Investigating the inquiry-based instruction effects the 8th graders' perceptions about learning environments in the physical science

TSAI, Chih-Chung
TUAN, Hsiao-Lin
Graduate Institute of Science Education, National Changhua University of Education, Taiwan

The purpose of this study was to investigate the effect of inquiry-based instruction on 8th graders' perceptions about leaning environments in the physical science classes. There were 295 8th graders participated in the study, in the experimental group included five classes (n=155) that taught with three units of inquiry-based instruction which last for three months. In the control group, teachers used the textbooks to teach five classes of students (n=140). The What Is Happening In this Class?(WIHIC) questionnaire was implemented in both groups before and after eight months to collect students' perceptions about the constructivist learning environments. Results showed both inquiry-based and textbook-based instruction, the inquiry-based instruction would significantly ($p<.001$) increase students' perceptions positively. However, the inquiry-based instruction showed significantly higher gain scores ($p < 0.05$) than textbook-based instruction, especially in the scales of Teacher Support (TS), Student Involvement (SI), Investigation (IN), Cooperation (CO) and Equity (EQ). But the scales of Student Cohesiveness (SC) and Task Orientation (TO) showed undifferentiated. Four scales dominated students' perceptions of the learning environments about inquiry-based instruction; these were CO, TS, IN and TO (explained the variances over 5 %). The IN and TO scales related the Personal Development Dimensions and the TS and CO scales related the Relationship Dimensions (Dorman, 2003). At last, the results of Path analysis to discussing the relationships between the psychosocial factors about the Personal Development Dimensions and the Relationship Dimensions that affected by inquiry-based instruction.
Key words: inquiry instruction, inquiry learning, learning environment

Introduction

Nowadays, the reforms of scientific education in most countries not only focused on development student's knowledge and skills but emphasize inquiry teaching and learning develops problem-solving ability that could apply in everyday life (Abd-El-Khalick et al., 2004; NRC, 1996, 2000). Sandoval(2005)、Sandoval & Reiser(2004) pointed out in order to build the inquiry-based classroom environment must construct a community of practice like the scientists work. In authentic inquiry-based activities, the students take action as scientists did, experiencing the process of knowing and the justification of knowledge. In addition, Polman & Pea (2001), Sandoval & Reiser (2004), Savinainen, Scott & Viiri (2005), Watson, Swain & McRobbie (2004) all proposed that inquiry teaching must be explanation-driven; in this teaching context the teachers questioned and guided students to “doing on” and “mind on”. In this way, it could combine students' prior experiences to change the framework of their concepts and transferred these in different situations.

To fulfill the objectives, the science teachers needed to create a constructivist learning environment, where the students could elaborate their potential and construct learning groups, setting the models of communication through the interaction with learners and instructors. It was expected that the effect of students' learning could conform to the scientifically intellectual and attitudinal demands, and also develop related social values, because they had to take learning responsibility for themselves and group members. For this reason, to describing the change in the varied dimensions of learning environment is extremely important. When the students have positive feedback and reception about the feelings of learning science that could also improve students' learning achievement (Brophy, 1987, 1999; Fraser, 1998; Dart, Burnet, Boulton-Lewis, Campbell, Staarman, Krol & Meijden, 1999; Polman, 1999; Straits & Wilke, 2002; Walberg, 1981, 1984). This study aimed to investigate learners' perceptions about inquiry-based learning environment in various social-psychological viewpoints.

Literature Review

The theories of this study were based on the impact of constructivist on science inquiry, on learning environment, and on teaching design.

The Impact of Constructivist on Science Inquiry

Hosfstein and Lunetta (1982, 2004) defined inquiry as the ways of method, thinking, interpretation, which are adopted by scientists to study the nature, and the evidences based on scientific investigate, emphasizing learners have the abilities to study the phenomenon of the nature world, raise notions, interpret the results base on evidences, and debate their own statement to show the scientific spirit in the process of inquiry. Tjosovold and Marino (1977) indicated that inquiry teaching could help students not only investigate, explore, and discover problems, but also detect and solve problems by instinct. The researcher stated that methods and strategies where learners acquired scientific knowledge were not limited in some specific contents of subjects. During the process of inquiry, the students explored and experienced the procedures of scientific knowledge through reading, writing, doing, and communicating. Meanwhile, they formed a meaningful learning environment and regularized the knowledge through social negotiation. What the procedure needs was to establish a community of practice, and cultivate its own classroom culture. (Sandoval, 2005; Sandoval & Reister, 2004). Students held even more positive attitude toward science while learning from inquiry-based teaching methods than from conventional teaching methods. Meantime, if teachers were able to execute the theories of constructivism, and then students could gain practical epistemology through cooperative learning in the reality learning environment, it could also benefit students to promote the motivation. Many researches proved that constructivism-based and inquiry-based teachings were effective and efficiency teaching-learning styles. To improve learners' scientific learning efficiency, only inquiry-based teaching models could be introduced into the present study.

The Impact of Constructivist on Learning Environment

Henderson, Fisher, and Fraser(2000) showed that researches on classroom environment have significantly influenced the studies of present learning environment according to Lewin(1936、1952) theories. Lewin illustrated the relation between human behavior and environment with B=f (P, E).” B” was student’s environmentally influenced external behavior. “P” presented student the individual. “E” was the environment where students were in. In this way, Lewin could investigate the relation between students and environment by realizing their learning behaviors. According to past researches on quality of learning environments, for excellent teaching, the emphasis on students’ perceptions toward learning environments were required. Also, the learning environments should be based on the theory of Constructivism.

Moos (1974, 1979) divided learning environment into three dimensions. One was “relationship”, whose function was to confirm the nature and intensity of human relations and to assess the extent of support offering and assistance to others. The second dimension was “personal development”, which belonged to basic dimension in the overall learning environment, emphasizing personal growth and self-enhancement. The other dimension was “system maintenance and system change”, which comprised environmental order, assurance, maintenance and control of anticipation, and response to change. Thus, on the level of social psychology by Moss(1974，1979), Dorman (2003) thought the interactions in the classroom between teachers and students can be classified into the same parts, which are respectively personal relationship, individual development and social relationship. “Personal relationship” highlighted the relationships of communications and interactions. “Personal development” emphasized the effects of social cognitive upon personal learning efficiency. “Social relationship” stressed the way of social culture formed in the overall learning environment during the interaction.

The study analyzed dimensions in “What Is Happening In this Class? WIHIC”(Aldridge, Fraser＆ Huang,1999) and social psychology by Dorman(2003) & Moss(1974, 1979). Above, student cohesiveness, teacher support, and student involvement belonged to the dimension which Moss called “relationship”; investigation, task orientation, cooperation were classified into the dimension--”personal development”; equity belonged to “system maintenance and system change”. Explanations were as the following :(1) Student cohesiveness: Understand how inquiry teaching influenced learners’ friendship. (2). Teacher support: Review student’s perception of teacher’s help, kindness, trust, and close attention to students’ learning situation. (3) Student involvement: Understand students’ class participation and interest in inquiry-based teaching environment. It belonged to “relationship” dimension. (4) Investigation: Check if students could attend the objective of the study and design the procedure of experiment to solve problems that teachers brought up. (5) Task orientation: Know the level of students’ involvement in tasks of the present study and their attitude toward physics teaching. (6) Cooperation: Examine if students could collaborate while designing learning plan, rather than compete. (7) Equity: teachers should be impartial to every student, treating equally without discrimination.

The Design of Teaching

In the study, the curriculum design highlighted the connections of background knowledge and emphasizes the importance of situated learning. Besides, the study was on the basis of Resnick’s principles (1989) to develop peer support system and promote student’s motivation on science learning by increasing interactions between participants and opportunities to learning. Herron (1971) and Windschitl (2003) classified inquiry into the following four types on the basis of inquiry questions, procedure, and solution, but in this study was the guided inquiry. The design was based on “unit” in the Nested inquiry-based instruction model Nested inquiry-based instruction model (Tsai & Tuan, 2005). Nested inquiry-based instruction model merged constructivism teaching model by Bybee & Landes (1988) and Bybee (1997), inclusive of five stages of engagement, exploration, explanation, elaboration, and evaluation. The design of learning activities included: P (prediction), O (Observation), E (Explanation), Do (Do) and De (Design) (Crouch, Fagen, Callan & Mazur, 2004; White & Gunstone, 1992). They were categorized into 3 contexts (Figure 1):

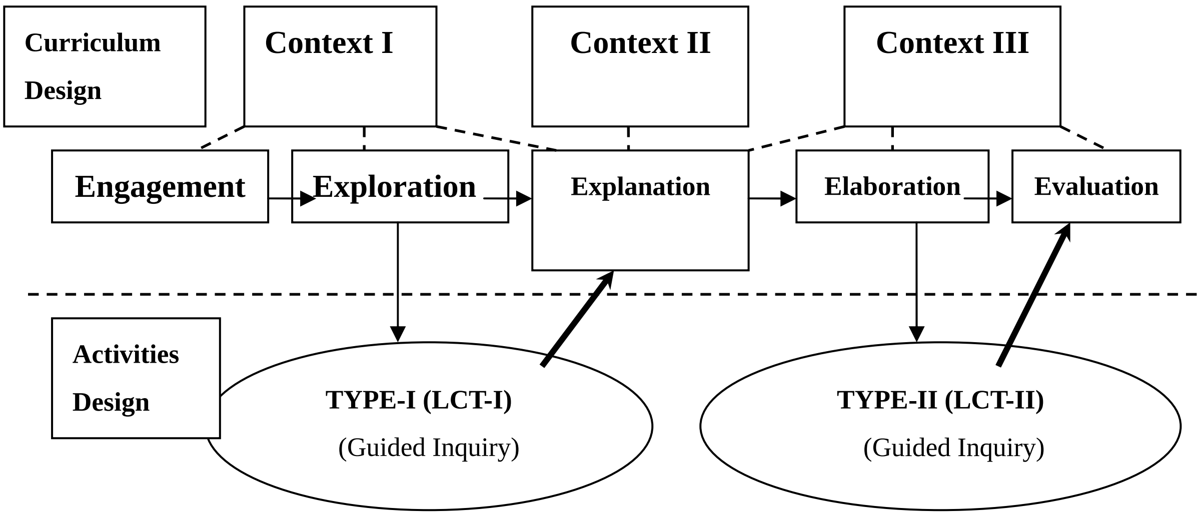

Figure 1: *Nested inquiry-based instruction model (Tsai & Tuan, 2005)*

1. Context I: Course design of context I in diagram 1 contained engagement and exploration in constructivism-based teaching model by Bybee. The stage “exploration” belonged to guided inquiry learning cycle Type-I (LCT-I) whose design ideas were P, O, E, Do, and De. Activities design in the stage was in terms of unit concept. Because of different qualities of text, the activities procedure followed P-O-E, O-P-E, P-Do-E, P-O-De, and O-P-Do-E, called Learning Cycle Type-I, [LCT-I] in the present study. And the following were the purpose of practice:

(1). Engagement: the initial stage of learning task in the whole unit. Teachers examined and reconstructed science concepts in the teaching unit, and instructed by the concepts of subject. Teachers help students reconstruct concepts to understand science concepts, the process of inquiry, and the skills of experiment. The stage established the background for the next stage— exploration.

(2). Exploration: Teachers modified the original teaching plan of experiment in textbooks, after new concepts were introduced. Students reconfirmed the learned new concepts, process, and skills on the basis of the new formed in the stage of Engagement. Activities in this stage were based on textbook but LCT-I style. Activities in “Exploration” were adapted from offered textbook activities. The students recorded experiment data on the form designed by teachers, discussed collected data, resulted in the conclusion, and shared with classmates the final result in context II.

2. Context II: the stage of “Explanation” in constructivism instruction model.
The main purpose of the activities in context II was to co-construct the level of knowledge. In context II, the demonstration of group conclusions balanced common views through group debates. Students experienced the process to form of knowledge and the process of knowledge justified. The importance of the stage lied in different concepts in context I. Students discussed and concluded formula or abstract idea which was conformed to scientific group. During the discussion, teachers could realize students’ learning situation and integrated follow-up inquiry issues to bring out issues in the next stage of context III.

3. Context III: elaboration and evaluation in constructivism instruction model were included. The purpose was for students to take up new knowledge and skills. Inquiry activities design was based on Learning Cycle Type-II，[LCT-II] in the stage of elaboration. The procedure followed P-De-E, De-Do-P-E, and De-P-Do-E for students to solve problems with their own design strategies. To combine daily issues and apply science knowledge, teachers and students discussed new inquiry issues which were formed for students.

Research Methods

In order to realize the influence of inquiry teaching on students’ perception of learning environment, the present study adopted questionnaires of “What Is Happening In this Class?

WIHIC"(Aldridge, Fraser, & Huang, 1999) to collect data of pretest and protest. The effective samples in the study were in inquiry-based teaching group (experiment group, n=214, class=5). Textbook-based teaching group (control group, n=165, class=5), which was at the same school and grade as study group, and the teachers with similar teaching experience. The two groups belonged to normal class grouping and had even learning performance in the beginning. For students in the five classes under Nested inquiry-based instruction model (Tsai & Tuan, 2005) during the first month of study preparation period at the beginning of semester, establishment of classroom rules and grouping to acquaint students with teamwork was the essential purpose. Nested inquiry-based instruction model practiced on the scale of midterm for one semester. Teaching materials included the following three units—"transformation of substance", "flotation", and "temperature and heat." There were 5 instructors included in the study. They were three female teachers and two male teachers, respectively, with the average teaching experience of 5 years. Teachers followed nested inquiry teaching model, participated in group meeting every two weeks, discussed the progress of teaching plan and shared their teaching reflections. And the analysis methods use the MANOVA and the Multiple Linear Regression Analysis to compare the differences between the experiment group and control groups and path analysis to analyze the inquiry-based teaching how influence the dimensions of learning environment.

Result

The result showed the difference of pretest and protest of inquiry-based teaching group and textbook-based teaching group. Then, the research discussed the difference and groped influential dimensions with multiple linear regression analysis. Last, the research analyzed path of dimensions to realize the effect of inquiry teaching on social psychology, proposed by Moss (1974, 1979).

The Influence of Different Teaching Methods

To understand the influence of different teaching methods on learning environment, the researchers analyzed collected data by MANOVA (Table 1). The result showed that "inquiry-based teaching group" (IT) and "textbook-based teaching group" (TT) had no significant difference in the initial. However, after changing the teaching method, inquiry-based teaching exceedingly improved in dimensions and overall aspect except for student cohesiveness and task orientation. Yet, textbook-teaching had no significant difference in all the dimensions. Although inquiry teaching could merely promote the positive perceptions of learning environment ,but the dimensions" Student Cohesiveness" and "Task Orientation" in a small range of growth. As to textbook-based teaching, the overall growth slightly increased but not significantly. The range of growth in Teacher support, student involvement, and cooperation slightly decreased. Overall, it showed that students had little perception on learning environment.

After practicing inquiry learning, students could percept the constructivist-based learning environment, which emphasized students' learning, concerned students' learning situation, elevate students' participation in learning process and played the volunteered participant. In teaching and learning, the increase of inquiry could improve the level of cooperation. Owing to the cooperative learning, students contributed to the practice group and were equally treated.

Table 1: *The differences of the inquiry based-teaching and textbook-based teaching (MANOVA)*

		Student Cohesiveness	*Teacher Support*	*Student Involvement*	*Investigation*	*Task Orientation*	*Cooperation*	*Equity*	*Overall*
IT	Pretest	30.51/6.52	23.77/6.92	23.07/7.43	22.01/7.68	27.95/6.92	27.15/(7.35	26.75/(8.02	181.22/ 40.12
	Protest	31.08/(5.70	25.84/6.31	24.89/6.60	24.46/6.98	28.66/6.39	29.05/6.52	29.41/7.17	193.39/ 36.38
	Sign.	0.82	0.01**	0.04*	0.004**	0.75	0.04*	0.003**	0.009**
TT	Pretest	29.50/6.55	22.39/6.86	21.77/6.68	20.69/6.96	27.05/6.73	26.77/7.16	25.71/7.84	173.88/ 38.74
	Protest	29.69/6.29	21.65/6.76	21.63/6.19	20.74/6.93	27.33/7.90	26.55/6.92	26.90/7.65	174.49/ 36.26
	Sign.	0.99	0.76	0.99	1.00	0.98	0.99	0.50	1.00
IT vs. TT	Pretest	0.39	0.18	0.23	0.27	0.59	0.95	0.55	0.23
	Protest	0.19	0.000***	0.000***	0.000***	0.32	0.007*	0.02*	0.000***

* IT means inquiry-teaching group. TT means textbook-teaching group. *, $p<0.05$；**,$p<0.01$；***, $p<0.001$

The influences about the inquiry-based teaching

Analysis of dimensions in various teaching methods on students' perception toward learning environment showed that dimensions of both inquiry-teaching and textbook teaching are positively related. However, textbook-based teaching group had no significant difference on perception of learning environment. Thus, the research focused on inquiry-based teaching and discussed those important dimensions that influenced students' perception of learning environment.

Inquiry teaching had great influence on the dimension of "Cooperation" of learning environment (Table 2.). The explained variance was up to 58%. Because the inquiry teaching emphasized the formation of a practice group in the process of problem-solving, after the inquiry teaching what students perceptively felt the most was the increase of cooperation and will. The secondary was teacher support, whose increase range of explained variance was 19%. The present study conducted guided inquiry. During the process, teachers were the characters of the guide and the supporter, assisting the establishment of classroom regulations or rules used in the practice group. Next, the explained variance of dimension of investigation was 8%. Inquiry teaching enabled students to personally experience the spirit of investigation and comprehend required skills while investigating. Last, the explained variance of dimension of task orientation was 6%. The dimension showed no significant difference (Table 1), but inquiry teaching indeed influenced perception of learning environment. The dimension discussed if students could take the responsibility for their own studying, including course progress and comprehension of context before learning. The major effects of inquiry teaching on learning environment included relationship dimensions and personal development dimension, proposed by Moos (1974, 1979). They conspicuously elevated social interactions between peers and teachers, personal growth, and individual competence.

Table 2: *The effect of inquiry-based teaching (Multiple Linear Regression Analysis)*

	Explained Variance（R^2）	Accumulated Explained Variance（R^2）	F Value	Significance
Cooperation	0.58	0.58	296.68	0.000***
Teacher Support	0.19	0.77	178.13	0.000***
Inquiry	0.08	0.85	121.99	0.000***
Task Orientation	0.06	0.91	142.62	0.000***

註：*, p<0.05；**,p<0.01；***, p<0.001

The relationships of inquiry-based teaching on dimensions of learning environment

Besides the discussion on major effects of inquiry teaching, to verify the relationship of dimensions, the present study according to environment classifying method by Dorman(2003) and Moos(1974,1979) categorized the environment into parts of "Relationship", "Personal development", "System maintenance and system change", setting up models in which "Cooperation", "Teacher Support", "Investigation", and "Task Orientation" reached statistic fitness. "Cooperation" and "Teacher Support" belonged to the dimension of relationship, and "Investigation" and "Task Orientation "belonged to the dimension of personal development. The above four scales were analyzed with LISREL8.7 statistic software in path analysis. The model showed in Figure 2. In the model, X^2 was 0.55, P value 0.46, refuting null hypothesis. GFI value was 1.00; AGFI value was 0.99; RMSEA value was 0.00; ECVI value was 0.09; NFI value was 1.00; IFI value was 0.99; RFI value was 0.98. The above values showed the model was suitable to explain the theory of the study.

The model presented that in the dimension of relationship, cooperation affected mostly and the path coefficient was 0.74. The next, the path coefficient of teacher support was 0.46. In the dimension of personal development, task orientation was the effective target and the path coefficient was 0.70. The path coefficient of investigation was 0.57. That proved inquiry teaching created collaborative and supportive learning environment, which offered opportunities for students to be responsible for studying and to experience the importance of inquiry in learning science.

1. The influence of inquiry-based teaching on the dimension of "Relationship":

(1). "Cooperation": The study design aimed to form a cooperation learning environment, where students could share data and information with one another to complete tasks by working together. In the process of the communication and interaction, they learned from peers and shared ideas, enculturing, and have positive scientific attitude. They became much familiar because in class or after class they had to gather around to finish the tasks and teaching target set by teachers. Petegem, Donche & Vanhoof (2005) proposed that in a meaningful and strategic learning environment, students were demanded to solve more problems or take challenges by teamwork, thus, an ideal constructivism-based teaching environment had to enhance peer cooperation. Students collaborated in teamwork to finish teacher's tasks in inquiry activities of the study.

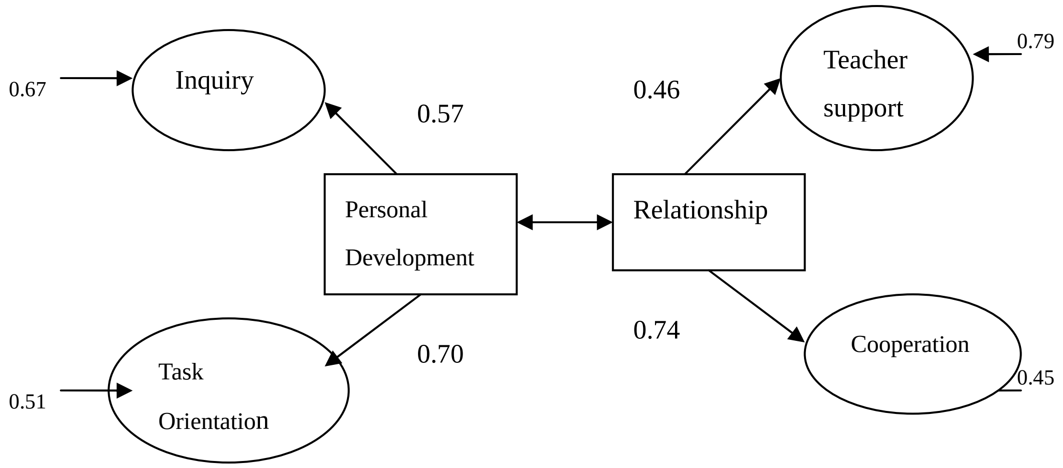

Figure 2: *Path Analysis of Classroom Environment*

(2).”Teacher Support”: Inquiry teaching greatly improved the growth of the dimension. Werch (1991) indicated that during learning process, students underwent a sequence of mental transformation such as genetic epistemology by Vygotsky (1978). With the help by expert, students could successfully transfer the period of mental transformation and participated in learning activities effectively. Hogan (1999) pointed out teachers’ addition of verbal interactions with students could promote students to think or reframed their own procedural knowledge. In the dimension of relationship, what students felt was the level of cooperation growth in inquiry teaching. They valued peer collaboration to complete tasks and attend learning goals.

2. The influence of inquiry teaching on personal development

(1). “Task orientation”: Pretest and protest of the dimension had no significant difference. The reason probably lied in the high original scores. Students placed importance on attending class punctually, worked hard on contents, and tried best to complete tasks given by teachers. In teaching, students’ consciousness of basic but required attitude and responsibility for completion of tasks was substantial for whichever teaching style. To lighten learning stresses, teamwork was compulsory in substitute of individual. In the process, students could be responsible for missions entrusted by peers or teachers to complete learning tasks in the worksheets. The result of the study showed that an open, orderly, well-organized, and well-planned inquiry-based learning environment could involve students into inquiry learning.

(2).” Investigation”: The dimension had no difference in the initial of inquiry-teaching group and textbook-teaching group. However, inquiry teaching could significantly enhance student’s involvement and participation. The range of growth was higher than conventional lecture teaching. The initial state shows the negative perceptions of this scale (The average of questions was 2.75). After practicing inquiry-based teaching, it increased and changed into positive inclination. The result showed that in the conventional teaching, students lacked inquiry-related experience. In inquiry-based teaching, Students could prove their thoughts by experiment and evidence and learn from doing.

In view of the above research result showed that for students, compared with past learning environment, inquiry teaching was a totally different learning experience. Nested inquiry teaching environment enabled students to devote to learning tasks actively and voluntarily.

Conclusion

The above research result showed that nested inquiry teaching influence two dimensions of relationship and personal development the most. The two dimensions included interactions between peers and teachers and students to develop a scientific inquiry practice group. In the inquiry-based teaching, students understood their capacity and took the responsibility for learning, yet teachers played a support and adviser, which were important roles. By the Nested inquiry-based instruction model n of the study, students could experience the process of inquiry and constructed meaningful knowledge through interactions, applying knowledge in daily lives.

In the inquiry-based teaching, teachers had to not only create an inquiry environment and practice of community, but offered required knowledge and skills to help students to acquire and improve the meta-cognition ability by debating. The environment of the study was based on students, emphasizing takers who influenced mutually constructed knowledge by interactions with one another. With teamwork, students would never feel helpless and isolated in learning, and developed learning strategies. Namely, students could involve in the process of scientific inquiry by the constructivist-based inquiry teaching.

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