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Validity Analysis Using the Rasch Model in the Development of Alkane Concept Test Instruments

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Abstract: This study aims to test the feasibility of the test instrument as a measuring tool for student knowledge of alkane compounds in the online form of 15 multiple choice questions on the concept of characteristics, physical properties, and nomenclature of alkanes. The questions were tested on 85 students who had studied the subject of alkanes. The feasibility analysis includes the level of problem difficulty, construct validity, content validity, and reliability. The results of the analysis show that the items developed are feasible according to the Rasch model.

Keywords: Alkane; Model Rasch; Organic chemistry; Validity

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Introduction

The subject of alkanes is an important part of basic organic chemistry courses (Crucho et al., 2020). Basic organic chemistry is the beginning for chemistry students or chemistry education students to know various kinds of organic compounds, one of which is alkane group compounds. Alkane compounds are widely used in everyday life (Zhang 2017), so understanding alkane compounds is important for chemistry students and chemistry education.

The current pandemic condition demands that learning be carried out online (Adams et al., 2020; Mulyanti et al., 2021), including basic organic chemistry lectures Ramachandran and Rodriguez (2020). In addition to learning, the evaluation process is also of course carried out online. The evaluation process must be able to measure the ability of students to master the concepts taught, one of which is the subject of alkanes in organic chemistry courses Harwood, Meyer, and Towns (2020). A test instrument will be able to properly measure student abilities, if the test is declared empirically feasible Winarti and Mubarak (2019). The feasibility of an instrument test can be proven in terms of its validity with the support of empirical calculation data Raker and Towns (2012).

The Rasch model is a measurement design that has been widely implemented as an analysis of the validity of the test instrument Rahayah Ariffin (2010), as a tool for measuring the latent nature of humans, namely cognitive abilities. So far, the questions that have been developed to measure students' abilities on the subject of alkane compounds have not been compiled online, moreover, their feasibility has been comprehensively tested as a tool for measuring the achievement of alkane learning in organic chemistry courses (Samara 2016). It takes a test instrument on the subject of alkane compounds that can be implemented online, as well as valid and reliable.

Method

The research method used is descriptive quantitative (Cohen et al,. 2018). The data was obtained from the results of student answers on tests given through the media google form (Blizak et al. 2020; Putri

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and Maria 2021), as many as 15 items in the form of multiple-choice to 85 students (15 males, 70 females) who had studied organic chemistry on the subject of alkanes. The results of student answers were analyzed using the Rasch dichotomy model through the Winsteps program (Goes et al., 2020; Vindbjerg et al. 2020). The subject matter of alkanes measured in this test includes the following sub-concepts: (1) Characteristics of alkanes: question code S1, S2; (2) Alkane nomenclature: question code S3, S4, S5; (3) Physical properties of alkanes: question codes S6, S7, S8, S9, S10; (4) Alkane conformation: question code S11, S12, S13, S14, S15.

Result and Discussion

The test instrument can be used as a measuring tool in measuring student abilities. Of course, it must meet several eligibility criteria from the test instrument. The results of student answers on the developed test questions are then converted into a logarithmic form called logit (logarithm of odd units). The logit value obtained then becomes a reference for the level of difficulty of the questions (in the form of a wright map), and the pattern of chances of answering the questions is compared to the range of areas received based on the Rasch model as a reference for the values of construct validity, content, and reliability of the test instrument studied. In this study, various instrument feasibility analyzes were carried out, including the distribution of the difficulty level of the questions, the unidimensionality of the test instrument, the content validity according to the fit of the Rasch model, and the reliability of the instrument (Pancorbo et al. 2020; Syahfitri et al. 2019).

Item Validity

The probability of answering the question becomes a reference for determining the level of difficulty of the question, of course, based on the ability of the respondent who answered it (Purnami et al. 2021). The difference in logit value shows how the question can be answered by students, a large logit value such as the question with the code S8 (Logit 3.15) in Table 1. The S8 question is the most difficult question for students based on the analysis by the Rasch model and vice versa. With the S3 question with a very low logit value, it is the easiest question.

The most difficult questions that measure the concept of alkanes on the physical properties of alkane compounds here are the questions that are considered the most difficult by research subjects in Figure 1. Problem S8, measuring students' understanding of the physical properties of alkane compounds, but with a higher level of difficulty, and explore students' analytical skills to answer these questions (S8). The results of this analysis indicate that questions that look simple in measuring the physical characteristics of alkane compounds will be difficult with the form of questions that require analytical power on alkane compounds, especially on the structure of cyclic alkanes (Timofte and Popuș 2019).

Table 1. The level of difficulty of the questions based on the logit value of the test items

Tes code	Logit Item	The level of difficulty
S8	3.15	Most difficult
S7	1.45	difficult
S9	0.9	
S15	0.78	
S4	0.63	moderate
S6	0.17	
S11	0.03	
S10	-0.15	
S13	-0.25	
S5	-0.33	easy
S2	-0.61	
S14	-0.98	
S12	-1.29	
S1	-1.75	easiest
S3	-1.75	

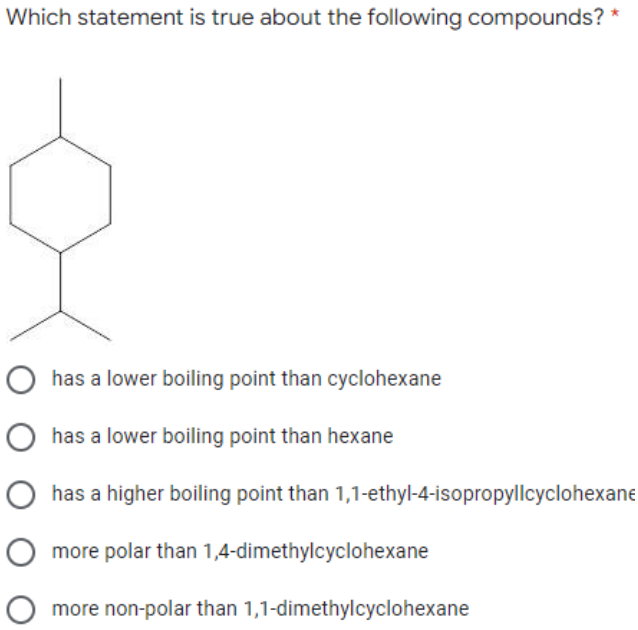

Figure 1. The most difficult questions based on student responses

S1 and S3 are the questions that are considered the easiest by students. S1 questions measure the concept of alkanes on the characteristics of alkanes in general, and S3 is a question that measures students' knowledge of alkane nomenclature. Here are the questions that are the easiest for students (Figure 2).

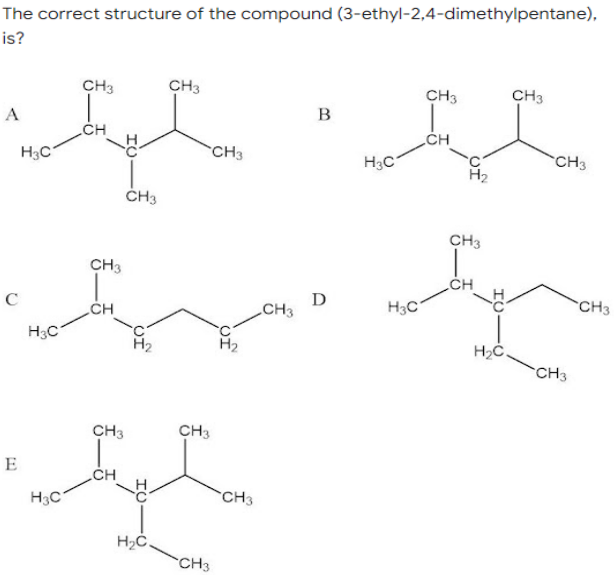

Figure 2. The easiest questions based on student responses

Figure 2 shows that the nomenclature of alkanes is considered very easy by students. Based on these findings, it can be concluded that students are very familiar with the concept of nomenclature on the subject of alkanes. Overall, the distribution of the level of difficulty of the test instruments developed in this study is illustrated in the following wright map.

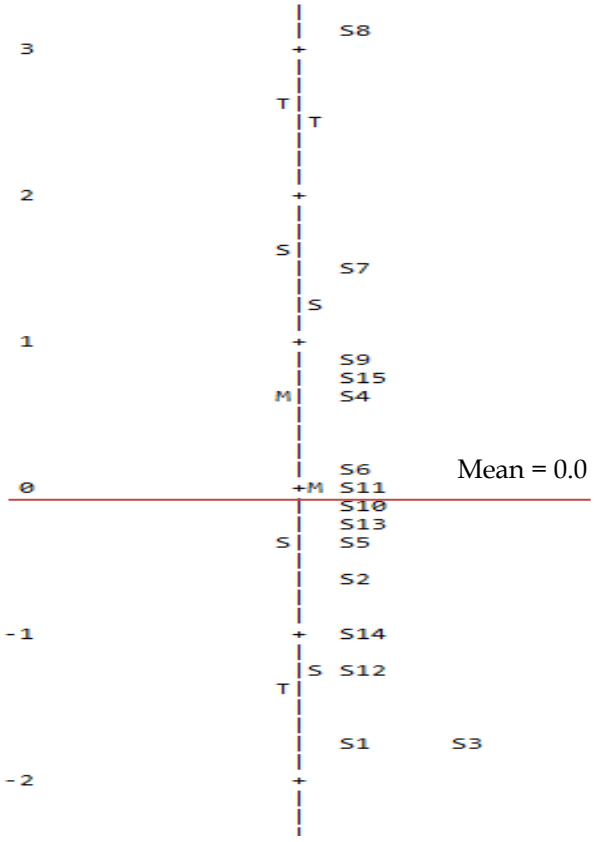

Figure 3. Map of the difficulty level of the questions from the average Rasch model

Figure 3 shows the questions are spread evenly, as many as 15 questions from the average logit value. Questions with greater difficulty than the average logit item value and questions with a lower level of difficulty include a balanced number of items. The results of this analysis show that the questions can measure students' abilities evenly at various levels. Both for students who master concepts well with a high level of difficulty and students with lower abilities with questions that are considered easy, based on the analysis of the Rasch model. The conclusion of this analysis is that each item can measure the concepts asked in the question well, based on the distribution of the difficulty level of the question from its logit value.

Construct Validity

The ability of a test instrument in measuring the expected variables can be stated as intact and comprehensively measures the ability of the students being tested if the value of uni-dimensionality includes a raw variance value of more than 20% and an unexplained variance value of <15% (Othman et al. 2014). Based on the results of the Rasch model analysis in this study, the raw variance was 31.1%, and the unexplained variance was 8.4%. The results of the analysis show that the questions can measure variables completely and unbiased, namely the concepts in the alkane subject of the organic chemistry course.

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

		-- Empirical --		Model
Total raw variance in observations	=	21.8	100.0%	100.
Raw variance explained by measures	=	6.8	31.1%	30.
Raw variance explained by persons	=	2.4	11.0%	10.
Raw Variance explained by items	=	4.4	20.0%	19.
Raw unexplained variance (total)	=	15.0	68.9% 100.0%	69.
Unexplned variance in 1st contrast	=	1.8	8.4% 12.1%	
Unexplned variance in 2nd contrast	=	1.6	7.5% 10.9%	
Unexplned variance in 3rd contrast	=	1.6	7.5% 10.8%	
Unexplned variance in 4th contrast	=	1.4	6.3% 9.2%	
Unexplned variance in 5th contrast	=	1.3	5.9% 8.6%	

Figure 4. The value of uni-dimensionality test

Content Validity

Another aspect of the empirical evidence of the validity of the test instrument in this study is how the statistical value of the results of the analysis with the Rasch model on the three fit item criteria, namely Outfit MNSQ, Outfit ZSTD, and PT Mean Corr. The ideal data, according to the Rasch model, is the most sensitive is the Outfit MNSQ value as the degree of randomness of the respondent's answer pattern on the test instrument being tested. The MNSQ Outfit value received by the model is < 1.5 (Boone 2016). If the Outfit MNSQ value is in accordance with the model, then the other criteria are considered to be in accordance with the model. In this study, it was found that the results of the analysis were based on the model criteria (Table 2), indicating that the

questions developed in this study had met the criteria of the Rasch model, it could be concluded that the questions were valid based on the content criteria or the content of the questions tested (Ariffin et al. 2010, 2010).

Table 2. Fit statistical of the test instrument

Question codes	Outfit MNSQ	Outfit ZSTD	PT Mean Corr
S9	1.42	2.9	0.24
S15	1.31	2.3	0.31
S2	1.27	1.3	0.23
S4	1.26	1.9	0.34
S12	1.04	0.2	0.35
S13	1.01	0.1	0.39
S8	0.65	-0.7	0.46
S10	0.98	-0.1	0.42
S11	0.97	-0.1	0.41
S14	0.93	-0.2	0.39
S7	0.91	-0.5	0.47
S1	0.78	-0.4	0.38
S3	0.76	-0.5	0.39
S5	0.88	-0.6	0.48
S6	0.83	-1.3	0.49

Analysis Differential Item Functioning (DIF)

In this study, the research subjects were 85 students, including 15 males and 70 females. A good test instrument, of course, does not differentiate based on gender differences. Good questions will be considered the same, both for men and women, from the aspect of the level of difficulty of the questions. In this study, the results of the DIF analysis showed that, in general there were no different levels of difficulty based on gender differences (male and female), as seen from the probability value greater than 0.05 (Figure 5) (Chan et al. 2020; Laliyo et al. 2020).

	Item	
D.F.	PROB.	Number Name
1	.5916	1 S1
1	.3839	2 S2
1	.0271	3 S3
1	.6019	4 S4
1	.3604	5 S5
1	.5438	6 S6
1	.1117	7 S7
1	.7978	8 S8
1	.5153	9 S9
1	.4396	10 S10
1	.2217	11 S11
1	.3918	12 S12
1	.2350	13 S13
1	.7731	14 S14
1	.5589	15 S15

Figure 5. The probability value of the test instrument

A probability value greater than 0.05 indicates that there is no bias on the items based on gender differences or DIF. Other supporting data for the absence of data bias based on student gender is the graph from DIF in Figure 6. Men are represented by L and women are represented by P, the graph shows that the level of difficulty of the questions is between the blue line (male) and the red line (female) did not differ significantly on each item from the 1st question to the 15th question (Boone 2016; Planinic et al. 2019).

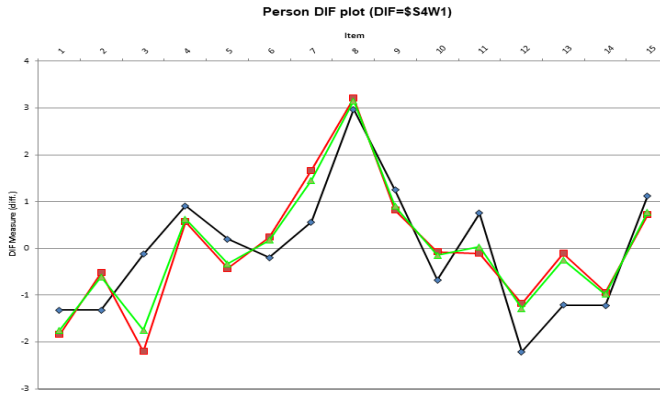

Figure 6. Differences of difficulty between men and women

Reliability

The last criterion of the feasibility of a test instrument is its consistency in measuring the ability of the subject, namely the reliability aspect. Reliability criteria include (Sumintono and Widhiarso 2015):

<0, 67 : Weak
0.67-0.80 : Fair
0.8-0.90 : Good
0.91-0, 94 : Very good
>0.94 : Excellent

Analysis by Winsteps Program in this study, the reliability of the question was 0.94 (Figure 7). This value indicates that the questions in this study are excellent in terms of consistency in measuring students' abilities. Other supporting data is the value of separation, which is greater than 3, indicating that the questions measure well the ability of students at various levels of knowledge (Ariffin et al. 2010; Zain 2017)

SUMMARY OF 15 MEASURED (NON-EXTREME) Item

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	51.5	81.6	.00	.29	.98	.0	1.00	.3
S.D.	17.0	2.4	1.24	.05	.10	.9	.22	1.2
MAX.	75.0	85.0	3.15	.38	1.20	2.0	1.42	2.9
MIN.	10.0	79.0	-1.75	.24	.87	-1.3	.65	-1.3

REAL RMSE .30 TRUE SD 1.21 SEPARATION 4.09 Item RELIABILITY .94
MODEL RMSE .29 TRUE SD 1.21 SEPARATION 4.15 Item RELIABILITY .95
S.E. OF Item MEAN = .33

Figure 7. Instrument reliability

Conclusion

This study aims to test the feasibility of the test instrument as a measuring tool for student knowledge on alkane compounds in the online form—15 multiple choice questions on the concept of characteristics, physical properties, and nomenclature of alkanes. The questions were tested on 85 students who had studied the subject of alkanes. The feasibility analysis includes the level of problem difficulty, construct validity, content validity, and reliability. The results of the analysis show that the items developed are feasible according to the Rasch model.

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