APPLYING THE RASCH MODEL TO EVALUATE THE EFFECTIVENESS OF INCORPORATING MULTIPLE INTELLIGENCES THEORY IN INFORMAL SCIENCE LEARNING USING THE MOBILE SCIENCE LAB PROGRAM

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Abstrak

Pembelajaran sains secara tidak formal telah dijalankan melalui Program Makmal Sains Bergerak. Program ini merupakan program kemasyarakatan yang dijalankan oleh pensyarah dari Pusat Pengajian Ilmu Pendidikan (PPIP) di Universiti Sains Malaysia (USM) dan dibantu oleh pelajar dan staf sebagai fasilitator. Program ini mengandungi 12 stesen mini yang boleh diwujudkan di kawasan sekolah atau di dewan sekolah. Teori Kecerdasan Pelbagai (KP) telah dimasukkan ke dalam aktiviti pembelajaran sains tidak formal Program Makmal Sains Bergerak. Kajian ini telah dijalankan untuk menilai keberkesanan menggabungkan teori KP ke dalam pembelajaran sains tidak formal menggunakan Model Rasch terhadap terhadap 300 orang pelajar sekolah rendah di Pulau Pinang, Malaysia, yang telah terlibat dalam program ini. Hasil kajian menunjukkan bahawa keseronokan dan minat pelajar terhadap sains selepas mendapat pengalaman pembelajaran sains tidak formal melalui Program Makmal Sains Bergerak telah meningkat. Keputusan juga menunjukkan peningkatan dalam Program Makmal Sains Bergerak perlu dilakukan dari perspektif pembelajaran. Kajian ini menunjukkan bahawa Program Makmal Sains Bergerak adalah program pendidikan yang berjaya dalam suasana tidak formal dan teori KP adalah berkesan apabila digabungkan dengan pembelajaran sains tidak formal dalam Program Makmal Sains Bergerak.

Kata Kunci: Pembelajaran sains tidak formal, Program Makmal Sains Bergerak, teori Kecerdasan Pelbagai, Model Rasch

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Abstract

Informal Science Learning was conducted through the Mobile Science Lab Program. The program is a community program conducted by lecturers from the School of Educational Studies (SES) at Universiti Sains Malaysia (USM) and supported by students and members of staff as facilitators. The program contains 12 mini stations that could be set up in the school ground or in the school hall. Multiple Intelligences (MI) theory was incorporated into informal science learning activities of Mobile Science Lab Program. This study was carried out to evaluate the effectiveness of incorporating MI theory into informal science learning using the Rasch Model with 300 primary school students of Penang, Malaysia, who involved in this program. Results showed that students' excitement and interest toward science after experiencing informal science learning through the Mobile Science Lab Program had increased. Results also showed that improvements in the Mobile Science Lab Program need to be made from the learning prespective. This study showed that Mobile Science Lab Program is a successful educational program in informal setting and MI theory is effective when incorporate with informal science learning in the Mobile Science Lab Program.

Keywords: *Informal science learning, Mobile Science Lab Program, Multiple Intelligences theory, Rasch Model*

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1.0 Introduction

Science is a subject that is often said to be difficult to learn and not interesting to students. Gordon (2000) states that students are not interested to learn science because teachers use out-of-date methods of teaching. To address the situation, a more practical approach to teaching is needed to increase student interest in science and in making science relevant to life. This aim can be achieved by the use of Informal Science Learning. Informal Science Learning is defined as learning outside of the school environment, not developed to be used for the purpose of examination and not developed to become a part of the school curriculum. Participation is voluntary and not through coercion (Crane, Nicholson, Chen & Bitgood, 1994). Therefore, Informal Science Learning can be defined as learning outside the classroom and not controlled by any particular teacher.

According to Gerber, Cavallo and Marek (2001), informal learning experiences become the preferred choice in science education as beneficial to student learning. This type of learning gives the students an opportunity to pursue a topic of personal interest on their own terms (Rennie, 2007). In this study, the idea of informal science learning can be concretized by providing a Mobile Science Lab Program for students. It is a community program conducted by lecturers from the School of Educational Studies (SES) at Universiti Sains Malaysia (USM) which is supported by students and staff as facilitators. Mobile Science Lab is defined as a mobile science centre which can be moved from one school to another. Just like most science centres and exhibitions in big cities, the mobile science lab is able to cater for the rural population especially rural students. Thus, for the research purpose, a Mobile Science Lab Program aims to cater science exhibitions for the economically disadvantaged primary school students in rural schools by giving them the opportunity to experience science learning in a fun, informative and informal way and also to stimulate their curiosity about the world they live in. Besides, with informal science learning through the Mobile Science Lab Program, the students' perceptions that science is boring can be changed and science can also be easily linked to the real life experiences of the students (Lee & Fradd, 1998).

Furthermore, the Mobile Science Lab Program is designed to facilitate and provide opportunities for students to gain experience, acquire the knowledge and skills and construct new knowledge with the guidance of facilitators. Before the facilitators can be directly involved with the Mobile Science Lab Program, they were guided by the lecturers from SES, USM who are also the experts of Informal Science Learning. The education is to make sure all facilitators can guide students well during the program and most importantly they must master the science concept associated with each activity. In brief, the facilitators' job is to (i) give guidance on how to conduct the activity by guided inquiry, (ii) ask questions in order to stimulate students' thinking and (iii) provide certain information about abstract concepts that are useful in formal learning in school or in students' daily lives.

The Mobile Science Lab Program consists of 12 mini stations which are portable and could be set up in the school grounds or in the school hall. Each station has its own hands-on activity involving science concepts and using daily life materials as informal science learning materials. These stations can be easily set up either in the school hall or on school grounds and the materials can be readily stored in boxes when not used. The characteristics of each science station are:

- Less text, more hands-on involvement
- Fun and interesting
- Simple and informal
- Involves the use of daily life materials and relates with daily life situations

The activities in each station of the Mobile Science Lab Program allow students to learn and work as scientists. Besides, students also learn and work in a team in order to investigate problems with scientific equipment using a scientific method. Students also propose a hypothesis, conduct experiments, collect data and arrive at conclusions through hands-on activities related to daily life. According to participants, this program gives the opportunity to do a fun and enjoyable learning activity that cannot be easily forgotten and more importantly, the Mobile Science Lab Program provides scientific knowledge in a fun and informal way. Before commencing the program, students were divided into small groups consisting of four (4) to eight (8) students per group. Each group moved from one station to another within two to three hours. The students' movements were monitored by facilitators. Before beginning the activities at each station, students were provided with a blank sheet of paper on which they were required to provide a summary of what they had learned in the previous station that they had visited.

In addition, all the science learning activities were designed based on the science curriculum in Malaysia and were related to students' daily lives. Figure 1 below shows some of the science materials from two stations of the Mobile Science Lab Program which consist of daily life materials. Figure 2 shows informal science learning activities at two stations of the Mobile Science Lab Program.

Figure 1: Science Materials of the Mobile

Figure 2: Informal Science Learning Activities of the Science Lab Program

In brief, the Mobile Science Lab Program involving informal learning has several advantages as stated below.

i. Development cost - the cost of developing the Mobile Science Lab Program is cheaper than that of constructing and furnishing a complete fixed laboratory (Szydlowski & Sheila, 2009).

ii. Easy to move and its activities can be adapted to meet the multidimensional cognitive, affective and psychomotor skills of students of all ages.

iii. A program that supports and complements the school science curriculum – the Mobile Science Lab Program can be a supportive program that can complement the students' learning in order to enrich their science culture by inculcating science interests, knowledge of science and attitudes towards.

Besides, the development and design of informal science learning activities for Mobile Science Lab Program was incorporate with Multiple Intelligences (MI) theory. Gardner's MI theory (1983) is a useful alternative with the ability of addressing individual needs. Furthermore, McKenzie (2012) stated that MI can supports and enhance learner's critical thinking, personal thinking and active learning. In fact, Gardner (1993) posits that intelligences can be educated or developed through learning and they need to be nurtured with appropriate encouragement, enrichment and instruction. In addition, MI approach emphasizes the exploration and understanding of the students in their learning process (Hopper & Hurry, 2000). This shows that this approach is student-centered. According to Carroll (2000), a student-centered approach is more effective in developing science process skills. This is because activities involving science process skills involve affective, cognitive and psychomotor dimensions of the student, especially while performing science experiments in groups. This situation is likely to be associated with the use of certain intelligence that allows scientific experiments done successfully. Based on the arguments put forward, the MI theory was integrated with informal science learning activities of Mobile Science Lab Program in order to nurtured and develop students' MI which consequently develop and enhance students' science process skills. The nine intelligences in MI theory are verbal-linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical-rhythmic, interpersonal, intrapersonal, naturalist and existential, which are briefly explained below.

Verbal-Linguistic Intelligence: This intelligence is defined as sensitivity to the spoken & written language and using a language to achieve goals (Gardner, 1993).

Logical-Mathematical Intelligence: This intelligence is the understanding and use of logical structure including patterns and relationships and statements and propositions through experimentation, quantification, conceptualization and classification (Armstrong, 2003).

Visual-Spatial Intelligence: This intelligence is defined as the ability to learn visually and organize idea spatially (McKenzie, 2009). This intelligence is stimulated by seeing concepts in action in order to understand them, as well as the ability to “see” things in one’s mind.

Bodily-Kinesthetic Intelligence: Interaction with one’s environment. This intelligence promotes understanding through concrete experience, which can include fine and gross motor tasks that promote understanding of skills and concepts (McKenzie, 2012).

Musical-Rhythmic Intelligence: This intelligence is defined as sensitivity to pitch, melody, rhythm and tone (Gardner, 1983).

Interpersonal Intelligence: This intelligence is defined as an ability to understand people and relationship (Gardner, 1983). According to McKenzie (2012), this intelligence promotes the social aspect of understanding through interaction, collaboration and feedback while working cooperatively with others.

Intrapersonal Intelligence: Access to one’s emotional life as a means to understand oneself and others (Gardner, 1983). This intelligence is a decidedly effective component of learning through which students place value on what they learn and take ownership for their learning (McKenzie, 2012).

Naturalist Intelligence: This intelligence is defined as the capacity to recognize and classify the numerous species of flora and fauna in one’s environment and the ability to care for, tame, or interact subtly with living creatures or with the whole ecosystem (Armstrong, 2003).

Existential Intelligence: This intelligence seeks contexts for real world understandings and applications of new learning which includes personal, communal and curricular connections (McKenzie, 2012).

2.0 Aim of the Study

This study was carried out to evaluate the effectiveness of incorporating multiple intelligences theory into informal science learning through Mobile Science Lab Program by applying Rasch Model.

3.0 Method

The study was carried out using a quasi- experimental design with pre and post test without control group. The samples of this study consist of 300 primary school students (150 male students and 150 female students) of Penang Malaysia, aged 12 and studied science at school. All samples completed the science activities and experiments of Mobile Science Lab Program in the informal science learning setting. Pre-test and post-test were employed in order to get the samples' response toward effectiveness of incorporating multiple intelligences theory into informal science learning through Mobile Science Lab Program.

4.0 Data Analysis

Data obtained were analyzed by Rasch analysis using the "Rack and Stack" approach described by Wright (2003). According to Wright (2003), racking and stacking allows the treatment of pre-test and post-test data by measuring the changes either by persons (patients, students, experimental subjects) from Time 1 to Time 2 or the functioning of test items and rating scales, even when identical data collection protocols are used. In addition, Wright (2003) stated that measures of persons and items must be in the same clearly defined frame of reference encompassing both time points, so that measurements of change will have unambiguous numerical representation and substantive meaning. Most analyses, including those using raw scores as measures, assume without verification that the functioning of test items and rating scales remains constant across time. Racking and stacking data are briefly explained below.

4.1 Racking the data

Racking data is done to see what data have changed. Racking refers to placing Time 1 and Time 2 data together horizontally. Persons are considered to be unchanged, but the items are to move between Time 1 and Time 2 (see Figure 3). This investigates what the impact of the intervention is on the difficulty of each item from the sample's perspective.

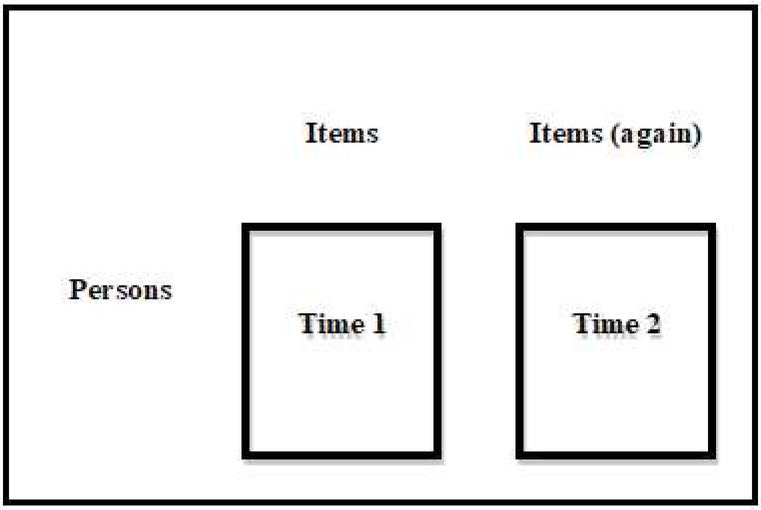

Figure 3: Racking data

(Adapted from Wright, 2003)

4.2 Stacking the Data

Stacking the data involves ascertaining who has changed. Stacking refers to placing Time 1 and Time 2 data together vertically. Items are considered to be unchanged, but the persons move between Time 1 and Time 2 (see Figure 4). This procedure investigates the impact of the intervention on the ability of each person to answer the items in the test.

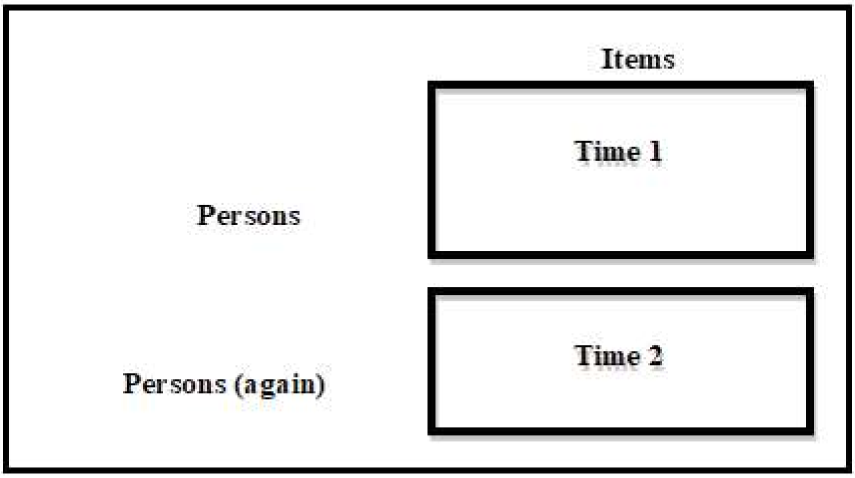

Figure 4: Stacking data

(Adapted from Wright, 2003)

According to Wright (2003), stacking involves treating students who completed the pre-test and post-test as different students, each of whom answered the same items. The rationale for stacking is that students change as a result of a course of instruction, so they are effectively different students. Therefore, the purpose of stacking is the examination of the ability of individual students to answer all items in the pre-test and in the post-test.

In this study, Rasch analysis by racking and stacking the data of the pre-and post-test responses indicated the (i) domains of interest in which students perceived they had improved during the Mobile Science Lab Program and the (ii) domains in which they perceived they were less interested in after the Mobile Science Lab Program.

5.0 Result and Discussion

5.1 Racked Data

The issue of interest with the racked data was the location of 50 items, 25 from the pre-Mobile Science Lab Program implementation and 25 from the post-Mobile Science Lab Program implementation. The item locations are shown in Table 1, together with changes in location (post-test location minus pre-test location).

Table 1: Item Locations and Changes in Location of Racked data

Pre-Test	Post-Test	Change in Location	Item Description
0.62	0.87	0.25	We learn science better when we do science experiments
0.21	0.37	0.16	I would like to join a science club
-0.45	-0.56	-0.11	I like watching science programmes on TV
3.58	3.4	-0.18	There are many exciting things happening in science and technology
1.17	0.96	-0.21	Science and technology are helping the poor
-1.33	-1.57	-0.24	I would like to become a scientist
-1.57	-1.87	-0.3	I would like to study more science in the future
-0.09	-0.4	-0.31	I like reading science books
-0.13	-0.45	-0.32	I would like to have a job working with science
0.57	0.21	-0.36	I like reading science magazines
-0.01	-0.4	-0.39	I look forward to science experiments
2.03	1.62	-0.41	Scientist has exciting jobs

-0.68	-1.13	-0.45	Science and technology makes our lives easier and more comfortable
2.35	1.9	-0.45	I like science experiment because I can decide what to do myself
-1.23	-1.71	-0.48	Science experiment is good because I can work with my friends
1.49	0.98	-0.51	I would like to become a science teacher
-0.26	-0.82	-0.56	I would like more science experiments in my science lesson
0.03	-0.62	-0.65	The benefits of science are greater than the harmful effects
-1.13	-1.87	-0.74	I would like to study science at university
1.53	0.72	-0.81	I would like to do more science activities outside school
-1.05	-1.87	-0.82	It is exciting to learn about new things happening in science
2.19	1.3	-0.89	I like science experiment because I do not know what will happen
0.87	-0.68	-1.55	Science technology is important for society
-2.06	-3.7	-1.64	Science experiments are exciting

The items with low negative locations attracted high numbers of positive responses. Based on the results in Table 1, negative changes in location indicated that students as a group knew more at the end of the Mobile Science Lab Program than at the beginning about the topic addressed by the item.

For example, the pre-test Item “Science experiments are exciting” was located at -2.06, so attracted a relatively high number of ‘positive’ responses. The same item in the post-test was located at -3.70, so attracted an increased number of positive responses. Therefore, the change in location was negative (-1.64) and this value indicated that, overall, the ‘excitement of doing science experiments’ was greater after the Mobile Science Lab Program than before it. This means that students become more excited and enjoyed their learning by learning science in an informal way through the Mobile Science Learning Program.

According to Rudolph (2002), science instruction in schools focuses narrowly on received knowledge and simplistic notions of scientific practice. This showed that formal science learning in school is focused on giving knowledge to students and involved limited student activities. But, informal science learning is on the other hand a learning experience that is self-motivated and completely voluntary on the part of the learner (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003; Rennie, 2007). In brief, students are actively involved in their learning. According to Dierking et al. (2003), in informal settings, students are free to explore and are able to pursue their scientific motivation. Thus, students become more excited doing science experiments after undergoing informal science learning through the Mobile Science Lab Program. This finding is supported by Feninchel and Schweingruber (2010) who said that,

> "*Through informal science learning, we can all experience this joy as our eyes are opened to the excitement and wonder that is science*"(p. xv).

Furthermore, Feninchel and Schweingruber (2010) also stated that successful informal science learning has been able to increase enjoyment. Based on the results, students' excitement of doing experiments had increased after learning science informally through the Mobile Science Lab Program. This means that the Mobile Science Lab Program is successful in increasing students' excitement in their science learning.

This finding is about items with low negative locations. Meanwhile, the items with high locations attracted relatively low numbers of positive responses; positive changes in location between corresponding items indicated students as a group perceived their interest in the topics addressed by the items was less at the end of the Mobile Science Lab Program than at the beginning. For example, referring to Table 2, the pre-test item '*We learn science better when we do science experiments*' was located at 0.62 and the same item in the post-test was located at 0.87. The change in location was +0.25.

Table 2: Example of item with High Locations

Pre-Test	Post-Test	Change in Location	Item Description
0.62	0.87	0.25	We learn science better when we do science experiments
0.21	0.37	0.16	I would like to join a science club
-0.45	-0.56	-0.11	I like watching science programmes on TV
3.58	3.4	-0.18	There are many exciting things happening in science and technology
1.17	0.96	-0.21	Science and technology are helping the poor
-1.33	-1.57	-0.24	I would like to become a scientist
-1.57	-1.87	-0.3	I would like to study more science in the future
-0.09	-0.4	-0.31	I like reading science books
-0.13	-0.45	-0.32	I would like to have a job working with science
0.57	0.21	-0.36	I like reading science magazines
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2.03	1.62	-0.41	Scientist has exciting jobs
-0.68	-1.13	-0.45	Science and technology makes our lives easier and more comfortable
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-1.23	-1.71	-0.48	Science experiment is good because I can work with my friends
1.49	0.98	-0.51	I would like to become a science teacher
-0.26	-0.82	-0.56	I would like more science experiments in my science lesson
0.03	-0.62	-0.65	The benefits of science are greater than the harmful effects
-1.13	-1.87	-0.74	I would like to study science at university

1.53	0.72	-0.81	I would like to do more science activities outside school
-1.05	-1.87	-0.82	It is exciting to learn about new things happening in science
2.19	1.3	-0.89	I like science experiment because I do not know what will happen
0.87	-0.68	-1.55	Science technology is important for society
-2.06	-3.7	-1.64	Science experiments are exciting

Therefore, students' responses indicated that, as a group, they believed to a limited extent that they learn science better when doing science experiments; their belief further decreased by the end of the Mobile Science Lab Program. Thus, it is suggested that the Mobile Science Lab Program did not successfully address the issue of learning. This is due to the program timing which is about two to three hours only with each group of students moving from one station to another within that time. This situation resulted in learning process occurring only for a short period of time. Therefore, for the improvement of the Mobile Science Lab Program from the learning aspect, the program timing will have to be longer than before so that the learning process that takes place is better and students are able to master and understand science concepts for each informal science learning activity conducted by them at each station of the Mobile Science Lab Program. Besides, as a result of this improvement, the Mobile Science Lab Program is expected to provide learning activities that will engage every student in a continuous collaborative process. This process of building and reshaping understanding will occur as a natural consequence of students' experiences and interactions within learning environments that will authentically reflect the world around them. Hence, students can relate science learning with their existing knowledge and also with their daily life. This is called meaningful learning. Meaningful learning is defined as conscientiously integrating new knowledge with knowledge that the learner already possesses (Novak, 1992). To summarise, the overall results of racked data are shown in graphical form in Figure 5.

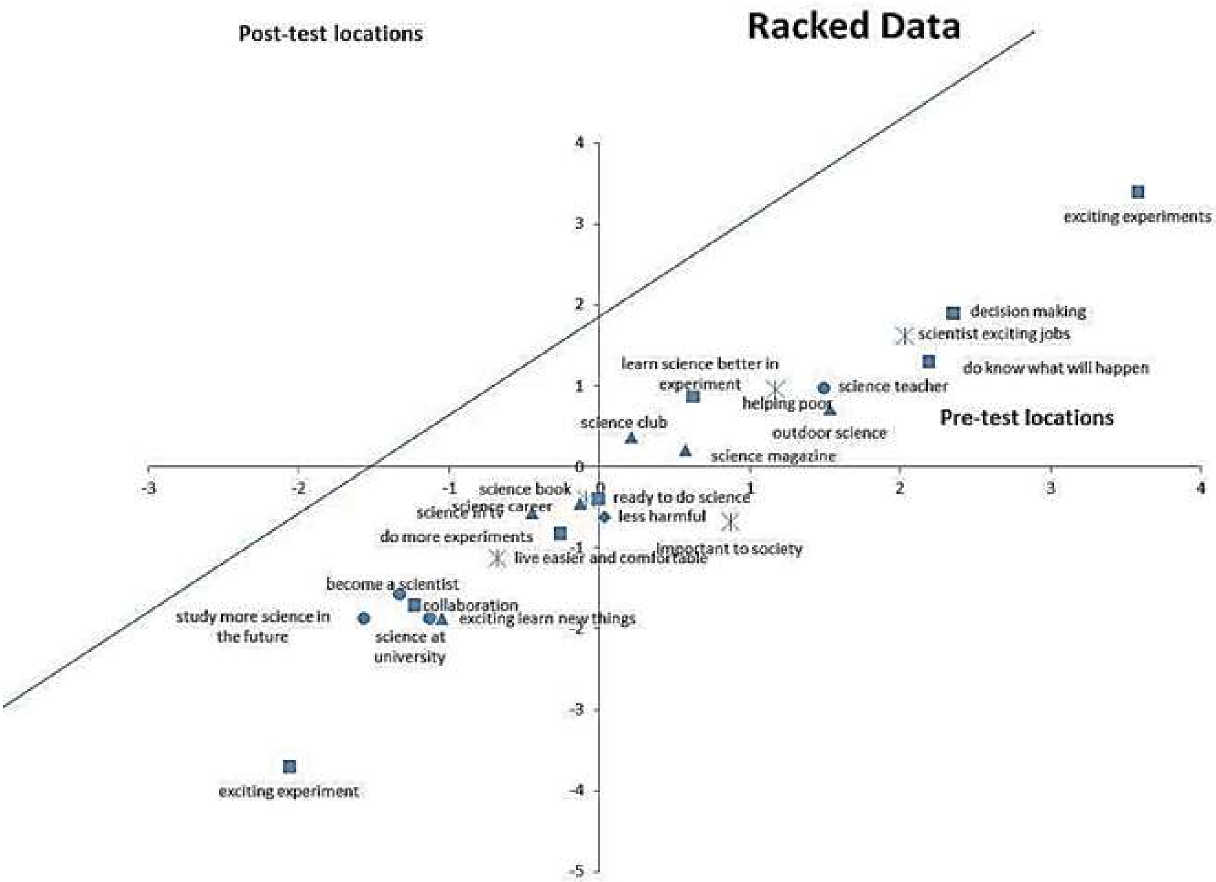

Figure 5: Pre-test and Post-test of Racked Data

5.2 Stacked Data

The interest with the stacked data was the pre-test and post-test locations of each student. High locations indicate students chose relatively high numbers of positive responses. In this study, high locations signify relatively high interest in science.

By referring to Figure 6, points on the graph that are close to the line y = x and above it indicate marginal gains, whereas points further away from the line indicate greater gains. Besides, points above the line y = x also indicate that post-test locations were greater than pre-test locations.

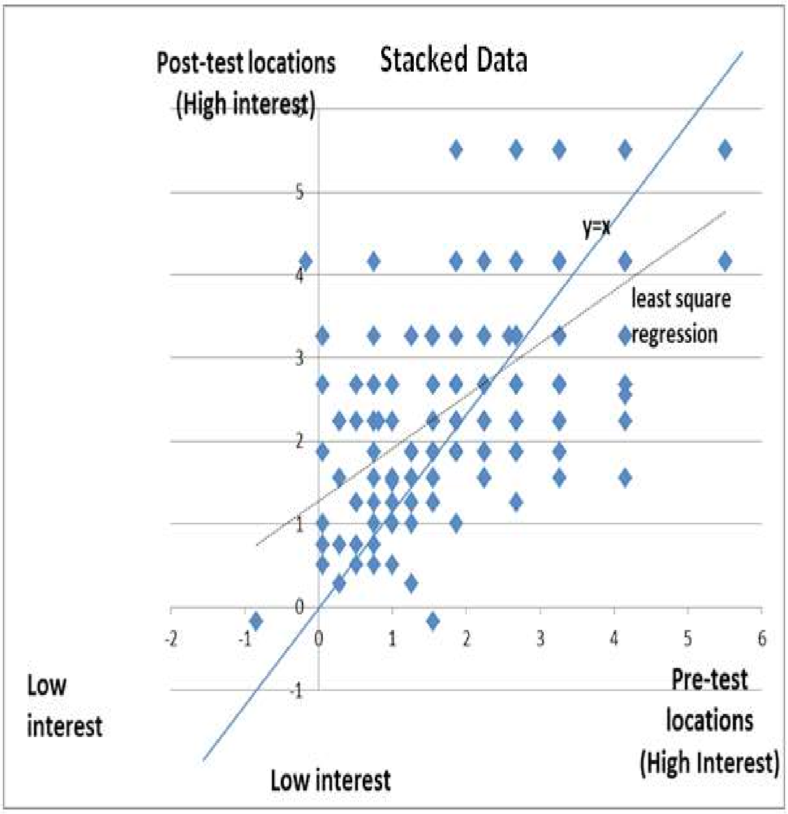

Figure 6: Pre-test and Post-test Locations of Stacked Data

Results showed that nearly half of the students (N = 148) chose more positive responses in the post-test than in the pre-test, which implies that they felt more interested in science after the Mobile Science Lab Program than before it. Meanwhile, 89 students were found to be remained unchanged regarding their interest in science and the level of interest of 63 students was found to decrease after the Mobile Science Lab Program.

This occurrence is because all students are different learners. According to Rennie (2007), knowledge is built on one's experience and since people draw from different experiences, individual learning outcomes could differ greatly. Therefore, students in this study displayed different levels of interest in science after the Mobile Science Lab Program.

However, overall, the majority of students in this study had increased their interest in science after learning science through the Mobile Science Lab Program. They felt good to learn science in an informal way through the Mobile Science Lab Program. Besides, they had freedom to explore and investigate the science activities at each station. According to Bell, Lewenstein, Shouse, and Feder (2009), for those with strong personal interests in scientific areas, learning experiences in informal settings potentially continue to supplement classroom science instruction. Therefore, increasing interest in science among the majority of students after the Mobile Science Lab Program was beneficial to students' learning. This study is consistent with the findings by Nooraida, Maznah, Salmiza, Mohd Ali, Jamalsafri, Zurida and Anna Christina (2012) who found that students were more interested in studying science after being involved in the Mobile Science Lab Projects. This finding is also supported by Ramey-Gassert, Walberg III and Walberg (1994) who found that informal science learning resources can be manipulated to attract and cultivate students' interest in science.

The designed informal science learning activities which integrated with MI, have enhanced students' excitement and interest in science. According to Brenda and Pamela (2000), MI can increase awareness about the learning process. One of the key advantages of working with MI is the emphasis it places on students exploring and understanding their own learning process. Therefore, students become responsible for their learning. This further increased students' excitement and interest in learning science through the Mobile Science Lab Program. Thus, incorporating MI theory into informal science learning through the Mobile Science Lab Program is effective, beneficial and useful for science education.

6.0 Conclusion

The findings of this study showed that students' excitement and interest toward science after experiencing informal science learning through the Mobile Science Lab Program had increased. This supports the belief that incorporating MI theory into informal science learning through the Mobile Science Lab Program is effective. Furthermore, this study also revealed that the Mobile Science Lab Program did not successfully address the issue of learning. Therefore, improvement of the Mobile Science Lab Program from the learning perspective needs to be considered based on practical experience. Overall, the Mobile Science Lab Program is a successful science education program in an informal setting that can complement formal science education at school and support students in science learning.

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