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Using Conceptual Change Theories to Model Position Concepts in Astronomy

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The roles of conceptual change and model building in science education are very important and have a profound and wide effect on teaching science. This study examines the change in children's position concepts after instruction, based on different conceptual change theories. Three classes were chosen and divided into three groups, including a model implicating group (n = 29), a conceptual conflict group (n = 31), and a model building group (n = 30). The researchers used a two-tier diagnostic instrument to inquire position concepts for elementary school students and interviews for gathering students' concepts. This study applies one-way ANCOVA (analysis of covariance) for data analysis. Results indicate that the three groups can improve their high-order understanding of the position concepts. The score of the model building group was significantly higher than that of the model implicating group.

Keywords: position concepts, model building, conceptual change

Introduction

Children's alternative concepts or misconceptions play a very important role in science learning. Up to 2007, there were 7,624 papers about this subject (Duit, 2007). The model and modelling are important keys to scientific development and necessary for learning science (Chiu, 2008). The study of concepts and mental models has been the main focus in science education recently. In the science category, there are many relative concepts about position in the set of wind and astronomy research and terrestrial magnetism. In the category of society, there are some units related to position concepts, like the research of a hometown, the position of a country, and a country internationally speaking. In the category of math, coordinates name a concept which includes the position concepts. The position concepts are the basic concepts of many subjects. If students could strengthen their position concepts, they may get a better understanding when learning these subjects.

However, most studies focus on major topics, such as conceptions of the Earth, gravity, the day-night cycle, the seasons, and the Earth-Sun-Moon System rather than position (Lelliott & Rollnick, 2010; Trumper, 2006a, 2006b). The purpose of the study is to inquire the position concepts of students by developing tools for clarification and discover their difficulties when learning. This study uses different strategies to indicate position concepts and tries to understand the differences between them.

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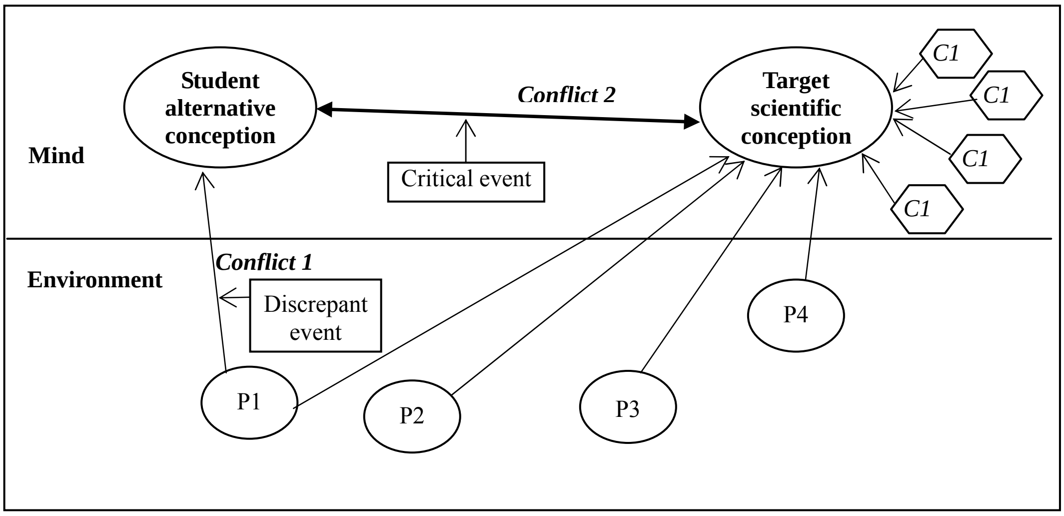
Theoretical Framework

Changing perspectives in science education have taken the form of “alternative concept”, “alternative framework”, or “misconception” in the early periods, then to “develop the teaching strategies for conceptual change” and now a “mental model building”. Each research form has a different approach and creates diversification. Consider this, the “conceptual change theory”, “mental model building”, and “conceptual change in model building” become the subject of this paper as researchers inquire the position concepts, which is a core concept in astronomy teaching.

Researching the Effect of the Conceptual Change Theory

Posner, Strike, Hewson, and Gertzog (1982) proposed four fundamental conditions that need to be fulfilled before conceptual change can happen in science learning: (1) There must be dissatisfaction with existing conceptions; (2) There must be a new conception that is intelligible; (3) The new conception must appear to be plausible; and (4) The new conception should suggest the possibility of a fruitful program. This theoretical framework, known as the “classical approach” to conceptual change, became the leading theory that guided research and instructional practices in science education for many years.

Extending from the theoretical framework of Hashweh (1986), Tsai and Chang (2005) proposed the framework of the conflict map (see Figure 1). The science concept mode and the framework of the conflict map proposed herein specifically assert that students should resolve two conflicts during the process of conceptual change: One exists between the new perception and students’ alternative conceptions (Conflict 1), and the other one exists between the student’s alternative conception and the scientific one (Conflict 2). The resolution of Conflict 1 does not necessarily clarify Conflict 2. Conflict 1 may be resolved through discrepant events, and the resolution of Conflict 2 could be achieved using critical events or explanations, relevant perceptions, and conceptions that explicate the scientific conception.



Notes. P1: the perception inducing a discrepant event; P2, P3, and P4: other supporting perceptions; C1, C2, C3, and C4: relevant scientific conceptions.

Figure 1. The framework of the conflict map (Tsai & Chang, 2005).

Discrepant and critical events pertain to anomalous data in which theoretical predications are in conflict with empirical data. In the case of a discrepant event, students are often confronted with an unfamiliar and new finding. However, in the case of a critical event, the students are invited to make an inference that contradicts a fact that is already well known to the learners or in the context of their experiences. The discrepant and critical events are usually presented in the format of discussion to encourage students to freely explore their ideas, concerns, and alternatives regarding these events.

From an ontological view, Chi, Slotta, and de Leeuw (1994) indicated that the increase and change of a concept are affected by one's rule of ontology. For example, students often consider heat as an object in the ontological category. In fact, heat is a process in the ontological category. Students are also expected to learn not only about static concepts, but also about dynamic concepts, such as the process of heat transfer and natural selection. Categorization is an important learning mechanism because a concept, once categorized, can inherit features and attributes from its category membership. Carey (1985) and Chi (1992) proposed that theories changing from one naïve theory to another can also involve ontological change. For conceptual change to occur, prior knowledge must conflict with new information. Chi (2005) proposed that instruction should be designed to target conceptual change at a different grain size and at the categorical level.

Vosniadou (2009) considered that the processes of students' learning and scientists' inquiring are very different. Lacking meta-cognition, testing systems, science theory, belief in the nature of science, emotion, etc., are often ignored when doing conceptual change research. The types of conceptual change include gradual, jump, or a mixture of these two types. The learner's native concept, the process, and surroundings could be reasons which affect the development of the concept.

A science teacher should realize the nature of conceptual change of students, try to find the difficulties of students' learning, and figure out the strategy and mechanism for conceptual change teaching. In order to understand the difference between incorrect knowledge and misconceived/conflicting knowledge, teachers must consider the presentation of knowledge at three different grain sizes: individual beliefs (a single idea, such as "A human heart has four chambers"), mental models (internal representation of a concept or an inter-related system of concepts, such as "the Earth" or "the circulatory system"), and categories (an ontological view of a concept, such as "Heat is not hot molecules or hot stuff, but more accurately, the speed of molecules, a process").

The Process of Mental Model Building

van Schaik, van Oers, and Terwel (2010) as well as Keijzer and Terwel (2003) found that teaching modelling co-constructively leads to better results in vocational secondary and primary education. Doorman (2005) proposed that the application of guided reinvention in teaching modelling helps secondary school students achieve a better understanding of graphing change. At an elementary level, Marquez, Izquierdo, and Espinet (2006) designed a six-week unit for Grade 5 students around modelling the evaporation and condensation phenomena, using a solar still as an anchoring phenomenon. The unit was designed to engage students in the modelling practices of constructing, evaluating, revising, and using scientific models of evaporation and condensation phenomena to explain how the solar still works and how other evaporation and condensation phenomena occur. Science teachers should not only realize the nature of a mental model but understand the modelling. Through the model building, teachers should pay more attention to the process to build the mental model and its structure.

From the mental model perspective, Linder (1993) indicated that conceptual change is achieved by any of the following: acquisition of new information (adding to the internal structure); reorganizing existing knowledge (reorganizing the internal structure), and no longer viewing some attributes of the structure as worthwhile knowledge (discarding some of the internal structure).

Buckley and Boulter (2000) proposed a framework of the model for the learner, and they thought that students use knowledge which they already have and integrate the new messages to increase their knowledge or change their concepts. Justi and Gilbert (2002) developed the structure of modelling (see Figure 2) and considered that all modelling must be based on its purpose for science teaching, so that they could build or fix the mental model or reorganize the new model.

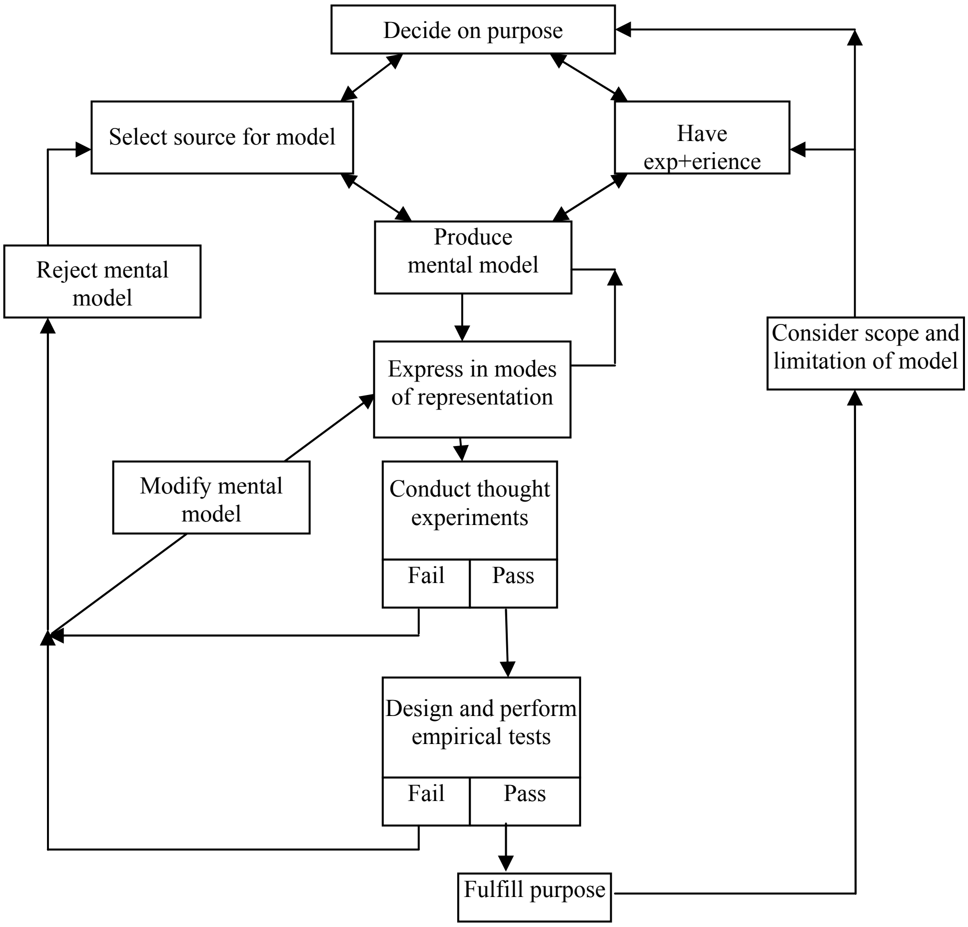


Figure 2. A "model of modelling" framework (Justi & Gilbert, 2002).

Schwarz and White (2005) created a curriculum, which is an inquiry-oriented curriculum, in which students learn about the nature of scientific models and engage in the process of modelling. The curriculum contained six steps, including questioning, hypnotizing, investigating, analyzing, modelling, and evaluating (see Figure 3). In previous curriculums, students began their inquiry by being presented with an interesting question about a situation involving force and motion, which is chosen for its simplicity (e.g., one-dimensional motion in a frictionless environment). They then developed hypotheses about what the motion of objects in that situation should be, based on their ideas about force and motion. Subsequently, they carried out investigations using real-world experiments and experiments with a computer simulation that follows the rules of Newtonian physics. They then used their data to evaluate their hypotheses and summarize their findings by creating a law, which takes the form of a written rule that is consistent with their observations. Finally, they evaluated the limitations of their model (current set of laws) and considered situations and phenomena that it could not explain.

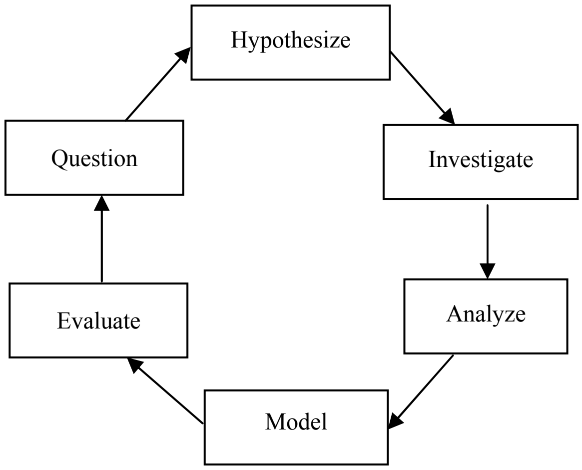


Figure 3. Scientific inquiry cycle (Schwarz & White, 2005).

According to the articles above, there are some implications for science teachers. First, besides considering the learner's previous knowledge and the learning context, the purpose for science learning must be based on an experiment, which could test the mental model of the learner; Second, after the learning, the learner must present his/her mental model to be the object that could have interaction with the experiment and then confirm or justify his/her original model; Third, the science teacher must provide the conditions for building a mental model, such as options of purpose, design of mental experiment, or real experiment. After the mental model of the learner passes the experiment, he/she should be reminded of the range and limitations of that model.

Using the Theory of Conceptual Change in Modelling Teaching

In real science learning surroundings, there are many strategies for modelling. Driver (1988) developed a teaching strategy POE (prediction, observation, and explanation). Students predicted the situation or what would happen before the teacher's demonstration presenting the conceptual conflict. After that, students explained how it happened and were made aware of the differences between the prediction and explanation. The teacher could help students to challenge their preconceptions by arranging the cognition conflict or demonstration.

Harrison and Treagust (2000) found that it is difficult for students to build a new model and use it. They thought teachers should plan for students' modelling before learning. They proposed FAR (focus, action, and reflection), a teaching model to help teachers. Focus involves pre-lesson planning where the teacher focuses on the concept's difficulty, the students' prior knowledge and ability, and the analogical model's familiarity. Action deals with the in-lesson presentation of the familiar analogy or model and stresses the need for the teacher and students to cooperatively map the shared and unshared attributes. Reflection is the post-lesson evaluation of the analogy's or model's effectiveness and identifies qualifications necessary for subsequent lessons or modifications the next time the analogy or model is used.

Clement (2000) proposed a framework of model-based learning. The framework connects concepts, such as an expert consensus model, target model, intermediate models, preconceptions, learning processes, and natural reasoning skills. By connecting and elaborating on these major areas, Clement (2000) succeeded in moving people's another step towards having a theory of conceptual change that can provide guidance to teachers in the form of instructional principles. Taken together, Clement (2000) reminded people that individual cognition, while not the only factor in learning, is a central determining feature of learning.

Schwarz et al. (2009) proposed defined scientific modelling that included the elements of the practice (constructing, using, evaluating, and revising scientific models) and the meta-knowledge that guides and motivates the practice (e.g., understanding the nature and purpose of models). They designed a learning progression for scientific modelling that includes two dimensions that combine meta-knowledge and elements of practice—Scientific models are used as tools for predicting and explaining, and models change as understanding improves. They stressed modelling practice as the interaction of the elements of the practice and meta-modelling knowledge (see Figure 4). The two types of goals, sense-making and communication understanding each emerge from the use of the practice elements and meta-modelling knowledge. Vosniadou (2007) argued that teaching for conceptual change should utilize but cannot solely rely on cognitive apprenticeship types of methods. Attention must be paid to the appropriate design of curricula and the acquisition of subject matter knowledge, together with the development of instructional methods that utilize socio-cultural processes, like classroom discussion, to develop students' meta-conceptual awareness and the ability to engage in intentional learning.

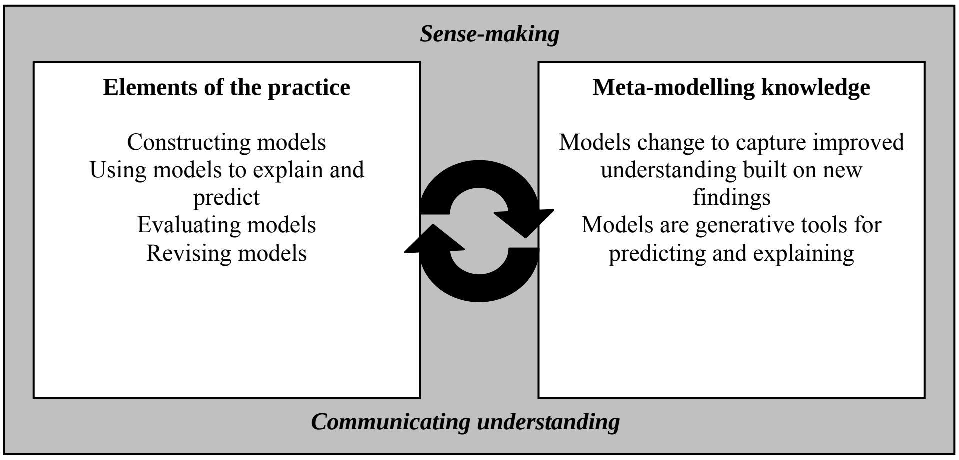


Figure 4. A learning process for scientific modelling (Schwarz et al., 2009).

These papers about model teaching have three characteristics: First, the teachers should take into account the preconceptions of students and lead students' learning on the basis of students' preconceptions; Second, analogy is a key for modelling. The teacher should use analogy well when helping students model; and Third, more attention should be paid in the reaction between the mental model and the information in the external world. Discussing, reflection, sharing one's opinion, and concept application will help students to clarify and strengthen their concept. The instruction design is based on these three characteristics in this study and attempts to help students and teachers in the science classroom to learn and teach the position concepts more efficiently.

A Review of Astronomy Education Research

Lelliott and Rollnick (2010) used a conceptual framework of "big ideas" in astronomy, five of which accounted for over 80% of 130 studies from 1974 to 2008: conceptions of the Earth, gravity, the day-night cycle, the seasons, and the Earth-Sun-Moon System. Shape, position, and movement are the core concepts of these five conceptions. It is recommended that future research should work across the disciplinary boundaries of astronomy education at school. Moreover, including frames of reference in astronomy education can enhance students' deep understanding of nature of science and scientific modelling. Students can be taught to make transformations between the heliocentric model and the geocentric one, while being conscious about the justification schemes they employ. Meaningful learning occurs when students tie their understandings to their own experiences (Shen & Confrey, 2010).

Falcão et al. (2004) adopted a model and modelling approach to investigate the astronomy educational potential of a science museum exhibition. It focused on patterns of relationship between the teaching models proposed by designers and students' models in regard to four exhibits concerning astronomical cycles. Four patterns of relationship were identified, ranging from low to high degrees of convergence between designers and students. The position concept became a core concept of the pedagogical model shape when students built their model depicting the day-and-night cycle, seasons, heat which varies according to geographical position, conservation of the Earth's rotational axis, and right orbit.

Children learn about the directions up and down prior to the directions left and right. Before they contact the position concepts north and south, they have to be familiar with those direction concepts. Poole, Miller, and Church (2006) proposed that people's acquisition of the space concept comes from the position and direction of movement and exploration of the surroundings, and that is the most effective way for children to increase their space cognition.

From these related articles, researchers could see that the position concept is one of the space concepts and it does not come to people naturally. It is generated by the interaction of surrounding stimulation. The position concept is also the infrastructure for learning many subjects. This study tries to help students model the position concepts and investigates the difference in learning resulting from different teaching strategies.

Methodology

Sample and Design

There were three classes, including 90 students in Grade 5, involved in this study and divided into three groups: (MG (modelling guiding), CC (conceptual conflict), and MI (model instruction)). One teacher taught all three classes. The quasi-experimental design was used in the study. All students received tests for position concept achievement and a position concept test before and one week after learning. Prior to instruction, six students, two from each class, had an unstructuring interview to collect their concepts. After the teaching process, they had a half-structured interview to confirm their concepts.

The Design of Instruction Process

The instruction processes in this study followed different strategies (see Table 1), which were based on different modelling theories.

MG. The instructional processes and teaching strategies of the MG group were based on the theory of the instructional modelling sequence for elementary curriculum materials from Schwarz et al. (2009). In this sequence, the teacher used questions about position and direction for an anchoring concept and then tried to make students engage in modelling their concept about the concept. After that, the teacher used some examples and phenomena to test and evaluate the model, and students revised and used the scientific model to explain how their model still works and how these phenomena occur. By discussing this with the teacher, students could refine their model and apply the model to predict and explain other new phenomena.

Table 1

The Main Process and Strategies of Three Different Instructions

Group	*N*	Main processes	Description of strategies
MI	29	Focus	Teacher focuses on the concept's difficulty, the students' prior knowledge and ability and the analogical model's familiarity.
			Teacher presents the familiar model.
		Action	Discuss the features of analogy and science concept.
			Draw similarities between the analog and target.
			Discuss where the analog is unlike the science concept.
		Reflection	Teacher evaluates the analogy's or model's effectiveness and identifies qualifications necessary for subsequent lessons or modifications next time the analogy or model is used.
CC	31	Prediction	Teacher introduces driving questions and phenomena for a particular concept.
			Students predict the situation or what will happen before the demonstration.
		Observation	Teacher demonstrates the conflict between the true situation and students' predictions.
			Teacher discusses with students the conflict between new perception and students' alternative conceptions and between students' alternative conceptions and the scientific one.
		Explanation	Students explain how it happens and the difference between the prediction and explanation. Teacher discusses with students about the conflict between students' alternative conceptions and the scientific one. Students make new predictions and try to find the way to test and apply their concept.
MG	30	Anchoring	Teacher introduces driving questions and phenomena for a particular concept.
		Phenomena	Teacher asks students to use a phenomenon that may necessitate using a model to figure it out.
		Construct a model	Students create an initial model expressing an idea or hypothesis. Discuss purpose and nature of models.
		Empirically test the model	Investigate the phenomena predicted and explained by the model.
		Test the model against other ideas	Test the model against other theories, and laws.
		Revise the model	Change the model to fit new evidence. Compare competing models and construct a consensus model.
		Use the model to predict or explain	Apply model to predict and explain other phenomena.

CC. The instructional processes and teaching strategies of the CC group were based on the theory which integrated the POE strategy from Driver (1988) and the framework of the concept from Hashweh (1986). The teacher used the strategy of POE for making the CC. The teacher could help students to challenge their preconceptions by arranging the CC or demonstration. In this sequence, students predicted the situation or what would happen before the demonstration in which the teacher presented the CC. Then, the teacher demonstrated the conflict between the true situation and the students' predictions. After that, students explained how it happened and were made aware of the difference between the prediction and explanation.

MI. The instructional processes and teaching strategies of the model instruction group were based on the teaching model of the FAR approach that involves the FAR aspects of expert teaching from Harrison and Treagust (2000). Before the class, the teacher focused on the concept's difficulty with position learning, the students' prior knowledge and ability, and the analogical model's familiarity. At the beginning of the class, the teacher presented the familiar model and discussed the features of the analogy and science concept. Then, the teacher drew similarities between the analog and target and discussed where the analog was unlike the science concept. After class, the teacher evaluated the analogy's or model's effectiveness and identified qualifications necessary for subsequent lessons or modifications to be noted the next time the analogy or model is used.

Tools

For the purpose of inquiry into the position concepts of students, there are three main tools applied in this study, including the position concepts achievements test, the position concepts test, and the half-structured interview.

The position concepts achievements test is formed by two dimensions of position (unit and subject), and taken from a school exam. The position concepts achievements test is the criterion-referenced test of the position concepts test and scores from it created the criterion.

The position concepts test is a two-tier test formed of check items. Students had the test before and after instruction. The main tool for diagnosing the concept followed the steps which Treagust (1988) developed. The two-tier test was effective on determining the students' misconceptions and also it might be used as an alternative to the traditional multiple choice test for assessment and evaluation of alternative students' achievement (Tüysüz, 2009). There were 28 students who took a pilot test with the position concepts test for this study. The concept test in this study adopted Cronbach's α coefficient (internal consistency) to testify reliability. Results from the reliability analysis of this study showed that the coefficient of the concept test was 0.66 in the pilot test, 0.77 in the formal test before instruction, and 0.70 after. The validity analysis of this research showed the criterion validity. The researchers took the position concept achievements test for the criterion. The Pearson coefficient was from 0.331 to 0.427 and all of the correlations were significant ($p <$ 0.05).

The half-structured interview was designed by researchers to interview the students to collect information regarding their misconceptions of the position concepts and inquire into the process of concept changing and modelling. There were six students who were selected from the three classes to take the half-structured interview.

Results and Discussion

Performance After Teaching Students' Position Concept

The main data collected in this research come from the pre- and post- position concept test. After data collection, the data were analyzed by the Statistical Package for Social Science (SPSS 12.0 for Windows). Prior to instruction, students in three groups were pre-tested in order to determine their previous understanding of a position concept. The results revealed the students in all three groups had an equal understanding of a position concept.

The descriptive statistics of the position concept test in this study (see Table 2) indicated that:

Table 2

The Distribution of Concept Situation

	Main concept		Position switch		Movement and position		Rotation of the Earth and position of the sunrise and moonrise	
	Sub-concept		Map	Graph	East and west	North and south	Sun	Moon
Pre-test	Number of correct	MI	9	8	21	6	4	3
		CC	10	7	22	5	3	3
		MG	8	8	23	6	3	4
	Percentage of correct	MI	31.0	27.6	72.4	20.7	13.8	10.3
		CC	32.3	22.6	71.0	16.1	9.68	9.68
		MG	26.7	26.7	76.7	20.0	10	13.3
Post-test	Number of correct	MI	27	28	26	19	14	15
		CC	28	29	28	24	15	23
		MG	28	28	29	28	26	27
	Percentage of correct	MI	93.1	96.6	89.7	65.5	48.3	51.7
		CC	90.3	93.5	90.3	77.4	48.4	74.2
		MG	93.3	93.3	96.7	93.3	86.7	90.0

(1) For the position switch: There are about 22.6%−32.3% of the students who did not figure out the questions if the position of north was not presented at the top of the model before instruction. Over 90% of the students figured out the same questions after teaching;

(2) For the movement and position: More than 71% of the students could figure out the relationship between movement around the Earth and position change from east to west. However, fewer than 20.7% of them could figure out the movement around the Earth and the position change from north to south. After instruction, the percentage of students from the three groups (MI, CC, and MG) who understood the concept was 89.7%, 90.3%, and 96.6% for the east and west sub-concept and 65.5%, 77.4%, and 93.3% for the north and south sub-concept;

(3) For the rotation of the Earth and the position of the sunrise and moonrise: Before instruction, few students could figure out the relationship between the rotation of the Earth and the position of the sunrise. After instruction, the passing percentages of the three groups (MI, CC, and MG) were 48.3%, 48.4%, and 86.7%. There were few students who could figure out the relationship between the Earth's rotation and the position of the moonrise before instruction. After instruction, the passing percentages of the three groups (MI, CC, and MG) were 51.7%, 74.2%, and 90.0%.

Comparisons of Different Teaching Strategies on Students' Position Concept

This study investigates the position concepts change for children with different instruction strategies. One-way ANCOVA and LSD (least significant difference) were carried out as a post hoc analysis to examine the effects of different teaching strategies on learners. The "teaching strategies" are the fixed factor, the "pre-test of the position concept" is the covariate, and the "post-test of the position" is the dependent variable. This research defined the score of post-test position concepts as learning effects.

Before using analysis of covariance, Levine's method was used to test the homogeneity of variances. No significant difference in the variance of treatment groups ($F = 2.48$, $P = 0.09$) was found. In other words, the basic assumption of homogeneity of variance was not violated. The results of ANCOVA are shown in Table 3. The pre-test score, as a covariate, had a significant influence on the post-test score of subjects ($F = 6.34$, $P <$

0.05). Furthermore, the teaching strategy ($F = 8.19$, $P < 0.05$) was a significant factor in subject achievement. However, no significant interaction effects between the class (teaching strategy) and the post position concept were found ($F = 2.49$, $P > 0.05$).

According to the previous analysis of ANCOVA, significant treatment effects were observed with teaching strategies. The post position concept test mean score and standard error for each group are shown in Table 4. A post hoc analysis (LSD method) was performed for further comparison (see Table 5). It showed that the MG group performed significantly better than the MI group on the position concept test mean score (mean difference 1.11, $P < 0.05$). Also, the CC group performed significantly better than the MI group on the position concept test mean score (mean difference 0.76, $P < 0.05$). However, there was no significant difference between the performance of the CC and MG groups. To sum up, the post hoc analysis revealed that the MG group and CC group performed better than the MI group.

Table 3

Summary Table of ANCOVA Analysis of Effects of Formative Strategies on the Test of Position Concept (N = 90)

Sources	SS	df	MS	*F*-value
Corrected model	46.92	5	9.38	6.34
Intercept	798.0	1	798.00	539.00
Class * Pre	7.13	2	3.57	2.41
Class	24.25	2	12.13	8.19
Pre	23.56	1	23.56	15.91
Error	124.36	84	1.48	
Total	2,342	90		
Corrected total	171.29	89		

Note. R-squared = 0.274 (Adjusted R-square = 0.231); * N = 90.

Table 4

Mean Score and Standard Error of Position Concept in Group

Group	Group number	Mean*	Standard error
MI	29	4.42	0.23
CC	31	4.77	0.22
MG	30	5.53	0.22

Note. *Adjust with covariate: Pre (mean = 1.7).

Table 5

Post Hoc Comparison (LSD Method) of Differences of Mean of the Post Position Concept Among the Three Groups

Groups (I)	Groups (J)	Difference of mean (I−J)	*SD*	Sig.
MG	CC	0.35	0.32	0.26
	MI	1.11*	0.32	0.00
CC	MG	-0.35	0.32	0.26
	MI	0.76*	0.31	0.02
MI	MG	-1.11*	0.32	0.00
	CC	-0.76*	0.31	0.02

Notes. *$p < 0.05$; Based on estimated marginal means; The mean difference is significant at the 0.05 level; Adjustment for multiple comparisons: LSD (equivalent to no adjustments).

Some Reasons for Students' Position Concept Change

Researchers had a half-structured interview with six students to discover their ability for modelling and reflecting the teaching plan. The findings are as follows:

(1) The position switch

Before instruction, most of the students had a basic position concept about the position distribution on the map. Most of the students knew the north is at the top, the east is on the right, the west is on the left, and the south is at the bottom of the map. About 30% of the students could understand and apply the position concept to the questions of position switch; over 90% of the students could figure it out. The three kinds of teaching strategies can effectively change students' original concepts. In the half-structured interview, one of the six students showed the reason why he changed his concept of the north as always being on the top of the map. Here is his response:

> T: Why did you choose A before? (The teacher pointed to question one of the position concepts test.)
>
> S1: I thought that north was always at the top of the map.
>
> T: So, what happened or what did you learn from the class?
>
> S1: I know that north may not always be at the top of the map, and south is on the right of this map (points to the map on Item 1 of questionnaire).
>
> T: Where is north on the map?
>
> S1: This (points to the left on map).
>
> T: Who could use the map? Can you tell me how did he or she use the map in what situation?
>
> S1: If someone wanted to go to the south, he would face south and use the map. North is not always on the top of the map, you can change it.

(2) The shape of the Earth

Most students could figure out the relationship between movement around the Earth and the position change of the east and west. However, some of them might be affected by the reason for the shape and rotation of the Earth, so that they have a misconception while dealing with questions about movement around the Earth and position changes of the north and south. More discussion followed:

> T: If a plane flies towards the north, what situation will happen?
>
> S2: It would eventually return to the original place.
>
> T: Why? Can you tell me the reason?
>
> S2: Because the Earth is spherical, like a ball. If you travel in any direction eventually you will go around the Earth; you will circle it.

(3) The rotation of the Earth and the position of the sunrise and moonrise

Most students understood the phenomenon of the position of the sunrise and moonrise. They understood that celestial bodies rise in the east and go down in the west. However, some students thought that there are some places where the Sun rises in the west and goes down in the east. Other questions included:

> T: So, you think that the Sun does not always rise in the east and go down in the west, right?
>
> S3: The east of Taiwan is west of America. The Sun rises in the east here and rises in the west in other places.

In addition, some students thought that the Moon going around the Earth is the major reason for the Moon rising in the east and setting in the west.

> T: Does the Moon rise in the east and go down in the west?
>
> S3: Yes, the Moon goes around the Earth and that is the reason why it rises in the east.

Conclusions

The position concept is a basic foundation for developing space concepts in all kinds of subjects. The instruction which was designed by the researchers could improve the position concept for children. Researches have shown that instruction using conflict, modelling, and inquiry strategies can successfully improve students' concept change (Tsai & Chang, 2005; Harrison & Treagust, 2000; Schwarz & White, 2005), which is consistent in this study of statistical results. All three forms of instruction in this study can promote students' understanding of the position concept. In addition, the present researcher regards it as an important factor to enhance the interactions between teacher-student and student-student by discussion, demonstration, presentation, and reflection in science teaching. These three instructions provided a useful framework for students to engage in deeper exploration and discussion by helping them with modelling or making more connections between existing experiences or knowledge and new concepts. Thus, students could construct better representations for the scientific concepts. In particular, exploration and discussion about the discrepant event and model are conducted in class, and these students are allowed to explicitly express their representations about the phenomenon derived from these events. This supposition is, to some extent, consistent with Thorley and Treagust (1987) who found that interpersonal conflicts and interactions can stimulate pupils' knowledge development and conceptual change.

The study found a variation in the performances of different classes with different strategies. The performances of the MG and CC groups are better than the MI group. The explanation for our findings may lie in the strategies used in the MG group being more effective for conceptual change of position concepts than the MI group. According to Schwarz et al. (2009), scientific modelling includes the elements of practice and the meta-knowledge that guides and motivates the practice. One possible factor may be that both the MG and CC groups provided learners with more opportunities to test and apply their model and that promoted their practice and meta-knowledge in the process of modelling to a greater extent than the MI group. The performances of all three groups were better after instructions. However, more opportunities to test and apply students' models are necessary.

The position concept is the core and basic concept of astronomy teaching and people's acquisition of the space concept of the position and direction from movement and exploration of the surroundings (Poole et al., 2006). Teachers could inspire students to model their concept and evaluate it by effective teaching strategies mentioned in this study. In a very elegant study, Vosniadou and Skopeliti (2005) had shown that model change in the domain of observation astronomy can lead to ontological change that helps an individual to recognize the world from different points of view. The findings of this research have important implications for position concept design in elementary school science courses, as well as for research into the benefits of modelling. This research is based on the concept change theories and tries to examine the mental model of students' change under different instruction. Some other reasons, such as emotion, attitude, effect, etc., may affect a change of intellect. Researchers suggested that different teaching strategies could integrate these multiple factors in future studies. To design the lesson plans, the researchers analyzed the position concepts in text books in elementary schools. To sum up this study, researchers integrated three characteristics with the teaching strategies worthy to be mentioned: (1) taking account of preconceptions and leading students' learning in the basis of students' preconceptions; (2) trying to create more surroundings and situations which can help students to test and respond to their model; and (3) paying more attention to the reaction between the mental model and information in the external world.

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