INDONESIAN JOURNAL
OF SCIENCE AND MATHEMATICS EDUCATION
https://ejournal.radenintan.ac.id/index.php/IJSME/index
04 (2) (2021) 172-182
ISSN: 2615-8639
DOI: 10.24042/ijsme.v4i2.9488
July 2021

ELABORATION OF HIGH SCHOOL STUDENT'S METACOGNITION AWARENESS ON HEAT AND TEMPERATURE MATERIAL: WRIGHT MAP IN RASCH MODEL

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Article Info

Article history:

Received: June 15, 2021
Accepted: July 15, 2021
Published: July 31, 2021

Keywords:

Heat and temperature
Metacognition awareness
Metacognitive self-reports
Rasch model
Wright map

ABSTRACT

This study aims to elaborate on the interaction between students' metacognitive awareness and the difficulty level of items in Heat and Temperature Metacognition Awareness Inventory (HeTMAI). This study uses a quantitative research method with the type of survey research. The respondents involved were 30 students and came from one the public high schools in eastern Indonesia. Metacognitive awareness was evaluated using the 26-item HeTMAI. Student responses are administered online, are voluntary and anonymous. The interaction between students' metacognitive awareness and items in HeTMAI was analyzed using the Wright map based on the Rasch model. The analysis results show that the student's average ability is 1.00 logit higher than the item difficulty level. The students' abilities ranged from -1.34 to 5.98 logit, and the item difficulty level ranged from -0.51 to 0.70. In general, it appears that most students tend to agree more easily with the statements in HeTMAI.

ELABORASI KESADARAN METAKOGNISI SISWA SEKOLAH MENENGAH ATAS PADA MATERI SUHU DAN KALOR: *WRIGHT MAP* DALAM MODEL RASCH

Kata Kunci:

Suhu dan kalor
Kesadaran metakognisi
Metacognitive self-reports
Model Rasch
Wright Map

ABSTRAK

Penelitian ini bertujuan untuk melakukan elaborasi interaksi antara kesadaran metakognitif siswa dan tingkat kesulitan item dalam Heat and Temperature Metacognition Awareness Inventory (HeTMAI). Penelitian ini menggunakan metode penelitian kuantitatif jenis survei. Responden yang dilibatkan sebanyak 30 orang siswa dan berasal dari salah satu SMA Negeri di Indonesia Timur. Kesadaran metakognitif dievaluasi menggunakan 26 item HeTMAI. Respon siswa diadministrasi secara online, bersifat sukarela dan anonim. Interaksi antara kesadaran metakognitif siswa dan item dalam HeTMAI dianalisis menggunakan Wright map berdasarkan Rasch model. Hasil analisis menunjukkan bahwa rata-rata abilitas siswa sebesar 1.00 logit lebih tinggi dari tingkat kesulitan item. Abilitas siswa berada pada rentang -1.34 sampai 5.98 logit, dan tingkat kesulitan item berada pada rentang -0.51 sampai 0.70. Secara umum tampak bahwa sebagian besar siswa cenderung lebih mudah menyetujui berbagai pernyataan yang ada dalam HeTMAI.

1. INTRODUCTION

One of the critical competencies that students need and must possess to maximize their academic achievement is metacognitive awareness [1], [2]. This skill refers to how a person is consciously able to manage their knowledge effectively. The effectiveness of managing metacognitive awareness will impact the emergence of innovations in solving the problems encountered. Students who have high metacognitive awareness tend to have better achievements [3]–[6]. This happens because students can take the necessary steps to plan appropriate strategies in solving the problems they face, evaluate the consequences and outcomes and modify the approach as needed, based on their previous knowledge [5].

Since it was first introduced, there has been a proliferation of research related to metacognition [7]. Various positive effects of metacognitive on students' abilities have been reported. Metacognition is associated with improved cognitive learning outcomes. Students who have good metacognitive awareness tend to be independent learners. They can make plans, implement them effectively and efficiently by monitoring activities, and evaluate their processes and results. If they encounter problems while solving problems, they will seek help from people who are considered to help. In addition, students with good metacognitive awareness will optimize their resources to solve the problems at hand. Therefore, metacognitive awareness impacts problem-solving abilities [8], [9] and communication skills [4]. Several studies have also reported a positive trend of metacognitive influence on students' cognitive learning outcomes [10]–[12]. Even Kristen et al. [13] found a more significant metacognitive contribution than scientific attitudes to cognitive learning outcomes. Therefore, metacognitive awareness is one of the needs for students to survive in the 21st century.

Over time, various types of Metacognitive Self-Reports have been produced [14]. For university students, Schraw and Dennison [15] created a 52-item Metacognitive Awareness Inventory (MAI). Junior MAI (Jr.MAI) versions A (12 items) and B (18 items) were developed by Sperling et al. [16] for students in grades 3 to 9. For university students, Meijer et al. [17] developed 63 questions for the Awareness of Independent Learning Inventory (AILI). Specifically, in the field of physics, Haeruddin et al. [18] and Taasoobshirazi and Farley [19] developed a problem-solving-based metacognitive instrument. Taasoobshirazi and Farley [19] developed a 24 item Physics Metacognition Inventory (PMI). Then Taasoobshirazi et al. [20] developed PMI part II into 26 items.

Physics Metacognition Inventory developed by Taasoobshirazi and Farley [19] and Taasoobshirazi et al. [20] consists of 6 factors incorporated into two components: Knowledge of cognition and Regulation of cognition. Declarative, procedural, and conditional knowledge are contained in the Knowledge of cognition component. Meanwhile, planning, monitoring, information management, debugging and evaluation are incorporated in the Regulation of cognition component. In its development, Haeruddin et al. adapting PMI for university students in the Indonesian context [21]. Then Sukarelawan et al. adapted PMI into Heat and Temperature Metacognition Awareness Inventory (HeTMAI) [22]. The developed HeTMAI supports the 6-factor PMI structure.

Metacognition includes higher-order thinking skills and is related to student intelligence [23]. Therefore, metacognitive awareness is one of the critical factors that influence students' academic success. Various literature reports a positive correlation of metacognitive awareness on student achievement [5], [11], [24]–[26]. On the other hand, every student has the same right to be successful in their academic career. The metacognitive awareness mapping study is preliminary to develop a learning model that trains students' metacognitive awareness. So that all students are expected to have metacognitive awareness in supporting their academic careers. Therefore, the exploration of metacognitive awareness becomes urgent.

Various studies have mapped the metacognitive awareness of students in Indonesia. Agustin et al. [27] mapped the metacognition of junior high school students in the Surakarta area. At the high school level, Herlanti [28], Sukarelawan and Sriyanto [2], and Rahman [29] each mapped students' metacognitive awareness in Bogor, Jakarta, Yogyakarta, and Serang. At the university level, Sugiyanti et al. [30] and Amnah [23] reported students' metacognitive awareness in Semarang and Riau. Meanwhile, Ijirana and Supriadi [31] and Misu et al. [32] mapped students' metacognitive awareness in Tadulako and Kendari. The mapping carried out by previous research was carried out on students and college students in western and central Indonesia. Limited studies are reporting metacognitive awareness mapping among students and college students in eastern Indonesia.

HeTMAI is a Metacognitive Self-Reports to evaluate students' metacognitive awareness of heat and temperature material. One approach to assessing students' metacognitive awareness is to use the Wright map in the Rasch model. Wright map is one approach that can be used to see how the interaction between items and person. This map visualizes persons and items on the same continuum [33]–[35]. So, we can see the hierarchy between the person's abilities and the difficulty level of the item. So, this study aims to describe how the interaction between students' metacognitive awareness in eastern Indonesia and items in HeTMAI through the Wright map (person-item map).

2. METHOD

2.1 Method

This study uses quantitative research methods [36], [37]. The type of research used is a cross-sectional survey study [38]. Figure 1 shows the research flowchart.

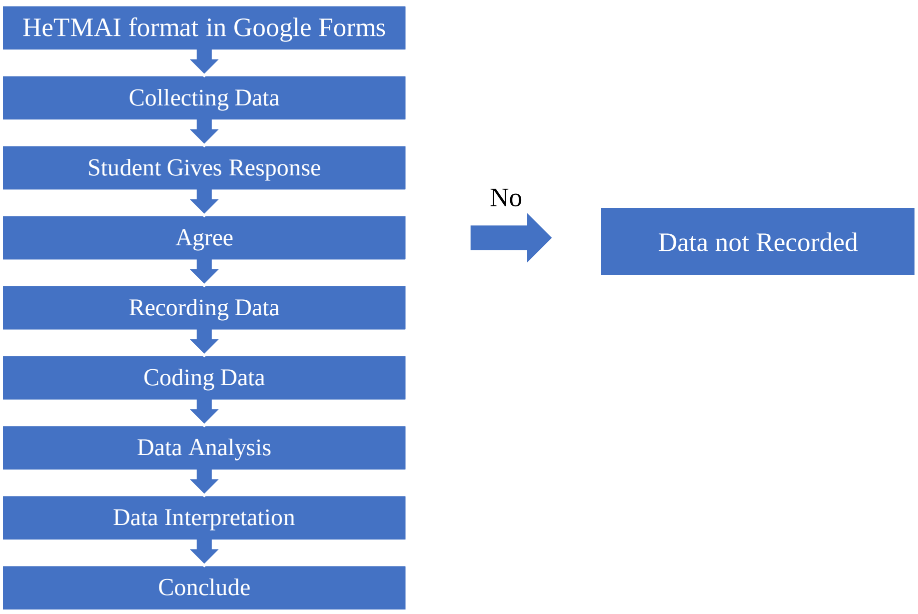

Figure 1. Research Flowchart

2.2 Respondent

This study involved as many as 30 students (67% female and 33% male) from grades XI and XII at a public high school in eastern Indonesia. Students were selected using the convenience sampling technique (not representative of the school population). The students' age ranged from 16 to 19 years (Mean = 17.1 years and SD = 0.79 years). Male students are coded with "L", and female students are coded with "P".

2.3 Instrument

Students' metacognitive awareness was explored using the Heat and Temperature Metacognition Awareness Inventory (HeTMAI) [22]. HeTMAI consists of 26 items spread over six components, namely: Knowledge of Cognition (KC, 6 items), Planning (PL, 5 items), Information Management (IN, 4 items), Monitoring (MO, 4 items), Debugging (DE, 3 items), and Evaluation (EV, 4 items). HeTMAI uses a 5-point Likert scale ranging from 1 (never) to 5 (always). HeTMAI has been validated using the Confirmatory Factor Analysis (CFA) method and meets the elements of fit to the model, convergent validity and discriminant validity. In addition, HeTMAI has also met the element of good reliability. Table 1 provides six examples of items in HeTMAI.

Table 1. Example Items in HeTMAI [22]

Item Code	**Statement**	**My condition**				
		1	**2**	**3**	**4**	**5**
KC1	"I am confident about my ability to solve heat and temperature problems"					
PL1	"I thought about what questions to ask before I started solving them"					
IN3	"I draw the free-body diagram to help me solve heat and temperature problems"					
MO2	"When solving heat and temperature problems, I sometimes evaluate how well I am doing"					
DE3	"I changed strategies when I failed to solve the heat and temperature problems"					
EV4	"After solving the heat and temperature problem, I looked back at the problem to see if my answer makes sense"					

2.4 Research procedure

Metacognitive awareness data was administered through an online survey. Before responding, students are allowed to choose whether to continue taking the survey or not. Student participation is voluntary and anonymous [39]. We assume that all data collected are responses given without coercion.

2.5 Data analysis technique

The collected data is entered into Ms Excel and later analyzed using Winsteps version 4.6.1. The interaction between person and item was analyzed using the Wright map in Rasch model. The logit person and item values are obtained through the person measure and item measure.

3. RESULTS AND DISCUSSION

This study describes how the interaction between students' metacognitive awareness and items in HeTMAI through the Wright map. The logit value of each person and item is shown in Table 2.

Table 2. Logit Values of Person and Item

	Person (Person code)	**Item (item code)**
HeTMAI		
Highest logit	5.98 (04L)	0.70 (IN3)
Lowest login	-1.34 (16P)	-0.51 (EV4)
Mean	1.00	0.00
SD	1.46	0.33

	Person (Person code)	Item (item code)
Per Construct		
Knowledge of Cognition		
Highest logit	5.93 (01P)	0.31 (KC1)
Lowest login	-1.99 (29P)	-0.35 (KC6)
Mean	1.62	0.00
SD	2.23	0.22
Planning		
Highest logit	5.16 (02P)	0.72 (PL3)
Lowest login	-4.97 (16P)	-0.39 (PL2)
Mean	1.47	0.00
SD	2.35	0.38
Information Management		
Highest logit	7.57 (04L)	0.20 (IN3)
Lowest login	-8.55 (30P)	-0.12 (IN4)
Mean	0.73	0.00
SD	4.94	0.13
Monitoring		
Highest logit	8.24 (04L)	0.11 (MO1)
Lowest login	-4.35 (16P)	-0.04 (MO4)
Mean	2.63	0.00
SD	3.90	0.06
Debugging		
Highest logit	4.45 (02P)	0.24 (DE3)
Lowest login	-1.60 (29P)	-0.34 (DE2)
Mean	1.41	0.00
SD	1.98	0.25
Evaluation		
Highest logit	6.08 (02P)	0.46 (EV2)
Lowest login	-2.16 (29P)	-0.37 (EV4)
Mean	2.21	0.00
SD	2.71	0.31

Based on Table 2, the highest logit value for the person in *HeTMAI* is 5.98, and the highest logit value for the item is 0.70. At the same time, the lowest logit values for person and items are -1.34 and -0.51, respectively. The average value of the logit person is higher than the item, namely 1.00 (logit person) with a standard deviation of 1.46 and 0.00 (logit item) with a standard deviation of 0.33. In the *Knowledge of Cognition* construct, the person logit ranges from -1.99 to 5.93. In contrast, the items logit went from -0.35 to 0.31. The average person logit is 1.62, and the standard deviation is 2.35. In comparison, the average logit item is 0.00, with a standard deviation of 0.22.

In the *Planning* construct, the person logit ranges from -4.97 to 5.16 with an average of 1.47 (SD = 2.35). Meanwhile, items logit are in the range of -0.39 to 0.72. The average logit item is 0.00, and the standard deviation is 0.38. The person logit in the *Information Management* construct ranges from -8.55 to 7.57. Simultaneously, the items logit increased from -0.12 to 0.22. The average person logit has a value of 0.73 and a standard deviation of 4.94. On the other hand, the average item logit is 0.00, with a standard deviation of 0.13.

The person logit ranges from -4.35 to 8.24 in the *Monitoring* construct, with an average of 2.63 (SD = 3.90). Meanwhile, items logit range from -0.04 to 0.11. The standard deviation for items logit is 0.06, and the average is 0.00. The highest logit value for a person in the *Debugging* construct is 4.45, and the highest logit value for an item is 0.24. At the same time, the lowest logit values for person and items are -1.60 and -0.34, respectively. The average value of the logit person is higher than the item, namely 1.41

(person logit) with a standard deviation of 1.98 and 0.00 (item logit) with a standard deviation of 0.25.

The person logit ranges from -2.16 to 6.08 in the last construct, *Evaluation*. Simultaneously, the items logit increased from -0.37 to 0.46. The standard deviation is 2.71, while the average person logit is 2.21. In comparison, the typical item logit has a value of 0.00 with a standard deviation of 0.31. The average person logit value is higher than the average item logit in each construct. Person's mean logit is higher than the average of this item, indicating the tendency of students to agree with each statement given in HeTMAI [40].

The interaction between person and item can be elaborated using the Wright map (person-item map). This map depicts a hierarchy between student abilities and item difficulty levels in HeTMAI on the same continuum [33]–[35]. The Wright map is divided into two areas: left and right [41]. The left area represents the location of the person's abilities, and the right shows the item's difficulty level. High-ability students will be placed in the upper-left area, and low-ability students will be placed in the lower-left area. Items with high difficulty will be placed in the upper-right area, and low difficulty items will be placed in the lower-right area. Figure 2 shows the location distribution of student abilities and item difficulty levels.

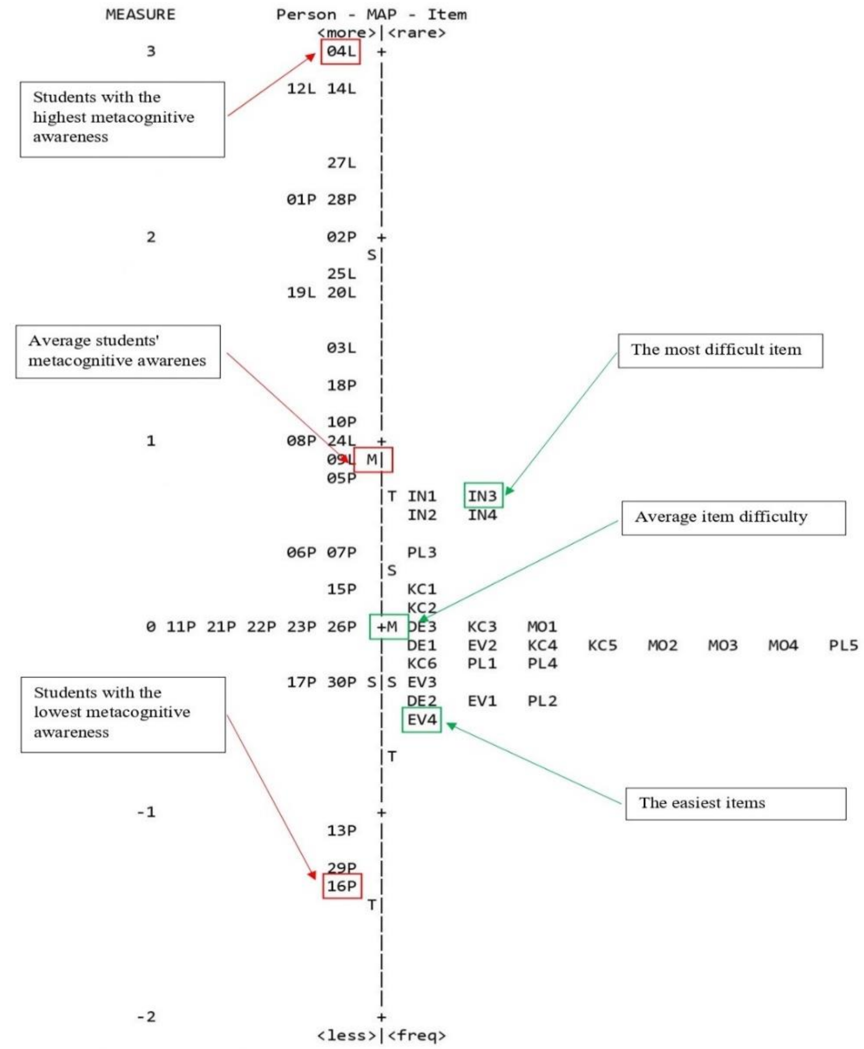

Figure 2. Wright Map of Students' Metacognitive Awareness on Heat and Temperature

From Figure 2, it appears that students with code 04L (fourth-order students are male) have the highest metacognitive awareness than other students. Meanwhile, students with code 16P (sixteenth female students) have low metacognitive awareness. The item coded IN3, "I draw the free-body diagram to help me solve heat and temperature problems", was the most difficult item for students to agree on. While the item with the code EV4, "After solving the heat and temperature problem, I looked back at the problem to see if my answer makes sense" is the item that is the easiest for students to agree with. The location of student 04L is higher than the location of all items on the Wright map. This shows that the probability of student 04L agreeing to all the statements in HeTMAI is greater than 50%. Meanwhile, the location of 16P students is below all the existing items. This shows that the student's probability of agreeing to all the statements in HeTMAI is less than 50%.

Although item IN3 has the highest level of difficulty, 16 out of 30 students (53%) have more than 50% chance of agreeing to each statement. This means that 53% of these students agree more easily with the statements in IN3 and the items below. This is indicated by the 16 students having a higher location than logit IN3 in the continuum. On item EV4 as the easiest item, 3 out of 30 students (10%) have a location below it. As much as 10% of these students have the opportunity to agree with each statement that is less than 50%. 10% of students tend to have more difficulty agreeing with the statements in item EV4 and other items above it.

The location of student 15P is equivalent to the location of KC1 "I am confident about my ability to solve heat and temperature problems". This shows that the probability of student 15P to agree with this statement is equal to 50%. At the same time, 5 out of 26 items (19%) have less than a 50% chance of being approved. Meanwhile, 20 of the 26 items (77%) have a more than 50% chance of being approved. The same analysis can be carried out on students 06P and 07P or 17P and 30P or other students with locations equivalent to certain items.

In general, most students have good metacognitive awareness. This is indicated by the location of students' average ability, which is higher than the average level of item difficulty. These findings align with our previous findings in high school students [2]. Students of classes X and XI already have the knowledge to consider, control, and understand learning objectives and strategies. Sugiharto et al. (2020) reported that high school students from urban and rural areas had metacognitive awareness in the "well developed and very good" category. This means that students can consciously manage the learning process and ways of thinking in everyday life.

Thus, the interaction between student abilities and item difficulty levels through the Wright map in HeTMAI can be elaborated through their respective locations along a continuum [42]. An item whose location is higher than the student's ability will have less than a 50% chance of being approved by the student. Items located lower than the student's ability have more than a 50% chance of being approved by the student. Meanwhile, the item's location, which is equivalent to the student's ability, has a 50% chance of being approved.

The results showed that the metacognitive awareness of high school students in one of the schools in eastern Indonesia was on average good. The results of this study are in line with studies that have been reported by several previous researchers [2], [28], [29], [43]. Contrary to our findings, several other researchers reported high school students in several regions of Indonesia to have low metacognition [44]–[46].

4. CONCLUSION

The results of the elaboration of the interaction between person and item using the Wright map show that most students agree more easily with various statements in HeTMAI. This indicates the high metacognitive awareness of students on the material of temperature and heat. However, a small percentage of students with low metacognitive awareness need special attention from the teacher or instructor. This needs to be done because one of the determining elements of students' academic success is managing themselves and learning.

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