Journal of Science and Mathematics
Education in Southeast Asia
2010, Vol. 33 No. 1, 39-64

Improving Students' Attitudes Toward Science Using Instructional Congruence

Ahmad Nurulazam Md Zain
School of Educational Studies
Universiti Sains Malaysia, Penang, Malaysia

Mohd Ali Samsudin
School of Educational Studies
Universiti Sains Malaysia, Penang, Malaysia

Robertus Rohandi
Sanata Dharma University,
Yogyakarta, Indonesia

Azman Jusoh
Sultan Abdul Halim Teacher Training Institute,
Kedah, Malaysia

The objective of this study was to improve students' attitudes toward science using instructional congruence. The study was conducted in Malaysia, in three low-performing secondary schools in the state of Penang. Data collected with an Attitudes in Science instrument were analysed using Rasch modeling. Qualitative data based on the reflections of teachers and students were also collected, since they provide valuable insight of the impact of instructional congruence on student learning. The results show that instructional congruence in science education promotes positive students' attitudes toward science, especially in the constructs of the practical work of science, science outside of school, future participation in science, and a combined interest in science. The results suggest that more effort should be made to integrate science learning in school with science-related experiences outside of school. Additionally, science teachers should concentrate more on making students feel more confident about their abilities in science.

***Key words**:* Instructional congruence; Attitudes toward science; Low-performing schools; Rasch model

Introduction

There is broad agreement among educators that every society must construct its science curriculum to fit its own particular needs and schooling purposes. Science education can provide some useful insight in the process of curriculum selection and construction. However, educators agree also that teaching should build on the interests and experiences of students. Experiences and interests among learners vary, and there is similar variation in what can be considered relevant and useful knowledge for students from different life situations. Haussler and Hoffmann (2002) cite results from an international survey showing that students' interest in physics declined worldwide during Secondary Level I. This lack of interest in science often manifests itself when students are at an age when they are permitted to make their own curricular choices (Sjøberg 2002). The above findings raise serious questions about the implementation of changes made in science curricula regarding the development of students' interest in science.

It has been found that science lessons typically fail to relate to the lives of marginalised groups (Lee & Fradd 1998). González and Moll (2002) introduced the concept of 'funds of knowledge' to identify the connection between the students' home experiences and their experiential knowledge, which should be valued as part of the epistemological tradition of the classroom. According to them, the "funds of knowledge" concept is based on the simple premise that people are competent and possess knowledge that comes from life experiences.

Bouillion and Gomez (2001) argue that incorporating funds of knowledge into learning environments promotes the development of a relationship between schools and homes. This relationship, in turn, "establish[es] and maintain[s] necessary trust among participants [keeping] the system active and useful". Establishing connections between school and home through the use of funds of knowledge requires teachers to not only incorporate the types of knowledge that are used at home but also to understand how that knowledge can be used to achieve a set of greater goals or purposes (González & Moll 2002). The challenge then is to create learning environments with connected meaning for students, which requires identifying powerful links bridging students' funds of knowledge with classroom instruction. To mediate students' everyday experiences and cultures with scientific understanding, Lee and Fradd (1998) proposed the notion of instructional congruence.

This study was undertaken to examine the use of instructional congruence on students' attitudes toward and interest in science in low-performing schools in Penang, and to use the implications from the findings to develop suggestions for improving teaching and learning in school science.

Instructional Congruence

Instructional congruence can be defined as agreement or harmony between the students' experiences and cultures, their goals and possible future careers, and school science. The congruence framework is based on the belief that if students' cultures are reflected in science instruction, the goal of providing effective science education for all students is more likely to be achieved.

According to Lee and Fradd (1998), mediating the nature of academic content with students' language and cultural experiences creates instructional congruence, which makes science content accessible, meaningful, and relevant for diverse students. Similarly, Moje, Collazo, Carrillo, and Marx (2001) argue that the way students engage with scientific discourse is shaped by the everyday discourses that they bring to the classroom. In order for teachers to help students develop a connection with the scientific discourse, they need to draw from students' everyday discourses, develop students' awareness of different discourses, including scientific ones, and finally make connections between students' everyday discourses and the science discourse. For example, a teacher could discuss how to use evidence or construct an explanation in science that is similar to how students perform the same tasks in their everyday lives.

An instructional congruence framework requires instructional strategies that address differences and similarities between everyday practices and scientific inquiry practices. These strategies help students to understand ways of talking and thinking in science that may be different from those of students' everyday experiences. Students need to understand how constructing an explanation in science or supporting a claim in science looks different than it does in everyday life.

Lee and Fradd (2001) summarise four important features of instructional congruence. These features are: integrating knowledge of students' languages and cultures with the nature of science, providing "subject-specific'' pedagogies that consider the nature of science content and scientific inquiry, promoting student learning in both science and literacy, and extending personal constructivism to sense making in the contexts of students' languages and cultures.

The instructional congruence framework, which integrates science with students' home languages and cultures, serves as a conceptual and practical guide for improving instructional materials development, classroom practices, teacher training, and student achievement. Lee and Fradd (1998) suggest that to establish instructional congruence, teachers need to know (a) who students are, (b) what the nature of science is and what kinds of language and cultural experiences the students bring to the learning process, and (c) how to enable students to understand science. Through the combined understanding of literacy and science, teachers can create a dynamic process that mutually supports teaching and learning (Lee & Fradd, 1998).

In the framework of instructional congruence, certain types of academic content and cognitive and discursive practices are associated with particular academic disciplines. All disciplines are made more accessible and meaningful for students when they are purposefully mediated by students' linguistic and cultural experiences. Instructional congruence can be used as a guiding principle for pedagogical practice. It aims to help students acquire scientific understanding, develop scientific inquiry practices, and engage with the scientific discourse by taking into account the relation to the students' home culture and language, and by devising instructional strategies that address both the discontinuities and the continuities between school science and cultural knowledge (Luykx & Lee 2007).

Effective instruction is a key to developing congruence between academic disciplines and students' cultural and linguistic experiences, particularly when there are substantial discontinuities. Thus, instructionally congruent teaching requires teachers to have knowledge of both the academic disciplines in which they specialise and the nature of student diversity in their schools (Lee & Fradd 1998; Moje *et al.* 2001). Luykx and Lee (2007) further suggest that teachers need to identify the student's experiences and resources from their home languages and cultures that could be incorporated into the teaching of science and to recognise how students' prior cultural and linguistic knowledge might connect with the specific demands of academic disciplines in order to adapt their instruction accordingly.

Luykx and Lee (2007) state that the aim of the instructional congruence framework is to create higher expectations for non-mainstream students and non-Western students. It also aims to reduce conflict with students' home cultures by adjusting curricular content appropriately. Instructional congruence can guide teachers in recognizing students' prior linguistic and cultural knowledge and in understanding how this knowledge relates to scientific content and practice. Such consideration of each student's starting point will help teachers to map out more effective ways for guiding students toward scientific understanding and effective scientific practices (Luykx & Lee 2007). Successful learning in science occurs when teachers incorporate students' cultural experiences, examples, and analogies, as well as artifacts familiar to students, into their instruction. This practice is rarely used in traditional science instruction. Traditional science teaching has often relied on examples and analogies drawn from the cultural knowledge and practices of the majority which may be unfamiliar to students from other backgrounds (Luykx & Lee 2007). Teaching science based on instructional congruence should include both majority and minority students' experiences and cultures.

Instructionally congruent teaching requires that teachers have knowledge of both academic disciplines and student diversity (Lee & Fradd 1998; Moje *et al.* 2001). Luykx and Lee (2007) suggest that teachers need to identify the rich experiences and resources that students bring to the science classroom from their home languages and cultures. They further suggest that teachers need to recognise how students' prior cultural and linguistic knowledge can be connected with the specific demands of academic disciplines and adapt their instruction accordingly.

This framework highlights the importance of developing congruence not only between students' cultural expectations and classroom interactional norms, but also between academic disciplines and students' linguistic and cultural experiences. It focuses on making connections between academic disciplines and students' cultural and linguistic experiences to develop congruence between them. The need to mediate these two domains is especially critical when they contain potentially contradictory elements. As Lee, Deaktor, Hart, Cuevas and Enders (2005) suggest, instructional congruence should emphasise effective instruction (or educational interventions) as teachers explore the relationship between academic disciplines and students' cultural and linguistic knowledge.

Developing a Sustained Interest in Science

Barton and Yang (2000) argue that one of the greatest barriers for effective learning is a lack of relevance in the science curriculum. By contrast, Sjøberg and Schreiner (2005) posit that the main explanation for low interest in science is a lack of motivation to pursue the subject in higher education. Thus, any improvement in science education needs to be accompanied by a parallel growth in interest in science and an increased understanding of basic scientific ideas and ways of thinking.

Basu and Barton (2007) maintained that the science curriculum is a key factor in developing and sustaining students' interest in science. There seems to be a broad agreement about the shortcomings of the traditional curricula that still exist in most countries. The implicit image of science conveyed by these curricula is that it is mainly a massive body of authoritative and unquestionable knowledge. Consequently, students may become disengaged from school science if their funds of knowledge are not incorporated into the science curriculum (Basu & Barton 2007).

Basu and Barton (2007) and Sjøberg (2002) further argue that to build on the interests and experiences of the learner, it may be necessary to abandon the notion of a common, more or less universal, science curriculum, in favor of curricula and teaching materials that are more context-bound and that take into account both gender issues and cultural diversity. It has also been argued that the problems related to low interest in science and negative attitudes toward science cannot be regarded as an isolated problem within schools, but need to be understood and addressed in a wider social, cultural and political context (Sjøberg 2002).

Genzuk (1999) has advocated the integration of students' life experiences and cultural and historical knowledge, collectively known as funds of knowledge, into teaching. Funds of knowledge are not possessions or traits of people in the family but more focus on the characteristics of people in terms of how they transform the knowledge into meaningful activity (González & Moll 2002). Thus, funds of knowledge represent the household's most useful cultural resources that are essential to maintain their well-being.

Methodology

Participants and Design

This study examines the usage of instructional congruence on students' attitudes toward learning science. The study was conducted in three low-performing secondary schools in Penang and included six science teachers and 214 students from Forms 2 and 4. The teachers were all female with two of them from each school. Three of them were teaching Form 2 and the other three were teaching Form 4. Altogether 110 Form 2 students and 104 Form 4 students were involved in this study. 117 were male students and 97 were female. Figure 1 shows the design of the study.

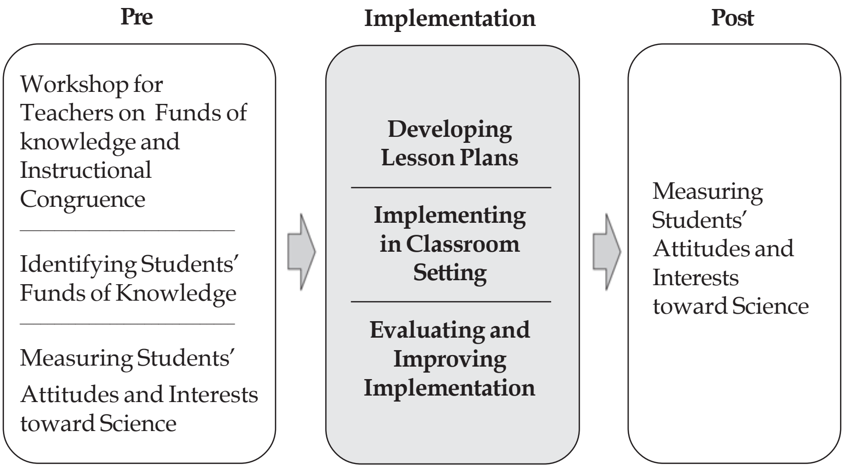


Figure 1. Research design.

Workshops for Teachers

A series of four professional development workshops were provided for the teachers in the study. The first workshop included an introduction to the concept of instructional congruence and a discussion of how to incorporate students' funds of knowledge into science lessons. A sample lesson plan was also presented and discussed. The second workshop provided instruction on lesson planning and designing student activities that adhere to the instructional congruence strategy. Teachers then implemented the instructional congruence strategy in their classrooms. In the third workshop, teachers discussed their instructional congruence lesson plans and their experiences in implementing the lessons. The teachers discussed problems they faced in implementing the lessons and possible modifications and improvements. In the fourth workshop, teachers exchanged and discussed the various student activity ideas that they had designed. In each workshop, discussion and sharing of ideas among teachers and between teachers and researchers were important. These discussions highlighted suggestions for further improvement in the teachers' lessons.

Data Collection

The "Attitudes in Science" questionnaire, developed by Barmby, Kind, & Jones (2008), was used in this study. This questionnaire was designed to evaluate students' attitudes toward and interest in science. The questionnaire consists of 37 items, separated into seven constructs representing students' overall attitudes toward learning science (See Appendix for a detailed list). The seven constructs are (1) learning science in school (items 1- 6; α=0.89), (2) self-concept in science (items 7-13; α=0.85), (3) practical work in science (items 14-21; α=0.85), (4) science outside of school (item 22-27; α=0.88), (5) future participation in science (item 28-32; α=0.86), (6) importance of science (item 33-37; α=0.77), and (7) combined interest in science (α=0.93). The combined interest in science construct is an aggregate of the scores for the constructs of learning science in school, future participation in science, and science outside of school.

As this instrument had not been used in Malaysia before this study, the questionnaire had to be translated into the Malay language. This translation was validated by two language experts. The translated instrument was first used in a pilot-study involving students from a single school in Penang. The Cronbach alpha coefficients of each construct were above 0.7 and 0.94

for the overall items, indicating that the data from the questionnaire is acceptable with regards to internal consistency for each construct. The students' responses were then categorised using a Likert scale. The categories in the Likert scale were labeled *''strongly disagree''* (coded 1), "*disagree*" (coded 2), "*agree*" (coded 3), and *''strongly agree''* (coded 4). The instrument was administered in the presence of science teachers who were able to provide assistance if the students encountered any difficulty. Overall, the administration of the questionnaires proceeded smoothly; all students had sufficient time to complete the questionnaire, and very few students had any queries about the items.

The data presented in this paper were collected within a relatively short period of time, three months after the teachers used instructional congruence strategies. The data were used to evaluate the effectiveness of instructional congruence in increasing student interest in learning science. In this study, students' attitudes toward science were measured before implementation (pre-test) and after implementation (post-test) of instructional congruence strategies. The pre- and post-test questionnaires were used to measure changes in student attitudes toward science following the implementation of instructional congruence strategies in teaching secondary science. In addition, qualitative data of teachers' and students' reflections of instructional congruence provided further insights to the study.

Data Analysis

Boone and Scantlebury (2006) explained that in recent years the Rasch model has been used to analyse large-scale assessment projects in many areas of study. In educational research, the Rasch model provides valuable tool for the development, modification, and monitoring of valid measurement instruments.

In this paper, the Rasch model was used to examine a change of students' attitudes toward learning science in three low-performing schools in Penang before and after implementation of instructional congruence into the teaching of science. Traditionally, changes in variables such as achievement and attitude of the students have been measured by the differences between pre-test and post-test scores. It is noted that the traditional approach might provide an inaccurate result of analysis. Raw scores are mostly test dependent and do not adequately represent response patterns, thus the different response patterns on test items may lead to the same raw score.

Moreover, the differences between pre-test and post-test raw scores do not separate changes due to experimental treatments from changes due to natural trends, such as maturation and experience, and raw score differences do not provide information about the magnitudes of changes. The Rasch models have been used to resolve problems posed by the classical pre-test and post-test score differences and provide additional information for more valid interpretations of the results.

In the Rasch model, scores measure possession of a single attribute. For the attitudes' scores in this study, the attribute could be transmitting as 'students are likely to agree with the items', whereas the items concentrate on a different extent of the attribute. The extent is named item-difficulty. High-difficulty items attract low scores while low-difficulty items attract high scores of attitudes toward science. However, unlike traditional methods, the attitude is not viewed as being linearly related to the total score of students, and item-difficulty is not viewed as being linearly related to the mean percentage score of items. Attitude and difficulty are determined by the pattern score of all students on all items. Thus, the Rasch model is useful for measuring with less ideal data and is used to analyse the change in students' attitude toward science before and after implementing the developed teaching method in this study.

The Rasch model transforms raw item difficulties and raw person scores to equal interval logit measures on a linear "meter stick". The position of each item on the line is determined relative to those items already positioned on the line. The relative positions are determined by comparing pairs of items with respect to their relative difficulties along the line. An advantage of this technique is that it provides equal and standard interval data. It allows data of different varieties to be easily compared. Once the items are lined up in order of difficulty, the positions of students can be plotted on this same line. The students' probable positions can be specified initially by a best guess as to their ability to correctly answer the items which define the variable. The technique shows both the positions of items and the positions of students. Eventually, the positions of students will become more explicit and more empirically determined as additional information on students' answers is incorporated in the calculation. This model is particularly important on monitoring the students' attitudes. If raw scores are equal to interval measures, however, the analysis may provide incomplete information (Boone & Scantlebury, 2006). Thus, this data conversion is important in order to provide good quality measurement.

The equal interval measures transformed by the Rasch model are used to map persons and items onto a linear (interval) scale. Such mapping (called person–item maps) produces useful tools for evaluating students' attitudes and can also be used to evaluate the effectiveness of the instrument. The order of the items in the person–item maps illustrates the level of difficulty for each item, allowing the identification of items with which it is more or less difficult to agree.

The Rasch model shows that the student's attitude toward learning science can be used to predict the student's response on a particular test item involving attitudes. Students whose logit value is the same as the logit value of an item have a 50% chance of correctly answering that item. Items above the students' ability level can still be answered correctly, but students have less than a 50% chance of correctly answering the item. Items listed below a student's ability are those that the student has more than a 50% chance of correctly answering. Consequently, the higher position of the item on the line, the more difficult it is to agree with the item. Conversely, the lower position of the item on the line means that the item is easier to agree with.

Results and Discussion

In this study, the teachers utilised students' experiences by creating activities and examples from the students' culture and daily life experiences through a variety of activities which emphasised instructional congruence. The lessons developed instructional congruence by using students' experiences to demonstrate and by helping students to understand how the concepts are related to everyday life. Teachers were able to make connections between students' experiences and science. They created "connected science", in which scientific knowledge is applied to students' real-life situations, and which allow students to feel more accepted and more willing to engage with and participate in science learning.

The Rasch Model Analysis

Prior to the analysis of the students' attitude toward learning science, the data were diagnosed in order to provide a precise and productive measurement. This process is similar to the process of calibrating an instrument. The data was analysed with a relevant parameterised uni-dimensional measurement model that fulfilled the essential measurement requirements of the Rasch model. Responses from 214 students to the 37 items of attitudes toward science were analysed using Winsteps (Rasch-Model Computer program). To use the items in the Rasch model, it was necessary for the *infit mean square* and *outfit mean square* for each item to be distributed between 0.7 and 1.4, and for the *point measure correlation* for each item to be greater than 0.3. According to these criteria, 10 of the 37 items (item 3, item 6, item 7, item 8, item 12, item 15, item 17, item 21, item 27, and item 36) were discarded from the Rasch analysis.

After diagnosing the data, the raw data (214 students and 27 items) from the pre-test and the post-test were transformed using Rasch analysis so as to order students' responses along the continuum of the measure of attitude toward science. Table 1 shows the summary statistics for the items. The pre-test's infit mean squares are between 0.78 and 1.38, and the outfit mean squares are between 0.78 and 1.40. By contrast, the post-test's infit mean squares are between 0.69 and 1.35, and the outfit mean squares are between 0.70 and 1.39. The point measure correlations for the pre-test are distributed from 0.42 and 0.75, whereas, the point measure correlations of post-test are distributed from 0.48 and 0.69. These statistics fall within reasonable ranges. The acceptable range for a good (productive) measurement is between 0.5 – 1.5 (Linacre, 2009).

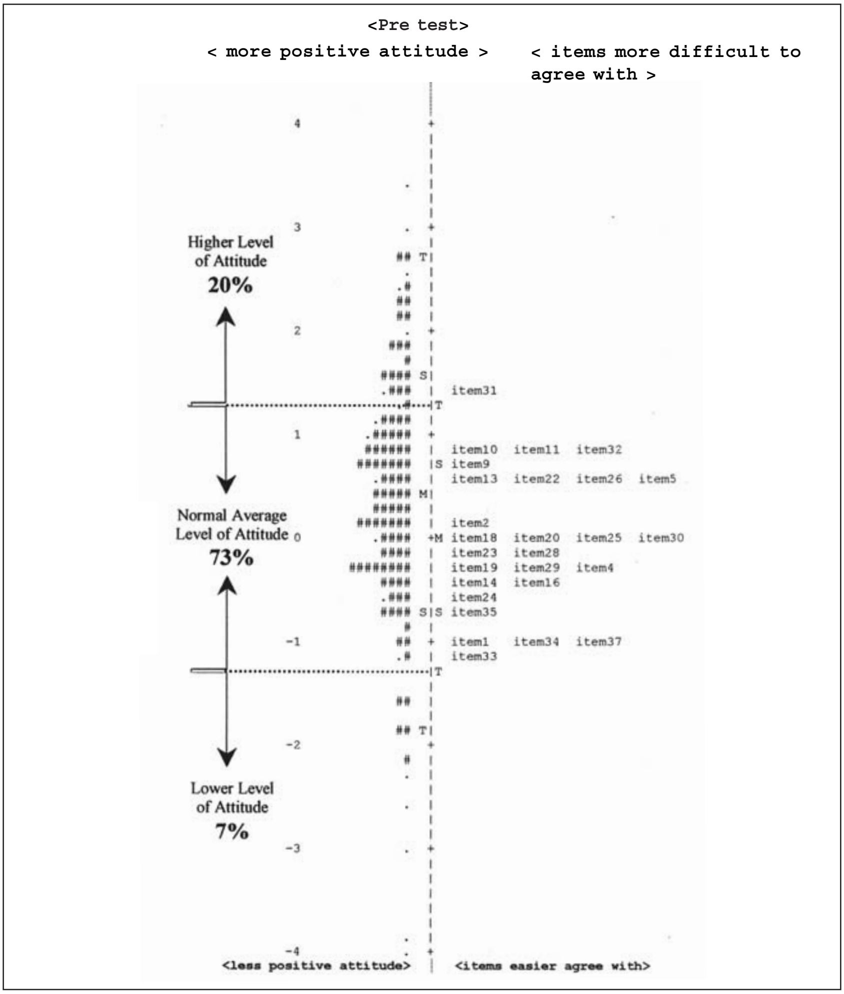
Table 1 shows that in the pre-test, the difficulty of the items is distributed from -1.14 to 1.46 logits. In the post-test, the difficulty of the items is distributed from -1.10 to 1.30. The items of the pre-test and post-test are evenly distributed along the meter stick. The distributions of students (n=214) according to their attitude and the (n=27) difficulty of the pre-test and post-test items are presented in Figure 2 and 3. On the left-hand side of each item-person maps in Figure 2 and 3, are shown the distribution of students. The students who are located at the top of scale represent the students with the most positive attitudes. On the right-hand side, items are listed in order of difficulty, with the item that is hardest to agree with at the top of the scale. Items located below the student are items that he/she is likely to agree with. Items located above the students are items that the students are unlikely to agree with.

Table 1
Item Statistics for the 27 Items

Item No.	Pre Test Measure	SE	Infit	Outfit	PTME	Post Test Measure	SE	Infit	Outfit	PTME	Items Measure Differences
item 1	-1.06	0.11	0.91	0.91	0.60	-1.05	0.11	0.92	0.88	0.63	0.01
item 2	0.09	0.10	0.79	0.81	0.60	0.27	0.10	0.69	0.70	0.68	0.18
item 4	-0.22	0.10	0.82	0.84	0.64	-0.05	0.10	0.80	0.80	0.68	0.17
item 5	0.62	0.10	0.86	0.88	0.56	0.62	0.10	0.87	0.89	0.63	0.00
item 9	0.66	0.10	0.96	1.04	0.54	0.92	0.10	1.13	1.17	0.51	0.26
item 10	0.82	0.10	0.81	0.86	0.57	0.81	0.10	0.85	0.87	0.58	-0.01
item 11	0.92	0.10	0.92	0.97	0.57	0.96	0.10	0.73	0.73	0.66	0.04
item 13	0.62	0.10	1.01	1.15	0.49	0.69	0.10	1.09	1.09	0.51	0.07
item 14	-0.38	0.10	0.98	1.00	0.61	-0.33	0.10	0.92	0.91	0.67	0.05
item 16	-0.44	0.10	1.09	1.15	0.54	-0.63	0.11	1.23	1.28	0.55	-0.19
item 18	0.07	0.10	0.85	0.87	0.62	-0.17	0.10	1.10	1.09	0.59	-0.24
item 19	-0.29	0.10	0.79	0.78	0.66	-0.34	0.10	0.86	0.83	0.66	-0.05
item 20	0.02	0.10	0.97	0.96	0.61	-0.31	0.10	0.96	0.92	0.64	-0.33
item 22	0.64	0.10	0.92	0.93	0.60	0.59	0.10	0.92	0.92	0.63	-0.05
item 23	-0.14	0.10	1.17	1.15	0.63	-0.06	0.10	1.26	1.26	0.52	0.08
item 24	-0.54	0.10	1.36	1.40	0.52	-0.61	0.11	1.02	0.98	0.58	-0.07
item 25	-0.01	0.10	1.15	1.15	0.62	-0.17	0.10	1.02	1.14	0.59	-0.16
item 26	0.50	0.10	0.78	0.78	0.65	0.43	0.10	0.95	0.94	0.65	-0.07
item 28	-0.15	0.10	0.82	0.79	0.75	-0.14	0.10	0.84	0.81	0.69	0.01
item 29	-0.23	0.10	1.03	1.00	0.71	-0.25	0.10	0.99	0.96	0.67	-0.02
item 30	0.00	0.10	1.02	1.00	0.67	0.13	0.10	0.87	0.84	0.68	0.13
item 31	1.46	0.10	1.38	1.32	0.42	1.30	0.10	1.26	1.30	0.48	-0.16
item 32	0.82	0.10	1.27	1.25	0.54	0.67	0.10	1.35	1.38	0.53	-0.15
item 33	-1.14	0.11	1.02	0.94	0.65	-1.10	0.11	0.90	0.95	0.57	0.04
item 34	-1.00	0.11	1.17	1.09	0.63	-0.86	0.11	1.09	1.04	0.55	0.14
item 35	-0.67	0.10	1.04	1.07	0.61	-0.50	0.10	1.16	1.17	0.52	0.17
item 37	-0.99	0.11	1.04	0.99	0.64	-0.84	0.11	1.15	1.39	0.59	0.15
Mean	**0.00**	**0.10**	**1.00**	**1.00**	**0.42**	**0.00**	**0.10**	**1.00**	**1.00**	**0.48**	**0.00**
S.E	**0.66**	**0.00**	**0.17**	**0.16**	**0.75**	**0.65**	**0.00**	**0.17**	**0.19**	**0.69**	**0.14**

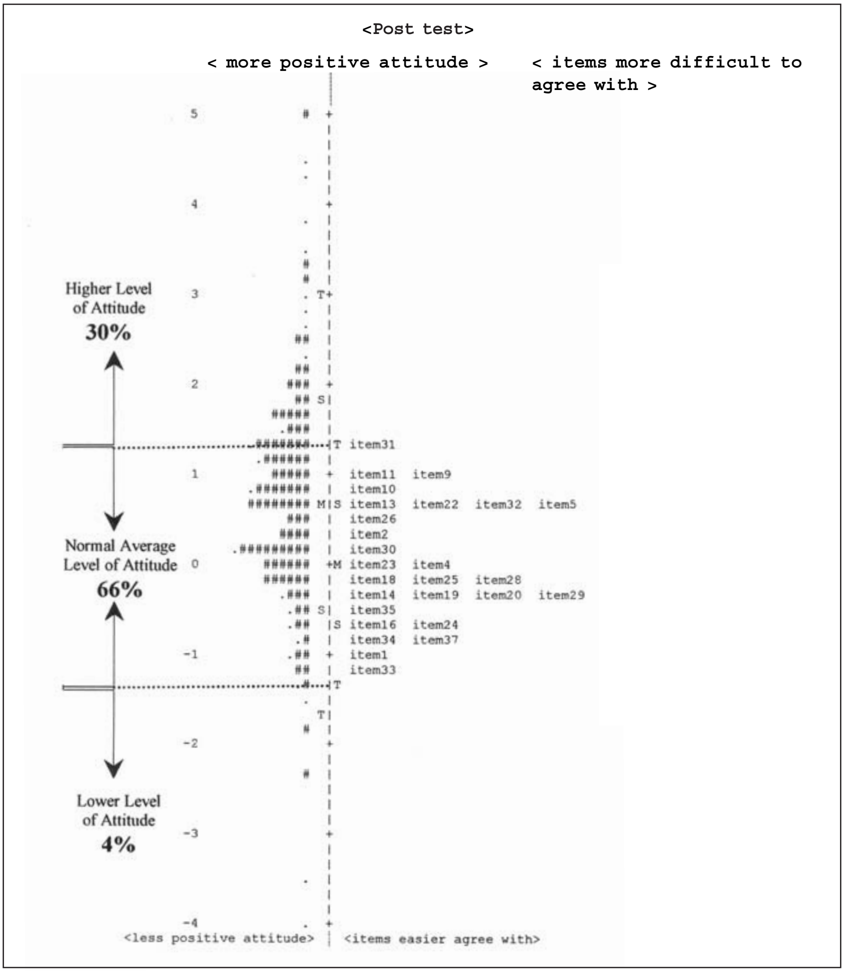
When the Rasch analysis was run for the pre- and post-test the mean attitude toward science was positive and above the mean item difficulty. The mean of logits value of the students' attitude in the pre-test was 0.41. This indicates that before implementing the instructional congruence strategy, the students already had relatively positive attitudes toward science. However, the mean student attitude in the post-test was 0.68 which indicates that the post-test attitudes toward science were more positive than pre-test attitudes by 0.27. Therefore, while students' had somewhat positive attitudes toward science throughout the course of study, their attitudes improved noticeably after instructional congruence strategies were emphasised in the study.

The items-person distribution on the map also provides valuable information on the students' attitudes. Looking at the distribution of item difficulty and standard error along a single continuum it appears that the students can be categorised into three distinct groups. As shown in Figure 2 and 3, prior to the implementation of instructional congruence strategies in the teaching of science (pre test), 20% (42 out of 214) of students had positive attitudes, 73% (157 out of 214) of students had normal attitudes, and 7% (15 out of 214) of students had negative attitudes. After instructional congruence strategies were implemented (post-test), 30% (64 out of 214 of students) had positive attitudes, 66% (142 out of 214 of students) had normal attitudes, and the remaining 4% (8 out of 214) still maintained negative attitudes. This finding indicates that the teaching of science with an emphasis on instructional congruence has a positive effect on improving students' attitudes toward science.



Note: Students are represented by the "#" and "." sign.
"M" marker represents the location of the mean measure.
"S" markers are placed one sample standard deviation away from the mean.
"T" markers are placed two sample standard deviations away.

Figure 2. Map of students relative to items in pre-test.



Note: Students are represented by the "#" and "." sign.
"M" marker represents the location of the mean measure.
"S" markers are placed one sample standard deviation away from the mean.
"T" markers are placed two sample standard deviations away.

Figure 3. Map of students relative to items in post-test.

However it is also notable that implementing instructional congruence strategies in the teaching of science had some effects on the item difficulty. The difference between means in the pre-test and post-test is presented in Table 2. Figure 4 presents the mean of the Rasch scores on attitude construct in the pre-test and post-test along a single continuum.

Table 2
The Mean Rasch Score Items of Attitude Constructs

Construct	Pre test		Post test		Mean differences
	Mean	SE	Mean	SE	
Learning science in school	-0.14	0.70	-0.05	0.72	0.09
Self-concept in science	0.76	0.14	0.85	0.12	0.09
Practical work in science	-0.20	0.23	-0.36	0.17	-0.15
Science outside of school	0.09	0.48	0.04	0.48	-0.05
Future participation in science	0.38	0.20	0.34	0.25	-0.04
Importance of science	-0.95	0.20	-0.83	0.25	0.13
Combined Interest	0.13	0.63	0.12	0.59	-0.01

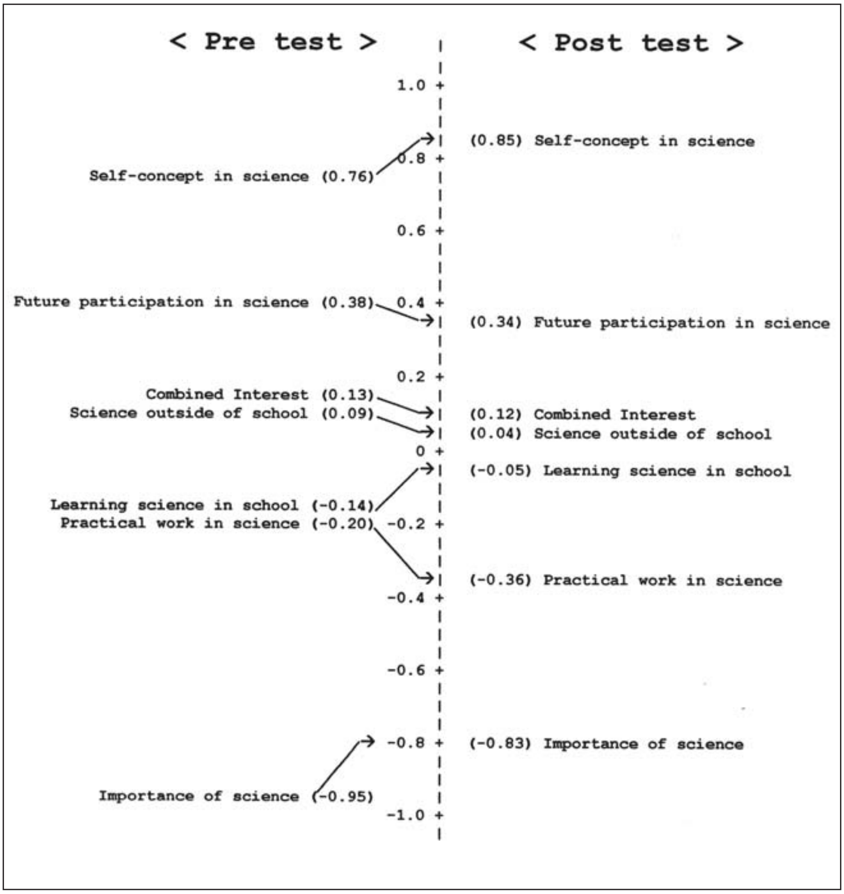


Figure 4. The mean Rasch score of attitude constructs on logits scale.

There are two kinds of mean score differences on the items in the Rasch model for each attitude respectively. A negative mean difference indicates that the difficulty of the items in the attitude construct decreased (it is at a lower position the logit scale) after the study's implementation. This means that the students were more likely to agree with the items after implementation than before implementation. Table 2 shows that there are four attitude constructs (practical work in science, science outside of school, future participation in science, and combined interest) with negative mean differences indicating that the students were more likely to agree with the items in the post-test than in the pre-test. On the other hand, three attitude constructs (learning science in school, self-concept in science, and importance of science) have positive mean differences, indicating that the students were less likely to agree with the items in the post-test than in the pre-test.

This result indicates that teaching science with an emphasis on instructional congruence improves student attitudes as they relate to the constructs of practical work in science, science outside of school, future participation in science, and combined interest. Items in the construct of practical work in science were easier to agree with after implementation (see Table 2). This result seems reasonable, since teachers in this study provided students with activities that focused on hands-on activities and since scientific inquiry is an important characteristics of instructional congruence (Bybee, 2003; Lee & Fradd, 2001). Teaching strategies that incorporated students' experiences caused students to enjoy and to be interested in science activities.

The mean of the Rasch scores for these attitude constructs did increase, but the increase is not significant. These evidences suggest that instructional congruence might have a positive effect on students' attitude in these constructs. However, teachers must make further efforts to improve student's confidence in science, in low performing schools.

The Teachers' and the Students' Reflections

In this section, qualitative findings are presented based on the teachers' and students' reflections on instructional congruence. One of the teachers, Mrs. X felt that this method of teaching could be effectively implemented in low-performing schools. During implementation, she found that incorporating students' funds of knowledge into learning science enhanced understanding and developed students' thinking skills, communication skills, and willingness to cooperate. She also believed it could be advantageous in terms of saving time and minimising discipline problems. The following is an excerpt from her reflections:

> *…….. of course saves time. Save time I mean … I don't have to do a lot of revision. I only did one time and then the next time I give exercise. They already can do. So I don't have to explain again and again. And then … reduce discipline problem so when the time they got thing to do, they don't give you a lot of discipline problems.*

Mrs. X explained that instructional congruence saves time because it allows her to give a short explanation of scientific concepts, since students are able to master the concepts by doing activities. Based on her experiences in implementing this method, Mrs. X felt that this method helps her to improve students' interest in learning science.

In Mrs. Y's reflection, she highlighted that instructional congruence makes students more excited about learning science. She found that her students were more engaged than they were in previous learning activities. She believed that through incorporating students' funds of knowledge into teaching science, she could increase the level of engagement and interest in learning science among her students. Mrs. Y implemented this method of teaching in only one class, but she observed that students from other classes were eager to know what happened in the treatment class. She expected to do similar activities for all of her science lessons in the future.

Similarly, Mrs. Z found that her students found the lessons to be more fun and exciting because the activities were related to their daily life and everyday activities. She felt that this method also encouraged students to think "outside of the box". She agreed that incorporating students' funds of knowledge makes science accessible for her students, especially those students who had previously struggled in science. She believed that this method had also narrowed the gap between science and related student experiences, allowing the students to talk more comfortably about science.

One of the science teachers involved in this study reported that 99% of the students agreed that the lesson was good and had benefited them. The science lesson was more interesting for the students. Students seemed engaged in the activities, making comments such as, *"I like because it is interesting. I like all activities teacher teach me like this*".

Students made positive comments about the activities in which they participated. The science lessons developed by their teachers made science concepts easy to understand, since the lessons clearly related to their daily activities. The performance of various science activities helped students to understand the concepts more easily and effectively related the concepts to their daily lives. Students found that they could apply science concepts in their daily lives. The following excerpts are examples of students' responses:

The students able to understand and remember either difficult concepts or facts easily.

I like because the activities make me understand science. The activities are also as interesting, fun, and exciting experience. I am interested to do more doing science.

Science is abstract because cannot be understood in a term, but when we have an additional example we would understand and realise the important and usage of science

This method is interesting for students because the teacher give students examples that are relevant and useful in daily life.

In my opinion, this method is very beneficial to the students. This is because we can apply it in everyday life.

As the students felt that the classroom atmosphere was supportive, they enjoyed doing the activities. The lessons became fun and challenging. Moreover, teachers provided support and positive feedback, which made the lessons easy to understand. The experience showed students that learning is fun and it stimulated students to think "outside of the box" and to be effective learners. For example, students responded that "*This method also can make the students to think scientifically*" and "*This make the student interested in science subject and produce a good work*".

The media used by the teachers, the topics covered and activities conducted, and the discussions were interesting. Furthermore, students said they became more interested in science, which made it easier to understand. Students felt that this method would also be beneficial in other subjects too. The following excerpts are example of students' comments:

Physics is an interesting subject. In making more and concerning physics research, like see for example this make it more [relevant to] reality, so they can understand it more easy. So I think, see for example, it is quite interesting so that the students can understand more about [what] they are doing

> *This method could also reduce the boring lesson because not only depend on ... discussion and conversation only. This method could also stimulate mind and to make students interested in. ... Through this method, it could facilitate students' understanding by showing the examples. So this method is very useful in learning this subject. As a suggestion, this method could also be used for other subjects.*

This qualitative data provide some insight into the potential benefit of implementing instructional congruence in teaching science. Promoting positive attitudes and high levels interest in school science can be achieved by providing more hands-on activities. Science should be taught and explained in a way that connects science with student's experiences and that shows the relevance of science in students' daily lives. Using instructional congruence is an effective way to teach science.

Conclusion

The results of this study demonstrate that the guidelines for instructional congruence developed here can be used effectively to develop positive attitudes toward science and to improve interest in learning about science among students. Science teaching that emphasises instructional congruence has an effect on student attitudes as they relate to the constructs of practical work in science, science outside of school, and future participation. Moreover, this result was achieved in a relatively short period of time. The teachers' efforts to integrate students' cultural experiences with classroom science concepts succeeded in promoting student understanding. When lessons utilised instructional congruence, students found science easier to understand and more meaningful and relevant to their daily lives. Lessons that emphasise instructional congruence helped students to make connections between science and their funds of knowledge (Lee & Fradd 2001; Luykx & Lee 2007). Students enjoyed their experiences in the classroom. This finding implies that science curricula should be more connected to science outside of school activities. How instructional congruence can be better implemented at low-performing schools to improve students' self-concept in science is a topic that calls for further exploration. As such longitudinal research designs might be further used to examine changing attitudes resulting from instructional congruence in science education.

References

Barmby, P., Kind, P. M., & Jones, K. (2008). Examining Changing Attitudes in Secondary School Science. *International Journal of Science Education, 30*(8), 1075-1093.

Barton, A. C., & Yang, K. (2000). The culture of power and science education: learning from miguel. *Journal of Research in Science Teaching, 37*(8), 871-889.

Basu, S. J., & Barton, A. C. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching, 44*, 466-489.

Bouillion, L. M., & Gomez, L. M. (2001). Connecting school and community with science learning: Real world problems and school-community partnerships as contextual scaffolds. *Journal of Research in Science Teaching, 38*(8), 878-898.

Boone, W. J. and Scantlebury K. (2006). The Role of Rasch Analysis When Conducting Science Education Research Utilizing Multiple-Choice Tests. *Science Education, 90*, 253-269.

Bybee, R. W. (2003). The teaching of science: Content, coherence, and congruence. *Journal of Science Education and Technology, 12*(4), 343-358.

Genzuk, M. (1999). Tapping into community funds of knowledge. In *Effective strategies for english language acquisition: curriculum guide for professional development of teachers*. Los Angeles: LAAMP/ARCO.

González, N., & Moll, L. C. (2002). Cruzando el puente: Building bridges to funds of knowledge. *Educational Policy, 16*, 623-641.

Haussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching, 39*(9), 870-888.

Lee, O., Deaktor, R. A., Hart, J. E., Cuevas, P., & Enders, C. (2005). An instructional intervention's impact on the science and literacy achievement of culturally and linguistically diverse elementary students. *Journal of Research in Science Teaching, 42*(8), 857-887.

Lee, O., & Fradd, S. H. (1998). Science for all, including students from non-english-language backgrounds. *Educational Researcher, 27*(4), 12-21.

Lee, O., & Fradd, S. H. (2001). Instructional congruence to promote science learning and literacy development for linguistically diverse students. In D. R. Lavoie & W. M. Roth (Eds.), *Models of Science Teacher Preparation* (pp. 109-126). Netherlands: Kluwer.

Linacre, J. M. (2009). *A user's guide to WINSTEPS-MINISTEP: Rasch-Model computer programs*. Chicago: Winsteps.com.

Luykx, A., & Lee, O. (2007). Measuring instructional congruence in elementary science classrooms: Pedagogical and methodological components of a theoretical framework. *Journal of Research in Science Teaching, 44*(3), 424-447.

Moje, E., Collazo, T., Carrillo, R., & Marx, R. (2001). Maestro, "what is quality?" language, literacy, and discourse in project-based science. *Journal of Research in Science Teaching, 38*(4), 469-498.

Sjøberg, S. (2002). Science and technology education current challenges and possible solutions. In E. Jenkins (Ed.), *Innovations in Science and Technology Education* (Vol. VIII). Paris: UNESCO.

Sjøberg, S., & Schreiner, C. (2005). How do learners in different cultures relate to science and technology? *Asia-Pacific Forum on Science Learning and Teaching, 6*(2), Foreword p.2.

Authors:

Ahmad Nurulazam Md Zain, School of Educational Studies, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia; e-mail: anmz@usm.my

Mohd Ali Samsudin, School of Educational Studies, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia; e-mail: alisamsudin@usm.my

Robertus Rohandi, Sanata Dharma University, Tromol Pos 29 Yogyakarta 55002, Indonesia; e-mail: rohandi@staff.usd.ac.id

Azman Jusoh, Sultan Abdul Halim Teacher Training Institute, Sg. Petani, Kedah, Malaysia; e-mail: azman799@yahoo.com

Appendix

Response Options for Measures of Attitudes Toward Science

Attitude measure	Item No.	Items comprising the measure
Learning science in school	Item 1	We learn interesting things in science lessons.
	Item 2	I look forward to my science lessons.
	Item 3	Science lessons are exciting.
	Item 4	I would like to do more science in school.
	Item 5	I like science better than most other subjects in school.
	Item 6	Science is boring.
Self-concept in science	Item 7	I find science difficult.
	Item 8	I am just not good at science.
	Item 9	I get good marks in science.
	Item 10	I learn science quickly.
	Item 11	Science is one of my best subjects.
	Item 12	I feel helpless when doing science.
	Item 13	In my science class, I understand everything.
Practical work in science	Item 14	Practical work in science is exciting.
	Item 15	I like practical work in science because you don't know what will happen.
	Item 16	Practical work in science is good because I can work with my friends.
	Item 17	I like practical work in science because I can decide what to do myself.
	Item 18	I would like more practical work in my science lessons.
	Item 19	We learn science better when we do practical work.
	Item 20	I look forward to doing science practicals.
	Item 21	Practical work in science is boring.
Science outside of school	Item 22	I would like to join a science club.
	Item 23	I like watching science programmes on TV.
	Item 24	I like to visit science museums.
	Item 25	I would like to do more science activities outside of school.
	Item 26	I like reading science magazines and books.
	Item 27	It is exciting to learn about new things happening in science.

Attitude measure	Item No.	Items comprising the measure
Future participation in science	Item 28	I would like to study more science in the future.
	Item 29	I would like to study science at university.
	Item 30	I would like to have a job working with science.
	Item 31	I would like to become a science teacher.
	Item 32	I would like to become a scientist.
Importance of science	Item 33	Science and technology are important for society.
	Item 34	Science and technology make our lives easier and more comfortable.
	Item 35	The benefits of science are greater than the harmful effects.
	Item 36	Science and technology are helping the poor.
	Item 37	There are many exciting things happening in science and technology.
Combined interest in science		(Items from Learning science in school, Science outside of school, and Future participation in science combined)