Gases Theory Representation Instrument (GeTRI): A Practical Tool to Analyze Sundanese Students’ Conception in the COVID-19 Pandemic

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Abstract. This research purposes to promote a Gases Theory Representation Instrument (GTRI) as a tool to identify the students’ conception on kinetic theory of gases. The method used in this research was FODEM (Formative Development Methods) model which has three comprehensive steps, which are need analysis, implementation, and formative evaluation. The participants involved in this research were 26 high school students in Sundanese tribe. The students’ responses were analyzed using Rasch model, which involved item reliability, person reliability, validity, difficulty level and students’ conception distributions. Students’ conception were classified into six categories which are Sound Understanding (SU), Partial Positive (PP), Partial Negative (PN), Misconception (MC), No Understanding (NU), and No Coding (NC). Based on the data analysis, it can be concluded that students’ conception are typically in the SU and PP categories. Besides, the Gases Theory Representation Instrument (GTRI) is reliable and valid to identify students’ conception on kinetic theory of gases.

1. Introduction
Conceptual understanding or students’ conception is an important thing in the learning process because it is not only to reconstruct the intelligence of associations but also to improve the combination of material that has been previously infatuated [1,2,3,4]. However, most students have frequently experienced misconception or misguided conception when they study some concepts, especially abstract concept that cannot be observed using sense of human [5,6,7,8]. They tend to have difficulty learning abstract concepts because their ability to imagine is still lacking and their cognitive level is not yet at an abstract level. Therefore, misconception is one of the major problems for the students that need to be assessed using appropriate tools to find suitable solution to solve it.

Many researchers, especially science education researchers, have implemented multi-tiers instrument to assess alternative conception, misconception, or students’ conception. This type of instrument has been developed from multiple choices question, and it added by two or more tiers such as tier for reason and tier for level of confidence. The research which conducted by Aminudin [9], for example, have promoted that there are six students’ conception categories which are Sound Understanding (SU), Partial Positive (PP), Partial Negative (PN), Misconception (MC), No Understanding (NU), and No Coding (NC).

The students’ responses that have been collected from the multi-tiers mostly analyze using commonly statistical analysis [10]. However, it is rarely found the researchers who developed instrument using modern statistical analysis such as Rasch Analysis. The Rasch model was firstly credited by Danish
mathematician Rasch [11] to nourishment precise measurement. Rasch measurement has been applied in a variety of application in education, school psychology, and numerous other areas [12]. It has been practiced, developed, evaluated, and expanded through surveys and tests [12]. Furthermore, Rasch analysis has been completed in several researches in physics education context, but exploration for multi-tier instruments is still rarely introduced [9,13]. Therefore, this research purposed to develop and promote an instrument in a specific physics concepts using Rasch analysis.

According to Gurel et al [14], there are 273 articles about developed instrument to diagnose students’ conceptions since 1980 to 2019. Some of them are Force Concept Inventory (FCI) by Hestenes et al [15] and Multitier Open-ended Light Wave Instrument (MOLWI) by Aminudin et al [9]. However, the instrument to assess Kinetic Theory of Gases is still rarely found. That is because kinetic theory of gases has huge range of concepts, and they are abstract. Thus, many researchers are not interested in using it as research material. Therefore, this study aims to promote and develop an instrument to assess students’ conception on Kinetic Theory of Gases.

2. Method

The Gases Theory Representation Instrument (GTRI) is developed using FODEM (Formative Development Methods) model. This model has three comprehensive steps which are need analysis (NA), implementation (I) and formative evaluation (FE) [15]. The participants of this study are 26 high school students who come from several schools in Sundanese tribe (West Java province). They consist of 12 male students (called as “Akang”) and 14 female students (called as “Teteh”), and they are mainly 17 years old. The participants were selected using random sampling technique from the total of 2.831 high schools in Sundanese tribe. The researcher can reach the participants because the instrument is delivered using online assessment.

The students’ responses were analyzed using two kinds of analyses. Firstly, the students’ answers were categorized based on the students’ conception criteria that has been developed by [9,13] as can be seen in the Table 1. Secondly, the students’ responses were analyzed using scoring as mentioned in the Table 1. This score was used to find the person reliability, item reliability, validity, and difficulty level using Rasch model on WINSTEP 4.4.5 software applications.

| Level of Conception       | Symbols | Tier-1 | Tier-2 | Tier-3 | Tier-4 | Score |
|---------------------------|---------|--------|--------|--------|--------|-------|
| Sound Understanding       | SU      | Correct| Sure   | Correct| Sure   | 4     |
| Partial Positive          | PP      | Correct| Sure   | Correct| Not Sure| 3     |
|                           |         | Correct| Not Sure| Correct| Sure   |       |
|                           |         | Correct| Not Sure| Correct| Not Sure|       |
| Partial Negative          | PN      | Correct| Sure   | Incorrect| Sure  | 1     |
|                           |         | Correct| Not Sure| Incorrect| Not Sure|       |
|                           |         | Correct| Not Sure| Incorrect| Not Sure|       |
|                           |         | Incorrect| Sure   | Correct| Sure   |       |
|                           |         | Incorrect| Not Sure| Correct| Sure   |       |
|                           |         | Incorrect| Not Sure| Correct| Not Sure|       |
|                           |         | Incorrect| Sure   | Correct| Not Sure|       |
|                           |         | Incorrect| Not Sure| Correct| Not Sure|       |
|                           |         | Incorrect| Not Sure| Correct| Not Sure|       |
| Misconception             | MC      | Incorrect| Sure   | Incorrect| Sure  | 0     |
| No Understanding          | NU      | Incorrect| Not Sure| Incorrect| Sure  | 0     |
|                           |         | Incorrect| Sure   | Incorrect| Not Sure|       |
|                           |         | Incorrect| Not Sure| Incorrect| Not Sure|       |
| No Coding                 | NC      | Incomplete Answer | - |
3. Result and Discussion
The results and discussion will be presented through FODEM model, as follows:

3.1. Need Analysis
In this stage, there are four main phases that were conducted by researcher, which are: 1) conducted literature studies to decide the concepts, 2) analyzed the concept objectives based on curriculum 2013 in Indonesia, 3) decided the format of instrument, and 4) developed the instrument. Based on those phases, the Gases Theory Representation Instrument consists of 8 questions (based on the number of the objectives) which has four-tiers in each question (based on the format that has been decided). One of the questions can be seen in the Figure 1.

![Figure 1. The example question of Gases Theory Representation Instrument](image)

3.2. Implementation
In this phase, the students’ ability on Kinetic Theory of Gases has been tested using Gases Theory Representation Instrument. Due to the current circumstance in Indonesia, the researcher was unable to examine the students directly in their school, so in this research, the authors used online assessment using Google form as shown in the Figure 2. Using this online assessment, the researcher would be able to connect with the students who come from different schools in West Java.

![Figure 2.a. Identity](image)

![Figure 2.b. The question of tier-1 and tier-2](image)

![Figure 2.c. The question of tier-3 and tier-4](image)
3.3. Formative Evaluation

The students’ responses were analyzed using two comprehensive steps. Firstly, the students’ answers are categorized based on the Figure 1 and the result can be seen in the Figure 3.

![Figure 3. Students’ conception categories](image)

Based on the Figure 3, it can be seen that Sound Understanding category has dominated by the students in every item, except item number 3. On the other hand, Misconception, No Understanding and No Coding become the minority of students’ conception. Looking in detail to the figure, Sound Understanding has the highest proportion in the item number six, which is exactly 16 students, followed by item number 1 and 2, exactly 14 and 12 students respectively. However, other items on Sound Understanding mainly reach by 10 students, while there are only 8 students who are categorized as Sound Understanding in the number 4.

Interestingly, Misconception and No Coding have the least proportion compared to the other categories. There is only one student who is categorized misconception in the number 3 and number 8, while none of them are categorized as No Coding in every item. Furthermore, the proportion of students who experienced No Understanding is quite low in every question, i.e., one student in the number 4 and three students in the number five. This condition can be happened because the researcher distributed the GTRI instrument just after the students learning Kinetic Theory of Gases. Moreover, the learning process was delivered using modern learning strategies.

The learning process in not only focus on formulas but also concepts of materials. Thus, the students have a good conception, and they are ready to correctly answer all kinds of problem. This finding is supported by several researches that have been done before such as by N.J Fratiwi et al [16], and Samsudin et al [10].

Secondly, the students’ responses were analyzed using WINSTEP 4.4.5 to discover more about the quality of items. These analyses include person reliability, item reliability, Cronbach Alpha, distinction level, and validity. The values of person reliability, item reliability and Cronbach Alpha can be seen in the Table 2.

| Person Reliability | Interpretation | Item Reliability | Interpretation | Cronbach Alpha | Interpretation |
|--------------------|---------------|-----------------|---------------|---------------|---------------|
| .67                | Sufficient    | 0.68            | Sufficient    | 0.71          | Good          |

According to the Table 2, we can see that the values of both person reliability and item reliability are categorized as “sufficient”, while the value of Cronbach Alpha is interpreted as “good” category. These interpretations mean that the Gases Theory Representation Instrument is reliable and can be implemented as a tool to analyze students’ conception on Kinetic Theory of Gases.
The next step of analysis is analyzing the difficulty levels. This analysis has been carried out using WINSTEP 4.4.5 with variable (wright) maps as the output. The difficulty levels support analysts to measure the strengths and weaknesses of instruments, and document test items, compare theories with experimental data, and provide guidance to other analysts [12]. The result of analysis can be seen in the Figure 4.

Based on the Figure 4, the distribution of students can be seen on the left side, while the right side tells the distribution of questions. The majority of students can answer all questions. In addition, it can be concluded that question number 6 (S6) is the easiest question on the instrument, while question number 3 (Q3) and 7 (Q7) are the most difficult questions compared to the others. Furthermore, we can also see the quality of students’ conception. 01P (Teteh) is the student who has the highest conception, while 21P (Teteh) is the student who has the lowest level of conception. Thus, the difficulty levels of GTRI have been spread equally from easy to difficult.

Moreover, the student who has the highest ability are 01P (Teteh), followed by 09P (Teteh) in the second place, while the students who have the lowest ability are 21P (Teteh) and 25P (Teteh). These facts indicate that the instrument did not have gender bias. It means that the instrument is valid and reliable to use [13].

After analyzing the person reliability, item reliability, Cronbach alpha and difficulty level, the researcher identified the validity and distinction level of GTRI. These analyses are also used WINSTEP 4.5.5 with summary statistics as the output. The results of these analyses can be seen in the Table 3.
### Table 3. Validity and Distinction level of Gases Theory Representation Instrument

| Sub-Concepts                  | Question number | MNSQ   | ZSTD   | PT Measure All Corr. | Validity Interpretation | Distinction Level Interpretation |
|-------------------------------|-----------------|--------|--------|----------------------|--------------------------|----------------------------------|
| Boyles’law                    | 1               | .63    | -1.24  | .61                  | Valid                     | Very good                        |
| Gas lussac’s law              | 2               | .78    | -.61   | .51                  | Valid                     | Very good                        |
| Charles’s law                 | 3               | 1.89   | 2.10   | -.12                 | Valid revision            | Need a revision                  |
| Ideal gas equation            | 4               | .56    | -1.74  | .55                  | Valid                     | Very good                        |
| Ideal gas pressure            | 5               | .88    | -.25   | .35                  | Valid                     | Good                             |
| Ideal gas kinetic energy      | 6               | 1.35   | .82    | .35                  | Valid                     | Good                             |
| Ideal gas velocity            | 7               | 1.24   | 1.02   | .44                  | Valid                     | Very good                        |
| Equipartition theorem         | 8               | .68    | -1.24  | .61                  | Valid                     | Very good                        |

Based on the Table 3, it is clear that almost all of the questions are valid and can be used as the instrument to assess students’ conception, except question number 3 about Charles’s Law. This is because the score of MNSQ is more than 1.5 and the score of ZSTD is more than 2.0. As a result, this question needs to do a slight revision, because the values of MNSQ and ZSTD are not far from the standard. In line with that condition, the value of PT Measure All Corr in number 3 is out of standard which is below than 0. However, other questions have “good” and “very good” predicate.

### 4. Conclusion

In conclusion, the Gases Theory Representation Instrument (GTRI) has been developed using FODEM model and the students’ responses have been analyzed using Rasch analysis on WINSEP 4.4.5 software. Based on analyzing phase, the instrument is reliable and valid to use to assess students’ conception in Kinetic Theory of Gases material. Likewise, the difficulty and distinction level are equally distributed and have an appropriate level. These results can be utilized by teachers to assess students’ conception as well as by researchers to carry out further research related to this topic.

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