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# CURIOSITY TOWARDS STEM EDUCATION: A QUESTIONNAIRE FOR PRIMARY SCHOOL STUDENTS

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## Introduction

The 21<sup>st</sup> century job market demands for individuals to possess a comprehensive knowledge and competitive working edge in the field of Science, Technology, Engineering and Mathematics (STEM). In most countries, STEM education is introduced in the national curriculum for its ability to act as a medium which prepares students that are innovative and creative thinkers, and this gives birth to an inventive society.

This significance of preparing students that think critically and are capable of creating new ideas is realized in the Malaysian primary school science curriculum - its main objective is to stir students' curiosity and expand their interest in the world around them (Curriculum Development Centre, 2014). At a basic level, curiosity is a positive emotional experience (Silvia, 2006). Curiosity makes learning meaningful and helps to achieve objectives found in science education (Ball, 2013).

According to Katz (2010), curiosity should be inculcated at the primary school level via a medium that propels a student's knowledge and designing skill - that is STEM education. Early exposure to STEM ensures that (a) a learning frame is instilled in a child's development; (b) student's critical thinking and reasoning skills are encouraged; (c) children's interest in learning and careers related to STEM are cultivated; (d) curiosity is expanded; and (e) children are exposed to experiences that are linked to the world around them (Bybee, 2013; Hoachlander & Yanofsky, 2011; Katz, 2010; National Research Council, 2011).

The Malaysian Ministry of Education (MOE) has taken pragmatic measures to ensure that the curiosity skill is prioritized in the curriculum. Curiosity is a Scientific Attitudes and Noble Values in the science curriculum which students strive for in 21<sup>st</sup> century learning (Curriculum Development Centre, 2014). This characteristic's significance is so apparent that it is regarded as the main objective in the drafting of the primary school science curriculum. Students that possess curiosity will interrogate new ideas and information, come up with inquiries, become independent learners and enjoy the learning experience (Kashdan et al., 2004).

Although curiosity has an important impact on students' learning, motivation, and creativity (Gurning & Siregar, 2017; Shenaar-Golan & Gutman, 2013; Shin et al., 2019), research about curiosity among students has not been thor-



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**Abstract.** *There are limited research studies about the development of questionnaire to assess the level of primary school students' curiosity towards STEM education. In this research, curiosity towards STEM Education Questionnaire (CQ-STEM) instrument was developed based on Berlyne's Theory of Curiosity. CQ-STEM consisted of 10 items measuring the two constructs of curiosity towards STEM, namely exploration and acceptance. A total of 166 fifth graders aged 10 to 11 years enrolled in five urban schools in Sabah, Malaysia made up the research sample. Rasch Measurement Model was applied to determine the validity and reliability of CQ-STEM. The validity of the CQ-STEM instrument was well established among the constructs of exploration and acceptance through the person fit, item fit, item polarity, unidimensionality, and variable map. The CQ-STEM instrument was found to have a high reliability with a Cronbach's alpha value (KR-20) of .93. CQ-STEM has an excellent item reliability and moderate high item separation value of .96 and 4.83 respectively. In conclusion, CQ-STEM has good validity and high reliability in measuring curiosity towards STEM Education among primary school students.*

**Keywords:** *curiosity towards STEM Education, primary school students, Rasch Measurement Model, validity and reliability, questionnaire development*

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ough (Shin et al., 2019). Research by Abdullah and Osman (2010) has proven that Malaysian primary school students' level of curiosity is still low if compared to its neighboring country, Brunei. The implication is worrying - based on the 2018 PISA Report of Achievement, the average literary score for science literacy among Malaysian students is 438, a little higher than Brunei (431) (Avvisati et al., 2018; Schleicher, 2019).

Shin et al. (2019) have suggested the continuous development of specific instruments due to the reason that the previous ones only measured curiosity in a general way. There is no specific instrument that measures students' curiosity towards STEM education. Thus, such an instrument was constructed, and this research was carried out to gather empirical evidence about the validity and reliability of the Curiosity towards STEM Education Questionnaire (CQ-STEM) using the Rasch Model of Measurement (RMM).

## Literature Review

### *Curiosity towards STEM Education*

One of the factors that influences a student's transformation into an active individual is their curiosity trait. In literal terms, curiosity refers to an individual's character that likes to search, explore, and gain knowledge. Raharja et al. (2018) defined curiosity as the desire to fill one's mind with new knowledge without any expectation of appreciation or extrinsic factors. This trait forms when conflict or uncertainty occurs (Reio Jr. & Petrosko, 2013) and acts as a motivation which encourages exploration (Berlyne, 1960; Day, 1968; Loewenstein, 1994). In the context of this research, curiosity is defined as a positive motivational-emotional system which encourages students to actively explore and receive information more effectively (Kashdan et al., 2004, 2009).

Without curiosity, knowledge-process activities, exploration, and innovation do not take place (Kashdan & Silvia, 2008). This concept clearly explains the connection between curiosity and innovation that can be created through STEM. Curiosity encourages students to learn technical skills and design that is emphasized in STEM education (Committee on STEM Education, 2018; Jin & Bierma, 2013; Kennedy & Odell, 2014; McDonald, 2016; Zollman, 2012) as well as innovative inventions which combines the four STEM fields (Bybee, 2010; Foster et al., 2010).

Curiosity drives the learning process in a lifetime (Reio Jr & Petrosko, 2006). In the context of this research, curiosity acts as the desire to motivate an individual to gain new knowledge and experience in exploring STEM. This view is supported by Kashdan et al. (2009) that stated the measurement of curiosity is based on two aspects that is, the aspect of exploration and acceptance. The aspect of exploration refers to searching for new information and experiences whereas the construct of acceptance is an individual's readiness in accepting originality, uncertainty, or unpredictability in everyday life.

Various studies on curiosity and its significance in the context of the teaching and learning process of STEM education show that curiosity motivates students to explore opportunities and challenges and stimulates their participation in STEM learning (Garrosa et al., 2017). Imperatively, curiosity is a significant characteristic, and it makes one have the ability to solve a STEM issue (Damanik & Bukit, 2013). Curiosity also trains students' minds to be more active, become an active observant, open new worlds and attracts the students' attention to learn (Baumgarten, 2001). This is in lieu of STEM education where students possess a high level of curiosity to explore the four STEM fields comprehensively.

In fact, there is a significant need for instilling curiosity towards STEM among students. Tsupros et al. (2009) proved that curiosity could expand students' STEM literacy and use it to face daily obstacles which are related to STEM (Bybee, 2013). Furthermore, curiosity encourages students to search for knowledge independently and explore experiences which prepares for the students, a comprehensive medium for studying (Tseng et al., 2013). Additionally, curious students show the tendency to be interested in science and exploring new and comprehensive STEM knowledge and skills (McDonald, 2016).

The Malaysian Report on the Development of Education 2013-2025 focuses on the implementation of STEM as a basis for preparing STEM graduates that are trained to fulfill the demands of the job market which is the drive for Malaysia's economy. To achieve this, emphasis on developing curiosity towards STEM among students should be implemented explicitly starting from the primary level in order to give birth to STEM skilled individuals who are capable in solving universal issues, make decisions and who are inventive for the benefit of the future community. These clearly provide evidence for two matters: that a need exists to study primary school students' curiosity towards STEM and the need for an instrument that can measure curiosity among primary school students.



*Outline of the Theory of Human Curiosity*

The Theory of Human Curiosity, founded by Berlyne, was the outcome of a neurological research that studied the impact of curiosity on the actions and behavior of humans. Berlyne (1960) stated that curiosity is one of the motivational components that influences the improvement of opportunities in an individual. In Berlyne's Theory of Human Curiosity (1954, 1960, 1967, 1970), there are three concepts about curiosity which are: stimulant that acts as a catalyst for curiosity, the four dimensions of curiosity and two types of tendency for exploration.

The first idea proposed by Berlyne was that curiosity within one's self will motivate one to become proactive and show behaviors that are motivated by one's inner drive. This inner drive are actions such as reform, uncertainty, and conflict. The feeling of uncertainty appears when an individual is experiencing something new, surprising, or complex. This situation causes a high elevation of stimulation in human central nervous system. Thus, a human's respond when facing uncertainty is what is called as curiosity. Curiosity motivates human beings to construct behavior that can decrease levels of uncertainty (Gagne, 1985).

Apart from this, Berlyn's Theory of Human Curiosity proposes four dimensions of curiosity, which are:

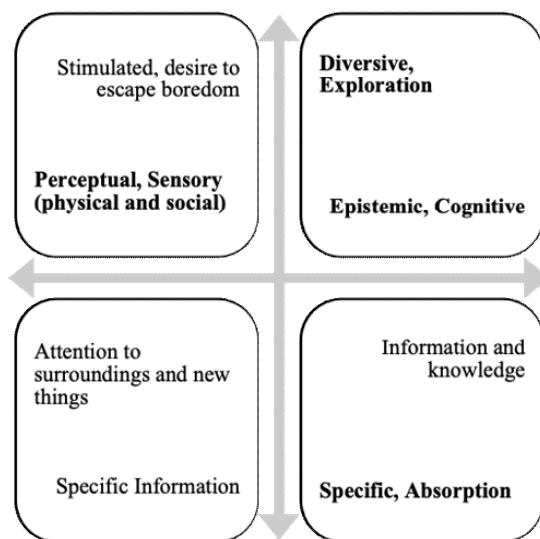
- (i) Epistemic-Cognitive – the desire to gain information and knowledge,
- (ii) Perceptual-Sensory – how a person gives attention to new things in their environment,
- (iii) Specific-Absorption – the desire to gain specific observations, and
- (iv) Diverse-Exploration – curiosity which motivates someone to look for stimulation to get out of boredom.

According to Rowson et al. (2012), a person who possesses the curiosity trait is most likely motivated by any combinations of the dimensions above. Figure 1 shows a dimensional map based on Berlyne's Theory of Human Curiosity. In the Perceptual-Sensory dimension, curiosity is associated with the search for information and is influenced by their surroundings. The combined Perceptual-Diverse dimension is influenced by several environment conditions that can make a person become motivated to search and explore without purpose. The Perceptual-Specific combination drives a person to seek for a specific experience in order to feel it. This type of curiosity is directed towards feelings of sense such as sight, hearing, texture, and also towards questions that are stimulated by their surroundings.

The Epistemic-Cognitive dimension is the desire to retrieve information or new knowledge. This dimension is more related to the cognitive (thinking) compared to experience. Next, the Cognitive-Diverse dimension is the type of desire which seeks to find information or knowledge, yet is focused on answering specific questions, such as solving an issue or doing an academic research.

Rowson et al. (2012) expounded the four dimensions - they are exclusive; that is, a person might own all four dimensions of the curiosity trait at one time depending on emotional and environmental factors. In tandem, it is not impossible for an individual to have a greater tendency towards one of the dimensions.

**Figure 1**  
 Dimensions in Berlyne's Theory of Human Curiosity



In relation, Berlyne (1960, 1967, 1970) also introduced two types of tendency of exploration that could influence behavior. They are, (a) the descend tendency - active in searching for various sources that are new and challenging, and (b) the focused tendency - active in searching for information thoroughly via a person's knowledge and experience. Both components are interrelated where the descend tendency aids in raising stimulants and new opportunities and the focused tendency supports increase of knowledge. The Curiosity and Exploration Inventory (Kashdan et al., 2009) which consists of two constructs, namely, exploration and acceptance, were created based on Berlyne's theory. The descend tendency encourages students to look out for various, new, and challenging sources which is in line with the exploration construct emphasized by Kashdan et al. (2009). In comparison, the focused tendency inspires students to search for information themselves whether through knowledge or experience. This complements the acceptance construct in the Curiosity and Exploration Inventory by Kashdan et al. (2009). In this research, the Curiosity towards STEM Education Questionnaire instrument was adapted from the Curiosity and Exploration Inventory (Kashdan et al., 2009). By appreciating Berlyne's Theory of Curiosity, the curiosity trait within students will give them the motivation to explore, accept information and be open to questions related to STEM in their daily life.

#### *The Rasch Model of Measurement*

The Rasch Model of Measurement is an effective solution to preparing instruments with high validity and reliability because it creates an in-depth statistical analysis (Bond & Fox, 2015). The Rasch Model analyses the capability of each respondent to answer the instrument and measures the difficulty of each item in the instrument (Wolins et al., 1982). Additionally, it can measure latent traits, for instance, thinking and human emotions (Aziz et al., 2015).

This model was created based on the Item Response Theory and is one of the statistics models that is adequate enough as it can measure the difficulty of an item and a person's capability at the same time (Deane et al., 2016). Consequently, the Rasch Model of Measurement can identify the validity and reliability of items and respondents. Moreover, the analysis from this model can be used to examine the validity of construct from an aspect of item polarity, item fit, person fit, and unidimensionality.

Although the Rasch analysis requires a longer time if compared to more traditional analysis types, it can provide a deeper understanding about an instruments' strengths and weaknesses (Boone & Scantlebury, 2005). Bond and Fox (2007) argued that the Rasch Model of Measurement is an effective solution in constructing instruments that are extremely valid and reliable though statistical analysis. Based on these strengths, the researchers have used the Rasch analysis to analyze the validity and reliability of the Curiosity towards STEM Education Questionnaire (CQ-STEM) instrument.

#### *Research Purpose and Research Questions*

In order to determine the suitability of the CQ-STEM instrument, the reliability and validity of the instrument needs to be evaluated. Thus, the purpose of this research was to evaluate the reliability and validity of the CQ-STEM instrument using Rasch Measurement Model.

Specifically, the research questions which were answered in this research are:

1. What is the validity value of the CQ-STEM instrument from the aspect of person fit, item fit, item polarity, unidimensionality as well as the benchmark for the item and person difficulty?
2. What is the reliability value of the CQ-STEM instrument from the aspect of Cronbach's alpha (KR-20) value as well as the reliability and separation indices for the item and person?

### **Research Methodology**

#### *Research Design and Sample*

A survey research design was used to obtain information regarding students' curiosity towards STEM education. Prior to administering the CQ-STEM instrument, the students were introduced explicitly to STEM through an intervention. The intervention consisted of six STEM lessons of 2 hours each, was conducted within 12 weeks. The STEM lessons encouraged students to solve ill-defined problems utilizing the STEM knowledge and engineering design process to design, build, and test their creations.



A total of 166 fifth graders were randomly selected as research sample from five primary schools in the district of Tawau, Sabah, Malaysia. According to Linacre (2002), a minimum sample size of 10 respondents is necessary in Rasch analysis for each item in the instrument to create accurate and consistent data at a 95% confidence. The CQ-STEM instrument contains 10 items and thus it requires at least 100 samples. Therefore, a sample size of 166 fifth graders is considered to be large enough to provide 95% confidence in the analysis. All selected students had a similar background where the selected schools were grouped in urban school clusters. The sample consisted of 87 girls (52.4%) and 79 boys (47.6%) aged between 10 to 11 years. Approximately 60% of student parents were government employees, while 40% were working in the private and business sectors.

#### *Ethical Considerations*

Permission to do the research was obtained from the primary school principals, teachers, and students. At the beginning of the research, all participants were given a letter of consent to ask for their parents' permission to participate in the research. The consent letter detailed the students' involvement in the research and the parents' consent indicating their understanding of the purpose of the research. All the participants were assured of the confidentiality of their response and of complete anonymity. All participants were informed that anyone could withdraw from the research without penalty and briefed on the purpose of the procedure for answering the CQ-STEM questionnaire. They were then allotted 15 minutes to respond to the CQ-STEM instrument.

#### *Instrumentation*

The questionnaire instrument in this research was adapted from the Curiosity and Exploration Inventory (CEI-II) (Kashdan et al., 2009). The CEI-II instrument measures the curiosity of an individual in general. Therefore, to adjust the instrument within the context of this research, adaptations were made towards statement items where the statements were modified in order to suit the context of STEM Education. The CQ-STEM instrument was developed from two constructs namely exploration and acceptance. As many as five items which consisted of items 1, 3, 5, 7 and 9 represented the exploration construct while five more items which consisted of items 2, 4, 6, 8 and 10 represented the acceptance construct. The instrument contained 10 items in the form of a 5-point Likert scale. The statements for each item are stated in Table 1.

Each of the items in the original instrument were adapted and translated into the Malay language through the process of double-back translation by two very experienced translators. After the translation process and items adjustment were concluded, the content validation process using the Content Validation Index (CVI) and construct validation were conducted to measure the validity and reliability of the CQ-STEM instrument.

**Table 1**  
*Statements of Items in the CQ-STEM Instrument*

Item	Statement
1.	I actively seek as much information about STEM in new situations.
2.	I am someone who really enjoys the uncertainties in my daily activities related to STEM.
3.	I am at my best level whenever I am doing something complex or challenging in STEM.
4.	Wherever I go, I would look for new experiences or things that are related to STEM.
5.	I look at challenging situations within STEM as opportunities to learn.
6.	I enjoy doing things related to STEM that are a little terrifying.
7.	I always look for experiences within STEM that challenges the way I think about myself.
8.	I am more interested towards STEM assignments that are unpredictable.
9.	I constantly look for opportunities within STEM to challenge myself.
10.	I am someone who easily accepts new experiences related to STEM.



### Data Analysis

The data of the research were analyzed to determine the validity from the aspect of content validity and construct validity. In determining the content validity agreement value, the researcher used the Content Validation Index (CVI). CVI gives an average rating of scores for all items evaluated by an expert. Davis (1992) posited that the values of CVI that was accepted for newly developed instruments were  $\geq .80$  while Polit et al. (2007) suggested the value of  $\geq .78$  for validity which involves at least three experts. This research uses the resolution proposed by Davis (1992) which is the value of .80 for new instruments. CVI analysis based on Polit and Beck (2006) is as the formula below.

$$\text{Content Validation Index (CVI)} = \frac{\text{Total score agreed by the experts}}{\text{Total overall score}}$$

To ensure the validity of the constructs in the instrument, the Winsteps version 3.73 software was used. This was done to ensure the quality of the instruments and precise data was obtained by the researcher before it was used in the context of the real research.

The first analysis was conducted by implementing the person fit analysis based on values by referring to the values of 'MEASURE', MNSQ Outfit, and ZSTD Outfit (Edwards & Alcock, 2010). Nevin et al. (2015) posited that if the value of ZSTD Outfit was more than 2.0 and the value of MEASURE was high, there might be a possibility that excellent students did not answer the low-level items carefully. Should the ZSTD Outfit exceed 2.0 while the value of MEASURE was low, it was highly probable that students with lower abilities were able to answer the 'difficult' items correctly. Therefore, misfit persons would be eliminated in order to increase the validity of the instruments (Lamoureux et al., 2008).

To ensure the item fit, Boone et al. (2014) along with Bond and Fox (2015) suggested three criteria which are Outfit Mean Square Values (MNSQ), Outfit Z-Standardized Values (ZSTD), and Point Measure Correlation (PTMEA-CORR). The value of the MNSQ Outfit informs the researcher about the item fit in terms of measurement while the PTMEA-CORR value shows whether the construct development has achieved its purpose (Bond & Fox, 2007). In other words, ZSTD gives the information to the researcher on whether the data collected accurately fits the instrument model. Any specific item that fails to fulfill any one of the criteria in Table 2 has to be modified or excluded in order to increase the value of the item fit (Sumintono & Widhiarso, 2015). Linacre (2002) posited that analysis of the item fit is to be conducted based on Infit and Outfit MNSQ values. Items with an index value within the ranges of .50 until 1.50 are productive for measurements. Should all the items fulfill the rules for MNSQ values, ZSTD values are not necessary for referral (Linacre, 2002).

**Table 2**  
*Fit Indices for Item Fit*

Statistics	Index
MNSQ Outfit	.50 – 1.50
ZSTD Outfit	-2.00 – 2.00
PTMEA-CORR	.40 – .85

Source: Boone et al. (2014)

Rasch analysis could also be used to identify the item polarity through the PTMEA-CORR value. A PTMEA-CORR value is that positive indicates that the items were able to be measured properly and vice-versa should the value be negative.

Researchers also studied the unidimensionality of the instruments to ensure that the instruments were capable of measuring the curiosity construct (Shea et al., 2009; Sumintono & Widhiarso, 2015). Principal Component Analysis provides the unidimensionality criteria based on the variance explained by measures (Sumintono & Widhiarso, 2015). Table 3 shows the value of the raw variance explained by measures that was received should be more than 20%, better if more than 40% and excellent if more than 60%. Meanwhile, the value for the unexplained variance in the first contrast should not be more than 15%.



**Table 3***Unidimensionality based on Raw Variance Explained by Measures*

Value	Interpretation
≥ 20%	Acceptable
≥ 40%	Good
≥ 60%	Excellent

*Source: Sumintono & Widhiarso (2015)*

The final analysis in the validity aspect was by referring to the person-item variable map. This map displays the average levels of item agreement that was answered by the respondents and the average ability of the person (students) in answering the questionnaire. This map can show whether the students' abilities are scattered normally across the map or not. The items scattered along the average range of the respondents' ability elucidates that the instruments were understandable and answerable by the respondents in the research sample.

From the aspect of reliability, researchers refer to Sumintono and Widhiarso (2015) for the values of Cronbach's alpha (KR-20), item and the person reliability index as well as item and person separation (Table 4). The person separation index was used in order to classify the levels of the respondents. A good separation index should be >2, as the higher the separation index goes, the better the respondents' classification levels. The item separation index was also used to confirm the item hierarchy. A lower item separation index, <3 proved that the size of the respondents' sample was not large enough to determine the item difficulty hierarchy within the instrument.

**Table 4***Reliability in Rasch Analysis*

Statistics	Index	Interpretation
Cronbach Alpha (KR-20)	< .5	Low
	< .6	Moderate
	.6 – .7	Good
	.7 – .8	High
	.9 – 1.0	Very High
Item and Respondent Validity	< .67	Low
	.67 – .80	Sufficient
	.81 – .90	Good
	.91 – .94	Very Good
	> .94	Excellent
Item Separation	>3	Good
Respondent Separation	>2	Good

*Source: Sumintono & Widhiarso (2015)*

## Research Results

### *Validity of the CQ-STEM Instrument's Contents*

The content validity portrays how far an item represents the trait which is studied by the researcher (Creswell & Creswell, 2017). Kline (2005) stated that an expert's view is needed to ensure the accuracy of the constructs as well as the clarity of its contents. For this purpose, the content validity of the CQ-STEM instrument was verified with the aid of four panel experts in the fields of curriculum, Science and STEM education. The panel evaluated the CQ-STEM items by giving their approval for each statement in the items. Their comments were noted and given attention to improve the items in the CQ-STEM instrument. Table 5 presents the list of panels who validated the contents of the instrument.



**Table 5**  
*Panel of Content Validation for CQ-STEM Instrument*

Name	Representative	Position	Area of Expertise
Expert A	Teachers Training Institute	Academic Lecturer of STEM Department (PhD)	Curriculum and Teaching (Science)
Expert B	Teachers Training Institute	Academic Lecturer of STEM Department	Science Education
Expert C	Primary School	Head of Science Panel (PhD)	STEM and Scientific Creativity
Expert D	Primary School	Science Subject Trainer	Primary School Science Education

For new instruments, Davis (1992) established that the CVI level should comply with the condition of  $\geq .90$ . Based on Table 6, the value of the validity index that was obtained after being validated by the experts was .86. This CVI value fulfills the terms for new instruments, and this also elucidates that the content validity for the CQ-STEM instrument is high and acceptable, as established by the panel of experts.

**Table 6**  
*Results of the Content Validation Index (CVI) of CQ-STEM Instrument*

Expert	Content Validation Index (CVI)	Expert's Opinion
Expert A	.80	Acceptable
Expert B	.90	Acceptable
Expert C	.90	Acceptable
Expert D	1.00	Acceptable
Average of the Content Validation Index	.90	

### *Validity of the CQ-STEM Instrument Construct*

#### *Person Fit*

Before the item polarity analysis and item fit was conducted, an evaluation was conducted towards the person fit beforehand to determine which respondents were misfit in this research. The misfit person was eliminated in the next analysis to gain a better analysis for the item polarity, item fit, unidimensionality, as well as the item-person difficulty level. Table 7 shows the person (respondents) who gave responses that were misfit with the Rasch analysis. Respondents were arranged according to the highest ZTSD Outfit value. All respondents were placed among the acceptable ZTSD Outfit values except for four respondents (044, 033, 057 and 052) which recorded values above 2.0. Respondents that presented a negative PTMEA-CORR value showed that they made ordinary decisions. As many as four respondents were removed and only 162 respondents out of 166 respondents were involved in the next stage of analysis.





**Table 7***Misfit order of the persons in CQ-STEM Instrument*

Person	MNSQ Outfit (0.50-1.50)	ZSTD Outfit (-2.0-2.0)	PTMEA-CORR (.40 -.85)
044	3.56	3.4	-.51
033	2.30	2.1	-.37
057	2.28	2.3	-.46
052	2.17	2.1	.02

*Item Fit*

Linacre (2007) emphasized that MNSQ Outfit value presents a strong value in determining item fit for the measurement of a construct. Boone et al. (2014) established that the range for a productive item fit is between .5 to 1.5 based on MNSQ Outfit and the range between -2 to +2 for ZSTD Outfit. Nevertheless, the ZSTD Outfit value can be ignored if the MNSQ Outfit has fulfilled the terms in determining item fit (Bond & Fox, 2007; Linacre, 2007). In other aspects, Boone et al. (2014) and Abdul Aziz et al. (2014) stated that items that were outside the MNSQ Outfit and ZSTD Outfit range and PTMEA-CORR are considered misfit. However, if the items fulfill one criterion, the item must be maintained (Sumintono & Widhiarso, 2015).

Table 8 reveals that items 7 and 8 are outside of the range. Nonetheless, all of the items comply with at least one criterion within the accepted range. Thus, no items were eliminated in this CQ-STEM instrument.

**Table 8***Misfit order of the items in CQ-STEM Instrument*

Item	MNSQ Outfit (.50-1.50)	ZTSD Outfit (-2.0-2.0)	PTMEA-CORR (.40 -.85)	Result
8	1.27	2.3	.68	maintained
6	1.07	.7	.70	maintained
1	1.04	.4	.84	maintained
2	1.05	.5	.81	maintained
10	.99	-.1	.83	maintained
9	.98	-.1	.82	maintained
5	.95	-.4	.80	maintained
3	.94	-.5	.73	maintained
4	.87	-1.1	.83	maintained
7	.70	-3.0	.81	maintained

*Item Polarity*

Item polarity analysis uses the PTMEA-CORR value to show that the items in CQ-STEM move in a similar direction following the construct that is being measured (Linacre, 2002). A positive value suggests that all the items function to a parallel direction whereas the negative value indicates that the item needs to be fixed or dropped. Based on Figure 2, the minimum PTMEA-CORR score was .68 while the maximum value was .84. The positive analysis of PTMEA-CORR proves that all the items moved in one direction in interpreting the construct that is measured (Bond & Fox, 2015).



**Figure 2***Analysis of Item Polarity Value*

INPUT: 162 PERSON 10 ITEM REPORTED: 162 PERSON 10 ITEM 5 CATS WINSTEPS 3.73

PERSON: REAL SEP.: 3.62 REL.: .93 ... ITEM: REAL SEP.: 5.12 REL.: .96

ITEM STATISTICS: CORRELATION ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	ZSTD	OUTFIT MNSQ	ZSTD	PT-MEASURE CORR.	EXP.	EXACT OBS%	MATCH EXP%	ITEM
8	506	162	.68	.14	1.27	2.3	1.27	2.3	.68	.79	46.3	62.2	Item 8
6	510	162	.60	.14	1.12	1.1	1.07	.7	.70	.79	59.3	62.2	Item 6
3	542	162	-.02	.14	.94	-.6	.94	-.5	.73	.78	61.1	62.5	Item 3
5	604	162	-1.31	.15	.94	-.5	.95	-.4	.80	.77	66.7	66.3	Item 5
7	551	162	-.20	.14	.71	-2.9	.70	-3.0	.81	.78	72.8	62.4	Item 7
2	490	162	.98	.14	1.02	.2	1.05	.5	.81	.79	51.9	61.7	Item 2
9	573	162	-.64	.14	.99	-.1	.98	-.1	.82	.78	56.8	63.1	Item 9
4	589	162	-.98	.15	.87	-1.1	.87	-1.1	.83	.77	64.8	64.6	Item 4
10	494	162	.90	.14	.99	.0	.99	-.1	.83	.79	62.3	61.9	Item 10
1	542	162	-.02	.14	1.12	1.1	1.04	.4	.84	.78	68.5	62.5	Item 1
MEAN	540.1	162.0	.00	.14	1.00	.0	.99	-.1			61.0	63.0	
S.D.	37.9	.0	.76	.00	.15	1.4	.14	1.3			7.5	1.4	

### Unidimensionality

Unidimensionality is crucial in determining the type of instrument which can measure in one direction and guarantees clarity in the findings of a research. Figure 3 exhibits that the value for Raw Variance Explained by Measures for the CQ-STEM instruments is 64.4%, close to the prediction made by the Rasch model. An index value above 60% is within the "Outstanding" level and this proves that the CQ-STEM instrument holds a strong unidimensionality. This means that the instrument is undeniably effective in measuring curiosity towards STEM education. The unexplained variance' value for the first contrast is 9.5%, and not over the control limit which is 15%.

**Figure 3***Analysis of Main Components*

INPUT: 162 PERSON 10 ITEM REPORTED: 162 PERSON 10 ITEM 5 CATS WINSTEPS 3.73

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

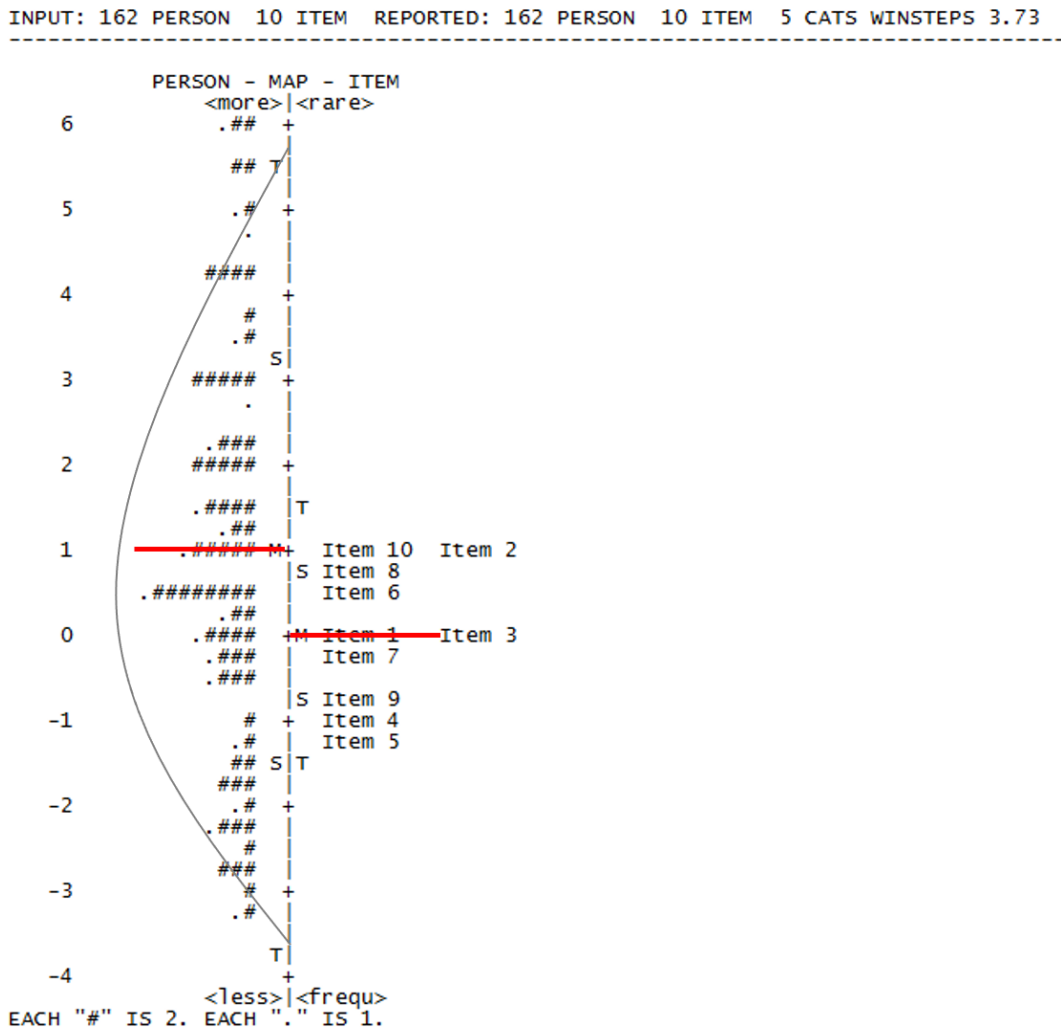
Total raw variance in observations	=	28.1	100.0%	Modeled	100.0%
Raw variance explained by measures	=	18.1	64.4%		64.5%
Raw variance explained by persons	=	13.4	47.8%		47.9%
Raw Variance explained by items	=	4.6	16.6%		16.6%
Raw unexplained variance (total)	=	10.0	35.6%	100.0%	35.5%
Unexplnd variance in 1st contrast	=	2.7	9.5%		26.8%
Unexplnd variance in 2nd contrast	=	1.4	5.1%		14.5%
Unexplnd variance in 3rd contrast	=	1.4	4.9%		13.6%
Unexplnd variance in 4th contrast	=	1.1	4.1%		11.4%
Unexplnd variance in 5th contrast	=	1.0	3.6%		10.1%

### Variable Map

It can be inferred from Figure 4 that the item difficulty in the instrument matches the students' ability and is answerable. This is because the students' ability average (red line on the left side) is close to the item difficulty average (red line on the right side). Based on the right side of the map, the average for the item difficulty is at .00 logit, whereas the left side of the map elucidates that the students' ability average is at +1.00 logit. The close logit values indicate that the items in the instruments are appropriate for the research sample.

Furthermore, the left side of the map presents the students' ability as scattered normally throughout the map. This denotes that the items in the instrument can be understood and answered by the students in the research sample. The map also demonstrates that items 10 and two have the highest logit and indicates that these items were the most difficult for students to agree on while item five shows the lowest logit. This indicates that item five was the easiest for the students to agree on.

**Figure 4**  
*Variable Map of CQ-STEM Instrument*



*Reliability and Separation Value of Item and Person*

Figure 5 illustrates the result of the reliability analysis and separation value, while Table 9 displays the summary of Cronbach's alpha (KR-20) value, the item reliability, person reliability, item separation and person separation index. The Cronbach's alpha analysis recorded the value of .93, revealing that the CQ-STEM instrument is highly reliable. The high reliability value of .96 is categorized as excellent (Sumintono & Widhiarso, 2015). At a value of 5.12, the item separation is accepted as a good item because it scored over 2.0 (Linacre, 2003) and can be categorized into five hierarchy of item agreement. These findings show that the respondent sample is enough to confirm the item agreement hierarchy in the instrument.



Besides, the Rasch analysis recorded an excellent reliability value that is, .93 (Sumintono & Widhiarso, 2015). At 3.62, the separation value is 'good' if the value is more than 2.0 (Linacre, 2003). 3.62 also verifies that the respondents can be grouped into four different strata in answering the items in the CQ-STEM instrument. This means that the respondents involved in this research can be grouped into four types of students that have different tendencies in giving their consent, which is, the scale for 'Strongly Disagree', 'Disagree', 'Agree' and 'Strongly Agree'. This division almost parallels the real SSIT-ITEM agreement scale division which is at agreement level five.

**Figure 5**

*Analysis of Reliability and Separation Value*

INPUT: 162 PERSON 10 ITEM REPORTED: 162 PERSON 10 ITEM 5 CATS WINSTEPS 3.73

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SUMMARY OF 162 MEASURED PERSON

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT		OUTFIT	
					MNSQ	ZSTD	MNSQ	ZSTD
MEAN	33.3	10.0	.88	.57	1.00	.0	.99	.0
S.D.	7.1	.0	2.34	.05	.44	1.0	.44	1.0
MAX.	47.0	10.0	5.95	.71	2.33	2.2	2.27	2.2
MIN.	19.0	10.0	-3.32	.51	.19	-2.8	.19	-2.8
REAL RMSE	.62	TRUE SD	2.25	SEPARATION	3.62	PERSON RELIABILITY	.93	
MODEL RMSE	.58	TRUE SD	2.27	SEPARATION	3.93	PERSON RELIABILITY	.94	
S.E. OF PERSON MEAN = .18								

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PERSON RAW SCORE-TO-MEASURE CORRELATION = .99  
 CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .93

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SUMMARY OF 10 MEASURED ITEM

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT		OUTFIT	
					MNSQ	ZSTD	MNSQ	ZSTD
MEAN	540.1	162.0	.00	.14	1.00	.0	.99	-.1
S.D.	37.9	.0	.76	.00	.15	1.4	.14	1.3
MAX.	604.0	162.0	.98	.15	1.27	2.3	1.27	2.3
MIN.	490.0	162.0	-1.31	.14	.71	-2.9	.70	-3.0
REAL RMSE	.14	TRUE SD	.74	SEPARATION	5.12	ITEM RELIABILITY	.96	
MODEL RMSE	.14	TRUE SD	.74	SEPARATION	5.26	ITEM RELIABILITY	.97	
S.E. OF ITEM MEAN = .25								

**Table 9**

*The Value for Cronbach's Alpha (KR-20), Item Separation, Item Reliability, Person Separation and Person Reliability of the CQ-STEM Instrument*

	Separation Index	Reliability Index
Cronbach's alpha (KR-20)		.93
Item	5.12	.96
Person	3.62	.93

## Discussion

The CQ-STEM instrument is the fine-tuned item of CEI-II adapted from Kashdan (2009) with STEM education element items constructed by researchers. During the initial stages, the CQ-STEM instrument had surpassed the

experts' agreement levels through the CVI with a value over .80 which translates to those items being able to be used and acceptable. Moving forward, the reliability and validity of the instruments were tested through detailed analysis processes using the Rasch Measurement Model. All the items had passed the six analysis aspects which are made up of person fit, item fit, item polarity, unidimensionality, item and person level of difficulty as well as the reliability and separation of the person-item.

Overall, the instrument validity analysis was conducted on the aspects of item and respondent fit, item polarity, unidimensionality as well as level of item difficulty and respondent agreement. In terms of person fit, out of a total of 166 people, four respondents were eliminated for being incompatible with the given response. The remaining 162 respondents were included in the analysis for providing meaningful responses. Through the item fit analysis, all the items in the CQ-STEM instrument could be retained for being in the range of one of the MNSQ Outfit criteria, ZSTD outfit and PTMEA-CORR. To determine the item polarity, a positive PTMEA-CORR analysis corroborates that all the items were moving in the same direction in interpreting the measurable construct (Bond & Fox, 2015). The value achieved by the Raw Variance Explained by Measures in the CQ-STEM instrument which was more than 60%, proves that the CQ-STEM instrument has high unidimensionality. In fact, this confirms that the instrument really measures the curiosity construct towards the STEM Education. Analysis on the person-item variables map demonstrates that all the items in the instruments were compatible with the research sample and it could be understood and answered by the respondents within the research sample. Nevertheless, there was a slight difference of +1.00 logit between the item difficulty average and the respondent difficulty. This could have possibly happened due to the high level of curiosity among the primary school students. The second possibility is that the number of items developed were not enough to fulfill the high number of students' responses.

In terms of reliability, the CQ-STEM instrument has a very high value of Cronbach's alpha and an excellent value of reliability for items and respondents. Ten Klooster et al. (2008) posited that a good item separation value (5.12) indicates that the CQ-STEM instrument has five different hierarchies of item agreement levels while the person separation value proves that the respondents could be divided into four stratas according to agreement levels. This finding indicates that the validity of the CQ-STEM instrument in assessing curiosity towards STEM education among fifth graders was high. Therefore, based on the validity and reliability inspection, the CQ-STEM instrument is proven to have adequate qualities in measuring the levels of curiosity towards the STEM education among year five students in primary school.

A number of researchers have developed questionnaires to study the curiosity of early childhood education students and primary school students. For instance, Piotrowski et al's (2009) questionnaire assessed the epistemic curiosity of children aged 3 to 8 years based on the students' interests and desire to gain information and knowledge. Post and Walma van der Molen (2019) developed a questionnaire for primary school students. They found that the development of students' curiosity is influenced by their representation of curiosity and attitudes toward epistemic curiosity.

The questionnaires of Litman and Spielberger (2003), and Aschieri and Durosini (2015) assessed the curiosity of adult students aged 18-65 years. The former assessed epistemic and perceptual curiosity while the latter assessed self-curiosity; the ways in which adults explore new things in their lives. Renner (2006) developed an instrument that measures the social curiosity of adults in terms of their thoughts, feelings, and behaviors. Kashdan et al. (2018) also developed a curiosity instrument for adults to assess their personality and emotional-related factors: joyous discovery, resilience to deprivation, stress tolerance, social curiosity, and thrill seeking.

In sum, many researchers have concentrated on epistemic curiosity, which is the desire to obtain information based on one's own interests and desires. The target groups of previous instruments were young children, high school students, higher education students and adults. No substantial instrument has been developed to date that investigates primary school students' curiosity towards STEM education. In Piaget's Theory of Cognitive Constructivism, students aged 10 to 11 are able to perform a logical investigation process and solve concrete problems (Pascual-Leone & Johnson, 2005). Therefore, it is important to take into account the level of curiosity towards STEM education among students at this level.

The development of the CQ-STEM instrument has enhanced the research of curiosity, being an instrument that measures the curiosity towards STEM education in primary school students, and its validity and reliability has been established. Additionally, the CQ-STEM questionnaire conforms to Berlyn's Theory of Human Curiosity, in which a student is stimulated by the four dimensions of curiosity. Students with high curiosity towards STEM education are influenced by their desire to gain knowledge, observations of new things around them, the desire to make in-depth observations as well as the desire to deviate from normal routines. Students who have these characteristics will certainly gain more knowledge and experience in STEM than students with low curiosity (Kashdan et al., 2004, 2009).



## Conclusions and Implications

This research has brought about a few implications that gives impact from a practicality and methodology standpoint. From a practicality aspect, the CQ-STEM instrument that was constructed was in connection with the original item about the curiosity from CEI-II with the STEM education items that were set by the researchers. This is because the instrument that was developed measured the curiosity levels in a general way. The inequality of the STEM education context gave implications towards inaccurate measurements because they cannot be considered as representing the real context. Therefore, the Curiosity towards STEM Education instrument (CQ-STEM) is seen to fill the void and overcome the issue of not having an instrument to measure the curiosity towards STEM Education among primary school students. The construction of this instrument is an early pragmatic approach in ensuring the continuation of curiosity towards STEM. The end goal is to contribute towards a birth of a generation that is innovative, creative, inventive and possess a comprehensive STEM knowledge.

In terms of the methodology aspect, the Rasch Measurement Model which was used to determine the validity and reliability of the CQ-STEM instrument was able to measure the validity and reliability of the person-item in detail and specifically. The Rasch model analyzed the instrument's validity from the aspect of person-item fit, item polarity, unidimensionality and item complexity levels, as well as respondent agreement provided prove that the CQ-STEM instrument has a high accuracy in measuring the curiosity construct towards STEM education. The instrument's reliability analysis results showed high scores of good person-item values. This indicates that the CQ-STEM instrument can be trusted to measure curiosity towards STEM education among primary school students.

Determining the validity and the reliability of the CQ-STEM instrument proves that the process of instrument development must be conducted in an accurate and correct manner. Priority is to be given in terms of validity and the reliability aspects to ensure that the instrument can be utilized multiple times. An instrument that has undergone the validity and reliability phase accurately and correctly could help the researcher to measure the studied variables and to come up with accurate results from those analysis. Furthermore, this finding supports other research so that the Rasch analysis on CQ-STEM instruments can be conducted on students in other areas. In conclusion, the validity and reliability analysis using the Rasch Measurement Model has successfully proven that the CQ-STEM instrument is very suitable for real field research in measuring the curiosity trait towards STEM education among fifth graders in primary schools.

The CQ-STEM questionnaire is limited to just 10 items for primary school students. This constraint points to the need for other studies that may require more items. In addition, this instrument was developed based on two constructs: exploration and acceptance. Future researchers may consider additional constructs such as representation of curiosity and children's attitudes toward epistemic curiosity, epistemic curiosity and perceptual curiosity, self-curiosity and personality and emotion-related factors in the development of a CQ-STEM instrument.

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