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CONTENT KNOWLEDGE IN GEOMETRY: BASIS ON THE DEVELOPMENT OF INSTRUCTIONAL VISUAL AIDS FOR COLLEGE STUDENTS

Jovelyn P. Gonzales Alyca P. Toraja
Mikko Jan D. Lopez, Edd
Institution: Altavas College, Altavas, Aklan

Abstract: The primary purpose of this study was to determine about the content knowledge in Geometry of Bachelor in Secondary Education Major in Mathematics students as basis on the development of instructional visual aids for college students. Data were obtained through a 50-item test questionnaire for the level of content knowledge in geometry and a 15-item checklist for the level of acceptability to determine the level of content knowledge in geometry of BSEd Math students as a basis for the development of instructional visual aids for college students. The data obtained were analysed and assessed using frequency count, percentage, and mean. Results showed that the level of content knowledge of Mathematics major in Geometry was "low". In line with this, the most appropriate product to be developed based on the results of the study was instructional visual aids. The instructional visual aid was then evaluated with "very highly acceptable" level of acceptability. This led to the conclusion that instructional visual aids substantially met the requirements for a thorough and excellent resource that students and teachers may employ in the teaching-learning process.

Keywords: Content Knowledge, Instructional Visual Aids, Development

Introduction

The word "geometry" in Greek means the measurements of the earth. The initial principles of geometry were developed by the Egyptians. One of the ancient Greek mathematicians, Euclid, is considered as the father of geometry. This is due to his tremendous contributions in this branch of mathematics (Cuemath).

Numerous studies have shown that students struggle to understand geometric concepts, which are crucial to learning mathematics. The student may hold the visualization and the verbal definition, but prefer the visual prototype when classifying and identifying geometric figures (Ozerem, 2012).

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A study conducted by Luneta (2014) finds that the majority of the student teachers have limited knowledge of basic knowledge of geometry and require not remedial, but re-learning of these basic concepts. In addition, results of the study conducted by Karpuz and Atasoy (2020) revealed that the teachers did not have sufficient content knowledge to cope with proof errors deriving from figural-concept interactions in geometry.

On the other hand, visual aids are cues which highlight information or break something down into simple steps that we can see. In fact, students learn more quickly, remember material more easily, and retain it more clearly with the aid of visual aids.

Results from the study by Oviawe and Uddin (2020) showed among others that the utilization of audio-visual resources as an instructional strategy in technical colleges had positive impact on students' achievement and interest in Geometry. Furthermore, in the study of Ngonyani (2018) revealed that many students in the schools studied performed poorly academically because teachers mostly relied on chalkboard as their major visual aid.

Based on the preceding indicator, the primary goal of the study was to determine whether the students had adequate geometry knowledge. And it is said that visual aids can considerably affect students‟ performance in learning. As a result, the purpose of this study was to determine about the content knowledge in Geometry of Bachelor in Secondary Education Major in Mathematics students as basis on the development of instructional visual aids for college students.

Statement of the Problem

The primary purpose of this study was to assess the content knowledge in Geometry of Bachelor in Secondary Education Major in Mathematics students of Altavas College as basis in development of instructional visual aids for college students.

Specifically, the study aimed to answer the following questions:

1. What is the level of content knowledge of Bachelor in Secondary Education Major in Mathematics in terms of Geometry subject?
2. What learning material can be developed based on the result of the study?
3. What is level of acceptability of the instructional visual aids for college students of Altavas College?

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Methodology

Research Design

The research design that was used in the study was Research and Development (R & D) design.

Participants and Validators

The respondents of this study were the BSEd Mathematics students of Altavas College, S.Y. 2022-2023. The respondents of the study were selected using census. A census technique is a statistical list-processing step in which every person in a population is examined. The population is related to the collection of all relevant observations. For the validators of this study purposive sampling was employed since the researchers chose to target certain individuals who have qualities relevant to the study. While the sample is unlikely to represent the population, those who participated in the study can contribute various pieces of information on the subject of the specific research question (Turner, 2020).

Correspondingly, the acceptability of the instructional visual aids for college students of Altavas College was determined by the validation of BSEd Mathematics students. Hence, the validators of this study were all the BSEd Math students of Altavas College. Participants in the study functioned as validators for the findings of this study through the use of 50 multiple choice questions and 5-point score scale that assessed the level of content knowledge, and 15-item Level of Acceptability Rating Checklist questionnaire with a 5-point Likert Scale measured the level of acceptability of the instructional visual aids.

Data-Gathering Instrument

Research questionnaires formulated by the researchers were used as the primary data collecting tool in this study. The survey questionnaire was composed of three (3) parts. Part I identified the socio demographic profile of the respondents. Next, Part II was the Level of Content Knowledge in Geometry Questionnaire. Lastly, Part III was the Level of Acceptability of Visual Aids Rating Checklist.

Socio demographic Profile Questionnaire. This questionnaire was used to determine the personal information of the respondents such as their names, which they can optionally provide, sex, and year level.

Level of Content Knowledge in Geometry Test. This questionnaire was provided through a multiple-choice test consisting of 50 items. Items were separated into five (5) topics in Geometry such as the Surface Area and Volume, Pythagorean Theorem, Circle,

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Analytic Geometry, and Congruence of Triangle. The test was validated by a geometry expert.

The level of content knowledge in geometry was measured from the vollected mean total scores and was categorized using the following scale.

Score	Description
40.01 – 50.00	Very High
30.01 – 40.00	High
20.01 – 30.00	Moderate
10.01 – 20.00	Low
0.01 – 10.00	Very Low

Level of Acceptability of Visual Aids Rating Checklist. The level of acceptability of the instructional visual aids rating checklist was patterned from Soltura, R. T. (2022). This is a rating checklist with the purpose of determining the level of acceptability of visual aids. A rating checklist as the data collecting tool for the level of acceptability is deemed suitable for the study because rating scale questionnaires quantifiably bracket varying opinions of a group of people through a set range. In total, there were 15 statements provided and a comment or suggestion box available right after the checklist for the respondent's specific recommendations for the improvement of the instructional visual aids.

The questionnaire was responded using a 5-point Likert Scale:

Scaling	Description
5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly Disagree

The mean was arbitrarily categorized as follows:

Mean	Description
4.21-5.00	Very Highly Acceptable
3.41-4.20	Highly Acceptable
2.61-3.40	Acceptable
1.81-2.60	Less Acceptable
1.00-1.80	Least Acceptable

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Results and Discussion

Level of Content Knowledge in Geometry Of BSEd Math Students

Table 1 indicates the level of content knowledge in Geometry of Bachelor of Secondary Education Major in Mathematics students of Altavas College.

The results in Table 1 appear to suggest that the BSED Math students of Altavas College have a moderate level of content knowledge in Geometry which equates to a mean of M=24.281

Table 1

Mean results of the content knowledge in Geometry of BSEd Major in Mathematics students

Year Level	Mean	Description
First Year	21.251	Moderate
Second Year	12.5	Low
Third Year	32.997	High
Fourth Year	30.375	High
TOTAL	**24.281**	**Moderate**

Mean Score	Scaling
40.01-50.00	Very High
30.01-40.00	High
20.01-30.00	Moderate
10.01-20.00	Low
0.01-10.00	Very Low

Based on the results, the BSEd Math students of Altavas College had varying levels of content knowledge across the five parts of Geometry. In other words, the student's levels of content knowledge were very different, varied, and spanned a wide range.

Generally, the data obtained in Table 1 indicate that second year BSEd Math students struggled the most and were the weakest in Geometry resulting in the lowest mean scores of M=12.5 with a description of "low". It suggests that students had difficulty comprehending the Geometry subject.

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A study conducted by Luneta (2014) employed that the majority of the student teachers have limited knowledge of basic geometry and require not remedial, but re- learning of these basic concepts. Similarly, a study by Sunzuma and Maharaj (2019) showed that 52.5% of the teachers were adequately prepared to teach geometry and both teacher-centered and learner-centered approaches were used during their training. It emerged that teachers are likely to teach using the approaches that they experienced during their training.

In contrast, third year and fourth year BSEd Math students demonstrated a "high" level of content knowledge in Geometry with the means of M=32.997 and M=30.375, respectively. This indicates that respondents who identified themselves as students could respond to and establish the subject and it showed that it was their area of strength since they understood it in class. It further highlighted that the instances were readily available or taught efficiently during the learners' prior education; hence it is figured that those would be the most uncomplicated parts for them. Relatively, this was implied in Aydin and Ubuz (2010) that aimed to determine the effects of metacognitive constructs on knowledge of geometry and to determine the relationships among knowledge of geometry.

Out of the four year levels, the first year level was found to have "moderate" level of content knowledge in geometry with the mean of M=21.251.

Overall, these findings are in accordance with the study of Karpuz and Atasoy (2020) that aimed to examine high school mathematics teachers' content knowledge of the logical structure of proof in geometry which showed that the teachers did not have sufficient content knowledge to cope with proof errors deriving from figural concept interactions in geometry. In addition to that, the teachers generally failed to base the information they obtained from figures on an axiom or theorem, to avoid sweeping generalizations based on geometric figures, and to make accurate changes in figures when contradictions emerged as a result of valid reasoning processes.

Instructional Visual Aids for College Students of Altavas College

The instructional visual aid is a learning material that introduces the Pythagorean Theorem and its process of solving. It includes the overview, objectives, topic discussion, and the evaluation. In this learning material, the parts were presented according to the order or from the form basic curricular grid and were revised and improved to fit in the chosen instructional visual aids. An overview of the lesson was presented, objectives discussed the competencies that the students should perform at the end of the discussion of the topic, and evaluation was being answered by the students at the end of the discussion to demonstrate what they learned.

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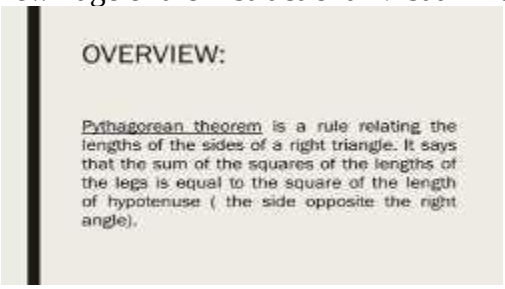
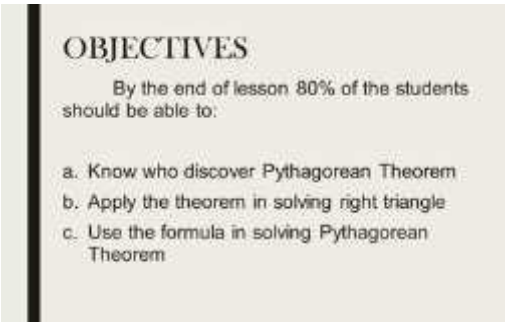
Table 3 shows the contents discussed in the instructional visual aids.

Content	Description
Title Page of the Instructional Visual Aids 	The figure shows the title page of the instructional visual aids. Being the very first page of the topic, the title page is a big factor to the first impression that potential readers have of the material. It showed the title of the topic to be discussed in the entire slide tech.
Overview Page of the Instructional Visual Aids 	The overview provided the general review or summary of a subject. It served as the introduction of the topic to be discussed. It discussed the overview of the Pythagorean Theorem..
Objectives of the Instructional Visual Aids 	The objectives presented the competencies that should be achieved at the end of the lesson. This image shows the objectives of the Pythagorean Theorem and what the learners should demonstrate after the discussion.

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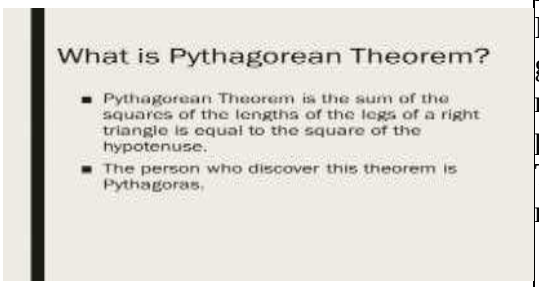
Discussion of the Instructional Visual Aids 	The discussion gave the body/main topic of the lesson, through the person who discover the Pythagorean Theorem and to its formula. It gave the idea and understanding to the potential readers of the topic. This part included the presentation of the meaning of the Pythagorean Theorem, discussion of the examples, and relating to a real life

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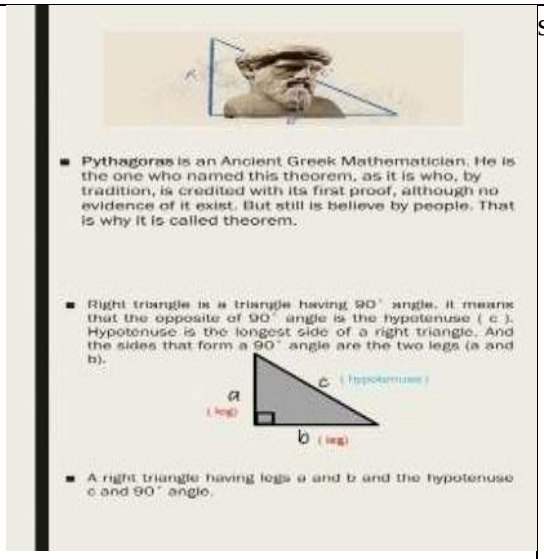
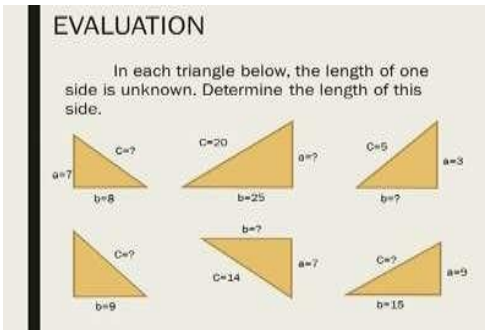
	situations and problems.
Evaluation of the Instructional Visual Aids 	The evaluation of instructional visual aids was the part where students were tasked to demonstrate what they learned in the discussion through a 6-item quiz. They were tasked to solve for the length of the unknown side. The purpose of this evaluation was to determine if the learners have learned.

Level of Acceptability of the Instructional Visual Aids for College Students of Altavas College

Table 2 below presents the level of acceptability of the instructional visual aids for college students of Altavas College.

The results shown in Table 2 indicate that overall, the level of acceptability od the instructional visual aids is very highly acceptable with a mean of M= 4.44.

Table 2

Level of Acceptability of the Instructional Visual Aids for College Students of Altavas College

Variable	Mean	Description
Level of Acceptability of Instructional Visual Aids	4.44	Very Highly Acceptable

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Mean Score	Scaling
4.21-5.00	Very Highly Acceptable
3.41-4.20	Highly Acceptable
2.61-3.40	Acceptable
1.81-2.60	Less Acceptable
1.00-1.80	Least Acceptable

The validators strongly agreed that the instructional visual aids‟ level of acceptability was "very highly acceptable" (M=4.44), which demonstrates that the content contained in the instructional visual aids conformed to reliable information, accurate citations, adequate style and organization, a systematic and brief explanation, and suitable visual support for the offered learning Activities. The additional information provided by the educational visual aids made the Pythagorean Theorem a simpler transaction, bridging lessons that are typically difficult or difficult to grasp through its examples linked with step-by-step explanations and a full description of each section. This indicates that the validators were very satisfied with the instructional visual aids quality. With this level of acceptability, the slide tech proved to have exceptionally served its purpose of being an instructional visual aid that provides additional aid in knowledge and application for Geometry to college students of Altavas College.

This finding parallels to the study of Madrazo and Dio (2020) that showed that the student participants were very much satisfied with the utilization of the learning modules that bridged their learning gaps in the conic section through independent learning. In addition to that, study of Goldsmith et al. (2016) analysis revealed that students whose drawings of a simple still life were extremely spatially disorganized and performed significantly worse on the geometric reasoning assessment than students whose drawings were at least adequate spatial representations of the scene. This study suggests that the connections between visual-spatial thinking in geometry and art may have educational consequences for how geometry is taught. For example, encouraging students who struggle in math classes to enhance their visual-spatial thinking skills may help them understand geometry.

As stated by one of the validators in the comment/suggestion section of the administered survey questionnaire, "instructional materials are highly needed as it serves an impetus towards students to do more and perform more". This finding supports the

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study of Ngonyani (2018) that appropriate use of visual aids has influence on students' academic performance. Through study findings, it was found that many children in the investigated schools struggled academically as a result of instructors' heavy reliance on the chalkboard as their primary visual assistance. They neglected to add more visuals to it to help students grasp and remember what they were taught.

The overall evaluation results of both the teacher- and student-validators were congruent with the previous study of Oviawe and Uddin (2020) tht aims to examine the effect of audio-visual resources as instructional strategy for iImproving students' academic achievement in geometry that shows the result that among others the utilization of audio-visual resources as an instructional strategy in technical colleges had positive impact on students' achievement and interest in Geometry. It was suggested, among other things, that technical drawing instructors used an audio-visual instructional technique while teaching technical drawing, particularly when teaching geometry, since it improves students' academic performance and interest.

Conclusions: Based on the findings of the study stated above, the following conclusions were drawn

1. Obtained from the questionnaire results developed through a multiple-choice, the level of content knowledge of Bachelor of Secondary Education Major in Mathematics in terms of Geometry was considered as "moderate". The findings revealed that students" have difficulty comprehending the Geometry subject. It is attributable to the fact that the students have limited knowledge of basic of geometry. This indicates that respondents who identified themselves as students could respond to and establish the subject, and it showed that it was their area of strength since they understood it in class. It further highlighted that the instances were readily available or taught efficiently during the learners" prior education; hence it is figured that those would be the most uncomplicated parts for them.

2. Using PowerPoint presentation as instructional visual aids for college students was created based on the results of the study. It is a learning material developed from the results of the pre-assessment questionnaire administered by the researchers. It includes the five topics in Geometry such as surface area and volume, Pythagorean theorem, circle, analytic Geometry, and congruence of triangle. In this instructional visual aid, the parts were presented according to the form of basic curricular grid. The instructional visual aids contain the parts which are overview, objectives, discussion, and evaluation. The objectives of the instructional visual aid consisted of competencies that the learners should be able to acquire after reading the material and

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should gain an understanding of the topic. The evaluation determined if the students understand the lesson better with the help of the instructional visual aids.

3. The developed instructional visual aid was evaluated to be "very highly acceptable" by both teachers and students, based on the accumulated overall mean findings. This means that the instructional visual aids for college students of Altavas College satisfied the criteria for a good and high-quality resource that can be used by students and teachers in the teaching-learning process. The material is concise, credible, and provides a specific step-by-step explanation and breakdown of the topic, along with sample problems that relate to real life situations. Aside from that, it supplies engaging activities and visual aids for the learners‟ cognitive stimulation. According to the teacher-validators who gave good comments in the instructional visual aid that was developed, implementing the visual aids serves an impetus towards students to do more and perform more. With the implications aforementioned, the instructional visual aid exceptionally serves its purpose as an avenue of additional information in Geometry.

Recommendations

Based on the findings and conclusions, the following recommendations were suggested by the researchers:

1. To the college students, it is recommended that they seek more resources for better understanding and comprehension of the Geometry subject. This makes them an excellent and independent learner.

To Mathematics instructors, it is recommended that their teaching and approach should be more compatible to the demands of the students. Instructors should be aware of students‟ strengths and weaknesses so that they can focus more in the topics that should need more attention. Teachers should learn new techniques for teaching in order to increase the effectiveness of math instruction. Teachers should seek out new sources or attend seminars where they can learn new techniques and methods for teaching that are more successful. Also, more consulting time is available to students who want to learn more about the subject.

To college administrators, it is recommended that they create detailed policies for using all available instructional resources, which are very helpful to the students in terms of providing guidance. Also, it is advised that they hold seminars to help teachers learn new techniques and approaches.

To the future researchers, it is recommended that students understand how important it is to improve mathematical abilities now more than ever in a time when people are continuously exposed to large volumes of information. A population that has

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had a good education in geometry will be better equipped to handle many of the challenges that it encounters and even use it to further their careers. As a result, people will be able to make more knowledgeable decisions and better judgments, which will have an effect on their quality of life beyond the personal and societal levels. In essence, this results in the improvement of the whole country.

2. To college students, it is recommended that they employ the instructional visual aids in their education in other to make the lesson more interesting and keep themselves engaged. Instructional visual aids can help them to be an independent learner. This will boost the level of knowledge they possess. With the help of the instructional visual aids, students can retain their knowledge clearly, remember easily, and apply it more efficiently. Students will have a greater capacity for independent functioning as a direct result of this, which will enable them to pursue academic excellence to a greater degree, particularly in the realm of mathematics. Students at Altavas College should make use of instructional visual aids, because through this material, they will be able to correlate what they are learning to the required specifications of the students in mathematics progress by utilizing comprehensive resources.

To mathematics instructors, to assist in teaching their students mathematics, it is advised that they make use of the instructional visual aids. a visual aids are an important part of oral presentations because they provide support for both the teachers and learners during the discussion. Visual aids can be used to give more details about the topic and to help the learners to understand what is being said. To keep their students motivated and focused, teachers should use a variety of instructional visual aids and strategies in addition to the standard methods of education.

To college administrators, it is recommended that they enact their support to this instructional visual aid through various forms of involvement. Administrators should give teachers enough resources so that they can push their limits in teaching their students the knowledge they desire to acquire. Administrators should provide teachers enough support they need so they can perform their bests, which would bring advantages to their students.

To the future researchers, it is recommended to conduct further research about the instructional visual aid and to have further evaluation for the improvement of the instructional visual aid. They may also develop other instructional visual aid, since the developed instructional visual aid has limited sources. The utilization and production of instructional visual aid is encouraged in order to fill in perceived gaps within the prescribed instructional materials and in order to provide additional approaches to motivate students.

3. To the college students, instead of relying solely on one resource, it is advised that they investigate reputable sources in mathematics. They should invest in determining their preferred learning preference, whether it is learning independently, learning with peers, learning under the guidance of instructors, or learning through instructional

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materials, in order to maximize their capacity in the comprehensive undertaking of mathematics.

To the mathematics instructors, it is recommended that they take into account the use of instructional visual aids in the mathematics learning process as a part of creating efficient teaching strategies. Additionally, it is strongly advised that teachers become more involved in their students' mathematical learning, taking the time to learn about their preferred learning styles, areas that need improvement and attention, and areas where their strengths can be developed.

To the school administrators, it is recommended that they create learning initiatives such as making use of instructional visual aids. May they take the initiative to include a variety of student-driven and subject-specific learning materials that foster a setting wherein students' innate motivation and satisfaction to learn are given primary focus and attention.

To the future researchers, it is recommended to conduct a pre-test-post-test quasi-experimental research design to assess the effectiveness of the instructional visual aids quantitatively. This may help identify any usage issues that might arise and help confirm its efficacy even more. Future researchers may also delve further into the area of educational materials, where they can elaborate on the creation of various research proposal types according to the research topic category.

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