

*High Scope Project Evaluation—The Impact of Congruency between Preferred and Actual Learning Environments on Tenth Graders' Science Literacy*

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**Abstract**

This study explored how the congruency between preferred and actual learning environment (PLE & ALE) impacted on students' scientific literacy in the innovative Sci-Tech Mind and Humane Heart (STMHH) curricula as part of the High Scope Project sponsored by the National Science Council of Taiwan. A pre-/post-treatment experiment was conducted with 34 tenth graders. We divided the students into two groups of "preferred alignment with actual learning environment" (PAA) and "preferred discordant with actual learning environment" (PDA) according to their scores from the PLE and ALE questionnaires. The results of this study revealed that most of the students in this study preferred learning in a classroom environment where student-centered and teacher-centered instructional approaches coexisted. Furthermore, the ANCOVA analysis showed that students in the PAA group had better learning performance over those in the PDA group with marginal statistical significance.

Keywords: learning environment, scientific literacy

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## Introduction

One important goal of science education is the enhancement of learners' scientific literacy, including students' science conceptual understanding, science procedural skills, and attitude toward science (*American Association for the Advancement of Science*, 1993). Research has recommended various teaching strategies and models for the promotion of science literacy. The perspectives of constructivism on learning and teaching, although with criticisms (e.g., Osborne, 1996), have been highlighted by science educators and researchers due to its profound influences in contemporary science education (Staver, 1998). From the perspective of constructivism, an individual learner's cognitive structure regarding a specific topic must be actively constructed through as a meaningful process rather than being directly transmitted from the teachers. Based upon the assertions of constructivism, many teaching methods and strategies, such as learning cycle (Karplus, 1997), inquiry approaches, and problem based learning (Barrows, 1980), have been widely demonstrated to be effective in promoting students' learning. Constructivist student-centered approaches are therefore increasingly recognized as having positive impact on cognitive learning and affective development (Esiobu & Soyibo, 1995). In Taiwan, educators have also advocated the implementation of student-centered strategies in science education at primary and secondary levels since 1990's (MOE, 1998; MOE, 2001).

Although constructivist teaching strategies have gained increasing recognition and are recommended by educators and researchers, the debate between teacher-centered and student-centered remains (Chall, 2000; Authors, 2006). Empirical studies of student perception on learning environments showed that students did not always embrace the constructivist student-centered approaches as the educators promoted. Rodrigues (2004) found that students from Western cultures accepted learning as a self-exploring process while Asian students expected to have direct guidance from teachers. Furthermore, authors (2006) have stated that most students in Taiwan seemed to prefer the mixed use of student-centered and teacher-centered approach in earth science classroom with a small number of students seemed to prefer a teacher-centered environment. We therefore hypothesize that students in Taiwan prefer learning in a mixed environment of student-centered and teacher-centered learning model. If this hypothesis is true, the development of appropriate teaching strategies for promoting students' science literacy in Taiwan would need to be re-formatted from the fully student-centered or constructivist-oriented approaches.

The purpose of this study was to evaluate the Taiwanese 10<sup>th</sup> graders' preferences of learning environment, and to examine the possible impacts of students' perceptions of preferred/actual learning environments on students' science literacy in an innovative Sci-Tech Mind and Humane Heart (STMHH) curriculum as part the National Science Council sponsored High Scope Project. The project aims to enrich high school students' humanistic perspectives and scientific literacy, including students' science subject knowledge, attitude toward science, and their understanding of the nature of science through integrated natural science and social science courses. As part of the STMHH project, this study investigated students' preferred and actual learning environment perceptions in the STMHH courses. We also examined the impact of congruency between preferred and actual learning environment perceptions on students' learning outcomes and science literacy. Three research questions were encompassed in this study: (1) what are the tenth grade students' learning

environment preferences? (2) to what extent do the tenth grade students perceive the designed learning environment as student-centered or teacher-centered? (3) what effects will the designed learning environments have on students' learning outcomes in terms of cognitive achievement and science literacy.

## **Method**

A total of 34 tenth grade students participated in this study. The STMHH curriculum was implemented in the fall semester starting from September 2008 till January 2009. The Preferred learning environment instrument (PLEI) and actual learning environment instrument (ALEI) were designed to quantitatively measure students' preferred and actual perception of learning environments respectively with focus on student-centered and teacher-centered dimensions. The students' responses in PLEI and ALEI were scored in 5-point Likert's scale. The PLEI and the ALEI were revised from the validated Earth Science Classroom Learning Environment Instrument (ESCLEI) (Authors, 2004). We divided students into two groups of "preferred alignment with actual learning environment" (PAA) and "preferred discordant with actual learning environment" (PDA) according to their PLEI and ALEI scores.

To measure student learning outcomes in terms of STMHH achievement, student attitudes toward the subject matter, and students' understanding of nature of science, we constructed and developed the Science Conception Test (SCT), and employed the Attitude toward Science Inventory (ASI) and the Understanding of Nature of Science Instrument (UNOSI) (Lin, 1996). All instruments have been verified to be with validity and reliability.

Based on the assumption that the preferred and actual congruence would affect students' learning outcomes (Fraser & Fisher, 1983), it was hypothesized that students' learning achievement and their attitudes toward science would be enhanced when they actually perceived the learning activities were congruent with their preferences. A univariate analysis of covariance (ANCOVA) was conducted to analyze how the students' learning achievement, understanding of nature of science, and attitude in the two groups were affected by the designed learning activities.

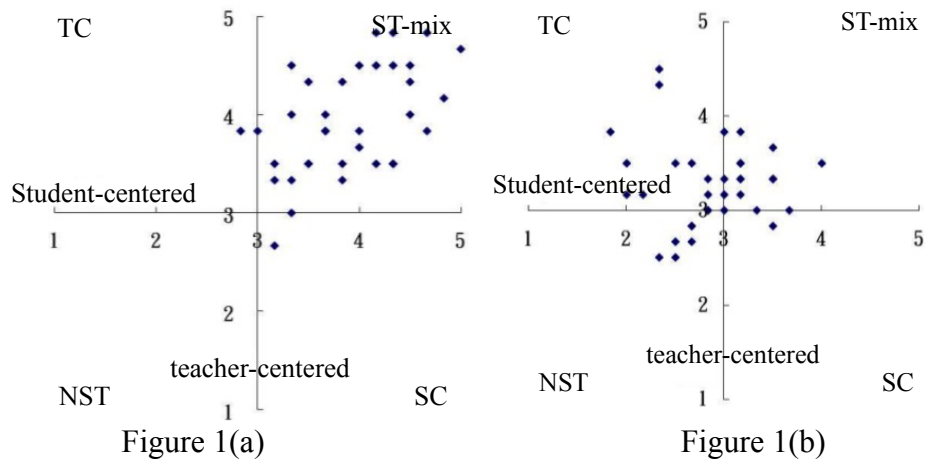
To meet contemporary calls for improvement in the interpretation and reporting of quantitative research in education (Thompson, 1996), this study reports practical significance (effect magnitudes) along with each statistical significance test. The effect size index  $f$  was used, since it is more appropriate for the analysis of variance or covariance (Cohen, 1988). According to Cohen's rough characterization (1988, pp. 284–288),  $f = 0.1$  is deemed to be a small effect size,  $f = 0.25$  a medium effect size, and  $f = 0.4$  a large effect size.

## **Result and discussion**

### ***Student perception on preferred and actual learning environment***

The mean scores of student responses in the student-centered and teacher-centered subscales were transformed into the format of (X, Y). For example, the upper right quadrant in Figure 1 represents that students prefer (or perceived) both the student-centered and teacher-centered learning environment, labeled as ST. The

upper-left quadrant represents that students prefer (or perceived) the teacher-centered learning environment (TC). The lower-right quadrant represents that students prefer (or perceived) the student-centered learning environment (SC), and the lower left quadrant represents that students prefer (or perceived) neither the student-centered nor the teacher-centered learning environment (NST).



As Figure 1(a) shows, in the pre-treatment survey, most of the students preferred the combined student-centered and teacher-centered (ST-mix) learning environment. In terms of actual learning experience, as indicated in Figure 1 (b), the students reported that the classes they used to attend tended to be teacher-centered learning environment.

This finding of this study echoes the previous studies that Taiwanese students tend to prefer a mixed model of student-centered and teacher-centered learning environment (Authors, 2006; Authors, 2004). This phenomenon may arise from students' cultural backgrounds. Tsai (2004) indicated that Taiwanese high school students' conceptions of science learning are associated with the society's learning-for-test culture, where preparing for tests is an educational goal (Authors, 2008). As a result, students regard teachers as an authoritative knowledge provider. Therefore, Taiwanese students may desire a student-centered learning environment whereas also seek for systemic guidance from the teacher. Thus, when developing teaching strategies and learning environment in Taiwan, teachers need to take into account of this phenomenon.

***Students' learning preference congruence and their learning outcomes***

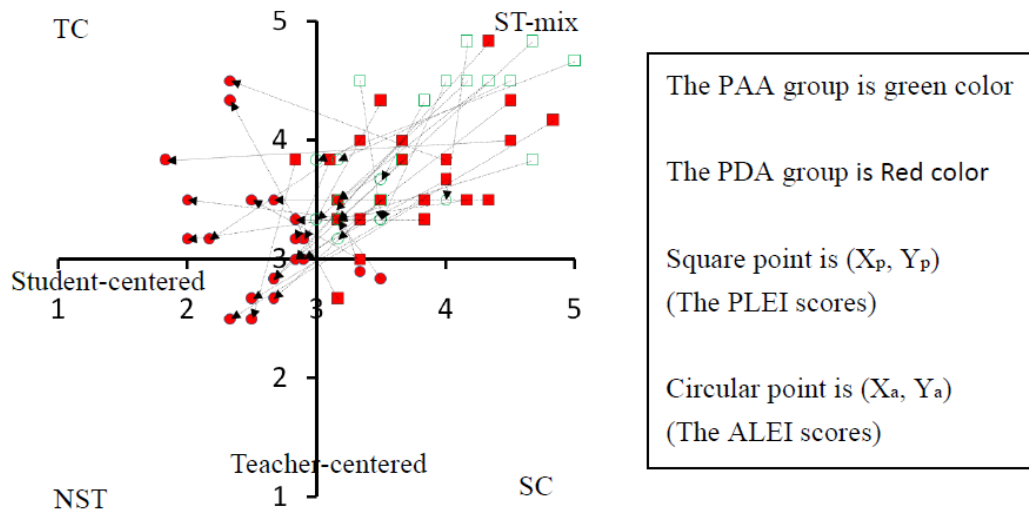


Figure 2: PAA group and PDA group

The mean PLEI scores of student responses in the student-centered and teacher-centered subscales were transformed into the format of  $(X_p, Y_p)$ , and the mean ALEI scores of student responses in the student-centered and teacher-centered subscales were transformed into the format of  $(X_a, Y_a)$ . As shown in Figure 2, 12 students with their  $(X_p, Y_p)$  and  $(X_a, Y_a)$  in the same quadrant were assigned to the PAA group and 22 students with their  $(X_p, Y_p)$  and  $(X_a, Y_a)$  in different quadrants were assigned to the PDA group. As shown in Table 1, it was found that there was a marginally significant difference between the PAA and PDA groups in terms of their performance (UNOSI,  $F(1, 32) = 2.93, p = 0.10, f = 0.31$ ). Furthermore, it was found that the performance of PAA group on SCT was higher than the PDA group with approaching large effect size ( $f = 0.3$ ).

Dependent Variables	group	Adjusted post-test scores		$F$	$p$	Effect size ( $f$ )
		Mean	(SD)			
SCT	PAA	60.4	(10.6)	1.69	0.2	0.3
	PDA	55.4	(10.5)			
ASI	PAA	2.53	(0.26)	0.28	0.6	0.1
	PDA	2.58	(0.26)			
UNOSI	PAA	3.09	(0.27)	2.93	0.10	0.31
	PDA	2.93	(0.27)			

Table 1. ANCOVA analysis

This finding revealed that students' scientific knowledge and understanding of the nature of science were better enhanced (with large effect size) when the learning activities are congruent with their learning preference. Previous studies have shown that students had better learning performance when the actual and preferred learning environments were more closely matched (Fraser & Fisher, 1983).

It should be noted that although the result was marginally statistically significant, a practical significance regarding the difference between the two groups via the ANCOVA analysis has been observed as approaching a large effect size. However, it is quite possible to observe a statistical significance with a large sample size (Cohen, 1988) for the results of this study. This result of approaching large effect size may

signify the possibility of finding statistical significance with a larger sample size in future studies.

The findings of this study suggest that design of instruction at secondary school level for the improvement of student science literacy should consider the preferred/perceived learning environment. That is, to decrease the discrepancy between preferred and actual learning environments might help students improve their performance in science learning.

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