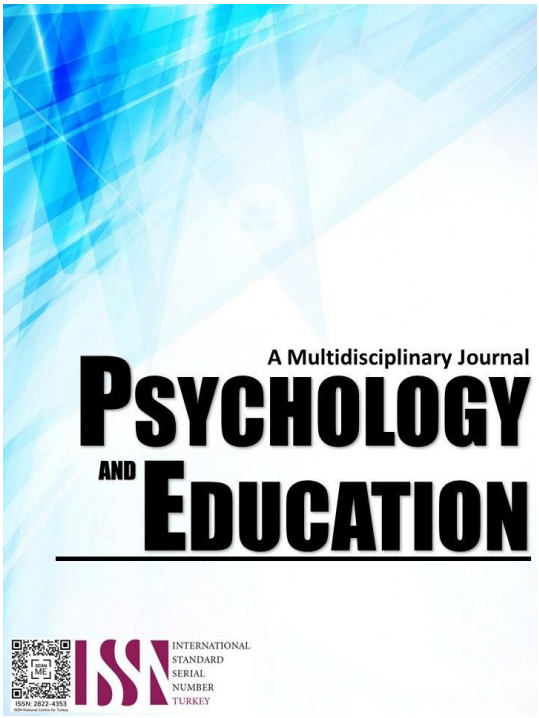
UNLOCKING THE DIFFICULTIES IN RECOGNIZING AND CONTROLLING RESEARCH VARIABLES THROUGH 4A MODEL INSTRUCTIONAL MATERIAL



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Research Article

Unlocking the Difficulties in Recognizing and Controlling Research Variables through 4A Model Instructional Material

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Abstract

This study aimed to unlock the difficulties in recognizing and controlling research variables through the use of 4A model instructional material. Learning competencies dealt with the basic principles of experimental research during the first two (2) weeks of the first quarter were developed. The said lesson includes identifying experimental variables and designing an experiment to test the hypotheses to be enhanced by the students. The respondents were the Grade 7 students with a sample size of 70 enrolled at Quezon Science High School using purposive sampling method. The said instructional material, achievement test, and the questionnaire on the level of acceptability in a form of Likert Scale of the said material were developed and validated. This study used one-group pretest-posttest design to test the significant difference between the pretest and posttest scores using t-test for dependent sample. In addition, weighted mean was used to determine the level of acceptability towards the material. The findings showed that the mean scores of the students in the pretest and posttest is 20.23 and 41.86, respectively. The computed t-value is 24.31 which is higher than the tabular value of 1.96 at 0.05 level of significance. Thus, the null hypothesis was rejected indicating that the 4A model instructional material is a valid tool in unlocking the difficulties in the said science process skill. The average weighted mean values for the following criteria on the level of acceptability are as follows: learning objectives (3.62); learning activities (3.54); accuracy and clarity (3.60); appeal (3.55); and usability (3.54). These criteria fall under "strongly agree" indicating that it is commendable for use. Summative evaluation of the instructional enrichment material may be done to determine the effectiveness of the material in recognizing and controlling research variables. Furthermore, other authentic learning experiences and performance assessment may be used to enhance further the skill in recognizing and controlling research variables.

Keywords: *4A model, instructional material, variables*

Introduction

Research is a student-centered approach to learning, but it is not something that science educators should expect to their learners to do totally independently. The research process for school students, especially in primary and lower secondary school, should be carefully guided and structured experience. It will not be sufficient to simply give students a research question and leave them to their own devices to find the answer. Instead, educators will have to plan each phase of the research carefully and preparing the students to ensure that they have all the prerequisite skills or that the research project is structured in such a way that the students will develop these skills as they work through research. One of these science process skills is recognizing and controlling experimental variables necessary to conduct experiments in research.

Padilla (2009) stressed that recognizing and controlling experimental variables are fundamental to science, allowing everyone to conduct investigations and reach conclusions. Educators are conceived that there is a serious educational gap in this area, both in bringing these skills inside the classroom and in training teachers to do this. It is obviously a multifaceted problem, which involves school administration and teacher education, as well as the development by students of the necessary social skills to collaborate effectively, share, debate, defend end extend ideas in groups.

For several years, science educators encountered such difficulties related to the academic performance of students specifically in the field of research. The said problem is still apparent among the several results of several assessments and evaluation conducted annually in which the general mean percentage scores (MPS) appeared to be consistently at the base. Due to the existing problem, educators must focus primarily with the enhancement of students' skill in controlling variables. That is, without training in the said appropriate skill, many students will not obtain the full benefit of research programs and will eventually result to considerable difficulty updating inquiry-related skills on their own.

The benchmark for science literacy calls for students by the end of the fifth grade to be able to recognize accurately variables when comparisons might not be fair because some conditions are not kept the same (American Association for the Advancement of Science, 2003). However, students of all ages have been shown to have difficulties in understanding and applying the concept to scientific inquiries involving problems of causal and correlational relationships (Ross, 2008; Sneider et al., 2004). The National Science Education Standards (National Academy of Sciences, 2005) noted that students still have trouble in variables and controlled experiments.

According to Aquino (2003), to acquire this skill, educators must adapt effective teaching approach. In education, instructional materials are the fundamental sources in to achieve the desirable learning objectives. Instructional enrichment materials are essential components in the educative process. It plays a pivotal role for the achievement of a wide variety of learning key concepts. It becomes

the main tool for classroom instruction. According to Queaño (2012), an ideal instructional material should have the following criteria in order to attain its ultimate purpose in the teaching-learning process: learning objectives, learning activities, accuracy, clarity, appeal, and usability. Hall et al. (2011) explained that learning objectives should be feasible to ensure that the learning outcomes can be attained resulting to life-long learning. Thus, learning objectives must be specific, measurable, attainable, realistic, and time-bound. Moreover, Wright (2010) pointed out that learning activities should have the integration of real-life problems within the context of local or global community to address the contemporary issues. Learning activities should provide meaningful experiences among the learners so that they can construct new knowledge and skills based from their schemata. Adding, Newby et al. (2006) highlighted that clarity and accuracy within the content of the instructional material play an important role for the learners to attain the desirable learning objectives. It focused on the appropriate sequence of the topics in consonance to meaningful learning. It also includes the validity of information and abstract concepts leading to the mastery of the learning competencies. Newby et al. (2006) also stressed the concept of appeal of instructional material. It refers to the layout and design of the said material that promotes the enhancement of motivation among the learners. Lastly, Keinonen (2008) explained that the usability of an instructional material must be considered in designing the said learning material. Usability refers to the property of the learning material in which it deals with the appropriateness to the learning ability of the students. It initiates motivation, self-confidence, and varied strategies for the learners to practice knowledge and skills. Usability fosters the maximum participation of the learners inside the class as well as the improvement when it comes to study habits and perceived difficult lessons. These variables are essential for the learners to enhance their skill in recognizing and controlling research variables.

If instruction is identified to help the learners for them to recognize and control variables, teachers need to determine also the content and the skills that must be understood from the instruction and experiments. The outcome of enhancing this skill frequently involves a discovery that can improve the lives of humanities or even protect the environment. One of the most important and pervasive goals of schooling is to teach students think. All school subjects share in accomplishing this overall goal. Science contributes its unique skills, with its emphasis on hypothesizing, reasoning from data, and manipulating the physical world through recognizing and controlling variables.

Controlling variables refers to the capability to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable (Padilla, 2009). Moreover, it refers to the ability of students to keep extraneous variables constant while investigating a factor or factors of interest. Student understanding of the control of variables in experiments has long been viewed as playing an important role in science education (Lawson et al., 2005; Linn et al., 2001). However, there are several negative outcomes in the learning process among the students in relation to recognizing and controlling variables experienced by the researcher.

There are learners in which they do not have the ability to identify exactly independent and dependent variables in a given situation and experiment (Gogos and DeBoer, 2007). Several learners find scientific research frustrating since they have some confusion on the variables that should be manipulated and that should be kept constant. In relation to this, there are some instances that students failed from the oral defense of their science investigatory project. One of the primary reasons of having such failure during the said assessment and evaluation is that constant variables were manipulated by the student-researchers while the independent variables were kept the same in their research study (Park & Pak, 1997; Chen & Klahr, 1999; Keselman, 2003). Therefore, the student-researchers came up with invalid and unreliable results of the findings as well as the conclusion of their experiments (Carin & Bass, 2001). Thus, students were unable to accomplish a science investigatory project most especially if it becomes unmanageable. It can be gleaned that the use of 4A model of instruction which is an example of constructivist approach can be used to facilitate the learning outcome, specifically the skill when it comes to recognizing and analyzing research variables (Aquino & Nacario, 2016).

The 4A model of instruction follows the four (4) basic steps namely activity, analysis, abstraction, and application. During the activity phase, the learners are expose to hands-on activities that will hook their motivation and interest for the introductory part of the new topic. After the activity phase, the learners are required to focus on their critical and reflective thinking about the activity that they accomplished. This stage refers to analysis. In the abstraction phase, the learners will acquire new insights about the abstract concepts related to the activity that was performed during the class instruction. The newly acquired knowledge and skills must be demonstrated to another new situations to solve problems. This part of the 4A model of instruction refers to application phase (Del Rosario, 2023). Furthermore, Del Rosario (2023) explained that 4A model of instruction promotes active learning and critical thinking. It further develops comprehensive and engaging learning experience thus it fosters student-centered approach since there is also a collaborative approach between teachers and learners (Baltazar, 2019). The 4A model instructional strategy promotes learners' potential to actively involve in the educative process. Furthermore, they can maximize their time in the different learning activities. It also provides an great opportunities for the learners to collaborate with their peers and enhance self-confidence and motivation (Baltazar, 2019).

Based from the research gaps stated above, the researcher aims to eliminate such misconceptions and to enrich the ability to recognize and control research variables among the Grade 7 learners prior to their experimentation. The researchers perceived that with the aid of 4A model instructional material, the skill in recognizing and controlling variables can be enhanced.

Research Questions

This research study sought to develop the skill in recognizing and controlling research variables prior to experimentation through the

use of 4A model instructional material among the Grade 7 students of Quezon Science High School. Specifically, it sought to answer the following sub-problems:

1. What is the level of conceptual understanding of the student-respondents in terms of recognizing and controlling research variables?
2. Is there a significant difference between the pretest and posttest of the student-respondents in terms of recognizing and controlling research variables?
3. What is the level of acceptability of the developed 4A model instructional material as perceived by the student-respondents in terms of:
    3.1. learning objectives;
    3.2. learning activities;
    3.3. accuracy and clarity;
    3.4. appeal; and
    3.5. usability?

Literature Review

Recognizing and Controlling Research Variables

Variable is the factor or condition or the effect of which it is being tested. In experimental research, there is an incorporation of a high degree of control over the variables in a research study. This control, if used properly, permits the students to establish causal relationships among the variables. Experimental research has two defining characteristics: manipulation of one or more independent variables and control over experimental variables. On the other hand, it offers several advantages in developing the said skill: (1) the students become skilled in searching for reliable evidence before formulating a conclusion; (2) the training on how to design on experiment is developed; and (3) such a controlled set-up enables students to follow the scientific method (Corpuz et al., 2006).

An independent variable is a variable whose values are chosen and set by experiments. To manipulate the independent variable, the students must expose the experimental units to such specific conditions called the treatments of the experiment. Depending on the design of the experiment, the independent variable may be manipulated by exposing the different group of experimental units to each treatment or by exposing each experimental unit to all the treatments in sequence by manipulating the independent variable. In this case, students must observe that changes in the level of the independent variable cause changes in the dependent variable being recorded (Abbott & Bordens, 2011).

The variable whose value that the students observe and measure in experimental design is called the dependent variable (or dependent measure). If a causal relationship exists, then the value of the dependent variable depends, at least to some extent on the level of independent variable (Abott & Bordens, 2011).

Manipulating an independent variable can be as simple as exposing one group of experimental units to some treatment and another group of participants to the absence of the treatment. In this most basic of experimental designs, the group receiving the treatment is called experimental group and the other group the control group. The control group is treated exactly like the experimental group except that it is not exposed to the experimental treatment.

The second characteristic of experimental research is control over the extraneous variables. Extraneous variables are those that may affect the experimental unit that the students wish to investigate but are not of interest for the present experiment. Experimental variables can be controlled by holding it to constant. If these variables do not vary over the course of the students' experiment, they cannot cause uncontrolled variation in their dependent variable.

Numerous research projects have focused on the teaching and acquisition of recognizing experimental variables. For example, Padilla et al. (2005) surveyed the skill in recognizing experimental variable among the 700 middle school students with no special skill training. They found out that only 10% of the students scored above 90% correct even at the eighth-grade level. Several researchers have found that teaching increases levels of skill in recognizing experimental variables. From these studies, it can be concluded that recognizing experimental variables can be taught and that when learned, readily transferred to new situations (Tomera, 2004). The teaching strategy which proved effective was using a combination of explaining, practice with objects that includes manipulation and control, discussions and feedback with observing.

However, there are factors that have been suggested to contribute to students' difficulty in understanding and applying control of variables that include developmental-related requirements (Inhelder, 2008; Kuhn & Angelev, 2006), complexity of task demands, degree of student self-directness, and the quality of instructional supports provided to students (Ross, 2008). For example, research has shown that students often do not learn to control variables without explicit instruction (Sneider et al., 2004), the application of control of variables is inconsistent and influenced by the content and the context of the problems encountered (Lawson, 2005). Duggan et al. (2006), in a review of data from the National Curriculum Council project in the United Kingdom, found that students' ability to identify variables declined with complexity of the task. In a study of seventh-grade students' science process skills in designing an experiment, Germann et al. (2006) found that less than half of students' experimental designs held nonmanipulated variables constant. Germann et

al. (2006) hypothesized that students' performance of these science process skills was related to a variety of factors, including their comprehension of the task, familiarity with the context, previous experience, and general understanding of science and science process skills, and communication abilities.

Other factors that have been shown to affect students' abilities to understand and apply control of variables include instructional factor such as: (1) a focus on memorizing procedures without explicit understanding about how and why to employ specific rules or procedures (Ross, 2008), (2) failure to help students notice salient features of sound designs versus bad designs in a given situation (Sneider, et al., 2004), and (3) use of procedures divorced from any meaningful context (Schauble et al., 2004). Corpuz et al. (2006) suggested several ways in order to develop the skill: (1) before proceeding, identify clearly the variable to changed; (2) be strict with keeping the rest of the conditions the same; (3) provide practice in this kind of activity. They will be trained in searching for cause-and-effects in some conditions in the environment; and (4) how to arrive at correct conclusions must be the objective. One of the possible ways to enhance this science process skill is through the integration of 4A model in which this instructional strategy can maximize students' engagement, collaboration, confidence, and motivation (Carreon, 2019).

4A Model Instructional Strategy

The 4A model instructional strategy follows the idea behind constructivism that encourage active, independent, experiential, and cooperative learning. It consists of four (4) major phases namely activity, analysis, abstraction, and application (Aquino & Nacario, 2016). In the activity phase, students will be provided learning experiences for the acquisition of knowledge and skills. During the analysis phase, learners process or analyze their experiences. New knowledge and skills should be linked to these learning experiences. As a result, learners begin to demonstrate new understandings and apply new skills. This is a process of generalization or abstraction. Lastly, under the application stage, leaners are allowed to use different procedures and the lessons they acquired from the activity to another activity (Nabayra & Sagge, 2022). The said learning model can be integrated among the instructional materials to foster effective learning process.

Instructional Material

Lardizabal (2001) mentioned that instructional materials usually consist of a package of learning activities, usually papers that have to be accomplished by the students. These materials may be used as a part of a course, as a complete course, or as a curriculum design. The essential parts of such material are: (1) statement of purpose or rationale of the module; (2) the pretest, which may show how prepared or unprepared the student is for the material; (3) the objectives, which state what the student is expected to know, do, or feel after accomplishing the material; (4) the instructional activities, which serve as "study guide" and which enable the student to meet the objectives, if done; and (5) the posttest, which measures what students have acquired from the material or if they have mastered the objectives.

Merano (2012) stressed that educators characterized it as self-operating for learning and instruction which is systematic in plausible manner. Hence, it can assist the learners to become self-reliant. The effectiveness of instructional material greatly relies upon the procedure and the level to address the needs of the teachers and the learners depending on the desirable goals (Bebell, 2004). Likewise, Vargas (2009) explained that instructional material should possess the following features: (1) arouses learners' motivation; (2) enhance the learners' skills and understanding; (3) introduce meaningful learning; (4) enrich mental models; and (6) scaffold the ability to come up with empirical means and conclusions. Furthermore, it expressed some important directions in designing and creating instructional material. This activity can be achieved by means of charts, graphs, maps, still images, animation or video to regulate the interest and motivation of the students in learning the subject matter.

Palila (2004) discussed that with use of the material, students can follow their time frame as well as the pace of their learning in accomplishing the activities within the said material. Moreover, there is a reasonable suggestion to get involved in creating the instructional material – it must be followed after the application of instructional goals, objectives, audience and instructional analysis as well as the techniques. Learning materials should rely on the learners' potential and aptitude. Nonetheless, learners get to involve in these activities through the utilization of the learning materials resulting to its validity (Vallesteros, 2004).

Nayve (2001) mentioned that instructional material can be used when it comes to enhancing problem solving and critical thinking skills. Likewise, validation of instructional material in Biology revealed that there is a significant difference between the pretest and posttest scores of the students in the achievement test. Therefore, the use of instructional material is effective in teaching science-related disciplines (Villaverde, 2003). In connection with these findings, Buendicho (2010) emphasized that instructional materials play a pivotal role in developing the learning of the students when it comes to the educative process.

Green (2000) stated that several researchers studied that human brain necessitates the generation of meaning of skills. The brain cannot effectively retain lots of unconnected facts so students need to see patterns in connection. When teachers give some tasks, it must be interesting, equally appealing and focused on essential understandings and skills. Thus, teachers must prepare instructional materials that will arouse the interest of learners (Tomlinson, 2003).

Lastly, Abrantes (2007) pointed out that students' motivation reflects input into the course, such as attention level in class, interest in learning the material, perception of a course's intellectual challenge, and acquired competence in the field. Students' interest facilitates

effective teaching and creates a more favorable learning environment.

Level of Acceptability of Instructional Materials

The level of acceptability refers to a series of predefined standards related to the performance of an individual's product, specifically an instructional material that enables someone to easily determine the instructional material's capability to perform its function within an acceptable range.

Hall et al. (2011) discussed the qualities of good learning objectives of an instructional material. They emphasized that objectives should be stated in terms of the realistic result that the students intend to achieve. Learning objectives must be specific, reasonable, achievable, and measurable within the available time limit. Therefore, all passing students should be able to demonstrate the knowledge or skill described by the learning outcome at the conclusion of the course. In this way, learning objectives should establish standards for the course. Furthermore, good learning objectives reflect and indicate the ways in which the described knowledge and scientific research skills may be used by the learner now and in the future through learning activities.

Wright (2010) emphasized that the most obvious characteristic of good learning activities is that they facilitate the attainment of intended learning objectives. Deeper understanding of knowledge and the ability to apply knowledge in real-life situations are likely to be attained if students work on problems or projects that reflect authentic professional situation or complex theoretical issues. The best example of this is the scientific research skills. Learning outcomes such as communication, problem-solving and time-management skills are well aligned with learning activities where students work alone or in groups on tasks that involve decision-making. Good learning activities of instructional materials are those that enable students to learn actively. The idea is rooted in a constructivist view of learning: learning is attained when learners actively construct their own set of meanings or understandings. Learning activities that facilitate active learning are often, also student-oriented – the focus is on the students' learning processes and how they work on tasks particularly in scientific research. This can be done through learning activities in the course that take into consideration students' learning needs and provide many real-life examples to illustrate scientific research skill concepts.

Newby (2006) defined clarity and accuracy as the capability of the instructional material to provide instructions, expositional or otherwise, which helps students come to a clear understanding of the material. Clarity and accuracy of instructional material has consistently been linked with increases in students' achievement. Clarity and accuracy are vital keys to help students understand the relationships between topics and make connections between what is taught and their own experiences. Important to the concept of clarity is the logical arrangement of instructional material for understanding that could be understood and processed easily by a certain group of students to master the concepts and ideas.

Appeal to the target users means that all words are spelled correctly, all fonts are legible, all margins set correctly, all media and resources linked to from the instructional material that are available. Hence, this refers to the instructional materials' layout that will establish the students' comfort and motivation (Newby et al., 2006). Moreover, if students consider the instructional material not visually appealing, it will negatively influence their perception of the instructional material. To make the instructional material more appealing, Newby et al. (2006) discussed the following guidelines: (1) use a limited number of colors; (2) use bright colors sparsely; (3) do not overuse pictures; and (4) do not avert attention from the main content. The idea of what is appealing is subjective and is ideally verified in a focus group.

According to Keinonen (2008), usability refers to the extent to which a learning instructional material can be used by its target audience to achieve specified learning objectives with efficiency, effectiveness and satisfaction. In the present research, usability is understood primarily as the product's usability attributes, which are measured through subjective user experiences with a self-evaluation questionnaire. Students' subjective perception of the instructional materials is equally important. Put simply, students judge an instructional material when it meets their initial expectations and when tasks can be performed easily. Hence, a good instructional material is finely attuned to the needs, expectations and motivation of its target audience. If the students' experiences match with the expectations, it will play a vital role in the overall learning experience. The actual learning experience should match or surpass the expectations.

In general, the acquisition of skill in recognizing and controlling variables enriches the potential of the learners to employ scientific ways of satisfying their own inquiries which is said to be a paramount goal which they carry up to adulthood. Through this skill, scientific attitudes can be integrated in which they will become more knowledgeable in performing scientific investigations like experiments. Recognizing and controlling research variables can be enhanced through a variety of teaching strategies such as problem solving and inquiry approach.

In relation to the use of several assessments and evaluations together with the existing problems nowadays encountered by the Philippine educational system in relation to the implementation of K to 12 Basic Education Curriculum, the researcher developed 4A model instructional material to elevate the students' skill in recognizing and controlling research variables. It should be accompanied with appropriate methods in assessing and evaluating the performance of the students who are involved in authentic tasks.

This research study differs from those previous existing studies conducted by researchers since it focuses only on a limited scope. In other words, the said study places more emphasis in just one component of scientific inquiry skill, which is, recognizing and controlling

research variables. Instead of achieving such knowledge and mastery of the learning content in several disciplines like biology, chemistry and physics, the goal of this study is focused primarily on the improvement of skill in recognizing and controlling research variables. This component served as the foundation of scientific investigations and experiments.

Methodology

Participants

The respondents of the study consisted of Grade 7 students with a sample size of 70 enrolled at Quezon Science High School through purposive sampling method. The school aims to produce students who are both academically inclined and substantially trained in the basic work skills making them globally competitive and value-oriented through relevant and responsive curriculum. In relation to the school's mission, several curricular programs were offered to address the student's needs and learning competencies.

The researcher selected this group of student-respondents for the said study since the first topic for the first quarter of Science 7 deals with the components of scientific investigation where the concept of recognizing and controlling experimental variables is embedded. This learning competency is prescribed under the K to 12 Basic Education Curriculum offered by the Department of Education.

Instruments

There are several research instruments that were used in the study to achieve such reliable and valid results and discussions which are essential for the attainment of the desirable objectives. To design an instructional material, the researcher utilized several literary sources like books, electronic references, learning competencies and other existing modules that provide a glimpse related to recognizing and controlling research variables within the research settings to acquire some ideas and concepts that eventually resulted to the plan on how this topic will be constructed. The said material includes: (1) stating the hypotheses, (2) identification of independent, dependent, constants and control variables; and (3) creating a research design necessary to conduct an experiment. It integrates the 4A model instructional strategy that consists of activity, analysis, abstraction, and application phases in consonance to constructivist approach. It was revised based from the recommendations of experts in the field. Adding, the researcher constructed a fifty-item multiple-choice and identification type achievement test to determine if the developed and validated instructional material had a positive impact on the students' performance level, specifically, in recognizing and controlling research variables. This achievement test was taken as the pretest and posttest after the student- respondents utilized the instructional material. All of the questions in the said assessment were categorized within the understanding, applying, and analyzing levels as prescribed under Bloom's Taxonomy for cognitive domain of instruction. In constructing the achievement test, the researcher consulted the secondary school head teacher of Science and Technology Department of the said institution for evaluation and validation with regards to test construction. Thus, several modifications were followed. In order to find out the level of acceptability of the instructional material in enhancing the skill in recognizing and controlling research variables, the researcher adapted a modified questionnaire of Queaño (2012) in a form of a Likert Scale. The format of this scale was a typical four (4)-level one namely strongly agree, agree, disagree and strongly disagree. To assess the acceptability of the developed instructional material, a questionnaire that consists of five (5) criteria was used. The questionnaire determined the level of agreement of the student-respondents on the acceptability of the instructional material in terms of: (1) learning objectives; (2) learning activities; (3) accuracy and clarity of the material; (4) appeal of the material; and (5) usability. The said instrument was pilot tested to verify its reliability. Cronbach's alpha was used as the statistical treatment to evaluate the reliability in terms of internal consistency of the said research instrument.

Procedure

To facilitate the study, the researcher first asked permission from the school principal to conduct the study in relation to ethical considerations.

The data gathering procedure involved two (2) phases. During the first phase, the researcher administered the achievement test that was taken as the pretest and posttest before and after the student - respondents utilized the instructional enrichment material respectively. The said achievement test was first administered before the utilization of the said material to evaluate the prior existing knowledge the students already possess about recognizing and controlling research variables within the experimental settings. The students' scores were gathered since these data were used in the subsequent procedures. After two (2) weeks of utilizing the instructional material, posttest was administered that was given to each student-respondent. Afterwards, the test results were collected.

Each Grade 7 student-respondent received the hardcopy of the instructional material. The said material was used by the researcher as his main educational material within two (2) weeks. If there are some queries among the student-respondents with regards to the directions given for each activity in the instructional material, they were taken into account for further understanding. The instructional material was used by the researcher during the classroom discussion since it served as the main reference material among the student-respondents following the 4A model. It also provided a wide variety of formative and summative assessments after the discussion inside the class to monitor the learning outcomes among the students. It also presents several learning activities that can be used to have additional tasks for further enrichment to extend the learning process among the students. The researcher utilized the said material within the first two (2) weeks of September as part of the first grading period, S.Y. 2023 – 2024.

The researcher administered the questionnaire on the level of acceptability and of the instructional material to the Grade 7 student-respondents at the end of the first grading period. Each student-respondent was given a copy of the said questionnaire. Afterwards, their responses were assessed and evaluated to determine the level of acceptability of the instructional material. Thus, the level of agreement of the students towards the developed instructional material based on the criteria indicated in the said questionnaire was determined. Mean, mean percentage score (MPS), t-test for dependent sample, and weighted mean are the statistical treatments that were u sed for data analyses with regards to the results of the pretest, posttest, and the questionnaire on the level of acceptability in a form of Likert scale, respectively.

Ethical Considerations

This study conforms to the standard of ethical considerations in research using the four (4) major principles: non-maleficence, beneficence, justice, and autonomy. In this study, student-researchers are free from any forms of harmful activities that could result to withdrawal or mortality in research. In contrast, the student-respondents gained benefits from the study by enhancing their science process skills specifically recognizing and controlling experimental research variables. They can perform authentic tasks based from the real-world scenarios as performed by scientists in exploring theories, laws, principles, and innovations for the betterment of the world community and the humanity. Moreover, the student-respondents were treated with fairness throughout the conduct of the study in which all of them have equal access to all the learning materials and activities regardless of their different background, religion, and culture. Thus, it follows the concept of inclusive education. Lastly, the student-respondents are well-informed about the procedure before, during, and after the conduct of the study in connection to debriefing as one of the essential components of ethical considerations.

Results and Discussion

Table 1. *Conceptual Understanding in Recognizing and Controlling Research Variables*

Source of Data	*n*	*M*	*SD*	*MPS*	*Interpretation*
Pretest	70	20.23	6.76	40.46%	Average

Table 1 revealed that the pretest mean score of the student-respondents is 20.23 and the standard deviation is equal to 6.76. This means that the pretest scores of the student-respondent is more heterogenous than their posttest scores. It indicates that the pretest scores are more widely scattered away from the mean score. In addition, it only indicates that they have an "average level" when it comes to the conceptual understanding regarding recognizing and controlling research variables based from the MPS value of 40.46%. It can be inferred that the learners do not have enough mastery in terms of recognizing and controlling research variables. Thus, there is a need to provide solutions to achieve functional knowledge and skills for the enhancement of scientific investigation. The result stated above is parallel to the notion that there are learners in which they do not attained such mastery in identifying exactly independent and dependent variables in a given research setting (Gogos and DeBoer, 2007). May students perceived that scientific research as difficult because they have weak foundation and understanding with regards on the variables that should be manipulated and that should be kept constant. Likewise, there are situations that learners failed during the oral presentation of their science investigatory project since the constant variables were manipulated by the student-researchers while the independent variables were kept the same in their research study (Park & Pak, 1997; Chen & Klahr, 1999; Keselman, 2003). Thus, they come up with invalid and unreliable results, findings, and conclusions (Carin & Bass, 2001). As a result, learners are not successful when it comes to the accomplishment of the science investigatory project specifically if it becomes unmanageable.

Table 2. *Significant Difference between Pretest and Posttest*

Source of Data	*Highest Score*	*Lowest score*	*Total no. of Items*	*M*	*SD*	*Difference between Means*	*t-value*	*Level of Significance*
Pretest	41	9	50	20.23	6.76	21.63	24.31	0.05

Table 2 shows the summary of values for testing significant differences between the pretest and posttest scores. The result demonstrates that out of 50 items, the mean score of the students in the pretest is 20.23 with a standard deviation of 6.76 while the mean score in the posttest is 41.86 with a standard deviation of 4.23. The standard deviation in the posttest is lower than that of the pretest. This result reveals that the pretest scores are more widely distributed than the posttest scores. To determine if the difference is significant, the t-test for dependent sample was applied. The computed t-value is 24.31 which is higher as compared to the tabular value of 1.96 at 0.05 level of significance. Since the t-value is greater than the tabular value, the null hypothesis that "there is no significant difference between the pretest and posttest scores of Grade 7 students" was rejected. It is evident that the gained scores in the posttest can be attributed to the utilization of 4A model instructional material in recognizing and controlling research variables. It only indicates that the student-respondents greatly improved their skill in recognizing and controlling research variables through the utilization of the instructional material. This positive outcome can be attributed to the learning objectives of the material that are specific, reasonable, achievable and measurable within the capability of the student-respondents. It also includes activities that consider the students' needs and provide real-life examples that facilitate active learning. It only means that the material matches the students' experiences with their expectations. Thus, they are able to demonstrate the knowledge and the skills. Numerous research projects have focused on the teaching and acquisition of recognizing experimental variables. For example, Padilla et al. (2005) surveyed the skill in recognizing

experimental variable among the 700 middle school students with no special skill training. They found out that only 10% of the students scored above 90% correct even at the eighth-grade level. Moreover, Merano (2012) noted that various researchers shared common concepts on the theories that will promote learning, improve mastery and enhance learning with the use of instructional materials. Likewise, Buendicho (2010) stressed that instructional enrichment materials play a vital role in enhancing the learning outcomes of the students when it comes to the teaching-learning process. Therefore, the quality of instruction depends upon the organization of information on which the instructional material was made. In the light of the findings, the researcher came up with the concept that the developed 4A model instructional material in recognizing and controlling research variables within the experimental settings is ready for adoption. Furthermore, it is a valid tool in teaching the basic principles of experimental research since the learners achieved the mastery of the said knowledge and skill. Indeed, the use of 4A model instructional strategy fosters active learning process since it promotes concrete learning experiences that includes hands-on activities for better understanding of the concepts. It supports the enhancement of science process skills which are essential for the accomplishment of real-world tasks within the science community. It can be interpreted that it is commendable for use. However, summative evaluation of the said instructional material may be done to determine the effectiveness of the material in recognizing and controlling research variables. Furthermore, other authentic learning experiences and performance assessment may be used to enhance further the skill in recognizing and controlling research variables. Adding, it can be utilized by other students with no separate research subject and for those regular high school students. It can be integrated with other science subjects that require the application of research variables within the experimental setting. Lastly, same type of material for other sub skills within the area of scientific inquiry may be developed to address the needs of the students to continue and foster the acquisition of the paramount goals of science education.

Table 3. *Weighted Mean Distribution on the Level of Acceptability of the 4A Model Instructional Material in Recognizing and Controlling Research Variables as to Learning Objectives*

	Statement	*SA (4)*	*A (3)*	*D (2)*	*SD (1)*	*WM*	*Descriptive Rating*
1.	The objectives of the learning activities followed the content standard of the subject matter.	48	22	0	0	3.69	Strongly Agree
2.	The objectives consist of clarified and specified learning tasks.	47	23	0	0	3.67	Strongly Agree
3.	The objectives in the material were attainable and measurable.	40	30	0	0	3.57	Strongly Agree
4.	Objectives clearly reflected the infused values in each activity.	38	32	0	0	3.54	Strongly Agree
	Average Weighted Mean					3.62	Strongly Agree

Table 3 presents the students' responses with regard to the acceptability level of the 4A instructional material in recognizing and controlling research variables as to learning objectives of the material. In terms of "the objectives of the learning activities followed the content standard of the subject matter", it has a weighted mean of 3.69 which is "strongly agree". This means that the instructional enrichment material contains learning objectives that are adherent to the benchmark related to the subject matter, specifically in the field of research. The same thing with the other criteria for the learning objectives of the material such as "the objectives consist of clarified and specified learning tasks", "objectives clearly reflected the infused values in each activity", and "the objectives in the material were attainable and measurable" have weighted means of 3.67, 3.57, and 3.54 respectively. These weighted mean values fall under the descriptive rating of "strongly agree". It implies that the material contains clear and well-explained learning objectives that are said to be within the level of capability of the students. The learning objectives integrate the values to be enhanced by the students. It only connotes that the objectives of the said material follow the ultimate goals of science teaching. The objectives are stated in terms of realistic result that the teachers intend to achieve. Hence, the objectives are specific, reasonable, achievable and measurable. The average weighted mean for the level of acceptability of instructional enrichment material in terms of learning objective is 3.62 which is "strongly agree". It only means that the instructional enrichment material contains objectives that provide well-defined and specific learning tasks as well as integrated values which are assessable and achievable that follows the content requirement of the subject matter. This positive rating confirms the characteristics of a good instructional material that the objectives must be properly and logically sequenced, specific, observable, measurable and attainable. Similarly, Bebell (2004) stressed that the effectiveness of instructional materials depends upon the manner and the degree to which they meet the needs of teachers and students based on the learning objectives.

Table 4 shows the acceptability level of the 4A model instructional material in recognizing and controlling research variables in terms of learning activities of the materials. The obtained weighted mean for the all items ranges from 3.47 to 3.66 that fall under the descriptive rating of "strongly agree." The respondents strongly agree on the statement that "activities that were developed to enhance the skill in recognizing and controlling research variables". This response indicates that the students learned how to manipulate the variables since the instructional material allows them to integrate knowledge and skills that requires them to use when performing experiments. The material also provides "activities that were presented in an organized manner" and "activities were distributed fairly from simple to complex". This can be attributed to the proper sequencing of topics of the instructional material in which the prerequisite topics were discussed first. Identifying variables comes first before the students create a design of an experiment to test the hypothesis. The material also includes "activities that were created to stimulate my interest in learning". It signifies that it facilitates active learning since the material provides a number of ways to enhance student participation in the learning process. The instructional material contains "activities that were arranged accordingly to develop critical thinking".

Table 4. *Weighted Mean Distribution on the Level of Acceptability of the 4A Model Instructional Material in Recognizing and Controlling Research Variables as to Learning Activities*

	Statement	*SA (4)*	*A (3)*	*D (2)*	*SD (1)*	*WM*	*Descriptive Rating*
1.	The activities were developed to enhance the skill in recognizing experimental variables.	46	24	0	0	3.66	Strongly Agree
2.	The activities were distributed fairly from simple to complex.	33	37	0	0	3.47	Strongly Agree
3.	The activities were presented in an organized manner.	45	24	1	0	3.62	Strongly Agree
4.	The activities were linked logically to other topics.	33	37	0	0	3.47	Strongly Agree
5.	The activities were created to stimulate my interest in learning.	39	31	0	0	3.55	Strongly Agree
6.	The activities were arranged accordingly to develop critical thinking.	40	27	3	0	3.53	Strongly Agree
7.	The activities were applied to real-life situation.	43	27	0	0	3.61	Strongly Agree
8.	Activities were suited appropriately to the needs of our group in the class.	38	32	0	0	3.54	Strongly Agree
9.	The activities can be understood easily.	35	34	1	0	3.49	Strongly Agree
10.	The learning activities were based naturally on infused values.	33	37	0	0	3.50	Strongly Agree
	Average Weighted Mean					3.54	Strongly Agree

Moreover, the material also contains "activities that were applied to real-life situation" since it contains activities that are simple yet it requires a period of exploration that can be found within the experimental settings. The material also contains "activities that were linked logically to other topics" since it has a weighted mean value of 3.47 that has a descriptive rating of "strongly agree". In addition, "activities were suited appropriately to the needs of our group in the class". This indicates that the material supports the cooperative learning that are commonly regarded as an essential approach in all disciplines. The acceptability level of the instructional enrichment material in terms of its learning activities is 3.54 which fall under the descriptive rating of "strongly agree". Based from the result of this study, the learning activities incorporated in the material provide the students several ways of assessing themselves. It helps the students to enhance their skills towards research variables. Vargas (2009) stated that instructional materials should stimulate students' interest, enrich students' experience, make learning meaningful and develop mental imagery as well as observation and generalization. Abrantes (2007) stressed that students' interest reflects input into the course, such as attention level in class, interest in learning the material, perception of a course's intellectual challenge, and acquired competence in the field.

Table 5. *Weighted Mean Distribution on the Level of Acceptability of the 4A Model Instructional Material in Recognizing and Controlling Research Variables as to Accuracy and Clarity of Material*

	Statement	*SA (4)*	*A (3)*	*D (2)*	*SD (1)*	*WM*	*Descriptive Rating*
1.	The material was logically arranged to supply order of understanding.	45	25	0	0	3.67	Strongly Agree
2.	The material was diversely supplied to master concepts and ideas.	36	34	0	0	3.54	Strongly Agree
3.	The instructions of the material could be easily understood and processed by our group in the class.	47	21	2	0	3.64	Strongly Agree
4.	The characters of the material were comprehensively, visibly, and intelligibly crafted.	39	31	0	0	3.56	Strongly Agree
5.	The activities of the material were logically connected to previous lessons.	43	27	0	0	3.43	Strongly Agree
	Average Weighted Mean					3.60	Strongly Agree

Table 5 presents the students' responses in relation to the acceptability level of the 4A model instructional material in recognizing and controlling research variables as to accuracy and clarity of the material. The weighted mean for all the items ranges from 3.43 to 3.67 which is categorized under the descriptive rating of strongly agree. In terms of "the activities of the material were logically connected to previous lessons", it has weighted mean of 3.43. It can be inferred that the flow of the lesson content is well-organized since the topics are related to one another. Likewise, for the other criteria such as "the characters of the material were comprehensively, visibly, and intelligibly crafted" has a weighted mean value of 3.56. This may be due to the graphics that stimulates motivation among the learners. The material was "logically arranged to supply order of understanding" has a weighted mean of 3.67. It means that the material helps the students understand the relationships between topics and make connections between what is taught and their own experiences. The material also "includes instructions that could be easily understood and processed by our group in the class", and "the material was diversely supplied to master concepts and ideas", have weighted mean values of 3.64 and 3.54 respectively. It indicates that the material integrates other disciplines since it contains knowledge of multiple disciplines such as biology and chemistry. In general, the result indicates that the instructional material delivers such contents that can be understood easily since the concepts are arranged thoroughly. This result corresponds to the study of Merano (2012) that instructional material develops self-pacing of learning and individualized instruction which is organized in logical sequence; therefore, it can help students to become independent. In addition, Green (2000) pointed out also that students need to see patterns in connection to enable the brain make its own meaning of ideas and skills since it cannot effectively retain lots of unconnected facts

The acceptability level of 4A model instructional material in recognizing and controlling research variables in terms of appeal of the material is illustrated in Table 6. All items for this criterion fall under the descriptive rating of "strongly agree" since the obtained weighted mean ranged from 3.44 to 3.62. In terms of "the information the material enabled me to develop critical thinking and problem

solving" and "the material provided varied benefit to my own learning capacity", both criteria received a weighted mean value of 3.60 and 3.57. It only suggests that the material developed the critical thinking and problem-solving skills in relation with the research variables of the learners.

Table 6. *Weighted Mean Distribution on the Level of Acceptability of the 4A Model Instructional Material in Recognizing and Controlling Research Variables as to Appeal of the Material*

	Statement	*SA (4)*	*A (3)*	*D (2)*	*SD (1)*	*WM*	*Descriptive Rating*
1.	The material's lessons captured my own interest.	31	39	0	0	3.44	Strongly Agree
2.	The exercises' layout established my comfort and motivation.	38	30	2	0	3.51	Strongly Agree
3.	The material provided varied benefit to my own learning capacity.	40	30	0	0	3.57	Strongly Agree
4.	The material stimulated my interest toward learning the lessons.	45	24	1	0	3.62	Strongly Agree
5.	The information forms the material enabled me to develop critical thinking and problem solving.	42	28	0	0	3.60	Strongly Agree
	Average Weighted Mean					3.55	Strongly Agree

The material also "stimulated my interest toward learning the lessons". This criterion has a weighted mean of 3.62 since the students were observed that they show cooperation during their laboratory experiments in research subject. The same thing with "the exercises' layout established my comfort and motivation" and "the material's lessons captured my own interest". These criteria have weighted mean values of 3.51 and 3.44 respectively. These results can be attributed to the presence of visual effects, graphics, photographs and font styles that are legible in the instructional material. The acceptability level of the instructional enrichment material in terms of its appeal is 3.55 which fall under the descriptive rating of "strongly agree". The result reveals that the instructional material provide a wide-ranging advantage in the learning outcomes of the students initiated by the curiosity and motivation that activates their ability to recognize and control research variables. In accordance with the results, the study of Nayve (2001) emphasized that the instructional material enhances the problem solving and critical thinking skills in relation to research variables. Vargas (2009) stated that the instructional material must be enhanced through several forms of media such as photographs and still images. These features enhanced the motivation of the students in learning the said topic. Tomlinson (2003) pointed out that when teachers assign work, it should be equally interesting, equally appealing and equally focused on essential understandings and skills.

Table 7. *Weighted Mean Distribution on the Level of Acceptability of the 4A Model Instructional Material in Recognizing and Controlling Research Variables as to Usability of the Material*

	Statement	*SA (4)*	*A (3)*	*D (2)*	*SD (1)*	*WM*	*Descriptive Rating*
1.	Instructional enrichment materials helped me gain satisfaction in recognizing experimental variables.	40	27	3	0	3.53	Strongly Agree
2.	The use of instructional material as an aid in learning scientific research skills made every topic more exciting and enjoyable.	39	29	2	0	3.53	Strongly Agree
3.	The instructional enrichment materials gave the students self-confidence in doing scientific research activities.	40	27	3	0	3.53	Strongly Agree
4.	The instructional enrichment materials create strategies that allowed me to practice knowledge and skills in my own pace.	31	39	0	0	3.44	Strongly Agree
5.	Instructional enrichment materials stimulated my own desire and interest to learn more about the subject matter.	37	32	1	0	3.51	Strongly Agree
6.	The material helped me gain maximum participation during the lectures and discussions.	40	30	0	0	3.57	Strongly Agree
7.	Instructional materials as tool for learning how to recognize experimental variables improved my study habits.	46	22	2	0	3.63	Strongly Agree
8.	I learned more when given activities suited to my ability.	40	30	0	0	3.60	Strongly Agree
9.	With the aid of instructional enrichment materials, I gained self-worth in dealing with research variables.	34	36	0	0	3.48	Strongly Agree
10.	Instructional enrichment materials improved my skill in recognizing experimental variables.	40	30	0	0	3.51	Strongly Agree
	Average Weighted Mean					3.54	Strongly Agree

Table 7 reflects the students' responses in relation to the acceptability level of 4A model instructional material in recognizing and controlling research variables as to the usability of the material. The obtained weighted mean for all the items in the usability of the material range from 3.44to 3.63 which got a descriptive rating of "strongly agree". The average weighted mean for the level of acceptability of instructional enrichment material in terms of usability is 3.54 which is "strongly agree". Based on the result of this study, the instructional enrichment material helps the students to learn how to recognize and control research variables since it provides a variety of learning activities that fit to their abilities. Hence, it improves the study habits and active involvement of the students in their own pace. The results conform to the study of Vallesteros (2004) that the instructional materials must depend on the learners' capability hence; many individuals will participate actively with the use of varied learning materials. Likewise, Palila (2004) mentioned in his research study that through the utilization of instructional materials, learners can regulate their time management as well as the

pace of their learning in accomplishing the different tasks as prescribed in the instructional module.

Conclusions

In the light of the findings, the researcher came up with the concept that the developed 4A model instructional material in recognizing and controlling research variables within the experimental settings is ready for adoption. Furthermore, it is a valid tool in teaching the basic principles of experimental research since the learners achieved the mastery of the said knowledge and skill. Indeed, the use of 4A model instructional strategy fosters active learning process since it promotes concrete learning experiences that includes hands-on activities for better understanding of the concepts. It supports the enhancement of science process skills which are essential for the accomplishment of real-world tasks within the science community. It can be interpreted that it is commendable for use. However, summative evaluation of the said instructional material may be done to determine the effectiveness of the material in recognizing and controlling research variables. Furthermore, other authentic learning experiences and performance assessment may be used to enhance further the skill in recognizing and controlling research variables. Adding, it can be utilized by other students with no separate research subject and for those regular high school students. It can be integrated with other science subjects that require the application of research variables within the experimental setting. Lastly, same type of material for other sub skills within the area of scientific inquiry may be developed to address the needs of the students to continue and foster the acquisition of the paramount goals of science education.

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