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Testing the Validity and Reliability of Conceptual Chemistry Learning Instruments during the COVID-19 Pandemic Using Rasch Modeling

Alusti Cundo Manik[1]*, Hari Sutrisno[2], Ifan Rivaldo[1]

[1] Master of Chemistry Education, Yogyakarta State University, Jalan Colombo No. 1 Karang Malang, Sleman, Yogyakarta, Indonesia.
[2] Chemistry Education, Yogyakarta State University, Jalan Colombo No. 1 Karang Malang, Sleman, Yogyakarta, Indonesia.

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Abstract: This study aims to determine the validity and reliability of students' conception of chemistry learning instruments during the Covid-19 pandemic using Rasch modeling. The developed instrument consists of 24 items tested on 150 students from 3 selected schools classes X, XI, and XII MIPA State Senior High School in Tuban Regency for the 2021/2022 academic year. Two experts tested the content validity of the instrument while the construct validity and item reliability used the Rasch model with Winsteps Rasch software version 3.73. The analysis of the Rasch model used is in the form of item and person separation and reliability, correlation and point measure, Item fit, item rating scale functionality and unidimensionality. The results obtained indicate that the conceptual instrument for chemistry learning that has been developed is valid and reliable. However, the COLS4, COLS6, and COLS11 items are invalid and should be revised or removed.

Keywords: Conception of Chemistry Learning; Rasch models; Instrument reliability validity

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Introduction

The Covid-19 virus pandemic has prompted rapid structural changes. There is a change in learning strategies that were originally face-to-face to non-face-to-face learning called online learning (Anugrahana, 2020). Online learning makes students not constrained by place and time to take lessons from their respective homes or from anywhere (Sadikin & Hamidah, 2020). However, Meidawati (2019)stated that online learning can reduce students' motivation and interest in learning. This is because students feel bored because they do not meet their friends and teachers directly (Yunitasari & Hanifah, 2020).

The current problem is the decline in students' motivation and interest in learning can affect their conception of learning. Where the conception of chemistry learning has a very big influence on the learning process of students (Hofer and Pintrich, 1997; Schommer, 1998; Sinatra, 2001). This is because chemistry has concepts that are related to each other (Üce & Ceyhan, 2019) so it has a high level of difficulty, which makes it difficult for students to understand (Shadreck, 2017). The difficulty of students in understanding chemistry is marked by the inability of students to understand chemical concepts correctly (Beerenwinkel et al., 2011; Bradley & Mosimege, 1998; Garnett et al., 1995; Herman, 1992; Johnstone, 2000; Kizilaslan, 2013; Nakhleh, 1992; Renner et al., 1990; Rogers et al., 2000). whereas gain a deeper understanding of chemistry, students must move

* Corresponding Author: alusticundo.2020@student.uny.ac.id

forward to explore their conceptions of learning (Tsai, 2006).

The conception of learning refers to beliefs or the interpretation of the learning and learning experiences of students in schools (Li et al., 2013; Tsai, 2004). Marton and Booth (1997) state that the conception of learning is reflected in the way students see learning, namely how they learn, and what they think. According to Fan and Bokhove (2014) that the concept of learning is different from Bloom's taxonomy which is seen from the point of view of student learning activities. So, Perez-Tello et al., (2005) define the conception of learning as a mental model formed by beliefs, academic emotions and the learning process of students themselves.

Based on Suyono's research (2020) on the conception of chemistry learning, it shows that the conceptions of most high school students tend to be unstructured or in pieces and not in accordance with the concepts being taught. This is because the conception of chemistry learning in high school is at a lower level and is focused on memorizing or simply practicing what the teacher teaches or reading in textbooks. While the conception of high-level chemistry learning is the application of what students have learned about their ability to see information in new ways (Zheng et al., 2018).

The conception of learning is very important for students because it can affect learning motivation (Negovan et al.,2015) and learning strategies (Dart et al., 2000; Vermunt & Vermetten, 2004) so tt can affect the quality of learning and academic achievement (Cano, 2005). Vermunt (1998, 2005) shows that students with a constructive conception of learning, namely learning as understanding, will be more skilled in planning deep-oriented learning strategies and are more likely to have an active role in the learning process, than students who are surface-oriented, which is only memorizing (Peterson et al., 2010).

Saljo (1979) identified five categories of learning conceptions consisting: (1) increasing knowledge, (2) memorizing, (3) acquiring facts or principles, (4) abstracting meaning, and (5) interpreting processes aimed at understanding reality. While Marton et al., (1993) there are 6 categories in1) increasing knowledge, (2) memorizing and producing, (3) applying, (4) creating abstract meaning, (5) developing interactive processes, and (6) learning as a personal change. Then Wong et al., (2019) divides itdividehree indicators, namely: (1) memorizing, (2) calculating and practicing and (3) understanding knowledge and seeing phenomena in new ways.

Besides that, Tsai (2004) and a number of studies (Tsai et al., 2011; Lin et al., 2012) also suggest that the conception of learning can be viewed as having a hierarchical order, from lower to higher levels. So, in this study, the conception of chemistry learning is divided into 2 aspects, namely low and high. Where the low learning conception aspects consist of: (1) memorizing, (2) testing, and (3) counting and practicing. As for the aspect of the conception of higher learning consists of (4) increasing knowledge, (5) applying, and (6) connecting knowledge.

The students' conception of chemistry learning instruments used in this study were then tested for validity and reliability using the Rasch model. Rasch model is a technique to determine item difficulty level and individual ability level(Tabatabaee et al., 2018). Where, the Rasch model can identify students who have higher learning conception abilities and can answer difficult items (İlhan & Güler, 2017). In addition, it can also identify possible items that are easily answered correctly by students (İlhan & Güler, 2017). Thus, in this study the Rasch model, can be used to see the probability of students' abilities in determining their conception of chemistry learning during the Covid-19 pandemic.

Method

This study uses a quantitative research design to measure the validity and reliability of the chemistry learning conception questionnaire for high school students. The questionnaire consists of 24 items which were developed by the researcher according to the theory that underlies the research and the available literature (Saljo, 1979; Marton et al., 1993; Wong et al., 2019). Because the instrument was modified by the researcher himself, so the error factor is very likely to occur (Periantalo, 2015). Therefore, a suitable data collection technique for psychological evaluation is a questionnaire/questionnaire.Items consist of 6 sub-aspects consisting of 3 aspects of low learning conception consisting of: (1) memorizing, (2) testing, and (3) counting and practicing; and 3 aspects of the conception of higher learning consist of: (4) increasing knowledge, (5) applying, and (6) connecting knowledge. To assess student responses, a 5-point Likert scale was used (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree).

Two experts tested the content validity for the science of conception of chemistry learning, while the construct validity and item reliability were analyzed using the Rasch model using Winsteps Rasch software version 3.73 (Linacre, 2011). A test is said to be valid when the data fits the model, which indicates the existence of a variance construct between the items and the theory response (Rosli et al., 2020). Word changes for each item are made to ensure students understand the content when answering.

The revised and validated questionnaire was then distributed to 150 students from 3 selected schools to be tested. The selected students consist of: classes X, XI and XII MIPA State Senior High School in Tuban Regency for the 2021/2022 academic year. Only students in the Mathematics and Natural Sciences major act as samples. This is because one of the research objectives is to find out the conception of chemistry learning that is specifically for students in the Mathematics and Natural Sciences department. At the time of data collection, students were informed that participation was voluntary and did not affect their grades. About 80% of data retrieval is done in a paper-based format and 20% is web-based via google form, because generally the response rate of web-based learners is only 30% (Tabatabaee et al., 2018).

Results and Discussion

The validity and reliability of the instrument were analyzed based on the reliability of items and persons,

Item and Person Separation and Reliability

Item and person reliability are a very useful measure in the Rasch model. Where the separation index can show the level of difficulty of item and person items. Index separation can separate item items from person specifically, so that they can separate them into different groups (Bond & Fox, 2015). Based on Fox & Jones (1998) for a good separation index value is greater than 2. The results of the research item and person separation index data can be seen in Table 1.

Table 1. Separation and Reliability of Items and Persons

Criteria	Person	Items
Separation	1.39	3.03
Reliability	0.66	0.90

Based on Table 1, it can be seen that the separation values for each person and item are 1.39 and 3.03. The value of person separation (1.39) is low which indicates that the respondents are less diverse so that the items are less sensitive in distinguishing the abilities of each respondent (Rosli et al., 2020). Meanwhile, the value of item separation (3.03) is quite good, so that the respondents are varied enough to be able to detect the items being developed.

To find out the item difficulty level map and the overall respondent ability map can be seen in Figure 1. Based on Figure 1, it can be shown that the item item number COLS4 is the item that has the highest level of difficulty or is difficult to be approved by the respondent. However, the COLS4 item items have not been able to measure respondents with a level of ability above it (2 respondents) causing the value of person separation to be low and item separation classified as good, therefore the COLS4 item item is not appropriate to measure students who have a very high conception of learning. In addition, the items COLS10 and COLS20 are classified as items with the lowest level of difficulty. Where, the difficulty level limit (according to the student's minimum ability) is in items COLS18, COLS24, COLS7. All items are considered good because they are still within the standard deviation limit (between two T symbols) (Rosli et al., 2020).

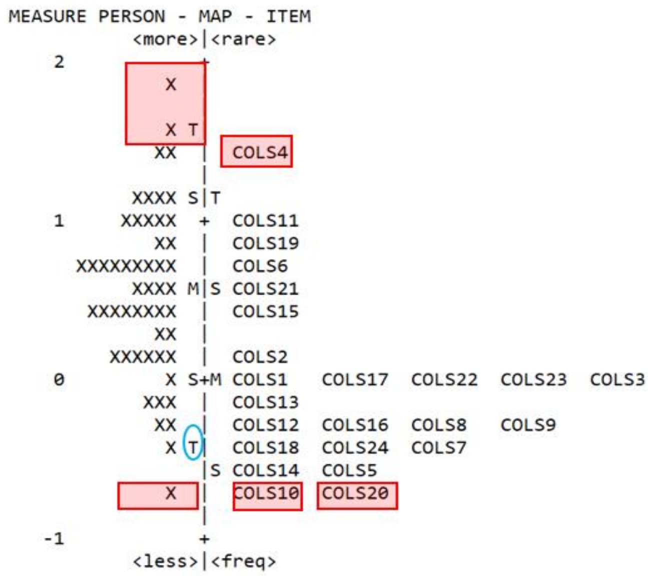

Figure 1. Overall Item Parameter

While the reliability values of the person and the research instrument items are 0.66 and 0.90, respectively (see Table 1). Based on Fox & Jones (1998) for a good and acceptable reliability value is > 0.80. The value of item reliability is classified as very good (0.90) where the item shows in terms of size and level of difficulty very well in assessing the ability of respondents. However, the value of person reliability is classified as less reliable (0.66), this indicates that the instrument developed is not able to distinguish between respondents who have high and low conceptions of chemistry learning. This low value can be caused by variations in the ability of respondents, length of instrument, several categories per item and targeting of sample items (Linacre, 2018).

Item Fit based on Correlation and Point Measure

Item fit based on correlation and point measure is used to analyze the extent to which items are suitable for measuring students' conceptions of chemistry learning. When there is an item that is not appropriate, it must be repaired or replaced which indicates that the respondent has difficulty in understanding the item (Wilmskoetter et al., 2019). According to Bond & Fox, (2015) to determine whether an item is fit or not, it can be observed using the Point Measure Correlation (PTMEA CORR) index value.

An item is categorized as very good if it has a PTMEA CORR index value of more than 0.4, a good category with a value between 0.3 – 0.39 and a moderate category for a value between 0.20 – 0.29 (Rosli et al., 2020). Meanwhile, for items with a value between 0 – 0.19 stated that the questionnaire failed to distinguish items. Bond & Fox, (2015) added that in survey research, for items that have a value less than or equal to 0, the researcher must re-evaluate the items.

Table 2 presents the results of the chemistry learning conception instrument based on the index value from the PTMEA CORR which states that the items COLS21, COLS12 and COLS24 are in the good category with values between 0.3 – 0.39. While the items COLS4, COLS11, COLS6, COLS19 and COLS22 are in the poor category with a value of < 0.19. So, based on Bond & Fox, (2015) these items must be evaluated or revised. Items that have a poor category are items with negative statements, this can trigger a lack of accuracy of respondents in answering the item statement of the instrument. In addition to the items mentioned above, the other items are included in the very good category with an index value of PTMEA CORR > 0.4.

Item is said to be FIT or not

Items said to be fit or not in measuring the construct of the chemistry learning conception instrument can be observed through the infit and outfit mean square (MNSQ) values. An item is said to be fit if it has an MNSQ outfit value of 0.5 < MNSQ < 1.5, if the item has an MNSQ value exceeding 1.5 then the item is not appropriate in measuring the instrument construct and if the MNSQ value is less than 0.5 then the item is easily predicted by the respondent (Bond & Fox, 2015). In addition to the index value of the MNSQ, the standard Z index value (Z-STD) is also important in determining the fit or not of an item, with a value of -0.2<Z-STD<+0.2 (Bond & Fox, 2015). According to Linacre, (2011) if the MNSQ value is accepted then the Z-STD value may be ignored, but if the MNSQ value has not been met.

Table 2 presents the results of MNSQ infit values from 0.63 – 1.78 and MNSQ outfit values around 0.57 – 2.31. There are 2 items that are not appropriate, namely exceeding the MNSQ standard value contained in the COLS4 (2.31) and COLS11 (2.06) items. While the results of the Z-STD instrument values that do not match or exceed the standard Z-STD values are found in COLS4 (4.24), COLS11 (4.59) and COLS6 (2.14) items. Based on the MNSQ and Z-STD values, the three items were out of reach, so the researcher decided to improve the three items (COLS4, COLS6 and COLS11). The refinement of item items is done by improving the language and scientific terms used.

Table 2. Research Instrument Statistics Items

Items	Infit		Outfit		PT MEA
	MNSQ	ZSTD	MNSQ	ZSTD	CORR
4	1.78	3.34	2.31	4.24	-.36
11	1.72	3.97	2.06	4.59	-.11
6	1.25	1.67	1.40	2.14	.26
19	1.24	1.61	1.26	1.48	.23
21	1.20	1.31	1.26	1.37	.33
22	1.05	.30	1.21	.84	.15
12	1.12	.52	1.17	.65	.38
15	1.07	.51	1.02	.17	.44
16	1.04	.24	1.06	.30	.58
18	.99	.05	1.04	.22	.50
8	1.02	.16	1.02	.17	.61
23	1.02	.16	.94	-.15	.46
9	.96	-.07	.91	-.21	.66
10	.90	-.22	.83	-.45	.47
20	.73	-.86	.85	-.38	.48
7	.83	-.53	.69	-1.00	.60
3	.78	-1.14	.82	-.66	.47
2	.79	-1.16	.81	-.76	.47
17	.80	-1.00	.79	-.82	.47
13	.79	-1.00	.66	-1.34	.50
1	.71	-1.58	.71	-1.20	.69
24	.70	-1.14	.66	-1.15	.35
5	.69	-1.07	.62	-1.27	.63
14	.63	-1.33	.57	-1.48	.69

Item Item Rating Scale Functionality

The rating scale on the items is used to see whether the choice/category scale (strongly disagree, agree, neutral, disagree and strongly disagree) can function properly or not (Rosli et al., 2020). The rating scale on the item items can be observed through the category measure value which is the average respondent's results in choosing that category. The category measure value increases along with the category value (Linacre, 2018). If the category measure value is irregular, it indicates that the category is not clearly defined by the respondent (Tabatabaee-Yazdi et al., 2018). This means that respondents cannot clearly distinguish the choice of categories.

The results of the functioning of the rating scale items of the learning conception instrument items can be seen in Table 3. Where, the category/scale of choice was selected proportionally by the respondents as evidenced by the lowest observed count value of 3%. Meanwhile, the category measure value increased consistently from -3.43; -1.15; -0.15; 1.02 and 3.81. There is no inverse value (up and down) which indicates that the respondent is not confused. Thus, respondents with an ability of -3.43 will tend to choose category 1 (strongly disagree), as well as respondents who have an ability of -1.15 will tend to choose category 2 (disagree) and so on.

Table 3. Rating Scale on Category Scale

Category	Count	MNSQ Infit	MNSQ Outfits	Category Measure
1 strongly disagree	37 (3%)	1.52	1.42	-3.43
2 disagree	273 (22%)	0.90	0.82	-1.15
3 neutral	102 (14%)	0.33	0.23	-0.15
4 agree	702 (50%)	1.13	1.28	1.02
5 strongly agree	136 (11%)	0.94	1.09	3.81

To represent*rating scale*on a categorical scale, you can use a probability curve for each category of respondents (see Figure 2). Where on the curve each category consists of peaks (the plot should look like a hill range), which indicates that each category has a characteristic in the part being measured (Tabatabaee-Yazdi et al., 2018).

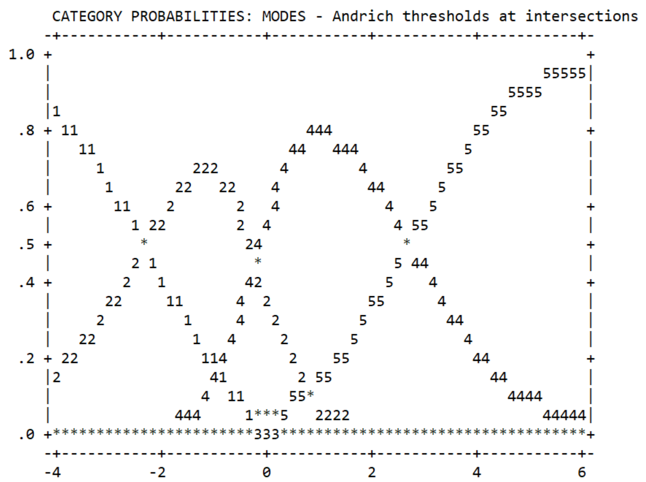

Figure 2. Category Probability Curve

Figure 2 illustrates that all categories consist of peaks on the curve that indicate the range of hills, so that each category represents one unit of the construct being measured.

Unidimensional

Unidimensional is used to determine the single size of an instrument based on principal component analysis (PCA) (Tabatabaee-Yazdi et al., 2018). The smaller the value of a residual, the more suitable the data will be with the Rasch model used. Linacre, (2018) also adds that the data will fit the Rasch model if the latent variable (learning conception) used describes all data information and the residual value characterizes a data noise. Therefore, the main factor used in determining the degree of unidimensionality or the overall suitability of the Rasch model data is the size of the eigenvalues. Boone et al., (2014) also stated that if the variance value is above 20.00%, then the data is multidimensional, this is due to the presence of secondary residuals that affect the scale of unidimensional data. As for the first variance value, it should not exceed 15.00% (Fisher, 2007).

Table 4 shows that the Rasch model proposed on the 24 items of the chemistry learning conception instrument has a variance of 31.90%; 22.30% for explain-by-item variance; 9.70% for the explain-by-person variance and the value for the total unexplained variance is 68.10%. As for the first unexplained variance of 12.80%, this does not exceed 15.00% as well as the second, third, and fifth unexplained variances. So, it shows that the concept of chemistry learning instrument developed is unidimensional, which means that there is no other variance outside the construct, so it can be used to measure what you want to measure.

Table 4. Output Dimensionality

	Eigen Value	%	Variance Unexplained (%)	Modeled (%)
Total raw variance in observations	35.27	100		100
Raw variance explained by measures	11.27	31.9		34.5
Raw variance explained by persons	3.41	9.7		10.5
Raw variance explained by items	7.85	22.3		24.1
Raw explained variance (total)	24.0	68.1	100	65.5
Unexplained variance in 1st contrast	4.53	12.8	18.9	
Unexplained variance in 2st contrast	2.90	8.2	12.1	
Unexplained variance in 3st contrast	2.51	7.1	10.5	
Unexplained variance in 4st contrast	2.21	6.3	9.2	
Unexplained variance in 5st contrast	1.66	4.7	6.9	

Conclusion

Based on the results of the analysis and discussion, it can be concluded that the chemistry learning conception instrument that has been developed is declared valid and reliable. Both from the content validity carried out by 2 experts. As well as the validity and reliability of the construct based on the Rasch model which shows that the items developed are in accordance with what is being measured. However, there are some invalid items such as COLS4, COLS6 and COLS11 that should be revised or removed. Thus, future research is expected to develop more items with item statements that are more clearly understood by respondents, especially for negative statements.

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