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Measuring Students' Level of Interest in Learning Embedded Systems Course: Instrument Development and Validation using Rasch Analysis

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ABSTRACT

Increasingly essential to several industries, including consumer electronics, medicine, and automobiles, are embedded systems. But students are frequently frightened by their complexity, which presents difficulties in schooling. This research solves these problems by using Rasch analysis to create and check a scale gauging students' interest in Embedded Systems Design courses. Following content validation by an expert panel, a theoretical framework for the scale was created using a thorough literature analysis. In a pilot study with 40 people, the dependability of the scale was assessed. A bigger survey including 365 students from several colleges produced a diverse sample for study using WINSTEPS 5.7.4 to evaluate the dimensionality of the scale items, which resulted in high reliability scores (0.70 for people and 0.97 for items). The results, nevertheless, showed an alarming pattern: embedded systems design attracted little interest from students, which may impede academic performance and knowledge. This absence of involvement emphasizes the pressing need for educational institutions to update their curricula and teaching methods to stimulate more interest and provide students with vital abilities for technology-driven labor. Overall, the research offers helpful tips for measuring interest in embedded systems of education and emphasizes the importance of addressing these challenges.

Keywords: Embedded system; Rasch; reliability; validity, and Interest

1. INTRODUCTION

Learner's psychological state of interest comprises focused attention, improved cognitive performance, tenacity, and affective engagement [1]. Interest is an aim-related component that helps people to learn, investigate, as well as seeking information on their own initiative, Deci and Ryan [2] said. Therefore, the crucial motivator for learning is the course's students' engagement. Positive emotions could result from a student's high interest in the course, which then influence learning-associated conduct and produce favourable educational result [3]. Student interest mirrors input into the course, including attentiveness level in class, desire in learning the contents, impression of a course's intellectual difficulty, and gained knowledge in the field. Student interest helps good instruction and builds a more positive learning atmosphere [3].

Embedded systems have become increasingly important in the industrial industry in recent years as they are used extensively in smart devices and digital electronics. The computational capacity of appliances has increased tremendously as digital design techniques have improved. With always growing functional capability, one can produce billions of chips at a moderate price [4]. The exponential scaling, however, complicated the design of these gadgets, so designers had to go farther in the hierarchy of abstraction to handle the added intricacy. Meanwhile, hardware and software interact to create embedded systems [5, 6, 7, and 8].

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Higher educational institutions that recognize the need of embedded systems offer courses on embedded system design to electrical and electronics engineering students to generate a continuous supply of competent graduates possessing the appropriate skill sets and amount to satisfy industry requirements both current and future. Developing and implementing embedded systems demands significant previous expertise across several different fields of study [9]. Among these fields are computer science; electrical and electronics engineering; computer engineering; real-time processing; distributed systems; optimization and evaluation; control and signal processing; and computer theory [10]. The embedded system design technologies used are changing so fast that knowledge must be kept current [11].

Embedded systems engineers therefore need to acquire skills in handling challenging, unwritten, open problems. To generate multiple points of view, this requires combining a range of multidisciplinary understanding, abilities, techniques, and instruments from many fields. Engineers thus need both hard and soft skills to negotiate the complexity of incorporating multicultural teams in significant projects spanning varied backgrounds [12, 13]. Since engineering is a means of producing engineers, many specialists have recommended modifying engineering education in universities of higher learning to satisfy industry. One method to accomplish this is by lowering the gap between industry demands and academic perspectives or employment skills for entry-level engineers [14, 15, 16, 17, and 18].

Many questionnaires have been developed throughout the years to assess pupils' readiness for research, employment, and college [19, 20, and 21]. Furthermore, Ryan [22] built an instrument to evaluate precollege Arabic-speaking pupils' attitudes toward science courses, Villafañe [23] designed a tool to assess students' prior knowledge and attitude toward learning biochemistry in postsecondary educational institutions, and author [24] constructed an instrument to measure students' prior knowledge readiness for the Chemistry laboratory course. Several studies using a gadget made to evaluate students' readiness for the Chemistry course have also been carried out. Furthermore, Luajean [25] and Bidya and Randy [26] created a system to assess pupils' existing mathematical understanding.

They devised a way to evaluate children's pre-existing attitudes and knowledge regarding STEM (science, technology, engineering, and mathematics) courses. Recent research indicates that there is not one tool developed only to assess undergraduate students' desire in studying embedded system design. The scientist is aware of this first time. Designed to evaluate how much Embedded Systems Design course learning enthusiasm influences students' academic performance, a scale founded on learning theory and measurement theory has been developed. This effort aims to produce understanding that can help to close the embedded system design knowledge voids.

The structure of this research paper is as follows: Section 2 describes the study methodology used to assess students' interest in embedded systems design. While section 3 mainly discussed the results and claimed findings. Finally, section 4 elaborates limitations and conclusion of the study.

2. METHODOLOGY

Employing an exploratory experimental design, this research looked at how students' enthusiasm in studying embedded system design affected their academic performance. This quantitative study comprises a literature review, document gathering, preliminary research, content validation, pilot testing, data collecting, construct validity, and a student awareness assessment. The instrument's construct validity was evaluated using data from universities in Malaysia, Sudan, and Saudi Arabia as well as the Rasch model.

376 qualified respondents were asked to finish the survey; 97.1% of the 365 forms turned to the researcher were done. Respondents were instructed to say if they agreed or disagreed on five questions from the level of interest scale shown in Table 1. The pool of questions was compiled using course outcomes (CO) and program goals (PO) from the selected universities as well as student feedback. The original scale included a 5-point Likert scale with labelled items: (1) strongly disagree, (2) disagree, (3) somewhat agree, (4) agree, and (5) strongly agree. The scale has two components. The first part of the questionnaire asks respondents for their demographic information, but the second one assesses how interested students are in studying embedded systems design. To help a group of experts evaluate the content validity of the scale, a validation form was also created.

Table 1 Level of Interest Scale Items

Item	Label
INT1	I am able to identify problems in engineering design process.
INT2	I am able to formulate engineering problems using principles of mathematics.
INT3	I can solve engineering design problems to meet specified needs.
INT4	I am able to use the techniques such as modeling necessary for engineering practice.
INT5	I am able to use new techniques (i.e., including contemporary engineering instruments essential for engineering applications).
INT6	I am able to identify problems in engineering design process.

To guide scale improvement and provide insights regarding the representativeness and clarity of the items, an expert panel determined the original scale's Content Validity Index (CVI) and Content Validity Ratio (CVR). The Cronbach's Alpha reliability coefficient was used to determine the internal consistency of the scale. Cronbach's Alpha is a reliability coefficient determined using the Statistical Package for Social Sciences (SPSS) 29.0. Forty fourth-year students from Universiti Teknologi Malaysia (UTM) participated in the reliability analysis using an online survey.

Rasch analysis with WINSTEPS 5.7.4 program was next employed to evaluate the design of the scale. Scale statistical analysis, Wright map, one-dimensionality, and local independence were used to assess the construct validity. Finally, SPSS 29.0 and WINSTEPS 5.7.4 assessed the students' enthusiasm in studying the embedded system design curriculum. The participants in the research were chosen using the cluster purposive sampling strategy. This sampling method was selected to get feedback on how much embedded system design learning interested pupils from different geographical regions [27, 28]. This study used the evaluation approach Akaslan and Law [29] created. Employing a threshold of 3.40, it measures the respondents' degree of interest.

3. RESULTS AND DISCUSSIONS

This section shows findings and debates emerging from this real-world study. First the findings of the content validity are presented; next, the pilot tests of the scales are reliability tested. The outcomes of the Rasch analysis are then presented, and finally the results on the students' interest to study the embedded system design are reviewed in light of the goals of the study.

3.1 Content Validity

In a methodological content validity examination, the scale's original version's content validity ratio (I-CVR), content validity index (I-CVI), Scale-CVR (S-CVR), and Scale-CVI (S-CVI) were determined. The scale's content is assessed by a group of thirteen (13) subject-matter experts.

The expert group consisted of five (5) academic specialists and eight (8) industrial experts. Using a validation form they got via email, participants assessed and confirmed the face and content validity of the scale. By marking how much they agreed or disagreed with the given scale elements, they were asked to rate the scale's clarity. Figure 1 shows the scale replies from the experts.
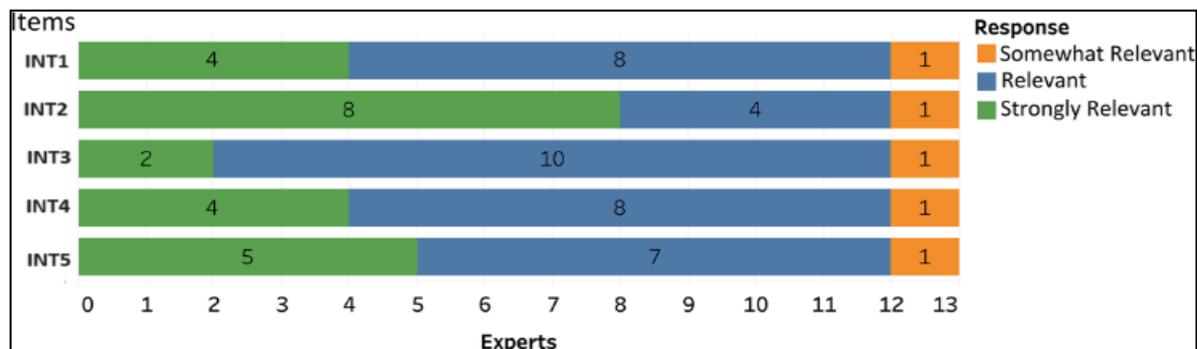

Figure 1. Experts' response to level of the scale.

As indicated in Table 2, the I-CVR and S-CVR scores are 0.85 and 0.92, respectively. According to the experts' generally positive responses, the scale's good content validity indicates that it might accurately gauge students' interest in learning embedded system design.

Table 2 Content Validity of the Scale

Item	Label	Validation		Decision
		I-CVR	**I-CVI**	
INT1	I am able to identify problems in engineering design process.	0.85	0.92	Accepted
INT2	I am able to formulate engineering problems using principles of mathematics.	0.85	0.92	Accepted
INT3	I am able to solve engineering design problems to meet specified needs.	0.85	0.92	Accepted
INT4	I am able to utilize the techniques such as modeling necessary for engineering practice.	0.85	0.92	Accepted
INT5	I am able to use new techniques (i.e., including contemporary engineering instruments essential for engineering applications).	0.85	0.92	Accepted
		S-CVR	S-CVI	Accepted
		0.85	0.92	

3.2 Pilot Test

This part showed the results of the second version pilot study conducted for the scale. For the pilot experiment, responses to an internet survey were obtained from forty (40) fourth-year students. Using SPSS 29.0 program, the collected pilot test data was processed. Cronbach [30] holds that a reliability coefficient (alpha) of 0.70 or greater is acceptable. Table 3 presents the findings of the pilot study of the scale. Values of 0.88 for Cronbach's alpha imply that the measure has strong internal consistency reliability. Removing one item (INT5), which has a low item-total correlation of 0.300 even if the scale is reliable, would boost its alpha score. The item was a quite significant component of the scale even with a small n = 40. Therefore, they would only be

eliminated if the figures remained poor with a greater student population [31, 32, and 33].

Table 3 Cronbach's Alpha of the Scale

Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
INT1	0.911	0.81
INT2	0.908	0.82
INT3	0.910	0.80
INT4	0.911	0.81
INT5	0.300	1.00

3.3 Construct Validity

Based on data from the main study, the construct validity of the scale was assessed in its last version. To confirm its efficacy, Linacre (2016) suggests using the Rasch model of Classical Test Theory (CCT) and Item Response Theory (IRT). The construct validity of the scale for statistical analysis, item fit analysis, differential item functioning, unidimensionality and local independence, and Wright map is investigated in this study using Rasch analysis of WINSTEPS version 5.7.4.

Statistical Analysis: The scale's reliability is 0.70 for people, 0.98 for items, and 0.74 for Cronbach's alpha, according to the statistical analysis results in Table 4. This suggests that the scale has high item reliability and adequate person dependability. The ZSTD INFIT and OUTFIT are both -0.2, but the individual's MNSQ INFIT and OUTFIT are both 0.99. The MNSQ INFIT and MNSQ OUTFIT values for the item are 1.00 and 0.99, respectively. In the meantime, ZSTD OUTFIT is -0.2 and ZSTD INFIT is -0.1. The data fits the Rasch model since the MNSQ INFIT and OUTFIT values for the individual and the item are around one and fall between the allowed range of 0.6 and 1.4 (Bond and Fox, 2007). Additionally, ZSTD INFIT and OUTFIT values fall between -2.0 and +2.0, which is the appropriate range recommended by Bond and Fox (2007). With an item separation of 6.20, the sample size is sufficiently large to discern between things with varying degrees of difficulty. According to Linacre (2016), the scale can differentiate between two levels of person-level interest skills, as seen by the person separation of 1.54 and the stratum value of 2.38, as shown in Table 4.

Table 4 Summary Statistics Analysis of the Scale

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|        TOTAL                      MODEL        INFIT        OUTFIT    |
|        SCORE     COUNT    MEASURE   S.E.    MNSQ   ZSTD   MNSQ   ZSTD |
|---------------------------------------------------------------------|
| MEAN    13.2      5.0      -.50     .79     .99    -.2    .99    -.2 |
| P.SD     3.0       .0      1.72     .17    1.17    1.3   1.18    1.3 |
| S.SD     3.0       .0      1.72     .17    1.17    1.3   1.18    1.3 |
| MAX.    23.0      5.0      4.10    1.89    9.90    4.7   9.90    4.3 |
| MIN.     5.0      5.0     -7.68     .62     .05   -2.7    .05   -2.7 |
|---------------------------------------------------------------------|
| REAL RMSE   .94 TRUE SD   1.44  SEPARATION 1.54  PERSON RELIABILITY  .70 |
|MODEL RMSE   .80 TRUE SD   1.52  SEPARATION 1.89  PERSON RELIABILITY  .78 |
| S.E. OF PERSON MEAN = .09                                            |
| CRONBACH ALPHA = .74                                                 |

|        TOTAL                      MODEL        INFIT        OUTFIT    |
|        SCORE     COUNT    MEASURE   S.E.    MNSQ   ZSTD   MNSQ   ZSTD |
|---------------------------------------------------------------------|
| MEAN  1014.6    415.0       .00     .09    1.00    -.1    .99    -.2 |
| P.SD    74.7       .0       .55     .00     .11    1.5    .13    1.7 |
| S.SD    83.6       .0       .62     .01     .13    1.7    .15    1.9 |
| MAX.  1088.0    415.0       .79     .09    1.12    1.5   1.12    1.5 |
| MIN.   909.0    415.0      -.53     .08     .84   -2.3    .82   -2.5 |
|---------------------------------------------------------------------|
| REAL RMSE   .09 TRUE SD    .54  SEPARATION 6.20  ITEM  RELIABILITY  .97 |
|MODEL RMSE   .09 TRUE SD    .54  SEPARATION 6.37  ITEM  RELIABILITY  .98 |
| S.E. OF ITEM MEAN = .28                                              |
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Table 5 shows the scale unidimensionality results. Local independence is also shown there. With an eigenvalue of 1.88 and an unexplained variance in the first contrast of 18.3%, the results show that 51.3 percent of the variance in the data is explained by several elements, 34.5% coming from people and 16.8% from things. In the first contrast, the measure-explained variance and the unexplained variance form a ratio of 2.80:1, which is somewhat less than the 3:1 threshold [34, 35, and 36]. Though the ratio issue of variance is present, the Rasch analysis demonstrates that the scale is a unidimensional construct with an eigenvalue of 1.88 and a sufficient measured explained variance (51.3%). Moreover, there is no violation of the local independence requirement as the residual correlations of each scale item are under 0.7 [36]. Consequently, there is no item redundancy and the goods on the level of interest scale are locally independent (residual correlation < 0.70).

Table 5 Standardized Residuals of the Scale

Level of Interest	Empirical (Observed)		Modeled (Expected)	
Total variance in observations	10.26	100.0%		100.0%
Variance explained by measures	5.26	51.3%		51.1%
Variance explained by measures (Persons)	3.54	34.5%		34.4%
Variance explained by measures (Items)	1.72	16.8%		16.7%
Unexplained variance (Total)	5.00	48.7%	100.0%	48.9%
Unexplained variance in first contrast	1.88	18.3%	37.6%	

Items Fit Analysis: The scale's item fit analysis is shown in Table 6. The MNSQ INFIT and MNSQ OUTFIT values range from 0.84 to 1.12 and 0.82 to 1.1, respectively. ZSTD OUTFIT values range from -2.5 to 1.2, whereas ZSTD INFIT values range from -2.3 to 1.5. According to these findings, all the goods' INFIT and OUTFIT MNSQ values fall within the permitted range, ranging from 0.6 to 1.4. Additionally, all items' OUTFIT and OUTFIT ZSTD values fall inside the permitted range of -2.0 and +2.0, except for item INT5, which has an INFIT score of -2.30 and can be disregarded [36]. The results show that all items are useful for measuring and need not be changed or removed, as shown in Table 6.

Table 6 Items Misfit Order of the Scale

Item	Measure	INFIT		OUTFIT	
		MNSQ	ZSTD	MNSQ	ZSTD
INT1	0.54	1.12	1.50	1.10	1.20
INT4	-0.34	1.11	1.40	1.12	1.50
INT2	-0.45	1.04	0.50	1.07	0.90
INT3	0.79	0.88	-1.5	0.84	-1.90
INT5	-0.53	0.84	-2.3	0.82	-2.50

The gender-specific differential item functioning of the scale was assessed. For the elements in Figure 2, a large DIF contrast is defined as > 0.31 logit, or nearly half a standard deviation (SD = 0.62). The results show no statistically significant gender differences in support rates for every item on the scale. According to the results, the scale findings might be relevant to every undergraduate enrolled in the Embedded System Design course.
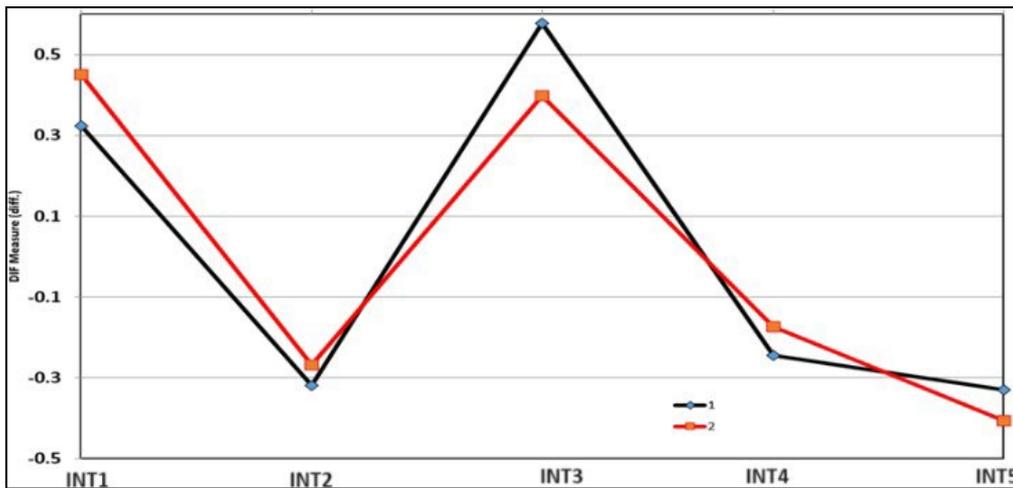
Figure 2. DIF analysis of the scale.

Wright Map: Figure 3 shows that there is no overlap or redundancy among the components and that all of them match the model well (-2 to +2) t value as recommended by Bond and Fox [37]. According to the Wright map, INT3, which is situated at +0.79 logit, is the most challenging item. This result means that most of the students who responded are unable to solve engineering design problems in a way that satisfies the requirements. The simplest item, however, is INT5, which is situated at -0.53 logit and shows that many respondents can use contemporary engineering tools for engineering practice.
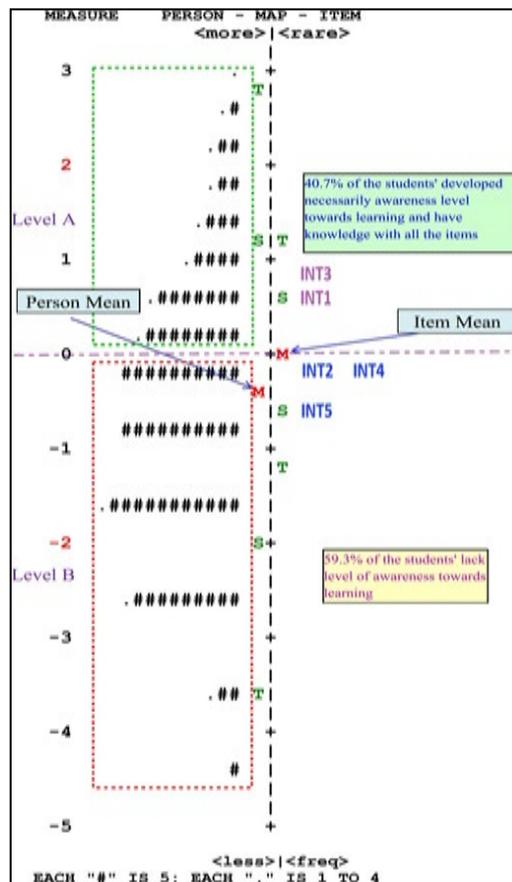
Figure 3. Wright map analysis of the scale.

3.4 Assessment of Level of Interest

The results of the assessment of the students' level of interest using SPSS 29.0 are displayed in Table 7. While the scale's overall mean score is 2.62, the results showed that all of the item mean scores fall below the necessary threshold of 3.40. The findings show that the respondents do not have the necessary degree of interest in understanding embedded system design, which would help them develop greater self-knowledge and make plans and improvements that would help them recognize issues and solve them.

Table 7 Items Mean Score of the Scale

Item	Label	Mean	Percent	Level of Interest
INT1	I am able to identify problems in engineering design process.	2.47	49.4	Poor
INT2	I am able to formulate engineering problems using principles of mathematics.	2.74	54.8	Poor
INT3	I am able to solve engineering design problems to meet specified needs.	2.43	48.6	Poor
INT4	I am able to use the techniques such as modeling necessary for engineering practice.	2.7	54	Poor
INT5	I am able to use new techniques (i.e. including contemporary engineering instruments essential for engineering applications).	2.77	55.4	Poor
Scale Mean Score		2.62	52.44	Poor

4. CONCLUSIONS

For this investigation, a dependable and exact scale to measure students' enthusiasm in studying embedded system design was developed. Although embedded systems are crucial and offer great job chances, the study's findings showed that students were surprisingly little interested in learning embedded systems design. Teachers and business leaders must know the underlying reasons of this indifference to build a labor that can help to develop this industry. The low interest in the course embedded systems design calls for a careful strategy. Including experiential activities and practical uses in the curriculum can help to bridge the gap between theory and practice. Additionally helpful is employing imaginative teaching techniques that make the subject matter more fascinating and relevant. Furthermore, motivating youngsters to explore this significant area even further could be teaching them about the many career choices available to them and the big effect buried systems have on modern technology. Teachers who put these techniques into action help to guarantee that pupils develop a more thorough grasp of embedded systems, therefore guaranteeing that the workforce is ready and willing to drive future technological advancements. Specific areas for more investigation include better grasp of the subtleties of students' experiences in embedded systems education.

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