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Assessing Urban and Rural Teachers' Competencies in STEM Integrated Education in Malaysia

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Abstract. In order to fulfil the need of sizeable skill workers, Malaysia will introduce STEM integration education in mainstream schools throughout the country. However, like any educational reform, one important issue that needs to be taken into account is the teachers' readiness especially in terms of their skills and competency in implementing the reform. As such, the purpose of this study is to assess differences between teachers' competency for STEM integration education between urban and rural teachers. A total of 244 teachers (urban = 129, rural = 115) are employed as sample in this cross-sectional quantitative study. Responses from an 18-item questionnaire were analysed using Rasch Model analysis to determine characteristics of item that measure competency between urban and rural teachers. The DIF analysis shows that items related to competency in (1) ICT integration, and (2) organizing co-curricular activities showed a significant difference in their measures between both sets of teachers. The result from this study would certainly provide useful information to relevant stakeholders, especially with regards to providing training for the teachers in the designated areas.

1 Introduction

In the quest to become a developed nation in 2020, Malaysia requires a sizeable number of skilled workers in science and technology. To meet the requirement, the government has turned its attention to encourage students to enrol in Science, Technology, Engineering, and Mathematics (STEM) subjects through the integration of STEM education in teaching and learning in the year 2017. STEM integrated education is defined as an approach to explore teaching and learning between any two or more STEM components or between one STEM components with another branch of knowledge [1]. The integration can occur in a particular unit of learning as well as through other related activities [2]. This is an effort to produce students with STEM literacy – defined as the ability to identify and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to make innovations to solve the problem. In order to achieve this, students need to have good experience with STEM subjects at school levels.

The roadmap for STEM integrated education in Malaysia is well documented in the Malaysian Education Blueprint 2013-2015 [3]. The blueprint underlines three steps to strengthened STEM education in Malaysia. Firstly, is to increase students' interest through new learning approaches as well as improved curriculum. Strategies that can be implemented range from the inclusion of higher order thinking skills to making subject content relevant to everyday life. Secondly, by improving teachers' skills and competencies through continuous training. Thirdly, the Ministry of Education has also put efforts to increase both students and parents awareness about the importance and opportunities in STEM fields.

According to reference [4], integrated curriculum such as STEM integrated education helps to provide more relevant and open experience for the students. They are required to apply problem-solving skills as well as their knowledge about STEM content to relate their learning experience with real life activities [5]. Reference [6] concludes that the main purpose of STEM education is to enhance one's ability to address STEM-related personal, social, as well as global issues. To do this, STEM education should emphasize on problem-based learning [7]. Apart from problem-solving, reference [8] mentions that STEM education is also necessary to produce students with the following knowledge and skills: innovation, creative, independent, logic, and IT-savvy.

Nevertheless, the proposed STEM integration education is expected to face some difficulties. Firstly, Malaysia is experiencing a decline in enrollment of science students at secondary school and university levels. In 2012, only about 33-40% students were learning science at school level [9]. As such, the aim to produce 500,00 scientists by 2020 might not be achieved. Secondly, Malaysian students' performance in science and mathematics at international level is far from encouraging. For example, in the Program for International Student Assessment (PISA), nearly 60% of the Malaysian respondents fail to achieve minimum benchmark in mathematics while 43% get a similar result

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in science [3]. Thirdly, apart from difficulties related to students' enrollment in STEM fields, Malaysia is also facing problems regarding the teachers' readiness in educational reform. For example, one of the factors for discontinuation of national-wide educational reform named *Teaching Mathematics and Science in English* (PPSMI) is attributed to the fact that teachers are not ready to teach those subjects in English. Rather, they are more comfortable to teach in their mother tongue [10]. While the Ministry of Education has taken many initiatives to overcome the two recent challenges, less attention, however, is focussed on the issue of teachers' readiness especially in assessing their competencies for STEM integration education.

2 Teachers' Competency for STEM Integration Education

Teacher is considered as an important factor in influencing successfulness in many educational reform such as integration of STEM education [11]. Reference [12] meanwhile, quotes that for STEM educators to function effectively, the teachers are required not only to understand their content taught but also have the ability to explain concepts and procedures. In addition, teachers themselves also need to immerse in technology so that they are able to explain how fun STEM integrated education is. This is important since there is a common fear that STEM is difficult both to learn and to teach. This misconception needs to be addressed to encourage more students to enrol in STEM-related areas. More importantly, there is a need to investigate teachers' readiness in the integration of STEM education, especially regarding their knowledge and skills so that this high-stake national-level educational reform can achieve its objectives.

One possible problem that may arise in implementing STEM integration education is the gap between urban and rural areas especially regarding facilities and other resources. Like many other countries, urban schools in Malaysia are said to enjoy better facilities and resources compared to their rural compatriot. The gap then leads to differences in students' achievement, provision of infrastructures as well as dropout among students learning science and technology. This will eventually result in socioeconomic imbalance between urban and rural areas. Also, it is also well known that urban schools enjoy better quality teachers. Despite this imbalance, the proposed STEM integration education is expected to produce similar results between the two set of schools. The existing gaps, therefore, is hypothesized as an important variable that determines the successfulness of STEM integration education. As such, the present study is conducted to assess differences teachers' competencies for integrating STEM education between urban and rural teachers. The findings provide information that may be useful to relevant stakeholders to be taken into consideration in implementing STEM integration education.

3 Method

3.1 Sample

Sample of the present study consists of 129 (52.9%) urban school and 115 (47.1%) rural school teachers. It comprises of 206 (84.4%) female teachers and 38 (15.65%) male teachers. The mean of their teaching experience is 13.6 years (SD = 7.3 years). The teachers are from the states of Penang, Kedah, Perak, and Selangor. Information on the main subject taught by the teachers is given in the following Table 1.

Table 1. Main Subject taught by the Sample.

	Subject	N	%
1	Mathematics	64	26.2
2	Science	63	25.8
3	Physics	14	5.7
4	Biology	15	6.1
5	Chemistry	25	10.2
6	Others	63	25.8
		244	100.00

3.2 Instrument

This study gauges responses of the sample using an 18-items questionnaire developed specifically for this study. The instrument covers various aspects of teachers' competencies such as academic, knowledge, as well as skills in integrating STEM education into their teaching and learning. Response on the item is measured using 6-point Likert scale continuum, where '1' indicates Strongly Disagree, while '6' denotes Strongly Agree responses.

3.3 Data Analysis

The data was analyzed using Rasch Model measurement framework. In a nutshell, this modern test theory provides significant advantages for a better precision in measurement of a unobservable construct such as teachers' competency. More specifically, the model transforms raw scores into an equal-interval unit of measurement such as in a ruler. This transformation is done in a procedure called calibration where both item difficulty and teachers' competency parameters are estimated. Scores from the parameters estimation process are called 'measures' and are defined in logits unit. The equal-interval property is important in this study since it does not only provide identification of the differences in teachers' competency but also able to demonstrate how much the differences is.

Even though it provides a huge opportunity for precision in measurement, Rasch Model comes with strong assumptions. Two important assumptions must be met before the data can be treated as equal-interval property. Firstly, the data collected must fit the model's expectation and secondly, the construct must pose a unidimensionality property [13]. Model – data fit is an important assumption for many estimation procedures like Rasch Model analysis. It helps to identify discrepancies between the model's expectation and the data collected to ensure that the measurement procedure can measure the intended construct adequately and at the same time keeping the unintended constructs in a reasonable proportion. In this study, model-fit issues are addressed by investigating the infit and outfit, mean-squares (MNSQ) by adopting the criteria of 0.6 – 1.4 logits set by reference [14]. Unidimensionality, meanwhile, assumes that items in a test measure a single construct [15]. In this study, a principal component analysis (PCA) of residuals procedure helps to identify the second construct, apart from the intended one that may become a threat to unidimensionality assumptions. This study applies guideline suggested by reference [13], where the unexplained variance from the first factor in the PCA of residuals procedure should be less than the strength of 5 items.

Apart from the assumption of model – data fit and unidimensionality, this study also run differential item functioning (DIF) analysis of every item in the instrument. The procedure is aimed at identifying how much each item is different between the urban and rural teachers. DIF contrast statistic from Rasch Model analysis offers the straightforward procedure to detect item that shows evidence of DIF. The values of > ±.5 logits indicate that the particular item function differently between urban and teachers [14].

4 Results and Discussion

The Rasch Model analysis from Winsteps 3.63 identifies two items (Item 10 and Item 11) which do not fit the model's expectation, and thus removed from further analysis. Table 2 shows final items' statistics from the Rasch Model analysis. All items demonstrate acceptable infit and outfit MNSQ values of between 0.6 – 1.4 logits. Meanwhile, based on Figure 1, the unexplained variance from the first factor is 2.8 which is about the strength of 3 items. Since the data fulfilled both assumptions of model-data fit and unidimensionality, the items' measure from the analysis demonstrates the property of equal-interval.

Table 3 demonstrates DIF analysis of all 18 items based on urban (examinee class 1) and rural teachers (examinee class 2). For Q1 (*I have the relevant academic qualifications to integrate STEM in teaching and learning*), DIF measure for urban teachers is −1.56 logits while rural teachers recorded a slightly lower measure of −1.84 logits. Even though there is a different of .28 logits [−1.56 – (−1.84 logits)] between both set of scores, the difference is not significant based on DIF Contrast statistic of .27 logits which is less than .5 logits [14]. Thus, it can be concurred that both urban and rural teachers endorse that they have the competency in terms of relevant academic qualification to integrate STEM education into teaching and learning. Overall, the present study recorded a satisfactory result where 14 out of 16 items (87.5%) function similarly across both urban and rural teachers, with only two items (Q13 and Q14), show otherwise.

With regards to Item Q13 (*I am able to incorporate ICT in integrating STEM in teaching and learning*), urban teachers show significantly more competence (measure= −1.15 logits) compared to rural teachers (measure= −.34 logits). The result is rather not unexpected since it is well known that urban areas enjoy

Table 2. Item Statistics

ENTRY NUMBER	RAW SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEA CORR.	item
1	958	232	-1.68	.12	1.31	3.0	1.18	1.7	.70	Q1
2	839	244	.61	.11	.73	-3.2	.72	-3.1	.86	Q2
3	800	244	1.07	.11	.86	-1.5	.82	-1.9	.84	Q3
4	876	244	.16	.11	.65	-4.2	.67	-3.6	.87	Q4
5	830	244	.72	.11	.77	-2.7	.74	-2.8	.87	Q5
6	821	244	.83	.11	1.10	1.0	1.05	.5	.83	Q6
7	886	244	.03	.11	.72	-3.3	.74	-2.7	.84	Q7
8	887	244	.02	.11	.70	-3.5	.68	-3.5	.84	Q8
9	975	227	-2.21	.13	1.19	1.9	1.12	1.2	.71	Q9
10	DELETED									Q10
11	DELETED									Q11
12	877	244	.15	.11	.91	-.9	.89	-1.1	.83	Q12
13	948	244	-.79	.12	1.27	2.6	1.31	2.8	.76	Q13
14	882	244	.08	.11	1.38	3.6	1.33	2.9	.73	Q14
15	885	244	.05	.11	.82	-2.0	.83	-1.8	.83	Q15
16	788	244	1.21	.11	1.26	2.7	1.26	2.5	.80	Q16
17	896	244	-.10	.11	.93	-.7	.83	-1.7	.81	Q17
18	900	244	-.15	.11	1.27	2.6	1.13	1.2	.77	Q18
MEAN	878.0	242.2	.00	.11	.99	-.3	.96	-.6		
S.D.	51.8	4.9	.89	.01	.25	2.6	.23	2.3		

		Empirical		Modeled
Total variance in observations	=	75.8	100.0%	100.0%
Variance explained by measures	=	59.8	78.9%	77.9%
Unexplained variance (total)	=	16.0	21.1%	22.1%
Unexpl var explained by 1st factor	=	2.8	3.7%	

Figure 1. Principal Component Analysis of the Residuals

Table 3. DIF Analysis

EXAMINEE CLASS	DIF MEASURE	DIF S.E.	EXAMINEE CLASS	DIF MEASURE	DIF S.E.	DIF CONTRAST	JOINT S.E.	t	d.f.	Prob.	item Number	Name
1	-1.56	.17	2	-1.84	.19	.27	.25	1.09	230	.2768	1	Q1
1	.77	.15	2	.42	.17	.35	.22	1.58	242	.1165	2	Q2
1	1.16	.14	2	.96	.16	.21	.22	.95	242	.3432	3	Q3
1	.22	.15	2	.08	.17	.15	.23	.65	242	.5141	4	Q4
1	.68	.15	2	.77	.16	-.09	.22	-.42	242	.6773	5	Q5
1	1.00	.14	2	.61	.17	.39	.22	1.77	242	.0787	6	Q6
1	.11	.15	2	-.07	.17	.18	.23	.80	242	.4250	7	Q7
1	.02	.15	2	.02	.17	.00	.23	.02	242	.9858	8	Q8
1	-2.05	.17	2	-2.41	.19	.36	.26	1.39	225	.1666	9	Q9
1	.16	.15	2	.13	.17	.02	.23	.10	242	.9181	12	Q12
1	-1.15	.16	2	-.34	.17	-.82	.24	-3.47	242	.0006	13	Q13
1	-.23	.15	2	.47	.17	-.70	.23	-3.11	242	.0021	14	Q14
1	-.02	.15	2	.13	.17	-.16	.23	-.69	242	.4896	15	Q15
1	1.06	.14	2	1.39	.16	-.33	.21	-1.56	242	.1202	16	Q16
1	-.02	.15	2	-.19	.17	.16	.23	.72	242	.4732	17	Q17
1	-.11	.15	2	-.19	.17	.07	.23	.32	242	.7500	18	Q18

better ICT facilities and internet connections, which in turns encourage them to integrate ICT in teaching and learning [16]. As rightly observes by reference [17], digital disparities between urban and rural school can be seen in terms of (1) funding, and (2) ready access to technology. Meanwhile, reference [18] argues that teachers at rural schools are also lacking regarding skill and experience as well as technical training. However, one of the most important issues regarding ICT integration is the (poor) internet connection at rural schools [19]. Therefore, one might speculate that STEM integration in rural school may face difficulty to implement the STEM integration education. In order to address this issue, researcher such as reference [20] have suggested that school leaders to adopt technology leadership style – where they took the initiative to lead technology integration in various aspect in school organisation such as in the (1) vision and leadership, (2) teaching and learning, (3) professional practices and productivity, (4) infrastructure, and (5) support, management and control of ICT. These comprehensive aspects of leadership are said to be a major factor that influences technology integration in schools.

Item Q14 (*I can organize co-curricular activities related to STEM integration for students*), urban teachers (measure = –.23 logits) also show significant more competency compared to rural teachers (measure = .47 logits). This is surprising since co-curricular activities is an essential component of the school curriculum and comprehensive guidelines have been provided to schools and teachers. For example, teachers can choose to rather extracurricular activities conduct activities for 45 type of clubs and society, 43 sports and games as well as 19 uniform units with time allocation between 60 – 120 minutes each week [21]. The result, however, certainly needs to be investigated further since co-curricular activities are identified as one important avenue to attract students' interest in science and technology especially when it is aligned with what been taught in the classroom.

5 Conclusion

Teacher is an important factor in determining quality as well as successfulness of STEM integration program. Therefore, it is important for them to acquire knowledge and skills especially the STEM-specific methods of teaching such as project-based learning. This study reports that in most cases, there is no significant differences between in teachers' competencies for both urban and their rural counterparts. However, the researcher is also able to identify two areas where gaps between urban and rural teachers regarding their competency in integrating STEM education exist. It was found that the rural teachers lack competency in incorporating ICT in teaching and learning. In contrast, the rural teachers are more competent in organizing co-curricular activities related to STEM integration compared to the urban teachers. The finding is rather important since if left unattended, it is highly unlikely that rural schools are able to get the benefits promised by STEM integration education. Ultimately, it will also affect the aspiration for 50% reduction in achievement gaps between urban and rural students come the year 2020.

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