

Development and Validation of Graphic Novel as a Supplementary Learning Material in Chemical Bonding

Maridelyn D. Gumonan*, Mary Allein Antoenette C. Bug-os

Department of Science Education, University of Science and Technology of Southern Philippines,
Cagayan de Oro City, Philippines

*Corresponding author: mdgumonan@gmail.com

Received September 03, 2021; Revised October 19, 2021; Accepted October 28, 2021

Abstract One of the most challenging tasks in teaching high school students is using appropriate learning material suitable to their level of proficiency, learning styles, and interests. This study aimed to develop and validate a graphic novel that can be used as a supplementary learning material in chemical bonding. The research utilized a design and development research design for the graphic novel development. An expert validation checklist was used to evaluate the validity of the graphic novel in terms of chemistry content, language, aesthetics, and social content. It was found out that the developed graphic novel has an overall rating of *excellent* as validated by the experts which signifies that the developed graphic novel has a high level of validity. It conforms to the criteria of instructional material development. Thus it can be used in teaching chemical bonding for Grade 9 students.

Keywords: *graphic novel, supplementary learning material, chemical bonding, validation*

Cite This Article: Maridelyn D. Gumonan, and Mary Allein Antoenette C. Bug-os, "Development and Validation of Graphic Novel as a Supplementary Learning Material in Chemical Bonding." *American Journal of Educational Research*, vol. 9, no. 10 (2021): 654-659. doi: 10.12691/education-9-10-8.

1. Introduction

Science in the K to 12 Curriculum is implemented in spiral progression and one of the core subjects is chemistry. The main goal of chemistry teaching is to develop more effective, pedagogically, and scientifically based sound strategies to teach high school students [1]. Teachers must know how to teach this subject to enhance students' understanding and interest [2]. Among the vital topics in chemistry is chemical bonding, which must be studied to fully conceptualize and understand the other topics connected to chemistry. Still, this topic is difficult for students because of its complexity [1,3]. The abstract and microscopic nature of the concepts and the many types of chemical bonding cause conceptual difficulties that lead to numerous misconceptions and may have greatly lowered the interest and confidence of many students [4,5,6]. In addition, the method of teaching chemistry to the students contributed to this difficulty [7,8].

Chemical knowledge can be represented and communicated at three different levels, which are the macroscopic, the sub-microscopic, and the symbolic levels [8]. Learning chemical bonding needs a mental picture or model to represent and explain the sub-microscopic level of the concepts [9]. To overcome this, it is essential to consider the kind of learning material, teaching resources, and instructional strategies to promote students' conceptual

understanding of chemical bonding [4,10]. Thus, developing a new set of learning materials that will supplement the textbooks in chemistry is essential. Recently, a variety of learning materials were designed to supplement the current textbooks to help the students understand the chemistry concepts that lead to higher motivation, aids in visualizations, opportunities for differentiation and cognitive support for students. This includes multimedia tools [9], Multitouch Learning Books (MLB) [11,12] and Multitouch Experiment Instructions (MEI) [13]. Instructional materials are essential and indispensable tools in learning every subject in the school curriculum. They enable learners to interact with words, symbols, and ideas to develop their reading, listening, solving, viewing, thinking, speaking, and writing [14].

One of the valuable instructional materials that can be a primary source of instruction is the graphic novel. Graphic novels are book-length comic books meant to be read as one story and include contents targeted towards a more mature audience [15]. The vivid imagery in the graphic novel can be a source of students' motivation, providing the scaffolding and contextual clues necessary for the students to move past decoding struggles to focus on comprehension of the narrative. It also requires readers to actively comprehend both text and images as they work together, leading to skills such as inference and synthesis [16]. In addition, the students reading the graphic novel retained and processed more complex content. They were also able to engage more positively than students reading traditional text [17].

Implementing graphic novels as a learning medium can improve the quality of learning achievement [18,19]. It can increase content knowledge, effectively convey information, and engage more than traditional texts [20]. Further, the developed comics and graphic novels are very suitable for use in chemistry learning which can achieve a good outcome among students and be an innovative teaching methodology with great potential in education [21,22].

In line with the discussions above, graphic novels may be used as instructional material in science classrooms, but designed and developed instructional graphic novels are not answered well. This study aims to design, develop, and validate the graphic novel as a supplementary learning material in chemical bonding. Results will be used as the basis for developing a better instructional graphic novel.

2. Methodology

2.1. Research Design

This study is a design and development research. The design and development research design was utilized for the graphic novel development to establish an empirical basis for creating instructional material, the graphic novel in chemical bonding. On the other hand, the quantitative-descriptive research design was used to determine the validity of the developed graphic novel in terms of chemistry content, language, aesthetics, and social content.

2.2. Research Participants

The participants of this study were composed of twelve expert validators: three experts in both chemistry content and chemistry education, three language experts, three experts for aesthetics, and three experts in social content. The validators were distinguished faculty members from different state universities, Education Program Supervisors and teachers that are lead-experts in instructional material development from the Department of Education. The validators were identified purposely and selected based on their expertise that matched the criterion in validating the graphic novel.

2.3. Research Instruments

Experts Evaluation Checklist. This is a 5-point Likert scale instrument used by the experts to evaluate the Graphic Novel's validity. The instrument to assess the validity of the content was adapted from Mamolo [23] and Torrefranca [24]. The validation tool for language and social content was adapted from the Department of Education [25] while the validation tool for aesthetics was adapted from the Department of Education [25], and Ali and El-Din [26]. All validation tool was modified to suit this study.

2.4. Data Collection

Data collection activities that were done in the study are described as shown in Figure 1.

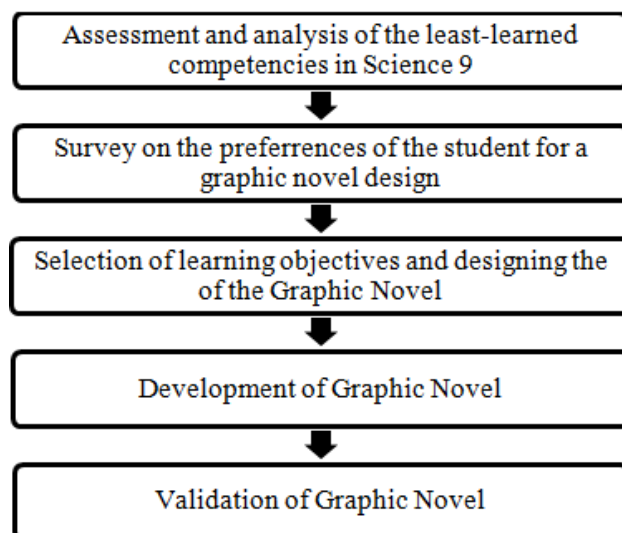


Figure 1. Schematic Diagram of the Research

Flow in the development of Graphic Novel in Chemical Bonding.

2.4.1. Analysis Phase

In this phase, the result of the diagnostic test conducted for SY 2020-2021 were examined. The results were used as the basis to determine the least mastered competencies in Grade 9 science as indicated in the Most Essential Learning Competencies (MELCs) prescribed by the Department of Education. This served as the content focus for the development of the graphic novel. In addition, science books and related materials on chemical bonding were examined as part of the need assessment. In analyzing the students' needs of learning material, the researchers interviewed the Grade 9 students. Based on the interview, students expressed that they have difficulty answering their printed Self-Learning Modules (SLM's) and other learning activities from the textbooks since they are text-heavy, have few illustrations, and are very lengthy. The students mentioned that they preferred printed materials that are visually appealing, interesting, short, and with plenty of illustrations. With this, it was decided to design and develop learning material in the form of graphic novel that will supplement the Self-Learning Modules (SLMs) and students' textbooks. Next, a survey was conducted with the Grade 9 students to determine their preferences regarding the character, plot, theme, and genre of the graphic novel they would like to read. The survey was done through online google forms and a printed survey questionnaire for those students who do not have access to the internet. Then, a review of related literature and studies was also carried out to determine the essential features to consider in making a graphic novel a learning material.



Figure 2. Developed Graphic Novel

2.4.2. Design and Development Phase

The design phase started with the selection of learning objectives and content of the graphic novel. Notably, the design of the graphic novel was grounded from the different kinds of literature. The writing of the storyline was in line with the content objectives which were anchored on the Most Essential learning Competencies (MELCs). The preferences of the Grade 9 students were also considered. The challenge in this phase is the integration of the least learned competencies in designing the material. Once the storyline was complete, the content was reviewed by two chemistry teachers and was subjected to grammar checking. The illustrator draws the graphic novel based on the storyboard using the updated storyline in the development phase. Figure 2 shows the developed graphic novel in chemical bonding. The crafting of the pretest and posttest which is based on MELCs was also done in this phase.

2.4.3. Validation Phase

Experts' judgments were sought to gather evidence that will support the adequacy of chemistry content, language, aesthetics, and social content of the graphic novel to the intended users. Twelve experts validated the graphic novel. The panel of experts comprises three content experts in chemistry and chemistry education, three language experts, three experts in aesthetics, and three social content experts. The validators evaluated the graphic novel based on the four indicators: chemistry content, language, aesthetics, and social content. All the comments, suggestions and

recommendations by the panel of experts were integrated for the revision of the graphic novel.

2.5. Data Analysis

The researchers utilized descriptive statistics such as means and standard deviations to analyze the evaluation ratings of the developed Graphic Novel experts. The interpretation of mean rating obtained for expert evaluation checklist and students evaluation checklist were as follows: 4.5-5.0 Strongly Agree/Excellent; 3.5-4.49 Agree/Very Good; 2.5-3.49 Undecided/Good; 1.5-2.49 Disagree/Fair; and 1.0-1.49 Strongly Disagree/Poor. The textual interpretation was used to report the supporting qualitative data.

3. Results and Discussion

The graphic novel was evaluated by twelve validators that are experts in their respective fields. The expert-validators are composed of three experts in both chemistry content and chemistry education, three language experts, three experts in aesthetics, and three experts in social content which are purposely selected based on their expertise. The chemistry content was assessed in terms of four factors: accuracy and appropriateness, format, evaluation and usefulness. The language was assessed in terms of four factors: coherence and clarity of thought, grammar and syntax, spelling and punctuation, and consistency in style.

The aspect of aesthetics was evaluated in terms of physical attributes, layout and design, typographical organization, visuals, and graphic quality. Lastly, for the social content, three aspects were evaluated: society, race, ethnicity and culture, and gender.

3.1. Chemistry Content

Table 1 presents the mean ratings of the expert-validators on the four factors under chemistry content. The overall mean rating of the chemistry content is *excellent* having a mean 4.89 (SD= 0.13). Moreover, the chemistry content's four factors, including accuracy and appropriateness, format, evaluation, and usefulness, were *excellent*. This means that in general, the chemistry content of the graphic novel has an excellent evaluation of its validity and meets all the standards specified in each aspect. The result is in accord with some related studies that the developed Chemic media (Chemistry Comics) and (Chemistry Cartoon) is fit to use based on its high validity [27,28]. In particular, format and evaluation obtained the highest mean (M= 4.95, SD = 0.08). This shows that the expert-validators find the graphic novel format or layout very organized, logically presented, and arranged from simple to complex, making each episode more interesting and suitable for Grade 9 students. In addition, the evaluation embedded in the graphic novel is appropriate, aligned with the learning objectives, and reflects what students learned during instructional activities. The accuracy and appropriateness got the lowest mean (M= 4.81, SD= 0.58). This is maybe due to some of the illustrations having minimal detail on the bonding of elements. The content is the most important consideration as an essential graphic novel feature, especially for classroom instruction [29]. The content must have a clear organization that aids reading comprehension and is interesting, relevant, and age-appropriate for the developmental level of the readers. A developed science comics or graphic novel must commit to having scientific accuracy [30].

Table 1. Expert's Validation in Terms of Chemistry Content

Criteria	Mean± SD	Description
Accuracy and Appropriateness	4.81±0.58	Excellent
Format	4.95±0.08	Excellent
Evaluation	4.95±0.08	Excellent
Usefulness	4.86±0.14	Excellent
Overall mean	4.89±0.13	Excellent

Legend: Excellent (4.50- 5.00); Very good (3.50- 4.49), Good (2.50- 3.49), Fair (1.50- 2.49), Poor (1.00- 1.49). SD: Standard deviation.

3.2. Language

Reflected in Table 2 is the mean rating of expert-validators in terms of language. The overall mean rating of the language is *very good* having a mean of 4.29 (SD = 0.54). The coherence and clarity of thought aspect got the highest mean (M= 4.67, SD = 0.44). This means that the statements are clear, logically sequence, easy to understand, and appropriate to Grade 9 students. The use of language that is not ambiguous, simple, and easily understood by readers is essential in graphic novel development [31,32].

Table 2. Experts' Validation in Terms of Language

Criteria	Mean± SD	Description
Coherence and Clarity of Thought	4.67±0.44	Excellent
Grammar and Syntax	4.11±0.67	Very Good
Spelling and Punctuation	4.33±0.58	Very Good
Consistency in Style	3.89±0.96	Very Good
Overall mean	4.29±0.54	Very Good

Legend: Excellent (4.50- 5.00); Very good (3.50- 4.49), Good (2.50- 3.49), Fair (1.50- 2.49), Poor (1.00- 1.49). SD: Standard deviation.

Although the graphic novel met the standards in terms of language and had an overall mean rating of *very good*, the validators recommended thorough editing and looking into the correct order and organization of thoughts to improve the graphic novel further. Moreover, the consistency in style got the lowest mean (M= 3.89, SD= 0.96). This is due to the use of all capital letters in writing the sentences in the dialogue and some inconsistencies in the tenses used. Overall, the validators commend the features of the developed graphic novel as the topic is well-selected and age-appropriate. They also pointed out some recommendations for improving the graphic novel regarding the technical aspects to be observed. An instructional material such as comics and graphic novels must use clear and concise language, be coherently structured, and logically arranged for the readers to easily grasp the material's content [33,34].

3.3. Aesthetics

The data in Table 3 shows the mean rating of the graphic novel in terms of aesthetics as evaluated by expert validators. The overall mean rating of aesthetics is found to be *excellent* (M = 4.74, SD = 0.17). Among the five criteria, the physical attributes (M= 4.94, SD = 0.10) got the highest mean while typographical organization got the lowest mean (M= 4.67, SD = 0.58). This could be attributed to the choice of the font style and size of the letters. It might affect the readability of the graphic novel. In general, the aesthetic quality of the graphic novel is pleasing and suitable for Grade 9 students and even for the lower years. The graphic elements such as colored illustrations and storylines with realistic characterization may attract all children of various ages and have a strong effect on keeping the story dynamic to the readers [31,35].

Table 3. Experts Validation in Terms of Aesthetics

Criteria	Mean ± SD	Description
Physical Attributes	4.94±0.10	Excellent
Layout and Design	4.73±0.31	Excellent
Typographical Organization (e.g., size of letters, choice of font, use of boldface and italics, etc.)	4.67±0.58	Excellent
Visuals	4.67±0.23	Excellent
Graphics Clarity	4.67±0.31	Excellent
Overall mean	4.74±0.17	Excellent

Legend: Excellent (4.50- 5.00); Very good (3.50- 4.49), Good (2.50- 3.49), Fair (1.50- 2.49), Poor (1.00- 1.49). SD: Standard deviation.

Overall, the physical attributes, layout and design, typographical organization, visuals, and graphics clarity remarkably conformed to graphic or comic book format. Further, the graphic novel has all the aspects of aesthetics

adequately covered and the quality of work is superior. Science comics should have educational merits and aesthetics as an important factor [30]. Further, a learning material should consider the design, format, and layout to ensure that the learning materials stimulate the learners' interest while maintaining readability and appropriateness of font style, layout, size, color, and format of the book [36].

3.4. Social Content

Table 4 presents the mean rating of the graphic novel in terms of social content as evaluated by the expert-validators. The data shows that the overall mean rating of the graphic novel in terms of social content is *excellent* ($M = 4.78$, $SD = 0.38$). The aspect of race, ethnicity, and culture got the highest mean ($M = 5.00$, $SD = 0.00$). This simply indicates that the content of the graphic novel portrays respect for racial, ethnic, and cultural diversity in our society. Moreover, the aspect of gender got the lowest mean ($M = 4.56$, $SD = 0.77$). This may be due to one of the scenes that shows stereotyping the father's role as the only one who will change the tires. The expert-validators also suggested a need for improvement in gender balance in terms of roles and capability of women. Overall, the text and illustrations in the graphic novel in all episodes are very clear and no ethnic bias is found. Hence it adheres to standards for social content for instructional material. In designing and developing graphic novels, the drawings and illustrations are important to represent different ethnic backgrounds and were gender-balanced [21].

Table 4. Experts' Validation in Terms of Social Content

Criteria	Mean \pm SD	Description
Society	4.78 \pm 0.38	Excellent
Race, Ethnicity and Culture	5.00 \pm 0.00	Excellent
Gender	4.56 \pm 0.77	Excellent
Overall mean	4.78 \pm 0.38	Excellent

Legend: Excellent (4.50- 5.00); Very good (3.50- 4.49), Good (2.50- 3.49), Fair (1.50- 2.49), Poor (1.00- 1.49). SD: Standard deviation.

3.5. Summary

Table 5 summarizes the mean ratings of experts of the developed graphic novel in chemical bonding as evaluated by experts in chemistry education, language, aesthetics, and social content. The different aspects obtained an *excellent* rating in ($M = 4.68$, $SD = 0.08$) chemistry content, ($M = 4.74$, $SD = 0.17$) aesthetics, ($M = 4.78$, $SD = 0.38$) social content signifying high validity of the material. Meanwhile, the aspect in language obtained a *very good* rating ($M = 4.29$, $SD = 0.54$) which means that the material is valid. Generally, the data showed that the overall rating of the validity of the developed graphic novel received an *excellent* rating from the experts ($M = 4.68$; $SD = 0.08$) signifying an excellent evaluation of the validity of the material. This means that the graphic novel generally meets all the requirements for a supplementary learning material in teaching chemical bonding. Comic books and graphic novels can be a powerful supplementary learning material or even substitute to the science textbook incorporating abstract concepts [35,37].

Table 5. Summary of Expert's Validation of the Graphic Novel in Chemical Bonding

Criteria	Mean \pm SD	Description
Science Content	4.68 \pm 0.38	Excellent
Language	4.29 \pm 0.54	Very Good
Aesthetics	4.74 \pm 0.17	Excellent
Social Content	4.78 \pm 0.38	Excellent
Overall mean	4.68 \pm 0.08	Excellent

The experts commended for having developed this type of supplementary material that can teach chemical bonding and cater to 21st-century learners. They also mentioned that this material could help the learners appreciate the lesson due to its comic concept. The details in the graphic novel are good since it raises the level of aesthetic quality. However, some cases need to be revised based on the recommendation of the validators. Most of the suggestions for improvement are in the aspect of aesthetics which include:

- The texts should not be in all capital letters since it will be used in school thus, standard format of writing texts should be observed;
- Color coding on the groupings of the elements as shown on the periodic table;
- Narration boxes may be added to supplement the needed additional information to a more detailed concept or story; and
- Reading strategies or instructions maybe include highlighting, underlining keywords, or encircling words that the students do not understand while reading the graphic novel.

4. Conclusion

This study aimed to develop and validate the graphic novel used in chemical bonding as supplementary learning material. The graphic novel was designed and developed based on the least learned competency of Grade 9 students in science and essential features of a graphic novel based on the recommendations of various literature. The developed graphic novel was found that to be acceptable as validated by the experts. This means that in general, that the graphic novel conforms to the criteria of instructional material development suitable to the Grade 9 students. The validation results served as the basis for improving the developed supplementary material before it will be utilized for instructions.

Acknowledgments

The authors would like to express their immense gratitude to the expert-validators who unselfishly shared their time and expertise in evaluating the developed graphic novel.

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