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# Analyzing Student Reactions to Interactive Learning Materials and Critical Thinking Capabilities Using the Rasch Model

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By creating interactive learning materials for the biochemistry course, this project seeks to improve the critical thinking abilities of students enrolled in the Science Education Program at one of the Bengkulu universities. Employing a research and development (R&D) approach considering the DDD-E (Decide, Design, Develop, Evaluate) model, the media was designed for Android devices and focuses on carbohydrate metabolism content. The main features include Program and Course Learning Outcomes, instructional materials, usage guidelines, and a profile section. Validation results from content and media experts confirmed the media's appropriateness for instructional use. Student responses, analyzed using the Rasch Model, indicated strong agreement regarding the media's usefulness. Moreover, the application of this interactive media significantly improved students' critical thinking skills, with an N-gain score of 53.67%. These findings suggest that the media is effective for use in biochemistry courses, although further research is needed to explore its application in other subject areas.

**Keywords: Interactive Learning Media; Critical Thinking Skills; DDD-E Model**

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## INTRODUCTION

Efforts to improve educational quality are inextricably linked to the quality of learning activities that might help students realize their full potential. A crucial aspect of Indonesia's development is education, and the government has worked to raise educational standards in a number of ways. Education is a deliberate and planned effort to create an environment of learning and the learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, morals, nobility, and the skills required by him, society, nation, and state, according to Law Number 20 of 2003 concerning the national education system.

Learning media can be used to convey messages or material information in the teaching and learning process, and selecting the appropriate learning media will undoubtedly affect the quality of learning. Learning is a type of activity that establishes a relationship of interaction in teaching and the learning process in order to develop student behavior in accordance with educational goals.

To enhance the quality of learning, lecturers and teachers must be able to use technology to develop interesting and practical teaching resources that students can use for independent study. In the industrial era 4.0, learning is focused on the ability to use information technology to encourage increased potential for students to increase the competitiveness of graduates.

With the aid of microscopes, films, slides, or images, interactive learning media can overcome the limitations of time, space, and the senses, as well as objects that are too big or too small for the senses to see (Zulhelmi et al., 2017). It can also improve critical thinking skills, which are the capacity to analyze, critique, and draw conclusions based on careful consideration or inference (Trianto, 2010).

Students can easily grasp the concepts of the material being taught while developing their own critical thinking skills thanks to interactive learning media's ability to grab their attention and foster learning motivation, both of which directly improve learning outcomes.

(Isnaneny et al., 2018) found that the development of interactive learning media can enhance students' critical thinking abilities by 28.4%, and (Komara et al., 2017) found that the use of interactive learning media significantly improved students' critical thinking abilities in their study titled "The Effect of Interactive Learning Media Tutorial Models on Critical Thinking Skills." (Husein et al., 2017) state that the use of interactive learning media can enhance students' critical thinking abilities and students' mastery of concepts.

The development of interactive learning media is considered necessary in order to support government policies, namely social and physical distancing, in efforts to tackle the Covid-19 outbreak in Indonesia. Specifically, at this time, the condition of learning in Indonesia is directed towards online or online learning (e-learning) in order to break the chain of spreading the Covid-19 virus, which is currently endemic. Students can still hone their critical thinking skills independently by using interactive learning media that are practical.

A more interactive role of media is required in order to help students grasp the abstract concept of metabolic reactions. One of the topics of study in biochemistry is metabolism, which includes the catabolism and anabolism of carbohydrates, proteins, and lipids. The characteristics of the topic of metabolism, especially carbohydrates, are difficult for students to understand because they use many complex chemical reaction pathways. Biochemistry is one aspect of study in the field of chemistry that can be used as a vehicle to equip knowledge, skills, attitudes, and scientific values in forming their knowledge.

## METHOD

Research and development, or R&D, is the category under which this study falls. This research refers to the Ivers and Baron's procedure (Wulandari, 2019). The development model used is the "DDD-E Model (Decide, Design, Develop, Evaluate)." DDD-E is a learning design that can be used in developing interactive learning media. In the Decide stage, the learning objectives and materials are formulated; the Design stage is carried out by designing the learning media; while in the Develop stage, the content of the learning media is validated by media experts and material experts. After validation is carried out and it is declared "feasible", the learning media will be implemented to science education students as an evaluation (evaluate) to determine student responses to the application of learning media and students' critical thinking skills after the use of media.

This research was carried out in one of the universities in Bengkulu. The sample in this study was Class A fifth-semester students taking biochemistry courses. The number of samples is 25 people.

The data collection techniques used were test and non-test. Data collection by test using pretest and posttest questions in the form of descriptions to measure students' critical thinking skills. Data collection using a non-test in the form of a questionnaire. There were 2 questionnaires given, namely a validation questionnaire for learning by experts and a student response questionnaire. Learning media validation questionnaires were given to material experts and media experts. Student response questionnaires are given to students to determine student assessments and responses to learning media.

Quantitative data from the interactive learning media validation questionnaire were obtained by giving a score on the Likert scale, which was converted to a scale of 5. While the questionnaire data on student responses to the use of interactive learning media for carbohydrate metabolism material were analyzed using the Rasch model and assisted by Winstep software developed by (Linacre, 2006). The Rasch model displays all interactions between respondents and objects at once. In the Rasch model, a value is seen based on a logit value that shows the probability of selecting an item in a set of responders (Wibisono, 2018).

To measure the increase in students' critical thinking skills, a normalized gain score was used (Hake, 1998, in Panjaitan et al., 2022). The N-gain is obtained from the reduction in the posttest score by the pretest score divided by the reduced maximum score by pretest score.

## RESULT AND DISCUSSION

***Results***

**1. Development of Interactive Learning Media**

The development of interactive learning media in this study begins with determining learning outcomes and materials. According to Ivers and Baron's procedure (Wulandari, 2019), in the DDD-E development model, this stage enters the Decide stage. Then, the learning outcomes and material are poured into the design in the form of a storyboard, which is a brief descriptive description of the flow of the interactive learning media application: carbohydrate metabolism from beginning to end. This stage is called Design.

The storyboard itself is based on a previously created block diagram and navigation structure. The block diagram of an interactive learning media application for carbohydrate metabolism material consists of a main menu page and a material page. The main page is the main menu of the application, which consists of several menus to access activities in the application. Meanwhile, the material page is the main menu that discusses carbohydrate metabolism, including supporting material in the form of slides and animated videos.

Based on the block diagram, researchers began to include content for interactive learning media. This activity is included in the develop stage. At this stage, researchers also began to select animated images and videos that match the material, determine the display color of the media and fonts, to include audio to explain the material in the animated video. In addition, the researcher also added a swipe to each screen in the form of an arrow as a clue. Swipe view helps to speed up the use of the touch screen so that it is more comfortable for fingers to open other pages.

Figure 1 is a display of the results of the design of an interactive learning media application for carbohydrate metabolism material which consists of the main menu page and material.

[Figure 1 about here.]

**2. Result of Feasibility and Effectiveness Assessment of Interactive Learning Media**

The generated interactive learning materials are then validated by two experts, namely material experts and media experts, who are experts in their respective domains, to make sure that the content is actually appropriate for students to use from the learning materials.

The validation of learning media with media professionals focuses on the display features (text display, color combinations, graphics, and navigation buttons) as well as the usage aspects (instructions for use and media interaction). The validation results from material and media specialists are then transformed into quantitative data via scoring, and the scoring results on each element are then converted into a five-point scale modified (Widoyoko, 2016), as shown in Table 1. Validation by material expert speakers focuses on two primary areas: learning (learning objectives, material delivery, and evaluation) and material (material relevance and selection).

[Table 1 about here.]

Data on the validation of interactive learning materials for Android-based carbohydrate metabolism content were gathered by material experts and media experts following grading in line with table 4.1. The results are displayed in Tables 2 and 3.

[Table 2 about here.]

[Table 3 about here.]

According to the validation results of material and media professionals, the generated interactive learning media apps are "feasible," implying that they can be utilized to teach biochemistry for carbohydrate metabolism.

The findings of the study of the student response questionnaire to Interactive Learning Media: Carbohydrate Metabolism are determined using the Winstep application with the Rasch model. In addition, the fourth stage of this study, Evaluate, involved 25 students evaluating the effectiveness of the generated interactive learning media through a small-scale trial (empirical).

A questionnaire comprising 21 statement items was used in limited trials to gauge student responses to Interactive Learning Media: Carbohydrate Metabolism. The questionnaire items were assessed using a Likert scale, with a maximum score of 4 and a minimum of 1. The response data was saved in Excel format and subsequently processed using the WinStep software.

From the data obtained using the Winstep Variable Maps data (Wright map), the results can be seen in the Figure 2.

[Figure 2 about here.]

According to the Winstep program analysis, the actual item reliability rating is 0.98 is 0.98, placing it in the exceptional category. The reliability of the test instrument in this work is assessed by real item reliability, which is more conservative than model item reliability (Boone, 2016). Reliability refers to the degree to which measurement results can be believed (Andersson et al., 2024).

[Figure 3 about here.]

In Figure 3, the variable map test comprises measures (displaying the logit scale) on the left and the distribution of items (statements) on the right. The test's statements are generally more difficult than the respondent's ability, as can be seen from the map on the right, which has 21 statements with validity levels of varying difficulty ranging from P15, the most difficult questionnaire item, to P1, the easiest questionnaire item. According to the questionnaire data, question number 1 (P1) has the lowest difficulty level, with an average logit item of -3.59. The item with the highest ability value is number 15 (P15), which has the highest ability value.

[Table 4 about here.]

The total count is 25 in Table 4 of the Response Item Analysis above, indicating that all respondents answered all of the items. The item column in the picture above indicates the degree of difficulty of the question items in the measure column; specifically, the questionnaire item with the hardest response is P15, while the one with the easiest response is P1. The difficulty level of the questions allows us to quickly assess which are easy and which are challenging.

[Table 5 about here.]

In Table 5, Level of Compliance The question above contains a table of fit items (item suitability). To determine if the response item data has a good fit if the Outfit Mean Square (0.5 <MNSQ <1.5), Z-standard Outfit (-2.0 <ZSTD <+2.0) and Point Measure Correlation (0, 4 <t Measure Corer <0.85) (Sadiman et al., 2011).

To analyze the ability of the respondents who filled out the eligibility questionnaire items given can be seen in the table below:

[Table 6 about here.]

The total count column in Table 6 Person Measure Order indicates the total number of questionnaire items that each respondent answered, while the total score column examines the total value that each respondent obtained. All respondents completed the 21 items in the given questionnaire, and the measure column in the above image displays each respondent's ability in logit units. The infit and outfit value table shows that the 25 respondents with the highest ability have MNSQ 2.33, ZSTD 3.54, and Corr 0.75, while the respondents with the lowest value have measure = -0.78, which is respondent number 22.

[Table 7 about here.]

Each respondent has at least one predetermined limit criteria value, as can be seen in the Person Misfit Table above. To see a more complete fit, see the Guttmann matrix (Figure 5). Table 7 above is used to analyze the suitability of the respondents. In addition to analyzing the ability of the respondents, it will also analyze the results of the suitability of the respondents. This is done in order to determine the consistency of the thinking of respondents in filling out the given questionnaire responses.

**3. Results of the Improvement of Students' Critical Thinking Skills (CTS)**

The increase in critical thinking abilities of Grade A students of Science Education is assessed using normalized gain (N-gain), which is based on the interpretation of the effectiveness of the N-gain. The same questions are given both before (pretest) and after (posttest) the use of interactive learning media for the material on carbohydrate metabolism (see Table 8).

[Table 8 about here.]

***Discussion***

**1. Development of Interactive Learning Media**

The creation of interactive learning materials on the topic of carbohydrate metabolism is necessary to speed up students' comprehension of this challenging biochemical material because interactive learning materials require students to investigate, evaluate, and attempt to investigate the concepts and principles presented within the material they are learning. This allows for a relatively quick development of a student's understanding of structure (Dahlan et al., 2011).

Interactive learning media: carbohydrate metabolism that has been made for Android-based tablets or smartphones. At the testing stage with several specifications of Android cellphones, there were no problems, except for phones with relatively small internal memory sizes. Even so, making applications has been minimized with an application size of 37.52 MB. Installing the application is done by sending an internet network APK file via WhatsApp (WA) messages. Applications that are delivered as a runtime air are merged with an APK file. In practice, this type of application combined with the air runtime cannot be run for some student smartphones. However, this is not a significant obstacle because the installation process can still be done by changing the settings in the cellphone or smartphone settings. In addition, applications that cannot be installed on a smartphone can still be installed on a laptop with the help of an Android emulator. Thus, all students can install interactive learning media applications for carbohydrate metabolism material on their Android-based cellphones or laptops.

**2. The feasibility and effectiveness of Interactive Learning Media**

According to Kusumah (Dahlan et al., 2011), interactive multimedia applications have advantages in explaining a concept because they require students to explore, analyze, and try to explore the concepts and principles contained in the material they are studying, allowing them to build a student understanding structure quickly. This is due to the integration of components such as sound, text, animation, images or graphics, and video that serve to maximize the involvement of the five senses in receiving information into the memory system (Ratnaningsih, 2016). However, designing interactive learning media applications cannot be considered easy. Interactive learning media that are designed must be in accordance with the learning outcomes and indicators, facilitate understanding of the material, and accommodate heterogeneous student abilities. Based on this, the interactive learning media application products go through validation tests by media experts and material experts as well as effectiveness testing on students. Testing on students needs to be considered, considering that students are users of the application.

Table 2 shows that the interactive learning media created by the researcher are in the "feasible" category with a score of 54, indicating that they have met the scope of material and learning strategies to achieve learning outcomes. According to the validation from media experts (see Table 3), the researcher's interactive learning media on carbohydrate metabolism is in the "proper" category with a score of 55, indicating that the material is deemed to have complete information for users. Applications in the form of comprehensive and detailed instructions for use make it easier for users to operate the learning media.

Twenty-five students in the fifth semester of class A of the Science Education Study Program will participate in a limited trial to test the efficacy of interactive learning materials for carbohydrate metabolism that have been deemed feasible by the two validators. The test consists of 21 questions with a maximum value of 4 and a minimum value of 1.

Figure 2 demonstrates that the map (person) variable test has a the actual reliability value of an item of 0.98, placing it in the exceptional category. Because of the high item dependability, it is possible to assume that the test instrument produced already comprises several more difficult and easier things, and this conclusion is consistent (Novinda et al., 2019). Figure 2 depicts the Variable Map (Person) Test, which consists of measures (showing the logit scale), a person representing the distribution of participants' abilities, and items representing the distribution of the difficulty level of the questionnaire items responded to by the responder. The figures above show that almost all respondents have a high level of ability to answer the questionnaire items. On the right side of the Wright map, there are 25 respondents with the highest degree of ability, one of whom is code number 07, and 25 with an average logit person score of +0.96. Respondent number 22 has the lowest ability (logit average of -0.78), whereas respondent number 25 has the most ability and the highest score for answering questions, according to the person variable map data. The variable map data shows that respondent number 22 has the lowest ability yet can still answer the most challenging response items, namely number 15 (P15). This signifies that practically all respondents agreed with every item in the questionnaire replies provided to respondents (in this example, students). The data also demonstrates that the questionnaire results are genuine and accurate.

It is good because it demonstrates that each question can provide information about the ability of the tested respondent, given that the distribution of the response items varies and is in groups. The data in Figure 3 Variable Maps Test (item) indicates that the item question number 15 (P15) has the highest value of ability with an average logit item +3.08. In principle, no respondent will be able to accurately answer the question because their skill is lower than the question's difficulty level.

In terms of the level of difficulty contained in the response items, this means that the items of responses to the questions are not very diverse, and the respondents' abilities are not significantly different. The larger variety of people's ability than the distribution of questions leads to the conclusion that people's (respondents') capacity fluctuates (Untary et al., 2020). The M-S-T distance on the Wright map above suggests that the respondents' competence is just slightly greater than the dispersion seen in the difficulty level of the response items. The distribution for student ability (left) is wider than the distribution for item difficulty level (right), as can be seen by comparing the distance between M-S-T on the Wright map above (Figure 3). In the context of the question's difficulty level, this indicates that the items of diversity are not far away, but from the perspective of student ability, the ability distance is very wide. Additionally, when comparing the logit item average with the logit person, it appears that the logit person is larger (+2.20 logit), indicating that the overall ability is only marginally higher than the question difficulty.

Using the map variable, the study of the comparison between the logit person and logit item/response items reveals that the person logit is much greater than the response item logit, indicating that the respondents' overall ability is higher than the response items' level of difficulty, meaning that nearly all respondents agree on every aspect of the provided response items.

According to the data in Table 5, all of the items for the Outfit Mean Square value have an MNSQ of 2.11, a ZSTD of 3.33, and a Corr value of -0.08, all of which are above the predetermined criteria. Therefore, item P8 needs to be reviewed again; if none of the values obtained fall within the specified value range, then these items need to be reviewed; if one criterion still satisfies the requirements, the question item does not need to be replaced or can be left in place. The ZSTD value is influenced by the sample size; if a very large sample is used, the ZSTD value will always be above the value 3. The suitability for response item 08 is shown in the curve below. In Figure 4, the ICC Expected Score Graph displays the three custom responses that are outside the boundaries of the Outfit trust space.

[Figure 4 about here.]

It is evident from Table 6's Person Measure Order that multiple respondents share the same logit value, indicating that they are equally capable and have the same raw score (total score). The Rasch model uses Winstep software, a computational tool, to analyze test instrument scores in order to determine the MNSQ Outfit, ZSTD Outfit, Point Measure Correlation, Item Reliability, and Cronbach Alpha. The MNSQ outfit is useful for determining whether the data is appropriate for the model being used; if the infit's mean-square value is greater than one, the instrument's variation is greater than the Rasch model's prediction; if the infit value is less than one, the instrument's variation is less than the Rasch model's predictions (Azizah & Wahyuningsih, 2020). Complementary data will be produced by combining item analysis and Rasch modeling analysis: Rasch modeling analysis can analyze the link between item questions and responses, while item analysis looks at the questions on the complete questionnaire; In Rasch modeling, respondents with the same score can be seen at their ability level, while in item analysis, respondents with the same score are considered to have the same ability. In Rasch analysis, the model can determine fit items, and person fit determination also uses the same criteria. (Nuryanti et al., 2018).

The restricted trial answer data in agreeing to the questionnaire response questions provided by the Interactive Learning Media for Carbohydrate Metabolism material can be utilized to establish whether respondents have higher ability, even if their logit values are the same. This data can be found in the scalogram.

[Figure 5 about here.]

The answers in the image above are similar to those of 25 respondents with the highest ability, including respondents 11 and 14. The similarity of the respondents' answer patterns indicates that they are cooperating or cheating when completing the questionnaire items, necessitating a re-evaluation. This respondent's scalogram shows an irregular/inconsistent response pattern; It also demonstrates that he tends to agree with the opinions submitted (high/difficult item scores), that are submitted, while on others, he tends to reject (getting low item scores/easy). This was most likely due to respondents' lack of enthusiasm to complete the scale at the time. The result is that their reactions vary and are inconsistent, depending on their attitude while responding to items. The overall response results are unaffected by this, though (Risdianto et al., 2020).

### 3. Enhancing Critical Thinking Skills (CTS) Students

This study measures critical thinking skills using six indicators: focus, reason, inference, circumstance, clarity, and overview (FRISCO). The N-gain test findings show that the medium category increased by 56%, the high category by 20%, and 24% moved into the low group or saw no rise in CTS.

Based on the average percentage of pretest and posttest scores, the CTS increased by 53.67%. This figure demonstrates that using interactive learning media for carbohydrate metabolism material has a significant impact on the critical thinking skills (CTS) of Science Education students in semester 5 class A. Figure 6 shows the students' average pretest and posttest scores.

[Figure 6 about here.]

In accordance with (Sadiman, 2011) assertion that the use of interactive media can provide students with direct (real) learning experiences in order to foster student learning motivation, an increase in students' Critical Thinking Skills (CTS) in learning Biochemistry for Carbohydrate Metabolism material. Students' motivation to learn on their own is demonstrated by their use of interactive learning materials. Additionally, interactive learning media for carbohydrate metabolism material is made simple and practical in order to facilitate student use.

As an application that is installed on an Android cellphone, interactive learning media can be used anytime, anywhere, and is a useful tool for students to learn independently in distance learning or online classes that were implemented during the Covid-19 pandemic, as evidenced by the increase in students' Critical Thinking Skills (CTS).

## CONCLUSION

Based on the results of the analysis, it is possible to conclude that the quality of the response questionnaire to Interactive Learning Media: Carbohydrate Metabolism is sufficiently high to be utilized to determine student replies. The fact that most respondents agreed with every item on the questionnaire suggests that students' opinions about Interactive Learning Media: Carbohydrate Metabolism are generally the same. The use of interactive learning media in biochemistry courses for carbohydrate metabolism material has a positive effect in the form of an increase in students' critical thinking skills (CTS) by 53.67%. This shows that the learning media is quite effective in improving students' critical thinking skills. However, more investigation is required to ascertain the student's response to Interactive Learning Media: Carbohydrate Metabolism in other subject matter.

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## LIST OF TABLES

**TABLE 1** / Conversion of a Five-Scale Score

| Interval value | Category |
|---|---|
| $X > 63$ | Very worthy |
| $51 < X \leq 63$ | Worthy |
| $39 < X \leq 51$ | Decent enough |
| $27 < X \leq 39$ | Less feasible |
| $X \leq 27$ | Very less feasible |

**TABLE 2** / Validation Results by Material Experts

| Aspect of assessment | Number of Item | Score | Category |
|---|---|---|---|
| Hand out | 9 | 33 | Eligible |
| Learning | 6 | 21 | |
| Total | 15 | 54 | |

**TABLE 3** / Validation Results by Media Experts

| Aspect of assessment | Number of Item | Score | Category |
|---|---|---|---|
| Display | 11 | 42 | Eligible |
| Usage | 4 | 13 | |
| Total | 15 | 55 | |

**TABLE 4** / Analysis of Response Item

Item STATISTICS: MEASURE ORDER

| ENTRY NUMBER | TOTAL SCORE | TOTAL COUNT | MEASURE | MODEL S.E. | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD | PTMEASUR-AL CORR. | PTMEASUR-AL EXP. | EXACT MATCH OBS% | EXACT MATCH EXP% | Item |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 41 | 25 | 3.08 | .37 | .83 | -.72 | .84 | -.71 | .04 | .21 | 68.0 | 57.7 | P15 |
| 7 | 42 | 25 | 2.95 | .37 | .86 | -.54 | .87 | -.51 | -.16 | .21 | 64.0 | 60.1 | P7 |
| 8 | 44 | 25 | 2.67 | .37 | 2.11 | 3.36 | 2.11 | 3.33 | -.08 | .21 | 48.0 | 64.1 | P8 |
| 4 | 45 | 25 | 2.53 | .37 | .48 | -2.27 | .48 | -2.29 | .37 | .21 | 80.0 | 66.0 | P4 |
| 5 | 45 | 25 | 2.53 | .37 | .73 | -1.00 | .74 | -.96 | -.39 | .21 | 80.0 | 66.0 | P5 |
| 19 | 45 | 25 | 2.53 | .37 | 1.76 | 2.37 | 1.77 | 2.38 | -.08 | .21 | 48.0 | 66.0 | P19 |
| 21 | 45 | 25 | 2.53 | .37 | 1.23 | .86 | 1.23 | .89 | .42 | .21 | 68.0 | 66.0 | P21 |
| 17 | 47 | 25 | 2.25 | .38 | 1.21 | .77 | 1.21 | .77 | .11 | .21 | 64.0 | 68.9 | P17 |
| 13 | 51 | 25 | 1.69 | .38 | 2.05 | 2.69 | 2.00 | 2.59 | .58 | .21 | 68.0 | 70.5 | P13 |
| 10 | 53 | 25 | 1.41 | .37 | 1.19 | .70 | 1.15 | .56 | .63 | .22 | 80.0 | 69.0 | P10 |
| 2 | 55 | 25 | 1.13 | .37 | .69 | -1.13 | .66 | -1.22 | .45 | .22 | 84.0 | 66.2 | P2 |
| 11 | 68 | 25 | -.62 | .38 | 1.38 | 1.33 | 1.43 | 1.46 | -.06 | .20 | 52.0 | 65.0 | P11 |
| 12 | 76 | 25 | -1.88 | .41 | .51 | -1.61 | .52 | -1.59 | .07 | .20 | 88.0 | 74.9 | P12 |
| 6 | 78 | 25 | -2.21 | .40 | .37 | -2.50 | .36 | -2.53 | .38 | .20 | 88.0 | 73.1 | P6 |
| 3 | 81 | 25 | -2.68 | .39 | .53 | -2.01 | .52 | -2.03 | .62 | .21 | 76.0 | 67.4 | P3 |
| 9 | 81 | 25 | -2.68 | .39 | .59 | -1.69 | .58 | -1.74 | .46 | .21 | 76.0 | 67.4 | P9 |
| 16 | 81 | 25 | -2.68 | .39 | .82 | -.63 | .82 | -.62 | -.17 | .21 | 76.0 | 67.4 | P16 |
| 14 | 82 | 25 | -2.84 | .39 | .56 | -2.01 | .55 | -2.02 | .68 | .21 | 80.0 | 65.7 | P14 |
| 20 | 83 | 25 | -2.99 | .39 | .90 | -.35 | .90 | -.35 | -.09 | .21 | 60.0 | 63.5 | P20 |
| 18 | 84 | 25 | -3.14 | .39 | .68 | -1.58 | .68 | -1.58 | .56 | .21 | 80.0 | 61.7 | P18 |
| 1 | 87 | 25 | -3.59 | .39 | .92 | -.38 | .93 | -.32 | .15 | .20 | 60.0 | 56.8 | P1 |
| MEAN | 62.6 | 25.0 | .00 | .38 | .97 | -.3 | .97 | -.3 | | | 70.9 | 65.9 | |
| P.SD | 17.3 | .0 | 2.51 | .01 | .49 | 1.6 | .49 | 1.6 | | | 12.0 | 4.3 | |

**TABLE 5** / Compliance Level of Question

Item STATISTICS: MISFIT ORDER

| ENTRY NUMBER | TOTAL SCORE | TOTAL COUNT | MEASURE | MODEL S.E. | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD | PTMEASUR-AL CORR. | PTMEASUR-AL EXP. | EXACT MATCH OBS% | EXACT MATCH EXP% | Item |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 44 | 25 | 2.67 | .37 | 2.11 | 3.36 | 2.11 | 3.33 | A-.08 | .21 | 48.0 | 64.1 | P8 |
| 13 | 51 | 25 | 1.69 | .38 | 2.05 | 2.69 | 2.00 | 2.59 | B .58 | .21 | 68.0 | 70.5 | P13 |
| 19 | 45 | 25 | 2.53 | .37 | 1.76 | 2.37 | 1.77 | 2.38 | C-.08 | .21 | 48.0 | 66.0 | P19 |
| 11 | 68 | 25 | -.62 | .38 | 1.38 | 1.33 | 1.43 | 1.46 | D-.06 | .20 | 52.0 | 65.0 | P11 |
| 21 | 45 | 25 | 2.53 | .37 | 1.23 | .86 | 1.23 | .89 | E .42 | .21 | 68.0 | 66.0 | P21 |
| 17 | 47 | 25 | 2.25 | .38 | 1.21 | .77 | 1.21 | .77 | F .11 | .21 | 64.0 | 68.9 | P17 |
| 10 | 53 | 25 | 1.41 | .37 | 1.19 | .70 | 1.15 | .56 | G .63 | .22 | 80.0 | 69.0 | P10 |
| 1 | 87 | 25 | -3.59 | .39 | .92 | -.38 | .93 | -.32 | H .15 | .20 | 60.0 | 56.8 | P1 |
| 20 | 83 | 25 | -2.99 | .39 | .90 | -.35 | .90 | -.35 | I-.09 | .21 | 60.0 | 63.5 | P20 |
| 7 | 42 | 25 | 2.95 | .37 | .86 | -.54 | .87 | -.51 | J-.16 | .21 | 64.0 | 60.1 | P7 |
| 15 | 41 | 25 | 3.08 | .37 | .83 | -.72 | .84 | -.71 | K .04 | .21 | 68.0 | 57.7 | P15 |
| 16 | 81 | 25 | -2.68 | .39 | .82 | -.63 | .82 | -.62 | j-.17 | .21 | 76.0 | 67.4 | P16 |
| 5 | 45 | 25 | 2.53 | .37 | .73 | -1.00 | .74 | -.96 | i-.39 | .21 | 80.0 | 66.0 | P5 |
| 2 | 55 | 25 | 1.13 | .37 | .69 | -1.13 | .66 | -1.22 | h .45 | .22 | 84.0 | 66.2 | P2 |
| 18 | 84 | 25 | -3.14 | .39 | .68 | -1.58 | .68 | -1.58 | g .56 | .21 | 80.0 | 61.7 | P18 |
| 9 | 81 | 25 | -2.68 | .39 | .59 | -1.69 | .58 | -1.74 | f .46 | .21 | 76.0 | 67.4 | P9 |
| 14 | 82 | 25 | -2.84 | .39 | .56 | -2.01 | .55 | -2.02 | e .68 | .21 | 80.0 | 65.7 | P14 |
| 3 | 81 | 25 | -2.68 | .39 | .53 | -2.01 | .52 | -2.03 | d .62 | .21 | 76.0 | 67.4 | P3 |
| 12 | 76 | 25 | -1.88 | .41 | .51 | -1.61 | .52 | -1.59 | c .07 | .20 | 88.0 | 74.9 | P12 |
| 4 | 45 | 25 | 2.53 | .37 | .48 | -2.27 | .48 | -2.29 | b .37 | .21 | 80.0 | 66.0 | P4 |
| 6 | 78 | 25 | -2.21 | .40 | .37 | -2.50 | .36 | -2.53 | a .38 | .20 | 88.0 | 73.1 | P6 |
| MEAN | 62.6 | 25.0 | .00 | .38 | .97 | -.3 | .97 | -.3 | | | 70.9 | 65.9 | |
| P.SD | 17.3 | .0 | 2.51 | .01 | .49 | 1.6 | .49 | 1.6 | | | 12.0 | 4.3 | |

**TABLE 6** / Person Measure Order

Person STATISTICS: MEASURE ORDER

| ENTRY NUMBER | TOTAL SCORE | TOTAL COUNT | MEASURE | MODEL S.E. | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD | PTMEASUR-AL CORR. | PTMEASUR-AL EXP. | EXACT MATCH OBS% | EXACT MATCH EXP% | Person |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 58 | 21 | .96 | .42 | 2.41 | 3.68 | 2.33 | 3.54 | .75 | .79 | 42.9 | 63.4 | 07 |
| 25 | 58 | 21 | .96 | .42 | 1.43 | 1.44 | 1.46 | 1.53 | .67 | .79 | 66.7 | 63.4 | 25 |
| 1 | 56 | 21 | .61 | .42 | .44 | -2.40 | .44 | -2.36 | .90 | .79 | 81.0 | 64.7 | 01 |
| 5 | 56 | 21 | .61 | .42 | 2.34 | 3.49 | 2.27 | 3.36 | .74 | .79 | 42.9 | 64.7 | 05 |
| 6 | 55 | 21 | .44 | .42 | 2.16 | 3.10 | 2.09 | 2.96 | .78 | .79 | 42.9 | 65.5 | 06 |
| 9 | 54 | 21 | .27 | .42 | .95 | -.09 | .96 | -.05 | .80 | .79 | 66.7 | 66.2 | 09 |
| 17 | 53 | 21 | .10 | .42 | .78 | -.72 | .77 | -.74 | .89 | .80 | 71.4 | 66.4 | 17 |
| 23 | 53 | 21 | .10 | .42 | .60 | -1.51 | .60 | -1.48 | .86 | .80 | 81.0 | 66.4 | 23 |
| 3 | 52 | 21 | -.08 | .42 | .83 | -.53 | .82 | -.55 | .91 | .80 | 61.9 | 66.5 | 03 |
| 4 | 52 | 21 | -.08 | .42 | 2.27 | 3.26 | 2.21 | 3.12 | .80 | .80 | 38.1 | 66.5 | 04 |
| 10 | 52 | 21 | -.08 | .42 | .31 | -3.16 | .30 | -3.17 | .91 | .80 | 90.5 | 66.5 | 10 |
| 11 | 52 | 21 | -.08 | .42 | .88 | -.33 | .85 | -.44 | .74 | .80 | 81.0 | 66.5 | 11 |
| 12 | 52 | 21 | -.08 | .42 | 1.00 | .10 | .97 | -.01 | .72 | .80 | 81.0 | 66.5 | 12 |
| 14 | 52 | 21 | -.08 | .42 | .88 | -.33 | .85 | -.44 | .74 | .80 | 81.0 | 66.5 | 14 |
| 16 | 52 | 21 | -.08 | .42 | .56 | -1.67 | .54 | -1.76 | .84 | .80 | 90.5 | 66.5 | 16 |
| 20 | 52 | 21 | -.08 | .42 | .41 | -2.50 | .40 | -2.55 | .90 | .80 | 90.5 | 66.5 | 20 |
| 21 | 52 | 21 | -.08 | .42 | .31 | -3.16 | .30 | -3.17 | .91 | .80 | 90.5 | 66.5 | 21 |
| 8 | 51 | 21 | -.25 | .42 | .30 | -3.21 | .29 | -3.24 | .91 | .80 | 95.2 | 66.3 | 08 |
| 13 | 51 | 21 | -.25 | .42 | 1.06 | .29 | 1.04 | .23 | .69 | .80 | 76.2 | 66.3 | 13 |
| 18 | 51 | 21 | -.25 | .42 | .87 | -.35 | .86 | -.37 | .92 | .80 | 57.1 | 66.3 | 18 |
| 19 | 51 | 21 | -.25 | .42 | .30 | -3.21 | .29 | -3.24 | .91 | .80 | 95.2 | 66.3 | 19 |
| 24 | 51 | 21 | -.25 | .42 | 1.71 | 2.08 | 1.76 | 2.15 | .94 | .80 | 28.6 | 66.3 | 24 |
| 2 | 50 | 21 | -.42 | .42 | .91 | -.20 | .91 | -.20 | .92 | .80 | 52.4 | 65.7 | 02 |
| 15 | 50 | 21 | -.42 | .42 | .32 | -3.08 | .31 | -3.12 | .90 | .80 | 90.5 | 65.7 | 15 |
| 22 | 48 | 21 | -.78 | .42 | .63 | -1.32 | .60 | -1.43 | .84 | .81 | 76.2 | 64.8 | 22 |
| MEAN | 52.6 | 21.0 | .02 | .42 | .99 | -.4 | .97 | -.5 | | | 70.9 | 65.9 | |
| P.SD | 2.4 | .0 | .41 | .00 | .67 | 2.2 | .65 | 2.2 | | | 19.5 | .9 | |

**TABLE 7** / Misfit Person

Person STATISTICS: MISFIT ORDER

| ENTRY NUMBER | TOTAL SCORE | TOTAL COUNT | MEASURE | MODEL S.E. | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD | PTMEASUR-AL CORR. | PTMEASUR-AL EXP. | EXACT MATCH OBS% | EXACT MATCH EXP% | Person |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 58 | 21 | .96 | .42 | 2.41 | 3.68 | 2.33 | 3.54 | A .75 | .79 | 42.9 | 63.4 | 07 |
| 5 | 56 | 21 | .61 | .42 | 2.34 | 3.49 | 2.27 | 3.36 | B .74 | .79 | 42.9 | 64.7 | 05 |
| 4 | 52 | 21 | -.08 | .42 | 2.27 | 3.26 | 2.21 | 3.12 | C .80 | .80 | 38.1 | 66.5 | 04 |
| 6 | 55 | 21 | .44 | .42 | 2.16 | 3.10 | 2.09 | 2.96 | D .78 | .79 | 42.9 | 65.5 | 06 |
| 24 | 51 | 21 | -.25 | .42 | 1.71 | 2.08 | 1.76 | 2.15 | E .94 | .80 | 28.6 | 66.3 | 24 |
| 25 | 58 | 21 | .96 | .42 | 1.43 | 1.44 | 1.46 | 1.53 | F .67 | .79 | 66.7 | 63.4 | 25 |
| 13 | 51 | 21 | -.25 | .42 | 1.06 | .29 | 1.04 | .23 | G .69 | .80 | 76.2 | 66.3 | 13 |
| 12 | 52 | 21 | -.08 | .42 | 1.00 | .10 | .97 | -.01 | H .72 | .80 | 81.0 | 66.5 | 12 |
| 9 | 54 | 21 | .27 | .42 | .95 | -.09 | .96 | -.05 | I .80 | .79 | 66.7 | 66.2 | 09 |
| 2 | 50 | 21 | -.42 | .42 | .91 | -.20 | .91 | -.20 | J .92 | .80 | 52.4 | 65.7 | 02 |
| 11 | 52 | 21 | -.08 | .42 | .88 | -.33 | .85 | -.44 | K .74 | .80 | 81.0 | 66.5 | 11 |
| 14 | 52 | 21 | -.08 | .42 | .88 | -.33 | .85 | -.44 | L .74 | .80 | 81.0 | 66.5 | 14 |
| 18 | 51 | 21 | -.25 | .42 | .87 | -.35 | .86 | -.37 | M .92 | .80 | 57.1 | 66.3 | 18 |
| 3 | 52 | 21 | -.08 | .42 | .83 | -.53 | .82 | -.55 | l .91 | .80 | 61.9 | 66.5 | 03 |
| 17 | 53 | 21 | .10 | .42 | .78 | -.72 | .77 | -.74 | k .89 | .80 | 71.4 | 66.4 | 17 |
| 22 | 48 | 21 | -.78 | .42 | .63 | -1.32 | .60 | -1.43 | j .84 | .81 | 76.2 | 64.8 | 22 |
| 23 | 53 | 21 | .10 | .42 | .60 | -1.51 | .60 | -1.48 | i .86 | .80 | 81.0 | 66.4 | 23 |
| 16 | 52 | 21 | -.08 | .42 | .56 | -1.67 | .54 | -1.76 | h .84 | .80 | 90.5 | 66.5 | 16 |
| 1 | 56 | 21 | .61 | .42 | .44 | -2.40 | .44 | -2.36 | g .90 | .79 | 81.0 | 64.7 | 01 |
| 20 | 52 | 21 | -.08 | .42 | .41 | -2.50 | .40 | -2.55 | f .90 | .80 | 90.5 | 66.5 | 20 |
| 15 | 50 | 21 | -.42 | .42 | .32 | -3.08 | .31 | -3.12 | e .90 | .80 | 90.5 | 65.7 | 15 |
| 10 | 52 | 21 | -.08 | .42 | .31 | -3.16 | .30 | -3.17 | d .91 | .80 | 90.5 | 66.5 | 10 |
| 21 | 52 | 21 | -.08 | .42 | .31 | -3.16 | .30 | -3.17 | c .91 | .80 | 90.5 | 66.5 | 21 |
| 8 | 51 | 21 | -.25 | .42 | .30 | -3.21 | .29 | -3.24 | b .91 | .80 | 95.2 | 66.3 | 08 |
| 19 | 51 | 21 | -.25 | .42 | .30 | -3.21 | .29 | -3.24 | a .91 | .80 | 95.2 | 66.3 | 19 |
| MEAN | 52.6 | 21.0 | .02 | .42 | .99 | -.4 | .97 | -.5 | | | 70.9 | 65.9 | |
| P.SD | 2.4 | .0 | .41 | .00 | .67 | 2.2 | .65 | 2.2 | | | 19.5 | .9 | |

**TABLE 8** / The Effectiveness of N-gain for Increasing Critical Thinking Skills

| Criteria of N-Gain | Total | Percentage (%) |
|---|---|---|
| Low | 6 | 24 |
| Medium | 14 | 56 |
| High | 5 | 20 |
| Average | | 53,67 |

## LIST OF FIGURES


**FIGURE 1** / Display of Interactive Learning Media

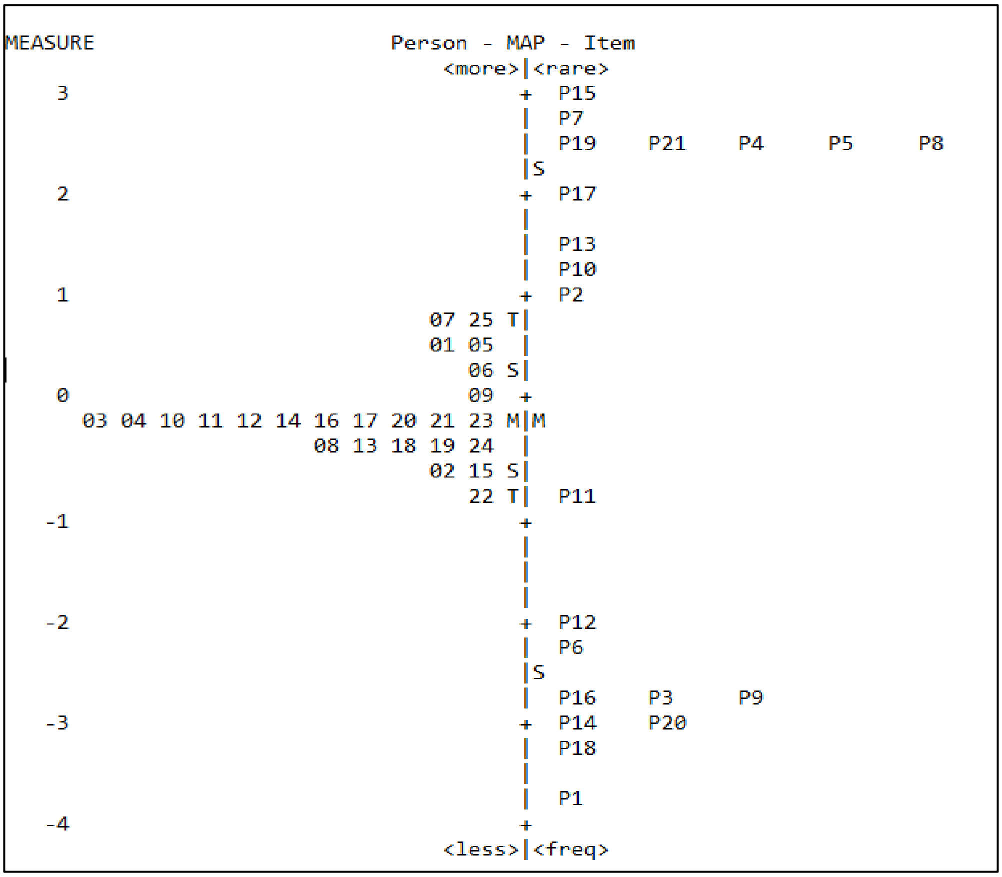


**FIGURE 2** / Variable Maps (Person) Test

```
MEASURE   Person - MAP - Item
             <more>|<rare>
    3              +   P15
                   |   P7
                   |   P19     P21     P4      P5      P8
                   |S
    2              +   P17
                   |
                   |   P13
                   |   P10
    1              +   P2
              XX  T|
              XX   |
               X  S|
    0          X   +
      XXXXXXXXXXX M|M
           XXXXX   |
              XX  S|
               X  T|   P11
   -1              +
                   |
                   |
                   |
   -2              +   P12
                   |   P6
                   |S
                   |   P16     P3      P9
   -3              +   P14     P20
                   |   P18
                   |
                   |   P1
   -4              +
             <less>|<freq>
```

**FIGURE 3** / Variable Maps Test (Item)

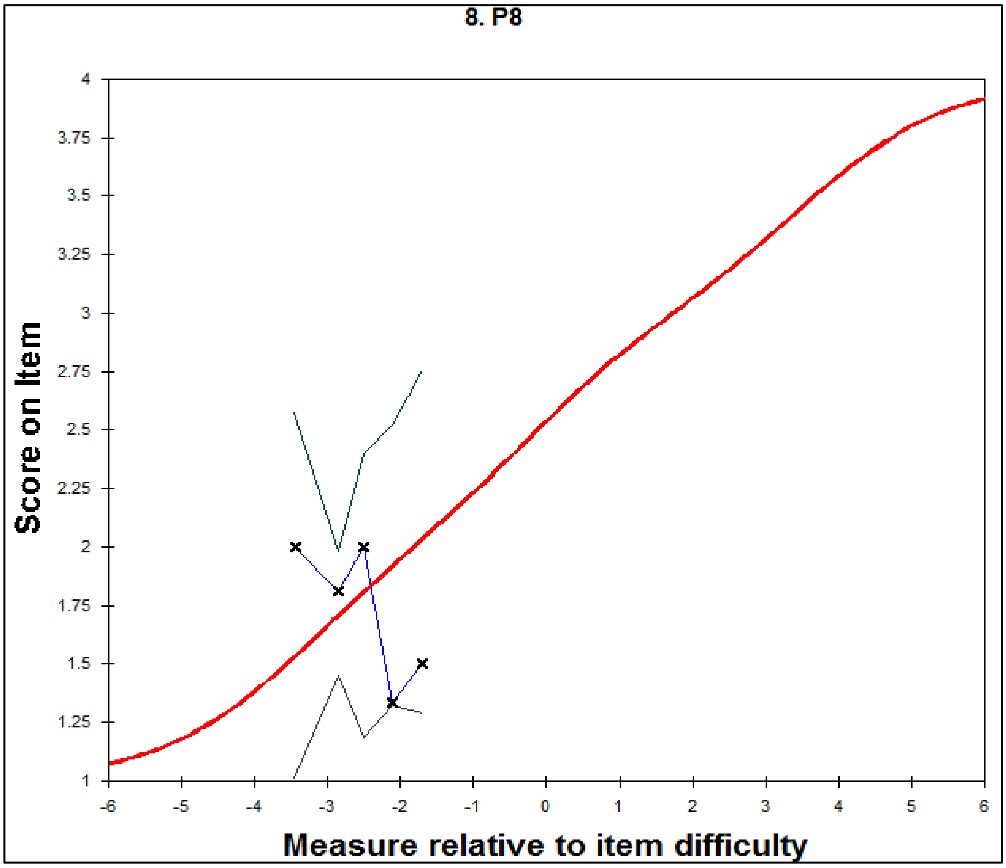


**FIGURE 4** / The ICC Expected Score Graph

```
GUTTMAN SCALOGRAM OF RESPONSES:
Person |Item
       | 121  1 11 111  12  1
       |180439662120374591875
       |---------------------
     7 +443443343434422112111  07
    25 +343444333222222234222  25
     1 +343444333322222222222  01
     5 +443443343234422112111  05
     6 +444434333242422112111  06
     9 +334334334323122221222  09
    17 +444333433322212211222  17
    23 +433334433222222212222  23
     3 +444333433322212211221  03
     4 +434443433321112121411  04
    10 +433333333222222222222  10
    11 +333333333322231232122  11
    12 +333333333422122222312  12
    14 +333333333322231232122  14
    16 +333333333222222222322  16
    20 +333333333232222222222  20
    21 +433333333222222222222  21
     8 +333333333322222222122  08
    13 +333333332322231232122  13
    18 +444333433322212211211  18
    19 +333333333322222222122  19
    24 +434444344322111111112  24
     2 +444333433222212211211  02
    15 +333333333322222222121  15
    22 +333333333321121222221  22
       |---------------------
       | 121  1 11 111  12  1
       |180439662120374591875
```

**FIGURE 5** / Scalogram (Guttman Matrix)

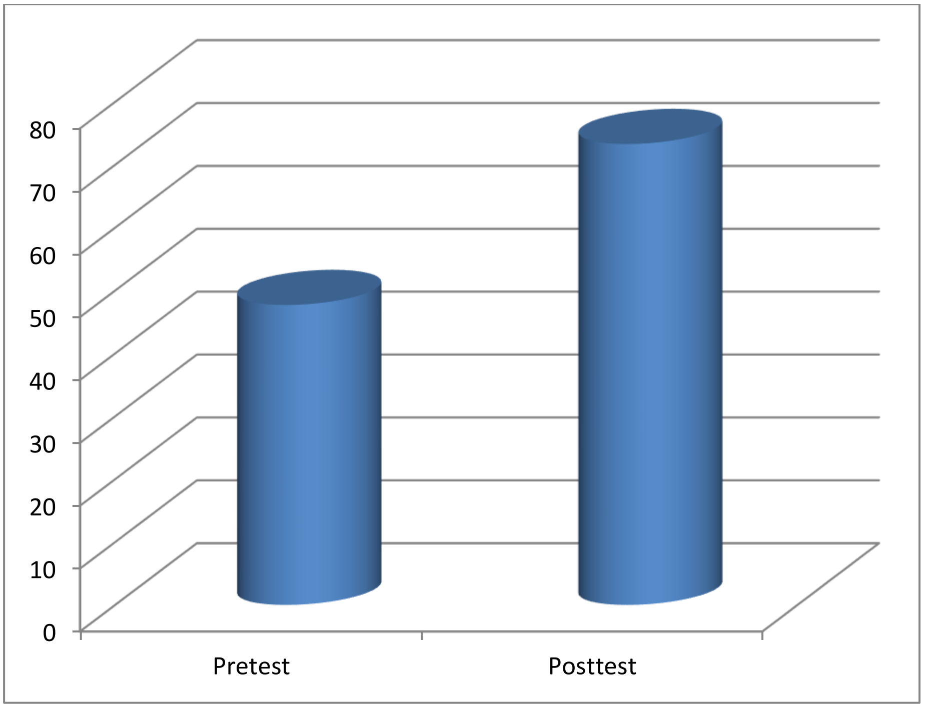


**FIGURE 6** / Mean Score of Pretest and Posttest