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Journal of Engineering Science and Technology
Vol. XX, No. Y (Year) PPP - QQQ

ITEM RESPONSE ANALYSIS OF UNDERSTANDING CONCEPTS OF MATERIAL CHEMISTRY WITH RADEC MODELS IN PHARMACEUTICAL STUDENTS

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Abstract

This study uses the RADEC model—Read, Answer, Discuss, Explain, and Create—to examine students' conceptual comprehension and identify misconceptions they have about the learning resources they are using. The research methodology makes use of descriptive quantitative data that is processed through analysis of the Rasch model's response pattern. Data was collected using multiple-choice test instruments, with 10 questions with concept material on classification, structure, and material properties, as well as the basic laws of chemistry. Respondents were taken randomly from as many as 20 people. Based on the data obtained, the questions were categorized into 10% very difficult, 40% difficult, 30% easy, and 20% very easy. In addition, based on their level of understanding, students were grouped into groups of 20% high, 35% moderate, and 45% low. Almost all high-ability students have difficulties understanding the basic law concepts of matter at level 2. The same students find it relatively easy to understand the structure and properties of matter at level 1 and relate material concepts macroscopically and sub-microscopically at level 3. This discovery is anticipated to serve as a guideline for other studies to specify processes in integrating diagnostic and summative measurement findings with the Rasch model in order to evaluate conceptual comprehension and diagnose more chemical misunderstandings.

Keywords: Concept understanding, Item response, Material, Radec, Rasch

1. Introduction

Response item analysis of understanding the chemical concepts of materials using the RADEC models in pharmaceutical students is very important to do because so far there are still many students who have difficulty learning chemical concepts. The material concept is the primary material studied by first-semester pharmacy students in introductory chemistry lectures. The concept of matter has the same abstract character as other chemical concepts [1]. In this study, students learn material concepts from understanding, classification, properties, and colloids to the fundamental laws of matter and their implementation without paying attention to multiple aspects of chemical representation [2]. Because the concept of the material presented is incomplete, students have difficulty understanding the concept of the material. Thus, students understand the concept of material that differs from one student to another [3]. This is because students have different ways of understanding a concept [4] that are even different from the concept issued by experts. Understanding concepts that are different from concepts issued by experts can be said to be in terms of misconceptions [5,6], bias [7], alternative frameworks [8], and student conceptions [9]. In this study, the term that is consistently used is a misconception. When students have a different understanding of concepts from experts and create misconceptions, it is essential to identify and improve concepts in learning. To overcome this misconception, the learning process is carried out by applying the RADEC model (Read, Answer, Discuss, Explain, and Create). This learning model directs students to study independently by reading and working on pre-learning questions, discussing with small groups to minimize misconceptions that may occur, presenting the results of discussions in large groups to ensure the concepts obtained are correct, and ends by making creations from understanding concepts what students understand [10].

To analyze the misconceptions experienced by students, many instruments have been developed, including using concept maps, essay tests, interviews, essays with interviews, and multiple-choice questions. In addition, some use multiple-choice instruments to perform analysis of misconceptions [11,12]. The use of multiple-choice instruments aims to diagnose misconceptions experienced by students. This misconception diagnosis tool is effectively used to determine the level of understanding of students' concepts. However, this type of instrument does not provide feedback (summative) and is not specific (unidimensional) [13], in addition to concluding the results of the analysis using a multilevel multiple-choice instrument. It is also considered weak because it is taken from the results of the raw score analysis and only provides limited feedback [14,15]. This is due to the limitations of the instrument in measuring student understanding. In addition, the reasons expressed by students in answering multiple-choice questions will also make it difficult for lecturers to make appropriate instructional decisions [16]. Over time, many researchers are currently focusing on cases of misconception, and new instruments have been developed that do not only diagnose students' conceptual understanding. Now, it has been developed by integrating diagnostic assessment with a summative assessment with the Rasch model, this instrument was first developed [17-19].

A good understanding of matter at the macroscopic, microscopic, and symbolic levels will affect the understanding of subsequent concepts such as macroscopic, microscopic, and symbolic atomic structures [20]. This fact demonstrates the value of logic in understanding chemistry as well as its complexity. Both teachers and students find this to be challenging [21]. Students must have a solid understanding of material principles in order to understand chemical concepts properly. The ability of students to interpret the state of particles when a material changes shape must also be measured in order to evaluate students' conceptual grasp of topics on material concepts [22–26]. Diagnostic techniques are frequently used in essay examinations, essays, and interviews to conduct research on the subject. On the basis of the initial findings, the equipment is further examined. This method is regarded as ineffective and significantly less accurate in identifying patterns of student misunderstandings and idea understanding. Although impractical, the majority of researchers in Indonesia measure student learning progress using traditional methodologies. According to lecturers, evaluating students' raw scores is an efficient way to gauge how well they are learning new material. Many people consider a student's raw score to be an early signal of the variable being assessed, and because of its transient character, it is unsuitable as a conclusive metric. Additionally, the information that raw scores offer regarding the decision-making process is restricted [27,28].

The originality of this research lies in the creation of a diagnostic tool that combines students' conceptual comprehension with diagnostic measurement of misconceptions on ideas from the learning material using the Rasch model item response pattern analysis approach. The study makes use of a number of test kits to measure student learning using the Radec model progress on numerous topics and to give practitioners and researchers information on scientific education. The goal of this study was to evaluate the instrument's efficiency in identifying misunderstandings regarding conceptual content and conceptual knowledge in students, as well as the instrument's gender-related effects and student patterns of conceptual understanding and misconceptions. Thus, the following research query is presented: 1) How well does the measurement tool capture students' conceptual understanding?

2. Methods

Students' comprehension of various chemical representations in the ideas of classification, structure, and qualities of matter, colloids, and fundamental laws of matter is addressed as a measurable variable in the descriptive-quantitative research method that is employed in this study. The learning process or the instructional materials were not altered by the researcher. In other words, no assistance is provided to pupils in order for them to complete all of the measurement instrument's questions.

The data collection stage is carried out for two months in the semester between the 2020-2021 school year; The process is carried out after obtaining approval from the university through the dean of the faculty, head of the study program, supporting lecturers, and to balance the code of ethics for research students who take part in the research have also given a letter stating their willingness to participate in the research until it is completed and without coercion. The university is willing to facilitate the data collection process according to a predetermined schedule.

Respondents were 20 people consisting of students from basic chemistry classes in the intermediate semester in one of the pharmaceutical study programs in Indonesia. learning is carried out using the Radec model and students learn independently, in groups (4 people per group), and large groups in one class. Table 1 displays the distribution of respondents.

Table 1. Demographic Profile of Respondents (N=20)

Respondents	Sum	Respondent Code
Man	4	P7, P8,P9,P10
Woman	16	P1,P2,P3,P4,P5,P6,P11,P12,P13,P14,P15, P16,P17,P18,P19,P20
Total	20	

The study's participants were chosen at random from the respondents who willingly volunteered to take part. Additionally, they do not receive learning assistance or any other particular care that would enable them to finish the measuring instrument. Because offline learning is still not an option in the Covid-19 pandemic scenario, students are expected to complete the instruments online under the supervision of a lecturer. Each student was given 30 minutes to complete all of the questions on the test. After the session is over, everyone submits their answers, and the number of submissions is assured to correspond to the number of participants. All participants in this activity are advised that the privacy of their identities is completely protected, and research.

2.1. Development of Instruments and Procedures

The construct map definition, item design, result form, and measurement model are the four basic steps that make up the design process as described in the recommendations [29].

Define the build map in Stage 1. Scalable constructions are defined in-depth by the map; if more constructs are assessed, the degree of the constructs will change qualitatively [30]. In order to gauge student development, it seeks to create a map of student knowledge [31,32]. The instrument, which is used in accordance with the Semester Learning Plan (also known as RPS), as shown in Tables 2, 3, and 4, incorporates factors, including students' conceptual comprehension and assumptions in elaborating material concepts [33].

Table 2. Conceptual Understanding Level 3

Level 3 Students can relate material concepts at the macroscopic and submicroscopic levels	
Rusting Phenomenon: Question	Q2
2. If the iron pipe is left in the air, over time it will form iron rust ($Fe2O3$). Iron rust is a...	
The phenomenon of coagulation events: Question :	Q5
5. Preconception of coagulation events in colloidal particles	
Brownian motion phenomenon:	Q6
6. Brown motion preconception	

Adsorption Phenomenon on Colloid:	Q7
7. Preconception of colloidal properties	

Table 3. Conceptual Understanding Level 2

Level 2 Students can explain the classification of matter and the basic laws of matter	
8. Students' preconceptions of colloids	Q8
9. Preconception of chemical equations	Q9
10. Preconceptions of the basic law of matter	Q10

Table 4. Conceptual Understanding Level 1

Level 1 Students can explain the structure and properties of the constituent materials	
1. Preconceptions about the nature of the components that make up matter.	Q1
3. Preconception of particle model structure	Q3
4. Preconception of the structure of the particle model	Q4

The process of pupils' conceptual development is characterized by variations in level of idea knowledge. Students are required to identify the structure and characteristics of the parts that make up the substance in the first level. Students are required to identify the classification and fundamental rules of matter at the second level. Students are also challenged to draw links between material concepts at the macroscopic and submicroscopic levels at the third level. The construct map also reveals the students' preconception tendencies for each stage.
Item Design and Evaluation at Stage 2 Choosing the things to be used as proof that pupils have a conceptual comprehension of the construct map is what this phase entails. Different items may be more or less useful at gauging pupils' conceptual knowledge. The selection of multiple-choice questions was made since they are seen to be more useful and efficient. Validation, reliability, and small-scale trials were used to construct the conceptual framework for comprehending test equipment. Each question has one correct answer and four distracting answer options. The distractor answer options were created in consideration of the students' general preconceptions as a sensible choice to divert students from the correct answer (see Table 2). The distractor assists to highlight the item's capacity for diagnosis [34]. A Q4 in Figure 1.

	The particle model is a type of particle a. Atom b. Elemental Molecules c. compound molecule d. atom e. element

Fig. 1. an example of the Q4 item design

The ability to identify the structure and characteristics of the material is tested in question Q4 of the exam. The right answer is option c, whereas options a, b, d, and e are distractions. An wrong response receives a value of 0, whereas a correct response receives a value of 1. There is just a 0.20 percent probability that any given student will select the right response. Based on their comprehension, students will select the response they believe is the right one. Students won't be able to guess the right answer if the distractor item choice is successful.

Stage 3: Design of the blank results, which includes the construct map and item correlation. In other words, it seeks to define the fit between the contents of the measured variable and the responses that students select. This phase strives to determine whether the correlation between the answers that students select and their conceptual comprehension. to be evaluated by pupils during testing. Ten test question items were obtained by the technique. The instrument's student responses were manually entered using a written answer sheet. The lecturer supervises this test while according to the predetermined timetable. All exam items must be finished by each student within the given 30 minutes. Because the activities are conducted online, instrument sheets are collected by submitting, and a checking mechanism is used to ensure that the number of instrument sheets obtained and the number of students taking the test match.

Stage 4: Rasch model analysis approach at stage four. As a result of the probabilistic expectations of item "i" and student "n," the analysis incorporates the method. Statement is the likelihood that student n will choose the correct response to item I (x = 1) and the likelihood that students will have misconceptions, given student ability, n, and item difficulty level [35]. By adding the logarithm function, the aforementioned equation is made simpler so that the likelihood of receiving the right response is equal to the student's aptitude minus the difficulty of the question. Items and student units (persons) are treated independently and on the same interval scale. Students' questions are graded on their degree of aptitude and complexity using odds or logs, which range from -00 to +00. When the distribution of items on the level of item difficulty is compared to the distribution of student ability levels, the effectiveness of the instrument may be judged in terms of how well it captures students' conceptual understanding and misconceptions. Additionally, based on the dimensions of the objects, the degree of student comprehension is identified. The previous procedures show the key distinctions between the Rasch model analysis and the more common raw score-based analysis; the latter is less reliable in assessing student abilities as evidenced from the difficulty level of various items [36,37].

2.2 Data Analysis

For this investigation, raw data were transformed into interval data using WINSTEPS software version 3.75 [38]. The conversion outcome is used to calibrate the data for the items' ability level and level of difficulty for the same measurement interval. Additionally, the diagnostic test item response pattern analysis was completed in three stages: 1) the transformation of the raw scores into homogeneous unit intervals and the effectiveness of the analysis of the measuring instrument; 2) the Differential Item Functioning (DIF) test for assessing the disparity in students' conceptual understanding; and 3) the item response patterns for diagnosing student preconceptions.

3. Result and Discussion

3.1. Reliability Test

. This study's person and item reliability test results show that for the person reliability findings. This reliability test's objective is to evaluate the consistency of the collected data. Table 5 displays the reliability test's outcomes.

Table 5. Summary of fit. Statistics

Parameter (N)	Measure	INFIT		OUTFIT		Separation	Reliability	SD	KR-20
		MNSQ	ZSTD	MNSQ	ZSTD				
Student (20)	-0.08	1.00	-0.15	1.10	-0.09	0.75	0.36	0.66	0.82
Item (10)	0.00	0.94	-0.18	1.10	0.21	2.01	0.80	1.70	

According to Table 5, a person's reliability score of 0.36 is equal to a person separation score of 0.75. In other words, the consistency of students' test-taking replies is viewed as less important. The Cronbach Alpha Coefficient (KR-20) score of 0.82, which denotes a positive interaction is generated between students and the test instrument, reveals that despite lacking, students nevertheless answer to item questions well. This progressively demonstrates a high association between student reactions to these questions and student knowledge, which is typically not fragmented in a way that makes it measurable [39]. This information is crucial for researchers and educators because it helps them build follow-up strategies, enhance student abilities, and identify common misconceptions [40]. These outcomes also yield an item separation index value of 2.01, which is comparable to an item reliability value of 0.80, and are relatively high. This demonstrates the goods' excellent uniformity. The outcomes of the infit and outfit scores, where the majority of the items are in the acceptable range for multiple-choice assessments, serve as proof for this.

To demonstrate the accuracy of the measurement, Figure 2 shows a graph of the measurement data. The measurement reliability value tends to rise the higher the end of the information function graph. Measurement data is placed very highly at the intermediate level of student ability (-3.0 logit to +3.0 logit). This demonstrates that students with moderate skill levels can obtain the best results with the TPKP instrument. These findings indicate that the equipment has a high degree of measurement accuracy.

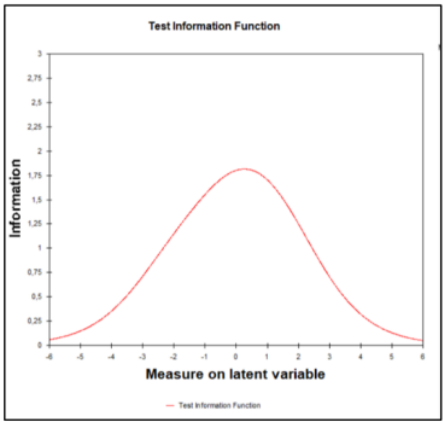


Fig. 2 The function of Measurement Information

3.2. Validity

To confirm that all items fit the Rasch model, the item Fit test is used to measure the validity of the items. The technique seeks to establish the test items' validity or assess whether they can accurately measure the desired characteristics. The criteria include point size correlation (PTMEA Corr), outfit mean square (MNSQ): 0.5 y 1.5, and z-standard clothing: -2.0 Z + 2.0. The association between item scores and body size that makes up the PTMEA correction must be positive and not too near to zero [33]. PTMEA Corr requirements: 0.4 x 0.8. If any one of the three requirements is not satisfied, the item is insufficient and requires more explanation. Both Outfit and Infit MNSQ are sensitive to chi-squares in identifying anomalous response patterns. There are two types of outlier responses: right answers that low-ability students correctly guessed on questions with a high level of difficulty, or erroneous answers that high-ability students carelessly provided on questions with a low level of complexity. The ideal MNSQ value is anticipated to be 1.0. Table 6 displays the findings of the item appropriateness study.

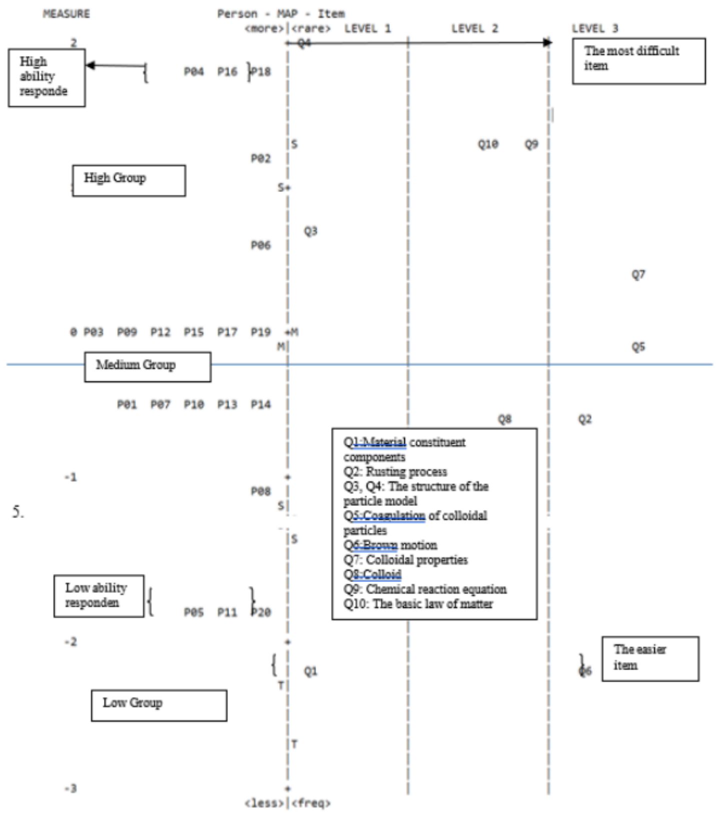
Table 6. Item Statistics: Misfit Order

Item	Measure	Infit		Outfit		PTMEA Corr
		MNSQ	ZSTD	MNSQ	ZSTD	
Q3	0.67	1.45	2.00	2.77	1.53	0.28
Q10	1.26	1.19	0.68	1.92	1.61	0.18
Q9	1.26	0.90	-0.25	1.56	1.12	0.42
Q5	-0.10	1.00	0.08	1.04	0.23	0.44
Q2	-0.06	0.89	-0.54	0.79	-0.58	0.54
Q6	-2,17	0.84	-0.28	0.73	-0.09	0.43
Q8	-0.60	0.84	-0.82	0.72	-0.87	0.58
Q4	2.03	0.83	-0.32	0.62	-0.30	0.60

Q7	0.14	0.64	-1.87	0.55	-1.65	0.74
Q1	-2.17	0.56	-1.17	0.31	-0.92	0.67

All items satisfied the Outfit MNSA criteria, and there was no negative PTMEA Corr, according to the item misfit data that was gathered. This implies that none of the items are abnormal, suitable, or legitimate. Even though certain goods don't fit any of the requirements, this doesn't degrade the items' quality. For instance, item (Q3) does not satisfy the Outfit MNSQ and PTMEA Corr requirements, and item (Q10) does not satisfy the PTMEA Corr requirements; this is assumed to be due to the small sample size, or N > 500.

Map of Wright: Person-Map-Item. The third step is to evaluate the consistency of the items' and students' ability tests' levels of difficulty, which are listed in Table 2. The degree of student skill will likewise increase as the item difficulty level does. Wright Data about the map: Fig. 3 depicts Person-Map-Items. Wright's earlier maps had the effect of covering nearly all student skills with every instrument component. The map shows a range of pupils' talents, from those with very high abilities (logit > 3.0) to those with very poor abilities (logit -2.0). No items matched the student's ability at the intervals of -3.0 logit to -0.5 logit and +1.0 logit to +3.7 logit, respectively, which also showed discrepancy. This shows that the information produced in the intervals is quite sparse and has to be expanded upon. The difficulty level of the things, on the other hand, is often between -1.0 and +1.0 logit, and these items frequently appear at the same level of difficulty. With a logit of +2.03, item Q4 is the most challenging, while items Q1 and Q6 are the simplest with a logit of -2.17.



5.

Fig. 3 Wright Map: Person-Map-Item

Based on the data in Fig. 3, it was found some interesting data, including Q4 questions being the most difficult questions when viewed from the measured value (X > 1.34), but they are at level 1. Q3 questions are at level 1, Q9 and Q10 questions are at level 1 . 2 and Q7 questions are classified as level 7 questions even though they come from different levels and have the same level of difficulty in the eyes of students, and the four questions, when viewed from the measured value (X = +1.34), are classified as difficult questions. For questions Q5 and Q2, Q8 came from different levels (Q5 and Q2 level 3, Q8 level 2) but received the same assessment by students, which was considered an easy question because of the measured value (X = -1.34). Questions Q1 from level 1 and Q6 from level 3 are considered to be the easiest questions for students because of the measured value (X < -1.34). Based on these data, the classification of questions was obtained, namely

10% very difficult questions, 40% difficult questions, 30% easy questions, and 20% very easy questions. Based on the data in Fig. 3, students are also grouped based on their level of ability into 3 groups, namely the high group (P4, P16, P18, P2), the medium group (P6, P3, P9, P12, P15, P17, P19), and the low group (P1, P7, P10, P13, P14, P8, P5, P11, P20). If group, 20% of students have an understanding of the concept of material in the high category, 35% of students are in the medium category, and 45% are in the low category. The data can be used by other researchers to develop the learning process to improve student understanding because there are still many students who are classified as low-group students. The prior cases revealed differences in the conceptual knowledge of the pupils, suggesting a comparatively low level of conceptual knowledge of the subject matter. Overall, the items' degree of difficulty is fairly similar to the construct being measured. As a result, the test's construct validity is strong [39–41].

3.3. The disparity in Level of Conceptual Understanding

The next step is to measure the disparity of students' conceptual understanding of the material concept using Differential Item Functioning (DIF). From these data, we can also analyze the misconceptions experienced by students from the tendency of students to answer questions, shown in Fig. 4.

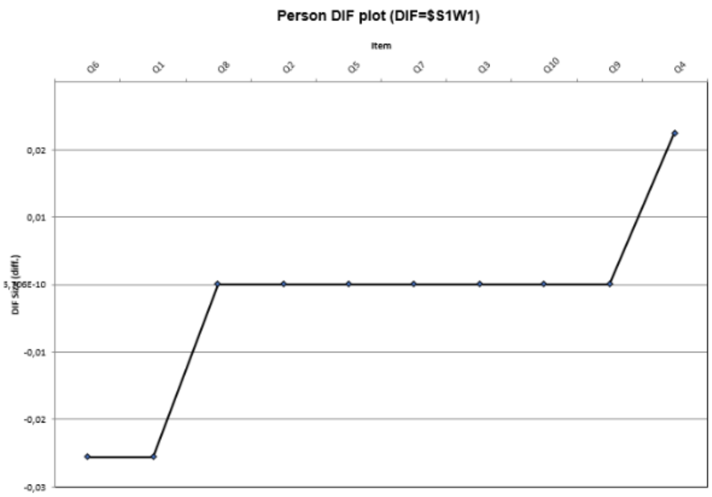


Fig. 4 Person DIF plot

Based on Fig. 4, the DIF plot shows the level of difficulty experienced by students. Question Q4 is a question that is considered the most difficult by students, as seen from the curve that is close to the upper limit. As for Q1 and Q6, the questions that are considered the easiest by students can be seen from the curve that is close to the lower limit. Based on the picture, it can be seen that the questions are arranged from easiest to hardest Q6, Q1, Q8, Q2, Q5, Q7, Q3, Q10, Q9, and Q4.

3.4. Patterns of Conceptual Understanding and Preconception

Using the option probability curve test, conceptual and preconception understanding patterns are analyzed [41, 42]. The option probability curve seeks to illustrate the likelihood of selecting each response option in order to clarify the level of performance of all students in the assessed item [43]. The test is predicated on the idea that when the distractor's choice curve declines, the correct response curve would rise [44]. The resulting curve for items affected by distractor choices typically does not follow the monotonous behavior of conventional items, for which each answer choice is considered separately.

Five possible answers are given on the test, producing five curves. Each curve shows how well students grasp a concept. Low-ability students frequently select items that will divert them [45]. Based on the five choice probability curves that will be displayed in Fig. 5, the pattern of students' conceptual comprehension and preconception is described below.

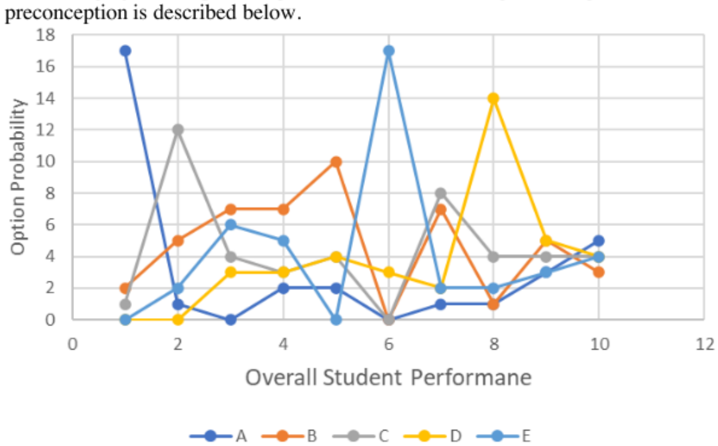


Fig. 5 Option probability curve

Based on Fig. 5 for Q1 questions, 17 students answered correctly so that Q1 questions became the questions that were considered the easiest by students; Q1 questions about the components that make up the material, and it was found that three students were fooled and had misconceptions. Students who experience misconceptions and are deceived think that the materials that still have their constituent properties when combined are elements and mixtures. Question Q2 is about the phenomenon of rust. Most of the students answered correctly if rust is a compound, but students who are confused and have misconceptions think that rust is an element, mixture, substance, and compound molecule. In the Q3 question regarding the particle model, a submicroscopic image of an elemental molecule was presented, but most students answered that the image was an element. Other misconceptions were also seen in the student's answer choices by answering atoms, molecules, compounds, and ions. In question Q4 about the particle model, a submicroscopic image of a compound molecule is presented, but most of the students answered that the image was an atom; another misconception was also seen from the student's answer choices by answering elements, molecules of elements, and ions. Question Q5 presented questions about events, including coagulation, and the correct answer is the process of treating stomach pain. Most of the students answered correctly, but there are still students who are deceived and had misconceptions by answering with clumping of latex and clearing mud from river water. In question Q6, the question contains Brownian motion, and most of the students answered correctly by answering that Brown's motion is a collision of medium molecules with colloidal particles. However, students are still misled and have misconceptions by assuming that Brown's motion is a collision between colloidal particles. In question Q7 about colloidal properties regarding adsorption, which was presented sub-microscopically with pictures, most of the students answered correctly. However, there were still students who were misled and had misconceptions by answering that colloid properties that can absorb ions on the surface are absorption, electrophoresis, and some consider electrophoresis. In the Q8 questions about colloids that are hydrophobic, most of the students answered correctly, namely fat in water, but students who had misconceptions and were deceived chose the answers of egg white in water, gelatin in water, and protein in water. In the Q9 question, students are asked to calculate the quantity of residue that will remain after the reaction; the majority of students had wrong answers and had misconceptions. Students are asked to calculate the mass ratio of hydrogen in question Q10; the majority of the correct responses came from 5 students, while the remaining students got it wrong by selecting the erroneous answer options and having misconceptions.

3.5 Discussion

The outcomes demonstrated that the tool had good efficacy, satisfied the criteria for person and item dependability, and had good construct validity. When used to assess conceptual comprehension and common misunderstandings across students, it was discovered that: First, all high-ability students had trouble comprehending material concepts at level 2 of the fundamental laws of matter. The same student found it reasonably simple to comprehend the level 1 questions' structure and nature, as well as the level 3 questions' linked macro- and micro-material ideas. Second, data on the responses of high-ability kids to particular items is highly systematic, repetitive, and consistent. This points to both a latent and permanent preconception. The item response pattern approach can investigate in depth and completely students' knowledge of concepts and preconceptions, according to the item option probability curve analysis for Q9 and Q10.

The Rasch model technique, which incorporates diagnostic and summative development procedures in the instrument, produces detailed, accurate, and measurable results in the order of verification. Preconception samples like Q4 and Q7 revealed that distractors were frequently picked over the right responses. Additionally, it reveals the key concepts that pupils lack familiarity with as well as the degree to which they hold misconceptions.

The strategy utilized in this study is a useful example for lecturers to use when assessing the learning process with Radec models, debunking common misconceptions, and tracking student learning progress. The combination of qualitative item production techniques and quantitative data analysis has made it possible for lecturers to examine in-depth student understanding, concepts that students grasp and/or do not understand, and misconceptions [46This finding is consistent with previous research showing that probability curves and Rasch model analysis can be used together to diagnose how students' misunderstandings affect their overall conceptual comprehension. Due to the interconnection of people and things, it would be very challenging to complete this project using a standard methodology. The item and test difficulty stay constant and independent of the sample used in the original validation, whereas the Rasch model, on the other hand, can overcome such dependencies. This suggests that the instrument items have complied with the demands of local independence and unidimensionality [47].

Overall, the study provides factual support for the claim that as a result of their learning process, pupils have unique preconceptions. This preconception is viewed as a barrier to pupils' conceptual understanding development. In this study, it was discovered that students' preconceptions were repetitive and organized. As a result, using traditional teaching techniques to intervene and alter pupils' beliefs is challenging [48]. Therefore, it's critical to use purposeful and strategic teaching strategies to get rid of students' misconceptions and foster the development of conceptual knowledge that is in line with science. As a result, lecturers must gather comprehensive data regarding the nature and traits of students' preconceptions [49, 50]. Item response pattern analysis is, thus, an efficient and effective way to get this data. In order to create effective and measurable learning designs to address student misconceptions, knowledge of students' preconceptions is crucial. This is consistent with earlier research, which contends that the learning process and student learning environment have a significant impact on the quality of learning progress.

4. Conclusion

With regard to testing students' conceptual comprehension and preconceptions when elaborating the properties of the material notion with Radec models, the measuring tool created has good validity and reliability. Following the instrument's implementation, the study discovered that:

1) Nearly all high-ability students struggle to comprehend the fundamental laws of matter at level 2. The same students find it relatively easy to understand the structure and nature of matter at level 1 and relate material concepts macroscopically and sub-microscopically at level 3.

2) The instruments given to students are categorized into 10% very difficult, 40% difficult, 30% easy, and 20% very easy.

3) In addition, students, based on their level of understanding, are grouped into 20% high, 35% moderate, and 45% low groups.

Acknowledgments

We acknowledged Universitas Muhammadiyah Prof. Dr. Hamka and Universitas Pendidikan Indonesia for helping with the process of this research.

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