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Instructional congruence and changing students' attitudes and interests toward science in "Low Performing" secondary schools

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Abstract

This study conducted in Malaysia, investigated the effects of instructional congruence in teaching science on changing students' attitudes and interests in science in three "low performing" secondary schools. In this study, the implementation of instructional congruence in teaching science significantly promotes a positive effect on students' attitudes and interests in the aspects of practical work of science, science outside of school, future participation in science, a combined interest in science and overall attitudes in science.

Keywords: Instructional congruence; students' attitudes and interest; 'low performing' school.

1. Introduction

Students' attitudes toward science have become a major concern of science education researchers during an attempt to increase interest, performance, and student retention. Studies in the science education literature emphasize that the development of a positive attitude toward science should be an important goal of the school curriculum. A positive attitude toward science 'leads to a positive commitment to science that influences students' lifelong interest and learning in science' (Simpson & Oliver, 1990). This is one reason why major science education reform efforts have emphasized improving students' interest and attitudes (Trumper, 2006). Barton and Yang (2000) argue that the content of science taught in schools is not relevant in the lives of students, which may affect their interest. Although teachers are often expected to focus on content-related goals, goals involving students' sense of belonging are also crucial. If students do not feel a sense of membership associated with science, science will not become a part of their identities, and they will be less likely to look out for interactions about science in future (Brickhouse *et al.*, 2000). This study aimed at examining the effects of instructional congruence on students' attitudes and interest toward science in three low performing schools in Penang.

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2. Instructional Congruence

Lee and Fradd (1998) proposed the idea of instructional congruence as “the process of mediating the nature of academic content with students’ language and cultural experiences to make the content accessible, meaningful, and relevant to a diverse group of students”. This instruction helps students to relate their language and cultural experiences to their experiences in the science classroom (McNeill *et al.*, 2005). Lee and Fradd (2001) summarize four important features of instructional congruence: 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 the personal construct in the contexts of students’ languages and cultures.

Instructionally congruent teaching requires that teachers have knowledge of both academic disciplines and student’s culture and diversity (Lee & Fradd, 1998; Moje *et al.*, 2001). Luykx and Lee (2007) further suggest that teachers must identify the rich experiences and resources that students bring from their home languages and cultures into the science classroom. The instructional strategy of connecting scientific discourse to everyday discourse involves identifying both differences and similarities between everyday practices and scientific inquiry practices. Teachers need to provide explicit instruction about the differences between students’ everyday discourse and scientific discourse (Lee, 2004), so that students understand the ways of talking and thinking in science are different from those of their everyday experiences. Teachers also need to draw from students’ everyday discourse (Moje et al., 2001) and make connections between scientific discourse and everyday discourse. The instructional congruence emphasizes the role of instruction (or educational interventions) as teachers explore the relationship between academic disciplines and students’ cultural and linguistic knowledge and devise ways to link the two (Lee *et al.*, 2005).

3. Attitudes and Interests toward Science

Science educators have struggled with defining science attitudes and differentiating among attitudes, beliefs, and values (Moore & Foy, 1997). The concept of “attitude” is defined broadly as used in the science educational literature. Oliver and Simpson (1988) define attitude as the degree to which a student likes science. Salta and Tzougraki (2004) summarize attitude as a tendency to think, feel, and act positively or negatively toward objects in our environment. Attitudes can be viewed as having three main components: cognitive, affective, and behavioral components (Salta & Tzougraki, 2004).

Osborne et al. (2003) have identified many features that influence on attitude: gender, structural variables (e.g., socio-economic class), classroom/teacher, and curriculum. Similar results of an analysis by Zacharia and Barton (2004) also showed that school variables (particularly classroom variables), such as how well students like their teachers, the science curriculum being used, or the science classroom climate, are key influences on attitudes toward science, with the strongest school-related correlation being how well students like or get along with their science teacher. Regarding the relationships between attitudes and other constructs in teaching and learning science, Siegel and Ranney (2003) reviewed other studies and found that: (1) attitudes affect students’ persistence and performance; (2) there are modest positive correlations between science attitudes and science achievement; and (3) activity-based and issue-oriented science instruction enhance positive attitudes toward science (Siegel & Ranney, 2003). Trumper also found that the quality of school science instruction is a significant determinant of attitudes (Trumper, 2006). Cannon and Simpson (1985) argue that changes in student achievement motivation were similar to changes in science attitude. For example, science self-concept at the 10th grade level is “a good predictor of both number and type of science courses a student will take during high school” (Simpson & Oliver, 1990).

There is broad agreement that all teaching should "build on" the interests and experiences of the students. In order for the educational content to be meaningful to the learner, it must have some sort of relevance and fit into the personal or societal context of the individual (Barton & Yang, 2000). Experiences and interests clearly vary among learners. It is also evident that there are similar variations in what is "relevant" and useful for students coming from such different backgrounds. Barton and Yang (2000) argue that the science curriculum’s lack of relevance is seen as one of the greatest barriers to good learning and the reason for students’ low interest in the subject and lack of motivation for pursuing science in higher education. One might expect the increasing significance of science to be accompanied by a parallel growth of interest in these subjects and an increased understanding of basic scientific ideas and ways of thinking. Science curricula are key factors in developing and sustaining students' interest in science (Basu & Barton, 2007). The implicit image of science conveyed by these curricula is that it is mainly a massive body of authoritative and unquestionable knowledge. Students disengage from school science if their experiences and cultures are not incorporated into the science curriculum (Basu & Barton, 2007). To enhance deep interest, Genzuk (1999) advocates integrating students' life experiences, cultural beliefs, 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 are rather characteristics of people in an activity (González & Moll, 2002). For example, Basu's and Barton's (2007) study aimed to connect the development of a sustained interest in science with the funds of knowledge that high-poverty urban students bring to science learning. The results showed that students develop a sustained interest in science when: (1) their science experiences connect with how they envisioned their own futures; (2) the learning environments support the kinds of social relationships students value; and (3) science activities support students' knowledge for enacting their views on the purpose of science (Basu & Barton, 2007).

4. Methodology

4.1. Participants

This aim of this study was to determine the effects of teaching science based on instructional congruence with students' attitudes and interests toward learning science. Participants were six science teachers and 214 students in Forms 2 and 4. They were recruited from three low performing secondary schools in Penang, Malaysia.
(Simpson & Oliver, 1990)

4.2. Teacher Training

The study involved a series of four workshops in the form of teacher professional development. These workshops aimed to introduce the concept of instructional congruence in teaching science to help the teachers deliver their lessons based on instructional congruence. The teachers continuously implemented the instructional congruence strategy during this study. The problems faced during implementation were discussed throughout the series of workshops. The first workshop provided an introduction to the concept of instructional congruence in teaching science, as well as a discussion of methods of incorporating students' funds of knowledge into instruction. An example of a lesson plan based on this strategy was also provided and discussed. The second workshop discussed the concept of lesson plans and student activities relevant to the instructional congruence strategy. The third workshop discussed the lesson plans produced by the teachers and their teaching experiences during implementation. Finally, the fourth workshop focused on various student activities that were carried out by the teachers during implementation and they shared their experiences. The discussion and sharing of ideas among teachers and researchers was an important part of each workshop. Suggestions identified during the workshops were highlighted by the researchers for further improvement in their teaching.

4.3. Data Collection

A questionnaire developed by Barmby, Kind, and Jones (2008) was used to evaluate students' attitudes and interest related to science. It consisted of 37 items that were separated into seven constructs representing students' overall attitudes toward learning science. The seven constructs were: learning science in school, self-concepts in science, practical work in science, science outside of school, future participation in science, importance of science, and combined interest in science. Combined interest in science consisted of the construct of learning science in school and outside of school. Because this instrument had not been used in Malaysian schools before, the questionnaires were first translated into the Malay language. The translations were then validated. The translated instrument was piloted with students from one school in Penang. The Cronbach's alpha coefficients of each construct were above 0.7, and for the whole instrument was 0.94, indicating that the data reliability was acceptable.

The data presented in this paper were collected in order to evaluate the implementation of instructional congruence in teaching secondary school science. In this evaluation, students' attitudes toward science were measured before implementation (pretest) and after implementation (posttest). For the purpose of this study, the questionnaire was used to examine students' changing attitudes and interests toward science during the implementation of instructional congruence. Some comments from students were used to provide further insight into this emerging issue.

5. Finding and discussion

Our findings indicate that students' views on science became increasingly positive throughout the study. After the study, means on each scale were between 2 and 3 (disagree and agree) on a 1–4 continuum (from *"strongly disagree"* to *"strongly agree"*). Paired t-tests were conducted to analyze whether there were significant differences in students' attitudes and interests before and after implementation of teaching with instructional congruence. Table 1 shows the results of the paired t-test analysis.

The results of this analysis show that the mean differences before and after the implementation of instructional congruence are statistically significant at $p<0.05$ in constructs of practical work of science, science outside of school, future participation in science, combined interest in science, and overall attitudes toward science. The increasing value of mean scores in these constructs shows that implementing instructional congruence in teaching science had a significant positive effect on the constructs listed in Table 1.

Table 1. Paired t-tests of students' attitudes toward science

Construct	N	Pre test		Post test		T	df	sig
		Mean	SD	Mean	SD			
Learning science in school	214	2.783	0.555	2.854	0.626	1.328	213	0.186
Self-concept in science	214	2.398	0.436	2.477	0.453	1.865	213	0.064
Practical work in science	214	2.728	0.556	2.887	0.622	2.786	213	0.006
Science outside of school	214	2.671	0.634	2.813	0.618	2.406	213	0.017
Future participation in science	214	2.507	0.688	2.642	0.700	2.000	213	0.047
Importance of science	214	3.001	0.655	3.077	0.631	1.208	213	0.228
Combined interest in science	214	2.662	0.552	2.777	0.577	2.182	213	0.030
Overall attitudes toward science	214	2.679	0.486	2.785	0.487	2.304	213	0.022

The most significant mean difference before and after the implementation of instructional congruence is for the construct of practical work in science. This result seems reasonable given that the teachers provided the students with hands-on activities as they implemented instructional congruence (scientific inquiry is one important characteristic of instructional congruence) (Bybee, 2003; Lee & Fradd, 2001). This teaching strategy emphasizes the incorporation of the students' experiences, interests, and enjoyment in science activities. Interestingly, the mean score of the statement, *"I would like to become a science teacher,"* increased substantially. This particular result suggests that the way the teachers delivered science instruction motivated students to see science teaching as an attractive career.

There is also evidence that mean scores for the constructs of learning science in school and the importance of science increased after implementing instructional congruence, although the mean differences were not significant at $p<0.05$. These findings indicate that instructional congruence also had a positive effect on students' attitudes about these constructs. However, the teachers still need to put effort into making the students confident in learning science which will improve their achievement, even though the schools under this study were categorized as low performing.

The findings of this study also call for improving the implementation of secondary school science curricula. Previously, content may not have been presented in ways relevant to the context of the students and schools. By presenting science not relevant could lead many students, especially those in low performing schools, to consider school science irrelevant and boring. Furthermore, this finding addresses an important consideration in implementing the curriculum, more effort needs to be directed to the integration of learning science in school and outside of school activities. This effort could be accomplished through activities such as participating in a science club, watching science programs on TV, going to science museums, engaging in science activities outside of school, and reading science magazines and books.

Students' attitudes and interests toward learning science may be strengthened by delivering more hands-on activities and improving the way science is taught. These changes can connect science with students' experiences, thereby emphasizing the relevance of science in students' daily lives. We expect that implementing instructional congruence in teaching science will engender these changes.

6. Conclusion

The present study demonstrated that instructional congruence had a significant impact on students' attitudes and interests toward learning science, especially in the constructs of the practical work of science, science outside of school, and future participation in science. Students' interest in science outside of school had the greatest effect on their interest in future participation in science. Teachers' efforts to integrate students' cultural experiences with scientific concepts promoted students' understanding. As identified through students' experiences during the implementation of instructional congruence, science became easier to understand, more meaningful, and more relevant to students' daily lives. The learning process that emphasized instructional congruence helped students to make the connection between science and their own funds of knowledge (Lee & Fradd, 2001; Luykx & Lee, 2007). Students enjoyed the experiences that they had in the classroom. However, science outside of school had a greater impact than science in school on students' interest in future participation in the field. This finding suggests that we must consider implementing science curricula that are related to students' out-of-school activities.

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