Development and Validation of Instructional Modules on Rational Expressions and Variations

Evelyn C. Torrefranca
E. Rodriguez Jr. High School, Mayon Avenue, Quezon City
euleraved@yahoo.com

Abstract Modular instruction is an attempt to individualize learning by allowing a student to achieve mastery of one unit of content before moving on to another. Module, as a self-instructional material, can be used as a supplementary material to help the student improve his/her mastery and as means to help the student catch up with the missed lessons. In this study, instructional modules on two content areas of Algebra taught to second year high school students were developed and validated. Specifically, module 1 consisted of 11 lessons on Rational Expressions, and module 2 consisted of nine lessons on Variations. Findings revealed that all the evaluators strongly agreed that the instructional modules satisfied the criteria for evaluating the modules. Meanwhile, the significant change in the pretest and posttest scores of student-participants before and after they were exposed to the modules signify that the modules brought out improvement in their knowledge of Rational Expressions and Variations. Possible replication of the study to cover other topics in Intermediate Algebra is recommended to

further support the findings that emerged.

Keywords: Instructional modules, rational expressions, variations

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Introduction

Mathematics instruction underscores understanding and establishing the relationship between the students' knowledge and intuition about the concrete structure and theoretical nature of mathematics. Because of its abstract nature, mathematics is also usually a subject that is best endured rather than enjoyed by most young learners who are not mathematically inclined (Acelajado, 2006). As educational leaders, it is thus significant to explore how instructional design can be used in a traditional learning environment to enhance teaching. Instructional design, which involves systematic development of instructional materials and activities, ensures that learners achieve specific learning goals or educational outcomes reflected in the education curriculum and provides relevant instructions suitable for a wide range of learning environment.

One of the important educational innovations in instructional design that can complement the traditional face-to-face instruction is programmed instruction in module form. This approach, often called modular approach, consists of self-directed learning activity packets that are self-instructional, self-paced, student directed, and place the responsibility of learning on the students. Basically, the basic principles of modular instruction involves the division of the curriculum into limited units or modules of learning which are assessed at the end of that unit, with the student building up a degree through such learning being credited (Jenkins
& Walker, 1994). Through this method, the teacher sheds the role of presenter, demonstrator, driller, and questioner, and now takes on the role of facilitator, initiator, monitor, coach, and coordinator. More importantly, it provides students opportunities to direct their own learning while they construct meaningful experiences about the concepts being taught.

For the past eleven years of teaching high school mathematics, the researcher strongly believes that developing mathematical understanding does not merely mean getting high scores in different assessments such as quizzes and tests or being able to solve drills in mathematics books; rather, it is manifested in the students' ability to relate and communicate to previously acquired knowledge and be able to identify its practical purpose. Hence, it is hoped that through the effective use of self-directed learning activity packets contained in the developed instructional module, students could be provided with an opportunity to become self-directed learners as they accept more responsibility in learning about the concepts and principles of Rational Expressions and Variations.

This study was designed with the premise that Rational Expressions and Variations (content areas under the domain of Algebra) can be taught significantly to second year high school students using instructional modules. Specifically, the topics included in the instructional module on Rational Expressions are the following: (1) properties of rational expressions;
(2) simplifying rational expressions; (3) fundamental operations involving rational expressions; (4) complex rational expressions; (5) solving equations with rational expressions; and (6) solving word problems involving rational expressions. On the other hand, the topics included in the instructional module on Variations are the following: (1) direct variation; (2) inverse variation; and (3) joint variation. The schematic representation of the topics included in the instructional modules is presented in Figure 1.

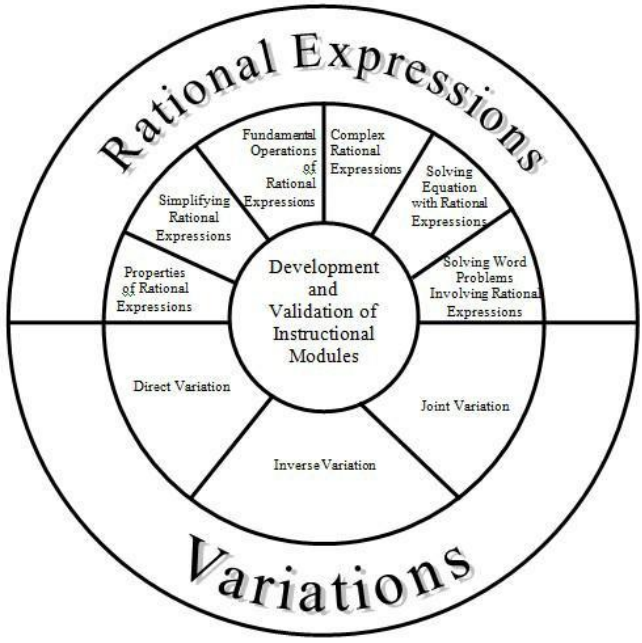


Figure 1. Schematic representation of the topics included in the instructional modules on Rational Expressions and Variations

The figure above shows the schematic representation of the topics covered in developing and validating the instructional modules on Rational Expressions (i.e., properties of rational expressions, simplifying rational expressions, fundamentals of rational expressions, complex rational expressions, solving equations with rational expressions, and solving word problems involving rational expressions) and Variations (i.e., direct variation, inverse variation, and joint variation).

Literature Review

Self-Directed Learning

The necessity for learners to become self-reliant, self-disciplined, and self-confident in their ability to direct their own learning is becoming increasingly important in today's sophisticated society. Self -directed learning (SDL) refers to the capacity of learners to plan, implement, and evaluate their own learning activities (Merriam, Caffarella, & Baumgartner, 2007) . That is, SDL contextualizes the process in which the learner takes the initiative and responsibility for setting his/her own learning goals, identifying and addressing gaps in his/her learning, identifying resources, selecting and carrying out learning strategies and evaluating his/her own learning (Loyens et al., 2008). In a similar vein, Guglielmino (2008) explicated self-directed learning (SDL) as an effective mode of learning for individuals to possess in the information age as it underscores the capacity of an individual to cope with constant changes. Given the high speed of information changes in the society, individuals must learn how to direct themselves in acquiring information and knowledge to be able to survive and compete with others.

This notion of SDL is further supported by Shaikh (2013) who argued that self-directed learning exists along a continuum; it is present in each person to some degree, and students differ in their readiness for self-directed learning. Self-regulated learners take on challenging tasks, practice their learning, develop a deep understanding of the learning material, and exert extra effort, which leads to academic success (Perry, Phillips, & Hutchinson, 2006). Hence, in order to prepare learners to live in a world that is marked by rapid and sweeping change, education needs to achieve two objectives: (1) to provide the appropriate content knowledge; and (2) to prepare learners with SDL skills that will serve them throughout their lifetime (Dynan, Cate, & Rhee

2008). That is, schools' learning activities must encourage the development of self-directed learning skills so that it may help students to succeed in their present and future learning.

Self-learning Modules

Various strategies have been developed to foster self-directed learning. For instance, Smedley (2007) offered a set of strategies that may assist self-directed learning readiness: creating a supportive learning environment; providing constructive feedback; encouraging self-assessment; using self- reflection; providing opportunities to engage in their own learning processes; and developing goal orientation values. These strategies may be helpful for teacher educators who consider taking a step towards fostering students' self-directed learning and helping students to survive and thrive in this information age.

In addition to these aforementioned strategies, an approach to self-directed learning requires the utilization of instructional materials that are designed to help the students to learn by themselves. These self-instructional materials, which could be in module form, consisted of self -contained, independent unit of instruction prepared for the purpose of attaining defined instructional objectives (Macarandang, 2009). Two distinctive features of self-instructional modules are the following: promotes self-paced learning and its availability at any time and at any place. As a self- pace learning material, it allows a learner to work at his/her own pace rather than the pace of the group, which can be too fast or too slow. The availability of the self- instructional material likewise allows students to learn when they wish rather than according to an external timetable.

Purposes of the Research

The main purpose of this research study was to develop and validate instructional modules on Rational Expressions and Variations.

Specifically, this study aimed to: (1) design instructional modules on Rational Expressions and Variations; (2) establish the content validity and reliability of the designed module; and (3) evaluate the designed module.

Methodology

Research Design

The present study utilized the design and development research approach to establish an empirical basis for the creation of instructional products, which are self-instructional modules.

In particular, the researcher utilized the ADDIE (Analysis, Design, Development, Implement, Evaluate) Model in developing the instructional modules on Rational Expressions and Variations, as shown in Figure 2.

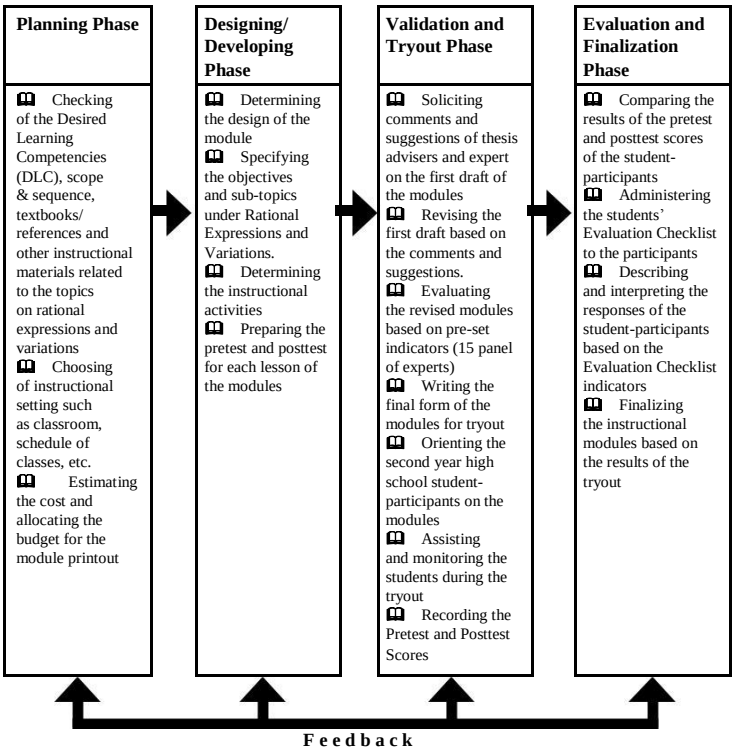


Figure 2.

Participants

The participants of this study were the students of a government-owned secondary school in Quezon City. Specifically, the second year high school students who were taking up Intermediate Algebra at the time of the study were included. Since the school uses homogeneous sectioning for the first two sections and heterogeneous sectioning for the other sections, the researcher used the first four sections that were assigned to her. The researcher decided to use sections II – Narra (A) composed of 51 students; II – Acacia (B) with 49 students; II – Banuyo (C) with 46 students; and II –

Banaba (D) with 47 students, following the regular schedule of classes to avoid disruption of classes during the tryout of the modules. Thus, there were 82 male students and 111 female students for a total of 193 students chosen as student-participants of the study.

Instruments

In gathering data relevant in this study, the researcher employed the following: (1) Experts' Evaluation Checklist of the Instructional Modules; (2) Pretest and Posttest for each instructional module; and (3) Students' Evaluation Checklist of the Instructional Modules.

1. *Experts' Evaluation Checklist of the Instructional Modules.* In order to have a basis for determining the acceptability of the developed instructional modules, a five-point Likert checklist was adapted from the theses of Marin (2003) and Marasigan (2003). Some modifications on the item format were made to better align them with the purpose of the study. Revisions were validated by the thesis adviser.

2. *Pretest/Posttest.* This achievement test was administered as a pretest to gather baseline information on what the students know prior to their exposure to the instructional module and as a posttest to measure the students' achievement after learning the content of the module. In developing the achievement test, the researcher adhered to the standard procedures in developing and validating a test, beginning with the development of test specifications up to gathering evidence that would support the validity and estimate the reliability of the test. The resulting reliability of the developed achievement test is 0.76, assuring that the scores

yielded by the test is an accurate measure of how much the student have learned on the areas of Rational Expressions and Variations.

3. *Students' Evaluation Checklist of the Instructional Modules.* This instrument is a five-point Likert checklist adapted from the theses of Marin (2003) and Marasigan (2003). Unlike the expert's evaluation form, the checklist for students focused only on the content and format of the developed instructional modules, yielding a total of 10 items.

Data Collection

Data collection activities that were done in the present study are described as follows:

Phase 1 – Planning Phase

The researcher examined books and related materials in Rational Expressions and Variations, which are the domains of Intermediate Algebra. The researcher also referred to and checked the Desired Learning Competencies and scope and sequence prescribed by the Department of Education for second year high school students. The goal of the researcher at this stage was to create a matrix that would show the essential competencies that must be demonstrated in Rational Expressions and Variations. Deciding and determining the specific competencies to be captured in the instructional module was done in Phase 2. Choosing of instructional setting, estimating the cost, and allocating the budget for the module printout were also considered in this phase.

Phase 2 – Designing/Developing Phase

After determining the target learners and the topics to be modularized, the writer structured the modules. In the process of developing the modules, outlined procedures were

adopted to achieve the purpose of this study. These are:

Stage 1. Determining the design of the module. The researcher identified the basic parts of the module, and the topics were laid out in the form of a curriculum grid. Basically, each lesson of the modules had the following components:

(1) Overview. This gives the students a bird's eye view of the module, and this motivates them to study each lesson in each module. It consists of the target population, prerequisite, objectives, and basic instructions on how to use the module that include the teacher's and learner's guides.

(2) Objectives: These are the specific competencies that the students should acquire for each lesson.

(3) Pretest. It is designed to determine learners' baseline knowledge about the concept.

(4) Learning Activities. These include the specific lessons that are aligned with the learning objectives of the module.

(5) Practice Tasks. These consist of exercises for all students to apply and review concepts or procedures.

(6) Posttest. It is designed to measure learners' understanding of the concept and their retention of the information gained from the module.

Stage 2. Specifying the objectives and subtopics under rational expressions and variations. Specific objectives for each lesson were taken from the Desired Learning Competencies for second year mathematics. In this stage, the researcher decided to make specific objectives based on the topics included in each module. There were 11 lessons covered by the Instructional Module on Rational Expressions and nine lessons covered by the Instructional Module on Variations.

Stage 3. Determining the instructional activities. In preparing the instructional activities for each lesson, the researcher ensured that they are written in clear and appropriate language suitable to the level of the target respondents who are second year high school students.

Stage 4. Preparing the pretest and posttest for each lesson of the modules. The items in the pretest and posttest were based on the specified objectives as identified in Stage 2.

Phase 3 – Validation and Tryout Phase

In order to gather evidence that will support the adequacy of objectives, content, format and language, presentation, and usefulness of the instructional modules to its intended users, expert judgments were sought by the researcher. In doing this, the first drafts of the instructional modules were printed and presented by the researcher to her advisers and an expert on the development of instructional modules in mathematics. Then, the researcher revised the said modules based on the comments and suggestions of the advisers and expert who were requested to read and evaluate the modules. Afterwards, the revised instructional modules were validated by 15 experts. This panel of experts consisted of seven mathematics teachers, three master teachers, one head teacher, three mathematics university instructors, and one test specialist. They examined the modules based on five indicators which include: (1) objectives; (2) content; (3) format and language; (4) presentation; and (5) usefulness of the instructional modules.

Phase 4 – Evaluation and Finalization Phase

In evaluating the developed instructional modules in Rational Expressions, two sources of information were used by the researcher: (1) feedback of the student-respondents

on the instructional module administered to them in terms of content and format; and (2) results of the comparison of the student-respondents' performance in the pretest (administered before they were given the module) and the posttest (administered after they finished the module).

Finally, the instructional modules were finalized based on the outputs yielded in the evaluation stage.

Data Analysis

The researcher utilized descriptive statistics such as percentages, means, and standard deviations in analyzing the evaluation ratings of experts and student-respondents as well as the pretest and posttest scores obtained by the student-respondents. Textual interpretation was also used in reporting the supporting qualitative data. In order to compare the evaluation ratings of experts with that of student -participants, statistical analysis using t-test for independent means set at 0.05 level of significance was performed. Finally, to ascertain the effectiveness of instructional modules, the pretest results were also compared statistically with the posttest results using paired t-test set at 0.05 level of significance.

Results and Discussion

Designed Self-Learning Module

Instructional modules on two content areas of Algebra were developed and validated. Specifically, module 1 consisted of 11 lessons on Rational Expressions and Module
2 consisted of nine lessons on Variations, listed as follows:

Rational Expressions

1. Definition and Domain of Rational Expressions
2. Simplifying Rational Expressions

3. Finding the Product of Rational Expressions
4. Finding the Quotient of Rational Expressions
5. Finding the Sum of Similar Rational Expressions
6. Finding the Sum of Dissimilar Rational Expressions
7. Finding the Difference of Similar Rational Expressions
8. Finding the Difference of Dissimilar Rational Expressions
9. Complex Rational Expressions
10. Rational Equations
11. Problems Involving Rational Expressions

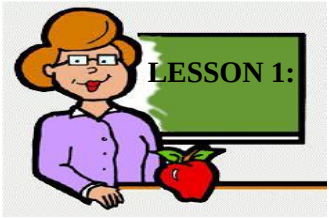
Variations

1. Writing the Equations of Direct Variations
2. Solving for the Constant of Direct Variations
3. Solving Problems Involving Direct Variations
4. Writing the Equations of Inverse Variations
5. Solving for the Constant of Inverse Variations
6. Solving Problems Involving Inverse Variations
7. Writing the Equations of Joint Variations
8. Solving for the Constant of Joint Variations
9. Solving Problems Involving Joint Variations

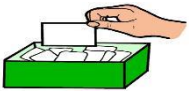
The developed instructional modules included the following parts: objectives, pretest, learning activities with illustrative examples, practice tasks, and posttest. The researcher ensured that the developed modules have built-in statements of objectives informing students about what they should be able to learn after instruction. Furthermore, the modules have the information sequenced in logical steps, and then testing (e.g. practice tasks, posttest) is undertaken to make sure that students can follow the steps. Lastly, the developed instructional modules made use of a variety of clues or prompts with some sort of graphics to capture and maintain the interest of students as they go about the topics covered in the instructional module.

For illustrative purposes, a sample of the developed instructional modules on Rational Expressions and Variations is presented below.

MODULE 1: RATIONAL EXPRESSIONS

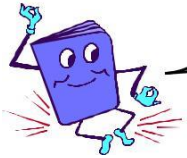


Definition and Domain of Rational Expressions



Objectives:

1. Define a rational expression.
2. Identify rational expressions.
3. Translate verbal expressions into rational expressions.
4. Find the domain of a rational expression.



Pretest:

1. What is the quotient of two polynomials?
   a. rational expression
   b. radical expression
   c. rational equation
   d. radical equation

Learning Activities:

DEFINITION: If P(x) and Q(x) are polynomials and $Q(x)\neq 0$, then $\frac{P(x)}{Q(x)}$ is a rational expression in x. P(x) and Q(x) are the numerator and denominator respectively of the expression.

Remember that a polynomial is a finite sum of terms of which is real number or the product of a numerical factor and one or more variable factors raised to whole number powers.

Thus, a rational expression is an algebraic expression which can be written as a ratio of two polynomials provided that the denominator is not zero.

Here are some examples of rational expressions and not rational expressions.

Illustrative Examples:

1. Find the domain (replacement set) of the rational expression $\frac{2x}{x-100}$.

Solutions:

a. Find the restricted value(s) of $\frac{2x}{x-10}$.

$x - 100 = 0$

$x = 100$

Practice Task:

A. Which of the following are rational expressions? Write RE if it is a rational expres-sion. Otherwise, write NOT on your answer sheet.

1. $23x$
2. $\frac{5}{x+5}$
3. $2x - 1$
4. $\frac{x+1}{x-1}$
5. $\frac{\sqrt{x}}{5}$
6. $\frac{x+1}{\sqrt{5}}$
7. $\sqrt[3]{x-1}$
8. $(2x+1)^{\frac{1}{2}}$
9. $\frac{3x}{(x-4)^{\frac{1}{4}}}$
10. $\frac{x^2+2x+1}{x^2+3x+2}$

Posttest:

1. What is the quotient of two polynomials?
   a. rational expression
   b. radical expression
   c. rational equation
   d. radical equation

Validation of the Developed Instructional Modules

As noted earlier, there were two groups who evaluated the general acceptability of the instructional modules on Rational Expressions and Variations developed by the researcher using the pre-determined criteria as follows: objectives, content, format and language, presentation, and usefulness using a scale of 1 to 5, with 1 as the lowest and 5 as the highest.

Evaluation of the Instructional Modules Based on Experts' Judgments

As presented in Table 1, the evaluators' overall average rating on the developed instructional modules is 4.90, signifying an excellent evaluation of its acceptability. The same holds true with the experts' evaluation average ratings on the different aspects of the module, ranging from 4.87 (content and format, and language) to 4.93 (objectives and usefulness).

Table 1. Evaluators' Rating.

Aspect of the Instructional Modules	Items	Means*	Standard Deviations*
1. Objectives of the Modules	1. The objectives are clearly stated in behavioral form.	5.00	.00
	2. The objectives are well-planned, formulated, and organized.	4.93	.26
	3. The objectives stated are specific, measurable, and attainable.	4.87	.35
	4. The objectives are relevant to the topics of each lesson of the modules.	5.00	.00
	5. The objectives take into account the needs of the students.	4.87	.35
	Overall	**4.93**	**.19**
2. Content of the Modules	1. The content of each lesson is directly relevant to the defined objectives.	5.00	.00
	2. The content of each lesson is simple and easy to understand.	4.80	.41
	3. The topics of each lesson are fully discussed.	4.80	.41
	4. The topics are supported by illustrative examples, and the practice tasks are suited to the level of the students.	4.80	.41
	5. Each topic is given equal emphasis in the lesson.	4.93	.26
	Overall	**4.87**	**.30**
3. Format and Language of the Modules	1. The format/layout is well-organized, which makes the lessons more interesting.	4.80	.41
	2. The language used is easy to understand.	4.93	.26
	3. The language used is clear, concise, and motivating.	4.80	.41
	4. The mathematical symbols used are well-defined.	5.00	.00
	5. The instructions in the instructional modules are concise and easy to follow.	4.80	.41
	Overall	**4.87**	**.30**

4. Presentation of the Modules	1. The topics are presented in a logical and sequential order.	5.00	.00
	2. The lessons of the modules are presented in a unique and original form.	4.93	.26
	3. The learning activities are presented clearly.	4.93	.26
	4. The presentation of each lesson is attractive and interesting to the students.	4.80	.41
	5. Adequate examples are given to each topic.	4.87	.35
	Overall	**4.91**	**.26**
5. Usefulness of the Modules	1. The instructional modules will motivate the students to study Intermediate Algebra.	4.93	.26
	2. The instructional modules will help the students master the topics at their own pace.	4.93	.26
	3. The instructional modules will allow the students to use their time more efficiently.	4.93	.26
	4. The instructional modules will develop the analytical thinking and reasoning skills of students in solving problems in Intermediate Algebra.	4.93	.26
	5. The instructional modules will serve as a supplementary material that can cater to the needs of the students.	4.93	.26
	Overall	**4.93**	**.26**
6. Overall evaluators' responses on the Modules	Objectives	4.93	.19
	Content	4.87	.30
	Format and Language	4.87	.30
	Presentation	4.91	.26
	Usefulness	4.93	.26
	Overall	**4.90**	**.26**

Legend:

Mean Rating	*Interpretations*	
4.5 – 5.0	Strongly Agree	Excellent
3.5 – 4.49	Agree	Very Good
2.5 – 3.49	Undecided	Good
1.5 – 2.49	Disagree	Fair
1.0 – 1.49	Strongly Disagree	Poor

In detail, all evaluators strongly agreed that the instructional modules have objectives which are clearly stated in behavioral form, specific, measurable, and attainable. Also, they strongly agreed that the objectives are well-planned, formulated, organized, and relevant to the topics of each lesson of the modules, and they take into

account the needs of the students. Likewise, the evaluators' responses showed that they strongly agreed that the content of each lesson is directly relevant to the defined objectives, and it is easy to understand. Furthermore, they strongly agreed that the topics of each lesson are fully discussed and supported by illustrative examples and practice tasks which are suited to the level of the students. Also, as shown in the table, the variation in the form of standard deviation of the responses is very small. With regard to the format/layout of the module, the evaluators agreed that the format/layout is well- organized. Likewise, the language used is clear, concise, motivating, and easy to understand. Regarding the presentation of the instructional modules, the evaluators strongly agreed that the topics are presented in a logical and sequential order. They further agreed that the lessons of the modules are presented in a unique and original form. Lastly, looking at the evaluators' responses on the usefulness of the modules, the evaluators strongly agreed that the developed instructional modules will motivate the students to study Intermediate Algebra. Furthermore, they strongly agreed that these modules will help the students master the topics at their own pace. Also, they strongly believed that these modules will allow the students to use their time more efficiently and can cater to their needs.

To justify the abovementioned evaluation of experts, inter-rater agreement was calculated across the different aspects of the instructional modules. Unlike the inter-rater reliability, which considers the ordering or relative standing of performance ratings, the researcher used the inter-rater agreement to measure the extent to which evaluators agree on the absolute level of performance (the numerical score) ratings on the different aspects of the module. In this way, evaluation results provided feedback on the strengths and weaknesses of the modules. Since, the experts' evaluation ratings are between 4 and 5, the exact and adjacent

agreement is presented to have a more realistic measure of the consistency of ratings. As shown in Table 2, the mean inter-rater agreement ranged from 91% (on content) to 96% (objectives). Across the different aspects of the instructional modules, the experts were consistent in their evaluation ratings of strongly agree that the objectives of the module are clearly stated in behavioral form (1.1) and relevant to the topics of each lesson (1.4). Similarly, the consistency in ratings was very high as to how the content of each lesson is directly relevant to the defined objectives (2.1), the mathematical symbols used are well-defined (3.4), and the topics are presented in a logical and sequential order (4.1).

Table 2. Inter-rater agreement among the 15 experts.

Aspect of the Instructional Modules / Item	**% Agreement**	
	Rating of 5 (Strongly Agree)	**Rating of 4 (Agree)**
1. Objectives of the Modules		
1.1	100	0
1.2	93	7
1.3	93	13
1.4	100	0
1.5	**93**	13
Average	**96**	
2. Content of the Modules		
2.1	100	0
2.2	87	13
2.3	87	13
2.4	87	13
2.5	**93**	7
Average	**91**	
3. Format and Language of the Modules		
3.1	87	13
3.2	93	7
3.3	87	13
3.4	100	0

3.5	**87**	13
Average	**91**	
4. Presentation of the Modules		
4.1	100	0
4.2	93	7
4.3	93	7
4.4	87	13
4.5	**87**	13
Average	**92**	
5. Usefulness of the Modules		
5.1	**93**	7
5.2	**93**	7
5.3	**93**	7
5.4	**93**	7
5.5	**93**	7
Average	**93**	

In sum, the evaluators strongly agreed that the five aspects of the developed instructional modules (objectives, content, format and language, presentation, and usefulness) can be described as excellent based on the aforementioned scale with an overall mean of 4.90 and standard deviation of 0.26. Meanwhile, the high inter-rating agreement signifies that the 15 experts consistently gave commendable rating to the various aspects of the instructional module, which added evidence as to the general acceptability of the module.

Evaluation of the Instructional Modules Based on Student-Participants' Judgment

Students also have evaluated the acceptability of the developed instructional modules in terms of its format and content. The responses of one hundred ninety-three (193) respondents were tallied per indicator/characteristic.

A similar trend of findings emerged as to how the student-participants evaluated the instructional modules. As shown in Table 3, the student-participants generally

perceived an excellent acceptability of the instructional modules with average rating of 4.71. In terms of format of the instructional module, the student- participants strongly agreed that the instructional module is arranged in a logical and sequential order. Moreover, they strongly agreed that the font size, font style, mathematical symbols, titles, and subtitles are readable and clearly defined. They further agreed that the instructions in the modules are well-emphasized, and tables/diagrams, illustrations, pictures, and captions are properly laid out for easy reference. They also strongly agreed that they can easily understand the objectives and instruction of each lesson of the modules. Furthermore, they strongly agreed that the illustrations, captions, and learning activities helped them to understand fully the topics. Also, they enjoyed answering the practice task in each lesson as presented in the form of trivia or puzzle. They strongly agreed that they enjoyed working and studying Intermediate Algebra using the instructional modules.

Table 3. Student Participants' Rating

Aspect of the Instructional Modules	Items	Means*	Standard Deviations*
1. Format of the Modules	1. The layout of the instructional modules is arranged in a logical and sequential order.	4.80	.42
	2. The instructions in the modules are well-emphasized.	4.61	.50
	3. The font size and font style of the instructional modules are readable.	4.71	.47
	4. The mathematical symbols used in the instructional modules are well-defined.	4.68	.47
	5. The tables/diagrams are well presented and easy to understand.	4.68	.49
	6. Key points and key concepts are well highlighted to focus attention while reading.	4.66	.50
	7. Titles and subtitles in the instructional modules are clearly defined.	4.80	.41
	8. Illustrations, pictures, and captions are properly laid out for easy reference.	4.58	.55

	9. The steps in the solutions of the given examples and practice tasks are arranged sequentially and easy to follow.	4.60	.51
	10. The instructional modules are generally formatted in a convenient manner considering the paper size used.	4.56	.54
	Overall	**4.67**	**.49**
2. Content of the Modules	1. I easily understood the objectives in each lesson.	4.93	.26
	2. I easily understood the instructions in each lesson.	4.87	.34
	3. I could work on the lessons at my own pace.	4.78	.44
	4. I understood clearly the ideas/concepts in each lesson.	4.72	.46
	5. The illustrations/captions guided me easily in following the instructions in the modules.	4.68	.49
	6. The learning activities helped me to understand fully the topic.	4.71	.46
	7. I appreciated the styles of illustrations and written expressions.	4.76	.43
	8. I enjoyed answering the practice task as presented in the form of trivia or puzzles.	4.75	.45
	9. I found it easier to study Intermediate Algebra using these instructional modules.	4.56	.53
	10. I enjoyed working through the lessons until I finished the whole instructional modules.	4.73	.45
	Overall	**4.75**	**.43**
3. Overall student-participants' responses on the Modules	Format	4.67	.49
	Content	4.75	.43
	Overall	**4.71**	**.46**

Legend:

Mean Rating	***Interpretations***	
4.5 – 5.0	Strongly Agree	Excellent
3.5 – 4.49	Agree	Very Good
2.5 – 3.49	Undecided	Good
1.5 – 2.49	Disagree	Fair
1.0 – 1.49	Strongly Disagree	Poor

A high quality self-learning material or module should contain sufficient activities to stimulate student to study constantly. As emphasized by Loyens (2008), in a self-directed learning environment, students have more freedom to generate and pursue their own goals and undertake critical evaluation of the materials they select. Based on the findings

that emerged, the activities integrated in the module were, one way or another, able to create a certain situation similar to classroom learning activity, as perceived by the student-participants.

Comparison of Students' Pretest and Posttest Scores on the Achievement Test

Using the non- directional hypothesis test at 0.05 level of significance, the researcher tested the null hypothesis that there is no difference between the pretest and posttest mean scores of the student-participants.

Table 4. Comparison of pretest and posttest scores of student-participants on module 1 and 2

	Paired Differences				
	Mean	**Std. Deviation**	t	df	Sig (2-tailed)
Module 1 Pretest - Posttest	7.28	0.01	33.99	192	.000*
Module 2 Pretest - Posttest	10.10	0.80	35.35	192	.000*

** significant @ p < .05*

As shown in Table 4, a paired sample *t* test successfully revealed a statistically significant difference between mean pretest scores in both modules ($p<0.05$). Since the mean posttest score is greater than the mean pretest score, this implies that that there is sufficient evidence to conclude that the exposure to the developed instructional modules generally brought about improvement in the knowledge of student-participants on Rational Expressions and Variations.

Additionally, a ten-item pretest and posttest per lesson of the instructional modules were answered by the student-participants before and after exposure to each lesson.

The t-test for dependent means was utilized to test the significant difference between the pretest and posttest mean

scores of the student-participants on the lessons covered in modules 1 and 2.

As shown in Table 5, a paired sample *t* test successfully revealed a statistically significant difference between mean the pretest scores and posttest scores obtained by the student -participants on the 11 lessons covered in module 1 and on the nine lessons covered in module 2, respectively. Since the mean posttest score is greater than the mean pretest score, this implies that that there is sufficient evidence to conclude that the exposure to the developed instructional modules brought about improvement in the knowledge of student-participants on the specific lessons covered in Rational Expressions and Variations.

Table 5. Comparison of mean pretest and posttest scores of student-participants on the specific lessons in module 1 and 2

	Paired Differences				
	Mean	**Std. Deviation**	**t**	**df**	**Sig (2-tailed)**
Module 1					
Pretest - Posttest					
Lesson 1	4.5	.3	32.87	192	.000*
Lesson 2	4.5	0	32.97	192	.000*
Lesson 3	4.3	0	32.79	192	.000*
Lesson 4	4.7	.3	32.93	192	.000*
Lesson 5	4.4	.2	32.71	192	.000*
Lesson 6	4.2	0	29.96	192	.000*
Lesson 7	4.2	.1	33.66	192	.000*
Lesson 8	4	.1	32.00	192	.000*
Lesson 9	4.3	.1	45.24	192	.000*
Lesson 10	4.5	.4	46.48	192	.000*
Lesson 11	4.7	.2	42.81	192	.000*
Module 2					
Pretest - Posttest					
Lesson 1	4.8	.3	62.96	192	.000*
Lesson 2	4.6	.4	61.87	192	.000*
Lesson 3	4.6	.4	38.61	192	.000*
Lesson 4	4.8	.1	41.15	192	.000*
Lesson 5	4.8	.1	35.54	192	.000*
Lesson 6	4.8	.2	37.11	192	.000*
Lesson 7	5	.1	38.26	192	.000*
Lesson 8	4.8	.1	39.05	192	.000*
Lesson 9	4.9	.1	36.77	192	.000*

** significant @ $p < 0.05$*

The findings demonstrate that the use of a well-designed instructional modules can be effective in improving students' knowledge and understanding of the topics on Rational Expressions and Variations. The significant differences between the mean pretest and posttest scores are in the affirmative, showing the effectiveness of the developed instructional modules. This is consistent with earlier findings that show how instructional materials can assist the teachers in presenting their lessons logically and sequentially to the learners (Isola, 2010) and as supported by Abdu -Raheem (2014) who showed how instructional materials aid explanations and make learning of subject matter understandable to students during the teaching-learning process.

Conclusion

On the basis of the findings, the developed instructional modules on Rational Expressions and Variations under the domain of Algebra are acceptable using the expert jurors' and student-users' separate assessments. The instructional modules, subjected to the statistical comparisons of evaluations, are also consistent between these two groups of evaluators.

Meanwhile, the significant change in the pretest and posttest scores obtained by students before and after they were exposed to the instructional modules signifies that the instructional modules brought out some sort of improvement in their knowledge of Rational Expressions and Variations. That is, the students learned from the modules and can go about it, with their teachers as facilitators of learning.

With all these essential information that transpired from the present study, it may be suffice to say that it could be possible for teachers to redirect the focus of classroom from

what it is to what their students are capable of doing and that would allow them to be responsible for their own learning.

Insights and Implications of the Study

The major contribution of the present study is that the students' understanding of Rational Expressions and Variations can be promoted effectively by students themselves if appropriate self-instructional learning materials are provided. Particularly in the context of K-12 Mathematics curriculum wherein students are expected to develop critical thinking and problem solving as they progress into the academic ladder, the findings of this study can be a signal for other teachers to follow their pursuit of helping students attain mastery in learning not only Rational Expressions and Variations but other topics in mathematics as well.

Likewise, the findings of this study brought about implications for both theory and practice regarding the usefulness of modules in classroom instruction and the teacher devising the modules. Specifically, the researcher has hopes that by redirecting the focus of her classroom from what it is to what her students are capable of doing through the use of self-instructional modules, she can provide quality mathematics instruction that will encourage second year high school students to accept more responsibility for their learning about the concepts on Rational Expressions and Variations. Lastly, through modular instruction, more time could be used for the teacher's explanation instead of note-taking. With this, time is maximized for student learning by spending it more on students' facilitated interaction, buzz sessions, and other interactive strategies instead of spending more time on the delivery of lessons.

Recommendations

Align with the thrust of the Department of Education to continually produce learning materials as part of the implementation of the K- 12 Program, the researcher recommends the following for future studies: (1) the developed instructional modules can be used to complement the teaching of Rational Expressions and Variations; (2) the study may be replicated by other researchers by preparing instructional modules for other topics in Intermediate Algebra and in other mathematics subject; conducting an experimental design to validate further the findings of the study; developing and tryout out modules using experimental approach in other areas of mathematics to test their effectiveness; and using other scale equivalence table in interpreting responses on a five-point Likert scale; and (3) attitudes of students towards modular instruction may be studied.

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