoons (Sengül & Dereli, 2010; St. Clair, 2018). Finally, using cartoons encouraged students to pose problems and made them realize that mathematics instruction is not just about providing the “correct short answers” but involving a rich dialogue. Thus, their imagination and creativity were unleashed (St. Clair, 2018).

This study focuses on the development of the Digital Interactive Math Comics (DIMaC) which relied on the positive results of comics to student learning and the need for ICT integration in the SHS program. This study specifically sought answers to the following questions:

(1) What least learned competencies of the SHS students in General Mathematics can be included in the development of DIMaC?

(2) How is the Digital Interactive Math Comics (DIMaC) developed?

(3) How acceptable is the Digital Interactive Math Comics for classroom use as evaluated by Mathematics experts, Information Technology experts, and education experts?

(4) What is the evaluation of the students on the DIMaC in terms of its usefulness, satisfaction, and ease of use?

2. Methodological framework

The researcher utilized design research. Specifically, it used the ADDIE (analysis, design, development, implementation, and evaluation) model in instructional development. This study is anchored on Learner-Centered Design (LCD) theory by Soloway, Guzdial, and Hay (1994). The theory highlights important things emphasizing learners’ growth and motivational needs to be integrated into designing software for their use. Since the study aimed at developing software, the Digital Interactive Math Comics (DIMaC), for the students to achieve the necessary competency in General Mathematics, it was anchored on the Learner-Centered Design (LCD) theory. This theory pointed out that “designing software from an LCD perspective keeps the learner in mind and, if done well, provides an effective and meaningful learning experience” (Soloway et al., 1994). This means that the DIMaC was designed for the specific audience with scaffolds along the way that was adaptive to what the learner needs. Moreover, designing considered the context, aesthetics, task for learners and tools needed to support those tasks.

2.1. The ADDIE model

2.1.1. Analysis phase

The first phase of the study, the analysis phase, was the assessment of the least learned competencies in General Mathematics. It included randomly selected grade 12 senior high school students in the seven public senior high schools of one school division of the Department of Education in Region 8. The assessment phase involved 425 students. The selection used a systematic random sampling in which all students from each strand from the whole division was listed based on the strand they belong. Those who were picked were included as participants to be assessed. They were told about the nature of the study and those who voluntarily participated were the participants of the research.

An 80-item General Mathematics Competency Test was the instrument used. It is a multiple-choice test in four choices. This test was utilized to assess the Senior High School competency in
General Mathematics. The test covered all the learning competencies stipulated in the curriculum guide of the Senior High program. General Mathematics was taught for 80 hours in a semester, that is why; in the table of specification if a certain learning competency was taught for 1 hour, one question was made for that competency. Moreover, if it was taught for 3 hours, there were three questions for that competency at a different level of difficulty. This was done to cover all competencies as stipulated and to have a fair distribution of the questions in the exam. It underwent face and content validity by eight Mathematics experts. After integrating their suggestions and corrections, it was pilot tested to Grade 12 students. The test is found to have a Cronbach’s alpha value of 0.788, an acceptable internal consistency.

On finding the least learned competencies, frequency count was used. Each question from the 80-item competency test corresponded for a learning competency. The notation used was 0 for the wrong answer and 1 for a correct answer. After doing so, it was tallied. The number of students who got the correct answer on a question was totalled and were ranked based on the most number of questions answered to the least answered question. After the ranking, the least learned competencies were identified. Six least learned competencies were included in the development of the Digital Interactive Math Comics (DIMaC).

2.1.2. Design and development phase
The initial design of DIMaC which involved writing of the storyline was based on the students’ responses from the survey questionnaire. Most of the students preferred “love story” hence, a storyline dealing on their love experiences was written. On the characters of the story, the students wanted characters like Superman, Wonder woman, Iron Man, and others. But since it may cause a problem in the copyright, the researcher has decided on who will be the characters involved. The choice of the characters and the storyline was purely from the researcher’s imagination. The challenge faced was integrating the least learned competencies on the storyline.

The inclusion of the least learned competencies in the storyline was in a mixture of style in writing. The topics that can easily be concretized like topics in business mathematics, was integrated directly in the dialogue. Meaning, the conversation has all the math concepts at the same time related to the genre of the story. While the characters talk about “love”, Mathematics concepts were being shared. On the least learned topics which are highly analytical, the scenario is that the main characters are in a school setting, or tutorial, or by a group where the math concepts and contents were given emphasis. Say, if it is in a classroom scene, the conversation is like in a detailed lesson plan where the students answer to the teacher’s questions and formally talking all about that concept.

The researcher made it sure to keep students reading the storyline while answering the questions eagerly by having an exciting plot. The storyline line is arranged in a way where students will not be bored by many Mathematics scenes and not be very overwhelmed by the storyline. The storyline is written in a way that balanced the Mathematics and story part.

After finishing the storyline, it was validated by an English expert who is also an author for corrections on the grammar and suggestions on the storyline. For the Mathematics being integrated, two Mathematics experts read and validated the contents. After the corrections from the experts were integrated with the updated storyline, it was then submitted to the illustrators for initial sketches.

On the development part, the corrected storyline was submitted to the illustrators. With the help of the researcher, all considerations for the characteristics of the casts like facial features, body size, skin color, and others were decided. The illustrators were responsible for the background and other necessary things. The researcher also made suggestions for the betterment of the illustrations. This phase took illustrators for almost four months. After which, it was then submitted to the programmer to code/program the illustrations and be able to use it on phone and make it
interactive. It took the programmer five weeks to complete the coding process. The final output was checked by the experts, researcher, and the adviser. All comments and suggestions made were then integrated into the DIMaC until those experts approved it for validation. All in all, the programmer upgraded the DIMaC app for 14 times.

Before the implementation phase, validation of Digital Interactive Math Comics (DIMaC) on its acceptability for classroom use was initiated. Chosen eight math experts, six IT experts, and eight education experts served as the participants. The instrument used was adapted from West Visayas State University (WVSU) Instructional Materials Evaluation Form C (Non-printed Materials). This instrument is a standard instrument in evaluating non-printed instructional material. This instrument was duly revalidated by a set of experts. This included 8 major aspects: Content, Instructional quality, Technical Quality, Storyline, Interactivity and Feedback, Presentation and organization, Accuracy and up-to-datedness of information, and Assessment. This was used by the math experts, IT experts, and education experts to rate on how acceptable is the Digital Interactive Math Comics (DIMaC) for classroom use. This was done to understand how acceptable the newly developed instructional material is.

### Score | Description | Interpretation
--- | --- | ---
3.51–4.0 | Very Acceptable | All aspect of instruction and work are very adequately covered and the quality of work is superior.
2.51–3.50 | Acceptable | Major aspects of instruction and work are covered and the quality of work is above average.
1.51–2.50 | Moderately Acceptable | The major aspect of instruction and work are covered with minimum acceptability.
1.0–1.50 | Barely Acceptable | Major aspects of instruction and work are hardly covered and the quality of work is of below-average quality.

Mean scores from the responses were analyzed and interpreted as follows:

On its analysis, mean and standard deviations were used. The mean score was used to know the level of acceptability (Barely Acceptable, Moderately Acceptable, Acceptable, Very Acceptable) the DIMaC was. The standard deviation was used to describe the variability of the data from the mean.

### Implementation and evaluation phase
The DIMaC was then implemented in a grade 11 classroom in one university of Western Visayas for 5 sessions. After which, the evaluation by the students followed. The instrument used was the adapted USE questionnaire by Lund (2001). This is used to evaluate the usefulness, ease of use, ease of learning, and satisfaction. The form was a 5-point Likert scale type. This was used as feedback from the students who used the instructional material in their Math class in terms of the

### Score | Description
--- | ---
4.51–5.0 | Very High
3.51–4.5 | High
2.51–3.50 | Average
1.51–2.50 | Low
1.0–1.50 | Very Low
material’s usability. This was validated by the panel of experts. Mean scores from the responses were analyzed and interpreted as follows:

On the analysis, mean and standard deviation were used. The mean score was used to know the level of usability (Very Low, Low, Moderate, High, Very High) the DIMaC was. The standard deviation was used to describe the variability of the data from the mean.

3. Results and discussion
This study aimed to develop a Digital Interactive Math Comics (DIMaC) based on the least learned competency of the Senior High School Students in General Mathematics. There were 15 least learned competencies; six from Functions and their graphs, three from Business Mathematics, and six topics from Logic. However, to finish the project in six months, six topics were included and was a consensus from the researcher, adviser, illustrators, and programmer.

3.1. Learning competencies included in the development of digital interactive math comics
Table 1 shows the 6 learning competencies included in the development of the DIMaC. These 6 least learned had the fewest number of correct responses from the 425 sample takers. Topping the list of least learned competencies is, determining the validity of categorical syllogisms with only 12.23%, sixth in rank is, solving problems involving inverse functions with 18.59%.

Similar findings with that of Herrera and Dio (2016) showed that the least learned topics for Functions were; on verifying if a given relation is a function and on graphing linear functions, quadratic functions and polynomial functions (24%). In basic business mathematics, the least mastered prerequisite competency mathematics is solving word problems involving simple interests. For logic, writing proof turned out as the least mastered.

3.2. The rationale of the DIMaC development
The Digital Interactive Math Comics (DIMaC) is a mobile program application in which a story of love, family, friendship, horror, action, etc. and Mathematics contents are integrated. This instructional material was developed to cater to the needs of 21st-century learners to learn and revisit the competencies they have not yet learned or mastered in the subject-General Mathematics. DIMaC provided an interesting storyline with a theme that was based on the student’s responses to

<table>
<thead>
<tr>
<th>Learning Competencies</th>
<th>%</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>determines the validity of categorical syllogisms. (Logic)</td>
<td>12.23</td>
<td>1</td>
</tr>
<tr>
<td>finds the domain and range of an inverse function. (Functions and their Graphs)</td>
<td>12.47</td>
<td>2</td>
</tr>
<tr>
<td>calculates the present value and period of deferral of a deferred annuity. (Business Mathematics)</td>
<td>14.82</td>
<td>3</td>
</tr>
<tr>
<td>justifies mathematical and real-life statements using the different methods of proof and disproof. (Logic)</td>
<td>17.88</td>
<td>4</td>
</tr>
<tr>
<td>illustrates the different methods of proof (direct and indirect) and disproof (indirect and by counterexample). (Logic)</td>
<td>18.12</td>
<td>5</td>
</tr>
<tr>
<td>solves problems involving inverse functions. (Functions and their Graphs)</td>
<td>18.59</td>
<td>6</td>
</tr>
</tbody>
</table>
the given survey. This offered students a way to be interactive by answering the intentionally blank bubbles that were posed by the characters in the story. This is done to engage students in the teaching-learning process.

The DIMaC is developed following the considerations provided by the related studies on the use of comics in the classroom, use of digital means in the teaching-learning process, and with a goal providing ICT integrated instructional material for the senior high school students in the country. It is also because researchers have shown that this kind of instructional material had a positive effect on students’ participation, motivation, and overall performance in the classroom. Moreover, the development is anchored on theories such as multimedia learning, and learner-centered design theory which are notable in instructional design.

3.3. Basic features of the DIMaC
This DIMaC has a love story/romantic comedy theme. This theme was chosen based on the survey done to the Senior High School Students. The title of DIMaC’s story is “5-second Rule in Love”. The initial storyline was written with the help of some Senior High School students who have given some input on how the story should flow. The first chapter of the story revolved around the love story of the main casts, Renj and Charis who were classmates since Grade 7 to college.
The planning phase for the Logo of the DIMaC (see Figure 1) was primarily of the researcher's idea but also with the programmer's opinion. This logo is the first image/scene that will appear when opening the app. The “fist” on the logo symbolizes a strong personality or a hero which denotes the application is like that of comics dealing with superheroes. The Mathematics symbols signified that the comics made has mathematical contents being integrated into its storyline. The sun rays below the “fist” symbolize the tech-savvy millennials who will be using the DIMaC in their Mathematics class.

The DIMaC app was distributed via share-it application. The DIMaC is provided with a password for all students to be at the same pace during the discussion of the contents. It is done this way so that the starting of every lesson, they will be opening the application at school simultaneously. The remaining topics can be revisited at home or anywhere they wanted for they already have passwords. Below the logo is a “Start Button” that will direct the students to the “About section” after providing the correct password. The “About section” explained what the application is all about and to whom will it cater. Also, it explains the symbols used in the app. Below the about section is a button that says “Begin Story”. By swiping left, the lessons' objectives are reflected. To proceed to the story, all they to do is to swipe left.

The DIMaC also has a “Cast section”. This section gave readers the ideas of the main characters of the story. Moreover, it has “Topics section” which lists all the topics included in the storyline.

The starting scenes dealt on a wedding scene where all those attended seemed against the wedding. This was done to captivate students' attention and to read the DIMaC up to the end.

3.4. Characters and storyline of the digital interactive math comics (DIMaC)

The main characters of the story were Charis, Renj, Chrisha, Lea, Mikay, Gino and Ryan (Figure 2). These set of characters were high school friends. Same experiences with the senior high school students who took part in the assessment and survey were portrayed by the characters for they helped in making the flow of the story.

3.5. Flow and functionality of DIMaC

The DIMaC like usual comics has its conversation written in bubbles. The difference is, it is digital and interactive. Interactive in a way that there were intentionally left bubbles where the students must write/encode their answers. The DIMaC is in a “Love-Math-Love-Math” flow and the students were just “swiping left” only to continue to the next scene or conversation. The first scene was an interrupted wedding to make it more interesting. During these scenes, all bubbles have dialogue in it. After which, the topic in Math being integrated into the dialogue followed. At this time, the conversation has blank bubbles in which the students must answer first before they can proceed to the next part of the story. The question posed in the DIMaC must be answered correctly first before proceeding to other scenes for that particular scene is “locked”. If in the first try the students got an incorrect answer, the app will say “Oops, your answer is incorrect, please try again”. Incorrect for the second time, the app will give a clue of the correct answer. If still incorrect after 3rd try, the app will say “It's time to ask the teacher”. After the third try, the teacher facilitated and gave some additional hints. If still some students were not finished in the topic, the teacher will explain the remaining part on the board or call some representative students who were able to finish the task to explain. This is so for the others to advance to the next task in the DIMaC. The teacher facilitated the whole time. The process continued until the chapter of the comics ended.

The Digital Interactive Math Comics (DIMaC) was used as an aid in the usual discussion of the topics in the classroom setting. It was used in the lesson proper. After reviews, drills, and motivation of the lessons, the DIMaC was utilized by the students. A specific learning competency took 45 minutes to one hour of the class session. The students opened the app simultaneously and after the password is given. At this moment, the students must read the story and be finished with all the scenes including
those with intentionally left bubbles. The teacher roams around ensuring that all the students are using the app. The teacher set the allotted time for every “locked” scene that needs answering.

Each competency has a maximum of 20 questions or 20 intentionally blank bubbles in the storyline. Once the students will reach these blank bubbles, they will have to solve it in their notebooks because the teacher will also check their notes after. That’s why; they should have their notebooks with them when using the app. The questions posed in the storyline are true or false, multiple-choice, and fill in the blank types of questions. But before any blank bubble is given, the concept is thoroughly explained first by the casts in the DIMaC. The questions are also in different level of difficulty. At the moment the students got an incorrect answer in the third try and nobody from the class has got it right, then the teacher will give additional clue until all will get the correct answer and will be able to proceed to the next part of the story.

This process continues until the storyline for the specific General Mathematics competency is finished or until the maximum time of 1 hour is over. At the end of each competency, the teacher will provide additional seat works or quiz using their solutions of the exercises as their reference/
notes. All students must be able to end the same scene in the storyline before the teacher will give the quiz. This is the same process for all six competencies included in the DIMaC.

3.6. Experts evaluation on the acceptability of the digital interactive math comics (DIMaC)

Table 2 shows the acceptability of the Digital Interactive Math Comics (DIMaC) as evaluated by eight Mathematics, six information technology, and eight Education experts. Generally, the data showed that the overall acceptability of the DIMaC is very acceptable with \( M = 3.63 \) and \( SD = 0.41 \). Moreover, the 8 criteria of the acceptability questionnaire got a very acceptable level. This means that the DIMaC, in general, have all the aspect of instruction and work very adequately covered and the quality of work is superior.

Also, the experts commended for having developed this kind of instructional material that caters the need for 21st-century learners. They further highlighted that the DIMaC is innovative, novel, interesting, and truly interactive. They also pointed out some suggestions for the betterment of the DIMaC and how it should be implemented in the classroom.

Similar results that of Pardimin and Widodo (2017) who developed a comic-based problem-solving in Geometry who found out that all its criteria in the validation were “very good”. The criteria that were included were; comic structure, content, organization, presentation, and writing, and language and readability. The experts may have evaluated it as very acceptable since comics according to Yang (2003) is motivating, visual, permanent, intermediary, popular, and can develop analytical and critical thinking skills.

3.7. Students’ evaluation on the usability of digital interactive math comics (DIMaC)

Table 3 below shows the Usability of Digital Interactive Math Comics (DIMaC) as evaluated by 38 students who used the DIMaC in their class in the implementation phase. The overall usability is found to be high having \( M = 4.14, SD = 0.50 \). Moreover, the four dimensions of the usability questionnaire which includes the usefulness, ease of use, ease of learning and satisfaction were also high. This means that for the students, all aspects of usability criteria are covered as they experienced during the utilization of DIMaC in the class.

The result of the study conforms to the study of Marianthi, Boulodakis, and Retalis (n.d.) stressing that the attitudes of the student teachers who were the participants of the study in using digital comics were generally favorable. Almost all the student-teachers held positive views about the value

| Table 2. Acceptability of Digital Interactive Math Comics (DIMaC) Based on the Eight Dimensions from Mathematics, Information Technology, and Education Experts |
|-------------------------------------------------|-------|-------|-------|
| Dimensions                                       | \( n \) | \( SD \) | \( M \) | Description            |
| Content                                          | 22    | 0.40  | 3.55  | Very Acceptable        |
| Instructional Quality                            | 22    | 0.23  | 3.81  | Very Acceptable        |
| Technical Quality                                | 22    | 0.32  | 3.55  | Very Acceptable        |
| Storyline                                        | 22    | 0.41  | 3.63  | Very Acceptable        |
| Interactivity and Feedback                       | 22    | 0.36  | 3.55  | Very Acceptable        |
| Presentation and Organization                    | 22    | 0.36  | 3.75  | Very Acceptable        |
| Accuracy and Up-To-Date Information              | 22    | 0.61  | 3.67  | Very Acceptable        |
| Assessment                                       | 22    | 0.45  | 3.55  | Very Acceptable        |
| Total                                            | 22    | 0.41  | 3.63  | Very Acceptable        |
of comics as a teaching approach. Also, they reported that the use of plurimedia or the digital comics process to be more attractive and interesting. Some of their respondents’ answers were; “stimulates the learner to think deeply into it”, “raise interest “are more attractive”, “break the boundaries of a traditional lesson”, “gives more opportunities for alternative teaching strategies” “connects everyday activities of students with life in school”, “gives more freedom to choose learning materials”, “realistic”, “promotes interactivity”. They claimed that the use of digital plurimedia webcomics may offer the possibility of promoting positive attitudes to teaching and learning amongst teachers-to-be.

4. Conclusion

The developed Digital Interactive Math Comics (DIMaC) based on the least learned competency of senior high school students in General Mathematics have met the acceptability criteria as evaluated by Mathematics, Information Technology, and Education experts. This means that in general, all aspects of instruction and work were very adequately covered, and its quality is superior. The high usability of DIMaC as evaluated by the students after the implementation may support the claim. Also, it can be indicated that the developed DIMaC conforms on the criteria of instructional material development. These could be true because using comics as tools in a variety of teaching and training settings can motivate students and that comics are motivating, visual, permanent, intermediary, popular, and can develop analytical and critical thinking skills. Moreover, students indicate that they found DIMaC to be useful in the classroom, easy to use, can be easily learned, satisfying, and worth recommending to a friend/colleague.

The use of Digital Interactive Math Comics (DIMaC) solicited positive experiences from the students because the app is unique, and it caters the 21st-century learners who are considered digital Natives. This may show that the way DIMaC was presented from the interesting storyline, appropriate contents, smooth interactivity, and pleasant use graphics were already well-thought and is an interesting and novel instructional material. This might be accounted on the combined pictures and texts present in the DIMaC which improves learning as explained in dual coding theory that supports the importance of imagery in cognitive operations.

Thus, Mathematics teachers may consider utilizing DIMaC in their classroom. Also, it is highly recommended for the learners to use this as an aid in the learning of the Mathematics concepts. Hence, this study adds to the body of literature on helpful instructional materials for utilization of today’s learners who are considered digital natives.

Funding

This work was supported by Department of Science and Technology-Science Education Institute Capacity Building Program for Science and Mathematics Educators (DOST-SEI CBPSME) under the scholarship and dissertation grant; and Visayas State University (VSU) under the financial assistance program.

Author details

Leo A. Mamolo
E-mail: leomamolo@gmail.com
ORCID ID: http://orcid.org/0000-0003-2859-8641

1 College of Education, Visayas State University, Baybay City, Philippines.

Table 3. Students’ Responses as to Usability of Digital Interactive Math Comics (DIMaC) Based on the Four Dimensions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>n</th>
<th>SD</th>
<th>M</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>38</td>
<td>0.40</td>
<td>4.07</td>
<td>High</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>38</td>
<td>0.49</td>
<td>4.02</td>
<td>High</td>
</tr>
<tr>
<td>Ease of Learning</td>
<td>38</td>
<td>0.48</td>
<td>4.38</td>
<td>High</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>38</td>
<td>0.55</td>
<td>4.11</td>
<td>High</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>0.50</td>
<td>4.14</td>
<td>High</td>
</tr>
</tbody>
</table>
Citation information
Cite this article as: Development of digital interactive math comics (DIMaC) for senior high school students in general mathematics, Leo A. Mamolo, Cogent Education (2019), 6: 1689639.

References


