# Validity and Reliability of Graphing Calculator Skills Test Items for Circles Topic (CGCST) Using Rasch Measurement Model Analysis: A Pilot Study

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## ABSTRACT

The Circles Graphing Calculator Skills Test (CGCST) is developed to test students graphing calculator skills for Circles topic. The test consists of Circles sub-topics, cognitive level of Bloom's Taxonomy and graphing calculator skills for Circles. Initially, there are 15 questions with 64 items. A pilot study was conducted using a descriptive quantitative design of 30 form two students in two schools in Negeri Sembilan. Samples were selected using simple random sampling method. To ensure the quality of the CGCST items, the items were analysed using Rasch Measurement Model by obtaining item reliability and item separation values. CGCST items not only have the content validity after being evaluated by three experts, but also have high reliability values. For construct validity seven misfit items were dropped from the 64 items. These 57 remaining items have positive PT-MEA Corr values.

**Keywords:** Circles Graphing Calculator Skills Test, Graphing Calculator, Technology, Bloom's Taxonomy, Rasch Measurement Model.

## 1. INTRODUCTION

In 2002, the Malaysian Ministry of Education (MOE) provided graphing calculators to 108 schools throughout Malaysia. However, the use of graphing calculators in Malaysia is still at the experimental stage and there are some schools that have not used it optimally (Nor'ain Mohd Tajudin, Rohani Ahmad Tarmizi, Wan Zah Wan Ali & Mohd Majid Konting, 2008). The MOE (2013) study in 2010 showed that only 80 percent of the teachers use technology less than an hour a week. Recognising this, MOE took the initiative by launching the Malaysian Education Blueprint 2013-2025 (MEB 2013-2025). Through the seventh displacement in MEB 2013-2025, MOE stressed that teachers should fully utilise the graphing calculator provided by MOE in their teaching and learning. Many studies showed that the use of graphing calculator in teaching and learning mathematics is very important as it helps students to develop their understanding of mathematical concepts (Ellington, 2003; Roszilah Hamid, Eliyana Othman, Siti Aminah Osman, & Noraini Hamzah, 2011; Megat Aman Zahiri Mgt Zakaria & Nurul Shuhadah Abdul Rahman, 2010; Noraini Idris et al., 2014), teaching and learning can save time and students can make learning reflection (Center for Technology in Learning, 2007), it can improve problem-solving skills (Ellington, 2003), and it can improve students' performance, mathematics thinking and reasoning (Noraini Idris et al., 2015).

However, teachers and students only use the graphing calculator in the teaching and learning process and do not use it in the examination. Therefore, teachers only use the graphing calculator as a tool (Nichols, 2012) for conceptual understanding and there is no emphasis on using the graphing calculator for the examination.

## 2. Why Do We Need Graphing Calculator Skills Test?

Pierce, Stacey and Wander (2010) study showed that 71 percent of 84 students agreed that the main thing in teaching and learning involving the use of technology is learning the technology skills first, compared to 5 percent of 84 students who agreed to learn the mathematical concepts first. After students acquired the technology skills, a form of test to measure the extent of the students' mastery on the technological skills should be administered. Therefore, the technology skills test needs to be developed.

In this study, the research using graphing calculator as a technology tool in teaching and learning Circles concepts. According to Forster and Mueller (2000), there are two forms of questions for a test involving the use of graphing calculator namely an active graphing calculator questions and neutral graphing calculator questions. For an active graphing calculator questions, the use of graphing calculators is needed to solve the questions. For neutral graphing calculator questions, students are given the choice whether to use graphing calculator or not when solving a question. However, in order to answer both questions the students need to be proficient in using graphing calculator. For those who do not master graphing calculator skills will have problems in responding to questions requiring the use of graphing calculator (Dick, 1998; Kokol-Voljc, 1999).

## 3. THE DEVELOPMENT OF GRAPHNG CALCULATOR SKILLS TEST FOR CIRCLES (CGCST)

The Circles Graphing Calculator Skills Test (CGCST) is developed to test students graphing calculator skills for Circles topic. Table 1 shows a summary of the CGCST. It consists of the sub-topic of Circles, the cognitive level of Bloom's Taxonomy and the graphing calculator skills. For the sub-topic, it covers six sub-topics i.e. circle basic, circle circumference concept, circle arc concept, circle area concept, circle sector area concept, and angle in the circle. For Bloom's Taxonomy cognitive level, CGCST only tests Lower Order Thinking Skills (LOTS) that is remembering and understanding levels (Churches, 2009). For graphic calculator skills, the test examining 13 graphing calculator skills namely drawing circles, radius, diameter, arcs and chord, find the values for radius, diameter, circumference, area, angle and arc, find the centre of circles and conducting computation operations. CGCST is provided in subjective form, containing 15 questions with 64 items and should be answered within an hour.

Table 1 : Summary of CGCST

| Sub-topic | Cognitive Level Bloom's Taxonomy | Graphing Calculator Skills |
|---|---|---|
| • Circle Basic<br>• Circle Circumference Concept<br>• Circle Arc Concept<br>• Circle Area Concept<br>• Circle Sector Area Concept<br>• Angle In The Circle | LOTS | • Drawing Circles<br>• Drawing Radius<br>• Drawing Diameter<br>• Drawing Arcs<br>• Drawing Chord<br>• Find the Radius Value<br>• Find the Diameter Value<br>• Find the Circumference Value<br>• Find the Area Value<br>• Find the Angle Value<br>• Find the Arc Value<br>• Find the Centre of Circle<br>• Conducting Computation Operations |

To simplify the analysis process, 13 graphing calculator skills have been encoded as S1 to S13. Table 2 shows the code for the graphing calculator skills.

Table 2 : The Code for the Graphing Calculator Skills

| No. | Skills | Code |
|---|---|---|
| 1 | Drawing Circles | S1 |
| 2 | Drawing Radius | S2 |
| 3 | Drawing Diameter | S3 |
| 4 | Drawing Arcs | S4 |
| 5 | Drawing Chord | S5 |
| 6 | Find the Radius Value | S6 |
| 7 | Find the Diameter Value | S7 |
| 8 | Find the Circumference Value | S8 |
| 9 | Find the Area Value | S9 |
| 10 | Find the Angle Value | S10 |
| 11 | Find the Arc Value | S11 |
| 12 | Find the Centre of Circles | S12 |
| 13 | Conducting Computation Operations | S13 |

Table 3 shows the details of CGCST items based on cognitive levels. There are 35 items that testing the level of remembering and 29 items testing the level of understanding. 1st skill (S1) to 5th skill (S5) are classified as remembering level while 6th skill (S6) to 13th skill (S13) is classified as an understanding level. For example Question 5:

*Find the length of circle radius with circumference 49 cm.*

This question testing two skills of remembering level (S1 and S2), and two skills of understanding level (S6 and S8). Firstly, students need to draw a circle (S1) and a radius (S2). Then, they need to find the circumference value (S8). By changing the circumference to 49 cm, student will get the value of the radius (S6).

By looking at Question 15 as another example:

*Given the area of a circle is 100 cm$^2$. A minor sector is* $\frac{1}{4}$ *from a circle and a major sector is* $\frac{3}{4}$ *from a circle. Find the area of the minor and major sector.*

This question tests two skills at the same level of understanding (S13). To find the area of the minor and major sector, the students should remember and know what the minor and major sector is. Then, they have to relate the ratio to the given area. This question tests the students' ability to use graphing calculator to conduct the computation. Since the question needs two answers of the area, hence the researchers writes twice S13 in Table 3. Same goes to Question 10 and Question 13 where both questions testing the student's skills of finding the angle values (S10).

Table 3: Details of CGCST Items Based On Cognitive Level

| Sub-topic | Cognitive Level | | | |
|---|---|---|---|---|
| | Remember | | Understand | |
| | No. Question | Skills | No. Question | Skills |
| 1.1 Circle Basic | 1 | S1, S2 | 1 | S6 |
| | 2 | S1, S3 | 2 | S7, S12 |
| | 3 | S1, S2 | 3 | S10 |
| | 4 | S1, S2, S4 | 4 | S11 |
| 1.2 Circle Circumference Concept | 5 | S1, S2 | 5 | S6, S8 |
| | 6 | S1, S2 | 6 | S6, S8 |
| 1.3 Circle Arc Concept | 8 | S1, S2, S4 | 8 | S6, S10, S11 |
| | 9 | S1, S2, S4 | 9 | S6, S10, S11 |
| | 10 | S1, S2 | 10 | S10, S10 |
| | 11 | S1, S2, S4, S4 | 11 | S6, S11, S11 |
| 1.4 Circle Area Concept | 7 | S1, S2 | 7 | S6, S9 |
| 1.5 Circle Sector Area Concept | | | 15 | S13, S13 |
| 1.6 Angle In The Circle | 12 | S1, S5 | 12 | S10 |
| | 13 | S1, S2, S5 | 13 | S10, S10 |
| | 14 | S1, S3, S5 | 14 | S10, S12 |
| Total | | 35 | | 29 |

## 4. METHODOLOGY

The pilot study was conducted using a descriptive quantitative design which refers to the collection of information and explains what would be studied (Grimes & Schulz, 2002; Lund Research Ltd, 2015; The Association for Educational Communications and Technology, 2001). A total of 30 form two students from two schools in Negeri Sembilan were selected as samples using simple random sampling method. The CGCST has the content validity from a lecturer and two teachers specialising in Mathematics and graphing calculator (Creswell, 2012; Messick, 1989; Wolfe & Smith, 2007). The content validity of CGCST also can be identified when there is a relationship between

the items developed with the content that has been taught (Van Blerkom, 2009). According to Horgas, Yoon, Nichols and Marsiske (2007), assessing the scale of content validity is a critical step in increasing the construct validity of the instrument. Based on the experts comments, CGCST items are made improvements before being administered to students.

The process of collecting data for CGCST involves two sessions; graphing calculator skills session and answering CGCST items session. During the graphing calculator skills session, each students was supplied with graphing calculator TI-Nspire CX model. In two hours students were exposed and experienced with the keys on the TI-Nspire CX and the skills needed to answer Circles skills questions. The graphing calculator skills involved were listed in Table 4 and Table 5. On the next day, students were asked to answer the CGCST within an hour. The students' responses were recorded and analysed according to Rasch Measurement Model using the Winstep version 3.72.3.

## 5. RESULTS AND DISCUSSIONS

The reliability and validity of the CGCST which consists of 15 questions with 64 items were discussed in 2 parts namely item reliability and item separation, and item validity.

### 5.1 ITEM RELIABILITY AND ITEM SEPARATION

Table 4 shows the values of CGCST item reliability and item separation. The CGCST item reliability is 0.91 and this value is approaching 0.92 as the reliability value of the Rasch model. This shows that the CGCST item reliability within the acceptable range because it exceeds the minimum reliability value (> 0.8) (Bond & Fox, 2015).

For item separation, the value of separation at least 2 indicates that the items can be separated into at least 2 groups (Bond & Fox, 2015). From Table 4, the item separation is 3.21. It shows that CGCST items can be categorised into at least three categories namely easy item, moderate item and difficult item.

Table 4: Reliability and Separation GCST Item

| | TOTAL SCORE | COUNT | MEASURE | MODEL ERROR | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD |
|---|---|---|---|---|---|---|---|---|
| MEAN | 17.9 | 30.0 | -.30 | .71 | | | | |
| S.D. | 8.9 | .0 | 2.78 | .34 | | | | |
| MAX. | 30.0 | 30.0 | 5.75 | 1.91 | | | | |
| MIN. | 2.0 | 30.0 | -5.68 | .46 | .33 | -1.9 | .06 | -.8 |
| REAL RMSE | .83 | TRUE SD | 2.65 | **SEPARATION 3.21** | **ITEM** | **RELIABILITY** | **.91** | |
| MODEL RMSE | .79 | TRUE SD | 2.66 | SEPARATION 3.39 | ITEM | RELIABILITY | .92 | |
| S.E. OF ITEM MEAN = .37 | | | | | | | | |

## 5.2 ITEM VALIDITY

Before the CGCST was administered in the pilot study, CGCST items went through the experts evaluation process to obtain the content validity and the researchers used the Scale Content Validity Index (Scale CVI) analysis as proposed by Lynn (1986) to check the suitability of the items developed. Table 5 shows the experts evaluation of CGCST items. Based on the results, only four items got the approval 2 with the Item CVI value 0.67. Whereas another 11 items got approval value 3 with Item CVI value 1.00. The Item CVI is the average for the experts' evaluation and the Scale CVI is the average for Item CVI. From Table 5, the Scale CVI for CGCST items is 0.91 which above the minimum value of 0.8 as suggested by Horgas et al. (2007).

Table 5 : Experts Evaluation against CGCST Items

| Item | Expert 1 | Expert 2` | Expert 3 | Amount of Approval | Item CVI |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 2 | 0.67 |
| 2 | 1 | 1 | 1 | 3 | 1.00 |
| 3 | 1 | 1 | 1 | 3 | 1.00 |
| 4 | 1 | 1 | 1 | 3 | 1.00 |
| 5 | 1 | 1 | 1 | 3 | 1.00 |
| 6 | 1 | 1 | 1 | 3 | 1.00 |
| 7 | 1 | 1 | 1 | 3 | 1.00 |
| 8 | 1 | 1 | 1 | 3 | 1.00 |
| 9 | 1 | 1 | 1 | 3 | 1.00 |
| 10 | 0 | 1 | 1 | 2 | 0.67 |
| 11 | 0 | 1 | 1 | 2 | 0.67 |
| 12 | 1 | 1 | 1 | 3 | 1.00 |
| 13 | 1 | 1 | 1 | 3 | 1.00 |
| 14 | 1 | 1 | 1 | 3 | 1.00 |
| 15 | 0 | 1 | 1 | 2 | 0.67 |
| Scale CVI | | | | | 0.91 |

For construct validity, items validity can be identified through the point-measure correlation (PT-MEA Corr) to find out whether all items are in one direction with the construct developed. Positive PT-MEA Corr. indicates the item has construct validity. If the item has negative PT-MEA Corr., the item does not measure what should be measured and should be dropped (Azrillah Abdul Aziz, Mohd Saidfudin Masodi, & Azami Zaharim, 2013; Bond & Fox, 2015).

Table 6 shows Q3S2 (-0.15) and Q2S3 (-0.03) have negative PT-MEA Corr. These items known as misfit item and should be dropped to maintain the validity of the CGCST construct. After Q3S2 and Q2S3 dropped, no more item that has negative PT-MEA Corr value and the CGCST items are in one direction with the construct developed and now, the CGCST could measured the students' graphing calculator skills for Circles.

Table 6 : Misfit Items Based On the Negative PT-MEA Corr Value

| Entry Number | PT-MEA Corr. | Item |
|---|---|---|
| 9 | -0.15 | Q3S2 |
| 6 | -0.03 | Q2S3 |

Besides using PT-MEA Corr analysis, the chi-square test also has been used to examine how far the data obtained satisfied Rasch Measurement Model conditions. Chi-square statistics refers to infit and outfit mean square (MNSQ). The criteria required for misfit item is the outfit MNSQ value exceeds the total of the mean and standard deviation (outfit MNSQ > M + SD) (Azrillah Abdul Aziz et al., 2013) and the Z Standardized (ZSTD) exceeds 2 (ZSTD> 2) (Bond & Fox, 2015; Linarce, 2012). After misfit item was dropped from the negative PT-MEA Corr (Table 6), the analysis continues to look at the outfit MNSQ> M + SD and ZSTD> 2. According to Table 7, the mean and standard deviation (mean + SD) is 2.45. This means that an item that has the outfit MNSQ> 2.45 and ZSTD> 2 is a misfit item. From Table 7, there are five misfit items have been identified i.e. Q5S3 (MNSQ 7.68), Q5S4 (MNSQ 6.01), Q7S4 (MNSQ 4.97), Q6S4 (MNSQ 3.38) and Q8S6 (MNSQ 2.57).

Table 7 : CGCST Misfit Items Based On Outfit Value

| Entry Number | Infit | | Outfit | | PT-MEA Corr. | Item |
|---|---|---|---|---|---|---|
| | MNSQ | Zstd | MNSQ | Zstd | | |
| 15 | 1.37 | 1.2 | 7.68 | 3.1 | 0.19 | Q5S3 |
| 16 | 1.46 | 2.2 | 6.01 | 4.0 | 0.17 | Q5S4 |
| 24 | 1.59 | 2.9 | 4.97 | 4.2 | 0.12 | Q7S4 |
| 20 | 1.19 | 1.0 | 3.38 | 2.5 | 0.36 | Q6S4 |
| 30 | 1.48 | 2.1 | 2.57 | 2.4 | 0.30 | Q8S6 |
| Mean | | | 1.11 | | | |
| S.D | | | 1.34 | | | |

## 6. CONCLUSION

Based on the pilot study, the value of reliability and item separation of CGCST is 0.91 and 3.21. High reliability of CGCST items indicates the consistency of CGCST items and it can be administered to other samples which have the same or nearly identical features. The item separation value of more than three indicates that CGCST items can be categorised at least into three categories, namely easy item, moderate item and difficult item. CGCST items are valid in terms of

content validity after being evaluated by three experts in Mathematics and graphing calculators. CGCST items have construct validity with PT-MEA Corr value for all items are positive. After the CGCST item was analysed, 57 items were retained from 64 items. Q3S2, Q2S3, Q5S3, Q5S4, Q7S4, Q6S4 and Q8S6 are seven misfit items which have been identified. With the remaining of 57 items, CGCST can be applied to actual study involving more samples.

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