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Third Graders' Understanding of Air Concepts Facilitated by the iPod Inquiry Teaching Method

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Abstract

The major purpose of this study was to determine the learning performance of the air concept unit for third graders in a primary school facilitated by the iPod inquiry teaching method. This study adopts a quasi-experimental method. Participants were third graders in a primary school in New Taipei city. The experimental group consisted of 53 students who received iPod inquiry teaching and the control group consisting of another 53 students who received regular teaching. The teaching content was the air concept unit for third graders. The research instruments consisted of an Air Concepts Comprehension Test (KR_{21} = .84) and the Scientific Attitude Scale (Cronbach α = .93). The research results showed that the performance in both the Air Concept Comprehension Test and the Scientific Attitude Scale for the experimental group was superior to that of the control group. The results showed that iPod inquiry teaching is conducive for promoting the scientific learning of the air concept unit for third graders in primary schools.

Key words: Air, iPod inquiry teaching; Learning effectiveness; Science education; Science teaching

Introduction

The rapid advancement in modern technology extensively affects our lives and learning styles. Presently, in the teaching and learning of science, we not only emphasize the development of scientific concepts, but also cultivate scientific literacy that involves reasoning, reasonable judgment and problem-solving abilities to meet future challenges (Huang, 1996). Therefore, teachers should constantly conduct research into their teaching to promote their professional growth.

Teachers need to be critical of the contents of textbooks and should be able to convey scientific knowledge that students can understand to clarify the relationship between science, technology and society and cultivate scientific reasoning ability. Further, teachers should help students to display positive attitudes toward science and facilitate their ability in problem-solving. Teachers have proposed many different teaching strategies and programs to promote students' science learning founded on the constructive view.

Posner, Strike, Hewson, and Gertzog (1982) first proposed the conceptual change model, and then researchers modified it into many other instructional strategies (Hewson & Hewson, 1983). By integrating the POE (Predict-Observe-Explain) strategy with the STS (Science, Technology, and Society) strategy, Lai (2009) proposed a format for scientific inquiry teaching with the features of "invitation - Prediction- operation-discussion (referred to as iPod inquiry teaching)". The iPod inquiry teaching strategy expects teachers to conduct more active and diversified ways of teaching that invite the participation and involvement of students and triggers better learning and promotes a positive attitude towards science.

It also expects teachers to retain the "Prediction" teaching process, to change relatively passive "observations" into positive procedures and applicable "operations" and to revise the original "explanation" into a "discussion" that can cover the scientific inquiry explanation and connect scientific phenomena and scientific theories, finally forming iPod inquiry teaching. Theoretically speaking, iPod inquiry teaching can take the students' emotions, skills and cognitive learning into account. Therefore, the main purpose of this study was to determine the learning effectiveness of the air unit facilitated by iPod inquiry teaching.

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Literature Review

The Teaching and Learning of Air Concepts

Wang and Hsiung (1997) noted that a concept is the basis of understanding. In this case, there are enough bases to understand the learning targets and explore more understandings and observations. Therefore, learning is closely related to the concept. Meanwhile, learning is affected by prior concepts and previous experience. Huang (1996) stressed, during the implementation of science teaching, science teachers should be aware of the students' misconceptions and further ascertain new teaching strategies to change their misconceptions and help the students establish correct scientific concepts. To avoid misconceptions during learning or to achieve changes in students' misconceptions, Ausubel (1968) believed new knowledge must be established about known subjects. Together with the original concepts of the students new knowledge is mutually assimilated, further changing the learner's cognitive structures into hierarchical and systematic knowledge. With the conflict between the new knowledge and the original concepts, the original cognitive structure will change. Consequently, he proposed the theory of "meaningful learning".

Air fills our surroundings, but we cannot see it or touch it. Air is necessary for our survival, as well for all animals and plants. Therefore, in science courses in primary schools, the establishment of air-related concepts is the cornerstone for the development of scientific concepts. In all science courses for third graders at primary school in Taiwan, the main air-related topics taught consist of the features of air, how wind is formed by the flow of air and the applications of air and wind. The related teaching content focuses on how air occupies space, and the fact it is compressible and has no fixed shape. The students are informed that wind is produced by the flow of air. To aid their understanding, they make air toys and simple wind anemometers. They are aware of the importance of air and know the applications of wind and air in their daily lives.

Chang (2000) found there are several features in the teaching of the air concept in Taiwan, and students feel that the most difficult concept is how "air expands when heated and contracts when cooled", followed by how "wind is formed by the flow of air". The students are easily confused by the amount of air and the air volume. When they believe the amount of air is unchanged, they will have the misconception of the air volume will not change. Henriques (2002) indicated that students' misconceptions can serve as a starting point for instruction. In science learning settings, when teachers are aware of students' understandings about a topic, they can tailor experiments and activities that challenge the students' views (Henriques, 2002; Osborne & Cosgrove, 1983). Henriques (2002) further indicated that knowing and using misconceptions is also useful for in-service teacher programs, as many teachers hold the same misconceptions as their students.

Lin (2006) found common misconceptions of primary school students in Taiwan when learning about the concept of air are: they do not know that temperature is related to atmospheric pressure and often believed that the higher the temperature, the higher the pressure; they do not know that height is related to atmospheric pressure and often believed that the greater the height, the higher the pressure; they do not know that the concentration of air is related to the atmospheric pressure. The children are easily able to understand the concept of high and low temperature rather than high and low atmospheric pressure. Akbaş and Gençtürk (2011) found that the most common misconceptions about the effects of atmospheric pressure and air concepts included (1) gases in the atmosphere can exert pressure if they suppress gravity, (2) gases in the atmosphere can only exert pressure if a force is applied, (3) pressure is a factor that affects temperature, (4) altitude affects pressure changes, (5) rain affects pressure changes, and (6) pressure increases when altitude increases.

From the above findings, regarding the learning and understanding of air concepts by primary school students, it may be deduced that they only rely on their daily experiences and interpret a known phenomenon based on their intuitive senses. However, some content that is taught in the unit on air is difficult to understand and the students cannot fully understand the meaning of the vocabulary. Consequently, misconceptions are generated. Therefore, during the teaching of the air unit, teachers should adopt appropriate teaching strategies to convey abstract concepts as specific ideas and establish the correct concepts appropriate teaching methods thereby avoiding any misconceptions.

The iPod Inquiry Teaching

Akbaş and Gençtürk (2011) indicated that the conceptual change methodology was developed based on the constructive approach and is widely used in teaching-learning activities. The conceptual change methodology represents an alternative approach that encourages students to change their ideas from misconceptions to scientifically correct concepts. Based on the conceptual change methodology, the iPod inquiry teaching method integrates the POE strategy (Gunstone & Mitchell, 1998; White & Gunstone, 1992) and STS strategy (Loucks-Horsley et al., 1990) and forms a set of inquiry teaching methods with the implications of the constructivist philosophy. The goal of iPod inquiry teaching is to provide a more independent space for students to construct their own ideas and understand a concept framework, thereby enhancing students' understanding of scientific concepts.

The focus and features of iPod inquiry teaching can be summarized as the following four points (Lai, 2009):

1. Positive and diverse ways are used in teaching activities to encourage the involvement of students. This is expected to trigger additional learning motives and a positive scientific attitude because lively learning situations can easily trigger the learning interests of the students. Consequently, the students' motives are triggered whilst having fun when learning, with positive benefits produced for any subsequent teaching activities. In the following inquiry process, with the implementation of actual operations and experiments, the students will become more involved in the teaching activities.

2. Retaining the original prediction from POE is expected to enable a full understanding of students' misconceptions of prior concepts, which can offer a reference for teaching and the basis for any changes in the teaching. Further, it can enhance and strengthen the mastering of scientific skills of students.

3. By changing the original "observation" step into an "operation" step from POE, it is expected that the students can change the relatively passive observations and further enhance their active participation. Through hands-on activities this study can develop the scientific concepts and experimental skills of students and facilitate an exploration of their prior conceptions, enabling students to acquire more effective learning and strengthen their scientific inquiries and experiences at the same time.

4. Finally, by changing the original "explanation" step into a "discussion" step from POE: the meaning of the POE "explanation" step is to make students compare the results of the prediction and observation and adjust them based on the differences or conflicts between the two. The teachers do their best to encourage students to elaborate their "explanation". In iPod inquiry teaching, the purpose of the "discussion" step is to cover scientific inquiry explanation, and connect the scientific phenomenon and scientific theory processes. In addition, from the perspective of cooperative studies, if the summary can be undertaken based on a group discussion, the effects will fit better with the learning circumstances of any group experiments. Moreover, groups can conduct further discussion and explanation regarding the topics and also appropriately reflect on the problems faced in the experiments. Further, through discussions with peers, students can be encouraged to put forward their own ideas and create a more positive and enthusiastic learning atmosphere.

Second, the implementation process of iPod inquiry teaching is shown in figure 1. The principles that should be considered are as follows:

1. i (Invitation): the design of the textbook should allow students to feel the interaction between science and life experiences. It should also represent the teaching circumstances and the real life-related issues to trigger the learning interests of students in science and offer experimental circumstances in which the students can conduct reasonable predictions. In this case, students may not always purely predict the results and the teachers should avoid too much guidance during the explanation of the issues to avoid influencing or limiting the thoughts of the students.

2. P (Prediction): during the implementation of the prediction, the teachers should inform the students that the prediction is not a test and that they only want to understand the thinking of the students. Regarding the completion method, teachers can choose to tick boxes when offering several possible scenarios or completely adopt open questions to allow students to fully express their ideas. The teachers should identify the misconceptions of students during the prediction process and revise or complement the students' knowledge to assist them in constructing the scientific concepts.

3. o (operation): the teachers should let the students familiarize themselves with the skills and methods of scientific inquiry through the actual operations of students. From the hands-on operations to the final experimental results, the teachers should require the students to record their findings of experiments. There are probably differences during the operation and the observations should be conducted in a direct way to avoid unclear and not incomplete records.

4. d (discussion):The teachers should encourage every student to express and share their ideas to enhance their degree of involvement. During cooperative learning with peers, the students with stronger learning abilities can lead other students and encourage their learning potential. At the same time, a discussion strategy can encourage students to deliver, communicate and discuss ideas among their peers, which will enhance the students' arguments and their interpretation abilities of scientific inquiry to achieve the construction and refinement of scientific concepts.

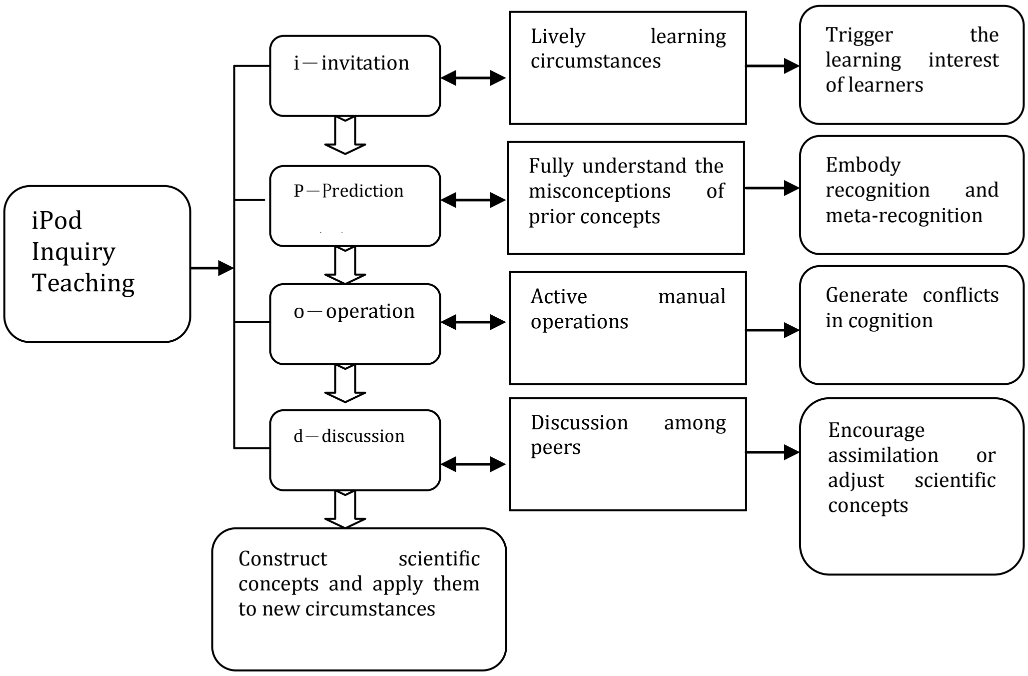

Figure 1. Teaching process and steps of iPod inquiry teaching

Empirical studies on iPod inquiry teaching indicate that there have been many successful experiences. Additionally, many iPod inquiry teaching cases have shown iPod inquiry teaching is conducive to the learning effectiveness of students (Hsieh & Lai, 2015; Lai, 2011, 2012, 2013; Lai & Chen, 2013; Shih & Lai, 2011, 2012; Shih, Huang, & Lai, 2012; Shih, Zhao, & Lai, 2012; Tsai & Lai, 2015; Yu & Kao, 2012). In summary, iPod inquiry teaching is not only in line with constructivist concepts, but also has practical effectiveness. If we can appropriately master the steps and implementation principles of iPod inquiry teaching, this study believes there will be more opportunities for learners to construct their ideas and understanding, which will lead to more effective and meaningful learning.

Research Method

This study adopted third graders attending a primary school in New Taipei City as the research participants, randomly chosen based on classes. When the second graders are promoted to third graders, the school usually regroups the students within dynamic classes. The features of the students in each class are similar. Therefore, taking four classes as samples, two of them were chosen as the experimental group (N = 53) and the other two were regarded as the control group (N = 53). The teaching activities of the experimental group were integrating Invitation step, Prediction step, Operation step, and Discussion step into teaching procedures. In addition, student's inquiry and experiment skills on science activities will be developed. This study adopted a quasi-experimental method to explore the learning outcomes of the air unit for third graders in primary school after the implementation of iPod inquiry teaching, based on the Air Concept Comprehension Test and the Scientific Attitude Scale.

Independent variables: the independent variables in this study are the teaching methodology for the experimental treatment and the teaching unit is "Invisible Air", the Kang-Hsuan version. The experimental groups adopted iPod inquiry teaching and the control groups followed the instructions specified in the textbook. The dependent variables: (1) the scores for the Air Concept Comprehension Test: based on the scores of the Air Concept Comprehension Test, the higher the score, the higher the learning achievements. (2) The scores for the

Scientific Attitude Scale: based on the scores of the Scientific Attitude Scale, the higher the score, the more positive the students' scientific attitudes.

Control variables: (1) the features of the students: to exclude the differences in the learning abilities of the students, this study regarded the pre-test scores of the Air Concept Comprehension Test and the Scientific Attitude Scale as the covariance factors and conducted ANCOVA to exclude the influence of the existing features of the students on the experimental results; (2) the teachers: the four classes involved in this study were taught by a single science teacher to avoid the confounding influence of different teachers on the experiment results; (3) the teaching content and teaching hours: this study adopted unit three "invisible air" in the textbook "Science and Technology" (Kang-Hsuan version) as the teaching theme. The teaching hours for the experimental group and the control group were the same (three classes a week, 40 minutes every class and a total of 12 classes); (4) the experimental circumstances: the implementation of pre- and post- tests were conducted by the teachers based on the implementation procedures. The experimental circumstances for these groups were controlled consistently to avoid any interference during implementation and the results were reviewed by teachers to avoid any influence on the variables by raters regarding the results of these two groups.

The research instruments consisted of an Air Concept Comprehension Test and the Scientific Attitude Scale. The Air Concept Comprehension Test consisting of 32 items which was aimed at assessing students' learning performance regarding air concepts (item difficulty ranged from .30 - .88, the degrees of item discrimination are all over .25 and the Kuder-Richardson reliability of the internal consistency reliability test is .84). Sample item for Air Concept Comprehension Test is "When squeeze a balloon what will be changed? (A) Shape will not change but volume will change, (B) Shape will change but volume will not change, (C) Both shape and volume will change, (D) Both shape and volume will not change."

Scientific Attitude Scale: the Scientific Attitude Scale (a four point Likert-type scale), which was aimed at assessing students' scientific attitudes, consisted of four Likert subscales, namely "attitude towards science courses", "science learning motivation", "science learning strategy" and "attitude toward science teachers". The number of items in the scale was 40. The Cronbach's α values for these four independent subscales were all over .74 and the Cronbach's α of the total scale was .93, indicating this scale had relatively good reliability. Sample item for Scientific Attitude Scale is "I think the science lesson is fun."

Results and Discussion

Learning Performance of the Concepts of Air

Before and after the teaching of the air concept unit to the experimental group and the control group, pre- and post-tests were administered using the Air Concept Comprehension Test. The mean and standard deviation of the test scores are shown in Table 1.

Table 1. The means and the standard deviations of the scores for the air concept comprehension test

Group	*N*	Pre-test		Post-test	
		M	*SD*	*M*	*SD*
Experimental Group	53	14.40	5.18	27.09	5.09
Control Group	53	14.96	5.50	21.58	5.67

Note: the maximum and minimum values are 32 and 0, respectively.

Table 1 shows that after teaching the air concept unit, the post-test scores of these two groups were higher than those of the pre-test scores. To further compare the learning performance of these two groups and testify whether or not there were any significant differences, the pre-test scores were adopted as the covariance and the post-test scores as the dependent variable. An ANCOVA was then performed and the analysis results are shown in Table 2.

Table 2. ANCOVA for air concept comprehension test

	SS	*df*	*MS*	*F*	*p*
between	905.199	1	905.199	48.496	.000***
error	1922.532	103	18.665		

*** $p < .001$

Table 2 shows that, after excluding the influence of the pre-test scores, the post-test scores of the experimental group for the Air Concept Comprehension Test were significantly better than for those of the control group (F = 48.496, p <.001). The research results show that the iPod inquiry teaching method promoted the performance of the students from the experimental group when they were taught the air concept unit.

The possible reasons for the significant improvement in the Air Concept Comprehension Test are as follows:

1. Triggers the learning motives of the students: the iPod inquiry teaching method adopted in this study made use of multimedia video animations, science toys and other teaching materials to demonstrate different teaching situations, employing diversified and interesting science phenomenon or issues that facilitated the science learning, attracting the attention of the students and arousing their curiosity. Learning in a lively and diversified learning environment can empower the students to enjoy more diversified learning experiences, which not only enables the students to focus and trigger their learning motives, but also allows students to have more fun when learning.

2. Strengthening thinking skills can enhance the capacity of scientific inquiry: through invitation, prediction, operation and discussion, iPod inquiry teaching can lead students to make full use of different scientific skills and methods in every step of the learning process. The students first employed their own prior knowledge to make predictions and predict the possible phenomenon through thinking, putting the predicted results into practice to verify their assumptions. Based on observations of the operation and experiments, this study deduced the possible reasons for the scientific phenomenon. After the iPod inquiry teaching, which is student-oriented teaching, the students are able to employ mental abilities and intelligence to exhibit their diversified thinking methods. These processes strengthen their thought processes, such as creative thinking, critical thinking and problem-solving, sharpen their acute perceptiveness, and infer the causal relationship for scientific phenomena and other skills during experiments. Therefore, the students are able to effectively promote their scientific inquiry abilities and improve their scientific learning at the same time.

3. Peer discussions can promote the construction of scientific concepts: regarding the discussion step of the iPod inquiry teaching method, through peer discussion and brainstorming activities among students, more ideas and information can be offered. Different perspectives achieved by the students are conducive to encouraging self-examination. Through joint discussions, the experiments can strengthen thinking. Divergent thinking generates more ideas and convergent thinking can help students to deduce results. Therefore, peer discussion is conducive to promoting the cognitive skills of the students. When the students share their ideas, through information generated during learning and the interactions with cognitive structures, the students can promote their construction of scientific concepts through assimilation and further promote their scientific learning effectiveness.

Learning Performance of Scientific Attitude

Before and after the teaching of the air concept unit to the experimental group and the control group, pre- and post-tests of the Scientific Attitude Scale were administered. The means and standard deviations of the test scores are shown in Table 3.

Table 3. The means and the standard deviations of the scores for the scientific attitude scale

Group	*N*	Pre-test		Post-test	
		M	*SD*	*M*	*SD*
Experimental Group	53	125.91	16.72	143.89	12.04
Control Group	53	137.75	15.03	139.55	21.88

Note: the maximum and minimum values are 160 and 0, respectively.

Table 3 shows that, after the teaching of the air concept unit, the post-test scores of these two groups were higher than their pre-test scores. To further understand the differences in and significance of the scientific attitude of the students in the experimental group, the pre-test scores were adopted as the covariance and the post-test scores as the dependent variable. An ANCOVA was then performed and the analysis results are shown in Table 4. Table 4 shows that the performance of the students in the experimental group in the Scientific Attitude Scale was significantly higher than that of the control group (F=5.660, p<.05). The research results show that the iPod inquiry teaching method enhances the attitudes of the students in the experimental group.

Table 4. ANCOVA for scientific attitude scale

	SS	*df*	*MS*	*F*	*p*
between	1506.800	1	1506.800	5.660	.019*
error	27422.334	103	266.236		

* $p < .05$

The possible reasons for the significant improvement of the attitudes of the students in the experimental group are as follows:

1. Diversified teaching activities: during the invitation step of the iPod inquiry teaching in this study, the teachers made use of multimedia videos, modeling balloons, science games, science toys, as well as everyday items. They used these with the application of scientific principles to illustrate different teaching aspects, which not only surprised and excited the students, but also empowered them to understand different scientific phenomena and strengthened their learning effectiveness. The prediction activities adopted later triggered the curiosity of the students and additional special hands-on activities enriched the learning. The iPod inquiry teaching method is equipped with a wide range of diversified teaching activities, ensuring the teaching curriculum is rich and innovative. With the help of multi-dimensional and multiple teaching activities, this study adopts daily life activities to integrate with the living experiences of the students. Offering multi-dimensional and multiple connections to the students when they are learning the various science concepts that enhance the sensitivity of the students when participating in science learning empower their feelings and life experiences and enable them to enjoy diversified and rich learning experiences. As a consequence, the students will have more interest in learning science.

2. Arousing the students' enthusiasm for active exploration of science: the iPod teaching inquiry methods adopted in this study, using prediction and hands-on operations in which the teachers lead the students to explore scientific knowledge during the learning process, enable the students to verify whether or not their own thoughts are correct. When students face unclear scientific principles, this will generate dissatisfaction with the concepts. To clarify any confusion, the students will form an internal driving force when learning science, which will motivate them to break through the learning dilemma. The peer discussion and joint conclusion can help the students reshape and adjust old and new concepts to construct new scientific concepts. For the exploration of scientific knowledge, the iPod inquiry teaching method not only enables students to acquire related scientific knowledge, but also encourages them to apply constructed scientific knowledge and principles into their daily lives. In summary, the iPod inquiry teaching method not only helps students to develop inquiry activities like scientists, but also arouses their enthusiasm for active exploration of scientific phenomena. Therefore, the learning interest of the students for science can be promoted.

3. Offers instant communication and a mutual feedback mechanism: during the iPod inquiry teaching discussion activities in this study, the students achieved consensus and offered conclusions. During the discussion, the students also shared their own thoughts and listened to others' ideas. During the process of reasoning and judgment, the group members shared their ideas and perspectives and also reviewed the validity of their own ideas. Therefore, discussion activities offer a great opportunity for instant communication and a feedback mechanism. From the positive attitude of the students in the discussions, the students had fun and found satisfaction in learning during the peer feedback. Consequently, the science attitudes of the students were enhanced.

4. Promotes the importance and value of learning science: the students made use of their knowledge to solve problems and also to come up with examples to apply the scientific principles they had learned into their daily lives. The students can apply the constructed scientific knowledge and principles in their daily lives. Diversified teaching materials offered by the iPod inquiry teaching method can lead to connections between scientific principles and the daily life experiences of the students and also promote the importance and values of learning science. Consequently, the motivation to strengthen science learning can be enhanced.

In summary, the invitation, prediction, hands-on operation and discussion of iPod inquiry teaching methods, equipped with diversified teaching activities, empowers the students with rich learning experiences and strengthens their inquiry skills. Through such meaningful learning, it is possible to construct scientific knowledge, arouse the students' enthusiasm for active scientific exploration, make learning fun, participate in peer discussions and provide mutual feedback and enable students' attitudes toward science to grow significantly. Consequently, this study claims that the iPod inquiry teaching method is effective for promoting students' attitude toward science and enhancing their performance.

Conclusion

In this study, the iPod inquiry teaching method explored the learning effectiveness of third graders in primary school regarding the air concepts unit. The research results show that the iPod inquiry teaching method certainly enhances the students' learning motives, strengthens their thinking skills, enhances their scientific inquiry abilities, deepens peer discussions, and promotes the construction of scientific concepts. Therefore, the performance in science learning can reach a significant level. Further, regarding the students' attitude toward science learning, the iPod inquiry teaching method is equipped with diversified teaching activities that can stimulate the students' enthusiasm for the active exploration of science. It also offers an instant communication and mutual feedback mechanism and enables the students to experience the importance and value of science. Consequently, the attitude and performance of the students toward science can be promoted. Hence, the iPod inquiry teaching method is suitable for the teaching of science in primary schools.

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