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EFFECTS OF INQUIRY LEARNING WITH DIFFERENT TASK ORDERS ON FIFTH GRADERS' INDIVIDUAL AND SITUATIONAL INTEREST AND CONCEPT ACHIEVEMENT IN SCIENCE EDUCATION

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Abstract. *Inquiry-based learning has been widely applied in the classroom. Different inquiry learning models may have different orders of performing tasks and discussing. In this study, the Discuss-Do (D-DO) inquiry model and the Do-Discuss (DO-D) inquiry model were applied in the science learning of two groups of fifth-grade students. Group 1 (n = 41) used the Discuss-Do model whereas Group 2 (n = 38) used the Do-Discuss model. Interest measurements and the Light Reflection Test were administered to the two groups prior to and following the experiment to investigate the effects of the two kinds of inquiry model on students' individual and situational interest, and concept achievement through learning the unit of Light Reflection in a science course. Results showed a significant difference in situational interest and concept achievement between the two groups. However, there was no significant difference in the individual interest of the two groups. Findings suggested that the adoption of the Do-Discuss model is more conducive to learners' development of situational interest and concept achievement, which has implications for exploring task order adjustments for inquiry-based learning, as well as in education for science instructors.*

Keywords: *concept achievement, individual interest, inquiry learning, science education, situational interest, task order*

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Introduction

Many international organizations focus on science education and emphasize the importance of scientific literacy, for example: Next Generation Science Standards (NGSS), Program for International Student Assessment (PISA), and Trends in International Mathematics and Science Study (TIMSS). Improving students' scientific literacy and science achievement have been important goals of science education worldwide (Grabau et al., 2022). The results of PISA have revealed differences in science literacy among students from different countries, which has further increased research related to teaching methods and teaching strategies in science education (OECD, 2016; OECD, 2019). The standards of science education around the world emphasize the importance of engaging students in learning science through making inquiries (e.g., NGSS Lead States, 2013). This learning approach is called inquiry learning (Wen et al., 2020). Inquiry-based learning has received much attention due to its advantages of guiding students to extract valid conclusions from hands-on experiments, to share solutions, and to build knowledge through practice and peer collaboration (Lederman & Lederman, 2019).

Previous studies have constructed many inquiry-based learning models for science education, such as the Prediction-Observation-Quiz-Explanation (POQE) model (Hong et al., 2019b), the Question-Observation-Doing-Explanation (QODE) model (Yang et al., 2021), and the Orientation-Decision-Do-Discuss-Reflect (OD3R) model (Anwar et al., 2018). A learning model is not a prescribed or uniform linear process. The effectiveness and specific phases of the inquiry model may vary depending on the subject content and learning environment (Pedaste et al., 2015).

Additionally, when conducting comparative studies, subject differences and the specific arrangement of tasks can have a significant impact on interest measurement data (Rotgans & Schmidt, 2014). Comparing previous studies, it was found that many inquiry models tended to add a new instructional

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phase or adapt some instructional phases. In science teaching, the roles of the doing task and discussion phases have been repeatedly emphasized (Hwang et al., 2018; Yang et al., 2021), and many inquiry learning models include these two phases, but the impact of the order of the two has not been explored in much depth. Therefore, for this study we designed the D-DO (Discuss-Do) and DO-D (Do-Discuss) models geared toward the same instructional content, with the models adjusting only the doing task and discussion phases to explore the effect of task order on students' learning effect.

It is worth noting that interest plays a positive role in science education. Interest is usually divided into individual interest, which is a relatively stable preference developed over a long period of study of a subject or topic, and situational interest, which is a relatively short-term response developed in response to a high level of stimulation experienced in an educational or life environment (Rotgans & Schmidt, 2017). Failure to examine individual and situational interests separately when exploring interest may result in misjudgment of students' interest development (Rodríguez-Aflecht et al., 2018). Therefore, this study analyzed the two types of interest separately.

Similarly, science concept achievement is also one of the important evaluation indicators to measure the effectiveness of science learning (Özdem, 2010). Zhao et al. (2021) found that when applying POE inquiry-based learning, learners achieved better concept achievement. However, if the task order is changed, it is worth exploring whether the students' concept achievement can be promoted. Therefore, this study aimed to explore the structure of the inquiry model in greater depth and to explore differences in the individual and situational interests and concept achievement of fifth graders based on the different inquiry models.

Literature Review

Task Order in Inquiry Learning

Inquiry learning was defined by Ketpichainarong et al. (2010) as the pedagogical strategies which take scientific inquiry and use general processes as the methodology of teaching and learning; it emphasizes students' question proposal, exploration, and problem solving. There are many inquiry-based learning models with different processes. For example, The Predict-Observe-Explain (POE) inquiry model has been shown to increase students' interest and willingness to continue studying science (Hong et al., 2014; Pegg, 2006). The Prediction-Observation-Quiz-Explanation (POQE) inquiry model (Hong et al., 2019b) was adopted to facilitate learners' conceptual knowledge acquisition. Comparing the above models, it was found that some tasks are presented in multiple models, but the order of the tasks may differ. In science teaching, inquiry-based learning sessions are constantly being adapted to different teaching contexts, and different inquiry-based learning models affect students' understanding of scientific concepts and interest differently (Bumbacher et al., 2018; Zhao et al, 2021). Therefore, attention should be paid to changes in students' concept achievement and interests when adjusting the order of tasks.

In exploring specific educational sessions, previous researchers have explained the significance of the phase of doing tasks while constructing models. Yang et al. (2021) developed the model of Question-Observation-Doing-Explanation (QODE), which highlights the importance of doing tasks during the process of inquiry learning. The discussion of learning-by-doing has also attracted the attention of researchers. The importance of the discussion of learning was emphasized by Favero et al. (2007) who found that in the discussion condition, students performed and rated the activity higher than those in the individual problem-solving condition. Other studies on the discussion phase have shown that discussion can be more effective in terms of encouraging and facilitating students' active performance during their learning (Hwang et al., 2018). Both the doing tasks and discussion phases have profound educational significance, and it is necessary to explore the appropriate order of the two to achieve better inquiry-based learning effects.

In exploring meaningful biochemistry learning, Anwar et al. (2018) proposed the inquiry model of Orientation-Decision-Do-Discuss-Reflect (OD3R) and found that it could improve practical skills and develop students' scientific attitudes. However, Anwar et al. (2018) did not examine students' interests and conceptual achievements. Based on the OD3R inquiry model, this study designed two inquiry models with different steps: the Orientation-Decision-Discuss-Do-Reflect (D-DO) inquiry model and the Orientation-Decision-Do-Discuss-Reflect (DO-D) inquiry model to explore the effect of task order in inquiry learning on fifth-grade students' interests and concept achievement in science education.

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Individual Interest (II) in Science Education

Durik and Harackiewicz (2007) proposed that individual interest (II) is characterized by persistence, disposition, and positive responses to certain categories of stimuli in different contexts. They argued that when students develop II in a subject, they will invest more time and effort in related domains to enrich their knowledge structure in following studies. That is, one key characteristic of II is that the individual spontaneously stimulates participation in the activity and maintains a high level of excitement. Previous research has shown that II plays an important role in science education. Hidi (1990) noted that II has an impact on knowledge construction and cognitive ability; moreover, interest in learning content directly determines students' attention levels and academic performance. In exploring II in science teaching practices, Taskinen et al. (2013) concluded that II in science teaching can be promoted in schools, for example, by providing a wide range of science activities and by teachers actively adopting richer teaching methods.

Cultivating students' II in scientific knowledge is one of the important goals of science educators (Renninger & Hidi, 2015). However, the existing problem is that students' II varies significantly and often does not correspond exactly to the subjects they need to study at the school level, especially in subjects such as science. Hidi and Harackiewicz (2000) reported that an important reason for cultivating students' interest in science was that their interest declines as they grow older. Previous studies have suggested that it is necessary for instructors to explore students' II in order to effectively enhance science education. Therefore, this study aimed to explore students' II in science education.

Situational Interest (SI) in Science Education

Situational interest (SI) was defined as the relatively brief interest that certain content elicits in a given situation (Hidi, 1990). For example, science activities in a planetarium or laboratory can generate a fleeting interest in science, even for those who are usually not interested in science. Many activities in the science subject area have been found to generate students' SI. For example, Nieswandt (2007) studied chemistry learning among ninth graders and found that hands-on activities, experimental demonstrations, and chemical phenomena in everyday life can elicit SI. Azevedo (2017) concluded that SI in STEM-based practices is important for maintaining the continuity of activities.

The educational significance of SI for students must also be emphasized. The main goal of science education is to increase students' interest in science subjects based on their understanding of scientific concepts. SI has a close relationship with learning according to previous studies. For example, Jung et al. (2019) proposed that SI was positively associated with learning in an outdoor education program. Similarly, sustained SI is thought to positively influence students' attitudes and individual interest in science (Hong et al., 2019a; Palmer, 2004). Rotgans and Schmidt (2017) also agree that students' SI is extremely important pedagogically because it is easily aroused and can be controlled to some extent by instructors. Thus, it makes sense to explore better guidance to promote students' SI.

Concept Achievement in Science Education

Research on students' conceptual achievement in science education has been quite active. The educational implications of concept achievement are a common theme that runs through this area of research (Kang et al, 2004; Voska & Heikkinen, 2000; Zhao et al., 2021). Concept achievement in science education can be enhanced with the help of emerging technologies or laboratory activities. For example, Falloon (2019) effectively enhanced students' concept achievement in physics through simulated experiments with circuit components; Uriel et al. (2020) used virtual and augmented reality technologies to improve students' understanding of basic science concepts. Many researchers have combined different forms of instruction to attempt to enhance learners' conceptual development in science. For example, Zhao et al. (2021) explored the influence of the POE inquiry-based model on students' concept achievement in a science course, this study results showed that POE could promote their concept achievement. If the task order is changed, it is valuable to explore whether their concept achievement could be promoted as well. One of the aims of this study was to further explore the effects of different task orders on students' concept achievement by adapting the specific instructional phases. Therefore, this study designed the D-DO and DO-D models to explore the effects of different task orders on concept achievement.

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Research Questions

Previous studies have provided new ways to explore students' interest and concept achievement; that is, under the condition that other tasks remain unchanged, the two phases of doing tasks and discussing were analyzed in different orders. The D-DO and DO-D models were conducted in different groups. Therefore, this study focused on the effects of task order in inquiry-based learning on fifth-grade students' interest and concept achievement for the topic of light reflection. The following research question was proposed.

Can the effects of the D-DO model and the DO-D model on students' 1) individual interest, 2) situational interest, or 3) concept achievement be identified, and what are the differences in the effects of the two models?

Research Methodology

General Background

To explore the effect of the different orders of DO and DISCUSS in inquiry learning on students' individual and situational interests and on their concept achievement, this study used a quasi-experimental design with pre-test and post-test for two groups of fifth-grade students from a primary school in Nanjing, China, in Fall 2020. Before the experiment, the two groups were tested using the Individual Interest Questionnaire (IIQ) (see Appendix 1), the Situational Interest Questionnaire (SIQ) (see Appendix 2), and the Light Reflection Test (LRT) (see Appendix 3). An experiment was conducted in the science laboratory and the learning context was the light reflection concept. After the experiment, the same instruments were administered as before the experiment.

Participants

There were 79 fifth-grade students (42 boys and 37 girls) in two groups participating in the study. Their average age was approximately 11 years old. There was no significant difference in the prior knowledge ($p = .840 > .05$), individual interest ($p = .695 > .05$), or situational interest ($p = .898 > .05$) of the two groups. Group 1 (G1, $n = 41$) participated in the D-DO model whereas Group 2 (G2, $n = 38$) participated in the DO-D model. The same science teacher taught both groups, and the two groups were provided with identical Light Refraction content. The science teacher had 15 years of experience teaching science. The students and teacher were informed of the study prior to the experiment. The results of the anonymous test were used only for research and improvement of teaching, not for commercial use, and the students had the freedom to quit at any time. In addition, the study was approved by the Ethics Committee of Nanjing Normal University (No. NNU 202207001).

Procedure

This study was implemented with fifth-grade students at a primary school in Fall 2020. Communicating with the teachers in the early stage, it was found that they adopted the exploratory way of discussing before doing work and presenting work in the content. This teaching process is similar to the D-DO inquiry-based learning in this study. Thus, G1 participated in D-DO inquiry-based learning, whereas G2 students performed experimental activities using the DO-D inquiry-based learning.

Firstly, both groups took a pre-test. The Light Reflection Test, Situational Interest Questionnaire, and Individual Interest Questionnaire were administered to understand their interest, and to identify their light conceptions knowledge, respectively. During the instruction, G1 participated in D-DO inquiry learning. Correspondingly, G2 participated in DO-D inquiry learning. Finally, both groups took a post-test. The same instruments were administered to all of the students in order to understand the effects of the task order on the students' Light Reflection concept achievement and two kinds of interest.

Design of the D-DO model and the DO-D model for Light Reflection

Both the D-DO and DO-D models in this study are based on the inquiry model. They consisted of five similar basic phases, except that the task order of discussing and doing was reversed (see Figure 1). In both models, the main task of the DO phase was for the students to make a periscope or kaleidoscope through the previous design.

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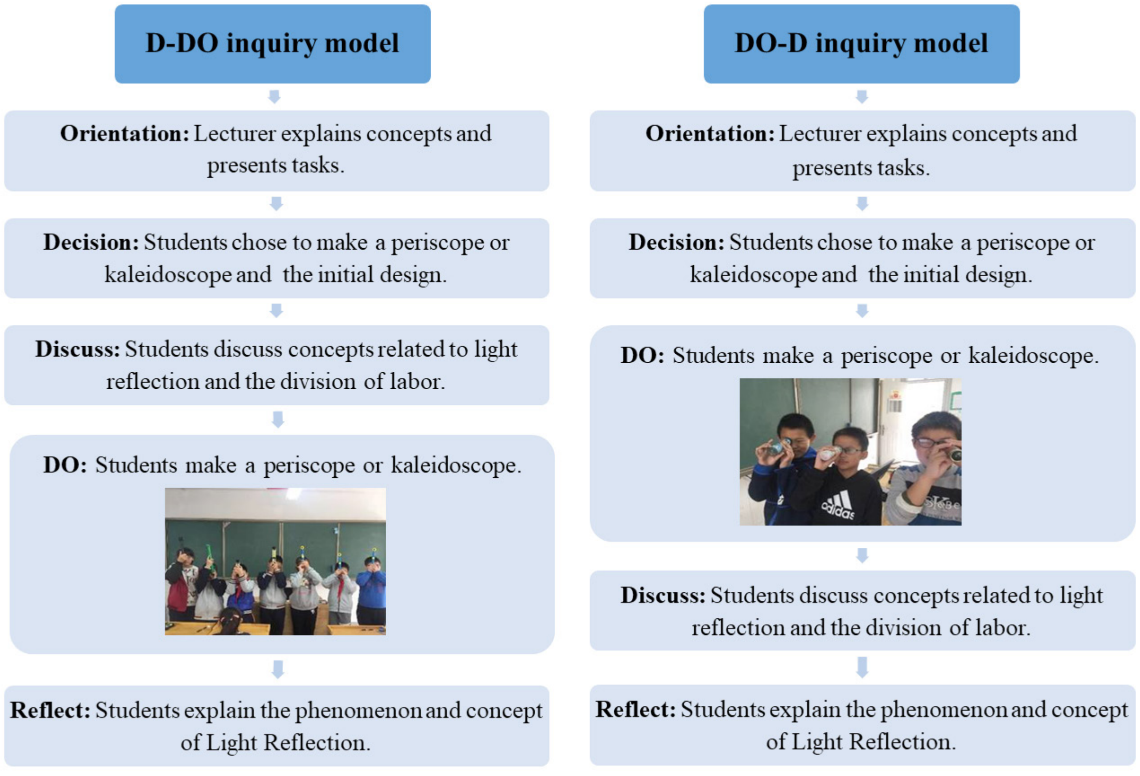
In this phase, students needed to link theory and practice and develop skills such as hands-on practice and problem solving. In the DISCUSS phase, students discussed the principles of light reflection and related concepts. This phase emphasizes teacher feedback and student discussion, which helps to broaden students' ideas and produce better reflections (Anwar et al., 2018).

Figure 1
Procedure of Two Types of Inquiry Model



Instrument

The questionnaire items were adopted from a previous study (Hong et al., 2019a). The researchers professionally translated the original items into Chinese. All items were scored on a 5-point Likert scale, where 1 stands for "*not true at all*" and 5 stands for "*very true for me*". The reliability of the constructs was subsequently tested.

Individual Interest Questionnaire (IIQ)

This study adopted the Individual Interest Questionnaire (IIQ) (Rotgans, 2015) to measure changes in students' II. This questionnaire has been used to measure the II of students at different ages from primary school to high school. It is common to adapt the IIQ to measure II in different subjects (Duchatelet et al., 2018; Roure et al., 2021). Rotgans' example items (e.g., I am very interested in chemistry) measure the students' individual interest in "biochemistry". If the measure is an interest in another subject or discipline, such as "physiology", "biochemistry" needs to be replaced with "physiology" in these items (Rotgans, 2015). In this study, "biochemistry" was replaced with "science". The IIQ has seven items, for example: I am very interested in Science. The Cronbach's alpha coefficient for IIQ was .805, which indicates that IIQ has sufficient reliability.

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Situational Interest Questionnaire (SIQ)

The Situational Interest Questionnaire (SIQ) (Rotgans & Schmidt, 2011) was adjusted to measure students' SI. This questionnaire was first proposed to explore changes in SI in classroom learning, focusing on concentration and affective dimensions for judgment. The follow-up study applied the questionnaire to examine the impact of learning environment elements and learning opportunities (Alexander et al., 2012; Swarat et al., 2012). This study explored the effect of task order on students' SI, so it was adapted in conjunction with the learning theme. The instrument includes six items, for example: I want to know more about today's topic. The coefficient Cronbach's alpha of the SIQ was .885, which demonstrated that the SIQ measure is adequate.

The Light Reflection Test (LRT)

Light reflection is a basic but important concept in physics education (Kroothkaew & Srisawasdi, 2013). Light and its properties are an interesting topic that has a strong appeal to students early in their studies (Varela et al., 2014). In science education in Chinese primary schools, the unit of Light Reflection is taught in the fifth grade. It is important for their future study (e.g., Light Refraction) that students acquire the concept of Light Reflection properly in this grade.

The Light Reflection Test (LRT) was to measure the students' concept achievement of Light Reflection before and after the treatment. It consists of five multiple-choice questions and five true-or-false questions. One point is recorded for each question. The same questions were used in the pre- and post-test, but in a different order. A team of two science teachers analyzed the test items in relation to the instructional objectives and confirmed that the content of the LRT instrument and the construct validity of the measure were appropriate for the participating students. Answer cards were scored by two independent raters for each student's LRT. Participants were awarded 1 point for each accurate concept. The inter-rater agreement was 0.87. When there were discrepancies, they were resolved through discussion.

Data Analysis

The pre-test and post-test interest and concept achievement data were processed in SPSS. Basic descriptive statistics of the numerical variables were determined. An independent sample *t* test was utilized to compute the difference in the pre-test and post-test of the interest and concept achievement, while the paired sample *t* test was used to analyze the difference in the change of interest between the pre-test and post-test in the two groups. In addition, the significance level of the independent sample *t* test and paired sample *t* test in this study was set at $p = 0.05$.

Research Results

Individual Interest in the Unit of Light Reflection

In Table 1, the paired-samples *t* test was used to analyze the differences in individual interest between the two groups in the pre- and post-test, and it was found that neither G1 ($t = -1.522$, $p = .136$) nor G2 ($t = -1.131$, $p = .265$) showed significant changes in individual interest in the pre- and post-test. Additionally, Table 2 shows the independent sample *t*-test results of students' individual interest in the light reflection unit. In both models of inquiry learning, no significant differences were found between the pre-test results of G1 and G2 ($t = -.394$, $p = .695$, Cohen's $d = .089$), and the results of the post-test showed no significant differences between G1 and G2 either ($t = -.086$, $p = .931$, Cohen's $d = .012$).

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Table 1
Paired-Samples t-test results for the Pre-test and Post-test of Individual Interest

Group	Test	Paired Differences			*t*	*p*
		M	*SD*	*SE*		
G1	Pre-test	3.955	.852	.133	-1.522	.136
	Post-test	4.066	.752	.117		
G2	Pre-test	4.034	.934	.152	-1.131	.265
	Post-test	4.083	.943	.153		

Note: G1: DO-D model, G2: D-DO model

Table 2
Independent Sample t-test results of Individual Interest

	Group	*N*	*M*	*SD*	*t*	*df*	*p*	*d*
Pre-test	G1	41	3.95	.852	-.394	77	.695	.089
	G2	38	4.03	.934				
Post-test	G1	41	4.07	.751	-.086	77	.931	.012
	G2	38	4.08	.943				

Note: G1: DO-D model, G2: D-DO model

Situational Interest in the Unit of Light Reflection

In Table 3, paired-samples *t* tests were used to analyze the differences in the situational interest of the two groups in the pre-test and post-test, and it was found that the post-test results for situational interest in G1 ($t = -3.518$, $p < .001$) and G2 ($t = -6.963$, $p < .0001$) were significantly different from the pre-test. The independent sample *t*-test results of the students' situational interest of the unit of light reflection are shown in Table 4. No significant difference ($t = -.128$, $p = .898$, Cohen's $d = -.049$) was found between G1 and G2 in the pre-test. However, the results of the post-test showed a significant difference ($t = -2.785$, $p = .007 < .05$, Cohen's $d = -.620$) between G1 and G2. The post-test scores of G2 ($M = 4.73$, $SD = .379$) were higher than those of G1 ($M = 4.38$, $SD = .702$). G2 had more success in terms of promoting situational interest compared to G1.

Table 3
Paired-Samples t-test results for the pre-test and post-test of Situational Interest

Group	Test	Paired Differences			*t*	*p*
		M	*SD*	*SE*		
G1	Pre-test	4.219	.723	.113	-3.518	.001
	Post-test	4.378	.702	.109		
G2	Pre-test	4.236	.455	.074	-6.963	.0001
	Post-test	4.728	.378	.062		

Note: G1: DO-D model, G2: D-DO model

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Table 4
Independent Sample t-test results of Situational Interest

	Group	N	M	SD	t	df	p	d
Pre-test	G1	41	4.22	.723	-.128	68	.898	.049
	G2	38	4.25	.469				
Post-test	G1	41	4.38	.702	-2.785	62	.007**	.620
	G2	38	4.73	.379				

Note: G1: DO-D model, G2: D-DO model

Analysis of the Concept Achievement of the Unit of Light Reflection

Table 5 shows the students' concept achievement of the unit of light reflection. No significant difference (t = .414, p = .140, Cohen's d = .094) was found between G1 and G2 in the pre-test. The results of the post-test showed a significant difference (t = -2.559, p = .013 < .01, Cohen's d = .565) between G1 and G2. Both G1 (M = 8.32, SD = 1.404) and G2 (M = 8.97, SD = .822) significantly increased students' concept achievement. G2 had more success in terms of promoting concept achievement compared to G1.

Table 5
Independent Sample t-test results of Concept Achievement

	Group	N	M	SD	t	df	p	d
Pre-test	G1	41	5.56	1.629	.414	77	.140	.094
	G2	38	5.42	1.348				
Post-test	G1	41	8.32	1.404	-2.559	65	.013*	.565
	G2	38	8.97	.822				

Note: G1: DO-D model, G2: D-DO model.

Discussion

Students' Individual Interest

In this study, there was no significant difference between the pre-test and post-test of individual interest in either G1 or G2. There was also no significant change in individual interest in either group after the adoption of the different inquiry models. The findings support earlier studies which found that II develops slowly with the passage of learning activities, and it is only after individuals continuously participate in a certain activity in a specific environment that significant changes will occur (Chen & Darst, 2002). It is difficult to observe significant changes in individual interest as a result of short-term learning. The motivational role of individual interest in learning is unquestionable, but it tends to be relatively stable and difficult to change. In addition, due to differences in individual knowledge and values, there is a huge difference in individual interest, and an in-depth study of individual interest requires the long-term practice of the DO-D model.

Students' Situational Interest

Based on the results of the paired samples t-test, this study found that the post-test results were significantly different from those of the pre-test, indicating that both inquiry models awakened students' situational interest. However, according to the results of the independent sample t test, learners in G1 and G2 had similar situational interest before, but their SI was significantly different after the different inquiry model interventions, with G2 able to experience better situational interest than G1. Situational interest is considered to be a transient interest that

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is elicited in many conditions through stimuli such as cultural differences, interesting experiments, or puzzling phenomena, and is therefore more likely to be evoked and to play an active role under the control of the teacher (Hauer et al., 2008). In this study, the DO-D model examines changes in situational interest by adjusting the order of tasks. When the DO-D model was used to support clear explanations of science concepts, lessons provided powerful stimulating experiences and students' situational interest was significantly improved. The task order was adjusted in a way that made sense in terms of exploring students' situational interest.

Additionally, the results of differentiation between individual and situational interest in the DO-D model also illustrate that individual and situational interest grow asynchronously, and both may have unique motivational functions as separate motivational entities at specific stages of learning (Alexander et al., 1995). However, the four-stage model of interest development proposed by Rotgans and Schmidt (2017) states that repeated arousal of situational interest promotes the growth of individual interest. It shows that it is possible to establish a connection between the two types of interest. The results of the study suggest that the DO-D model can influence situational interest; therefore, the DO-D model can be adopted to explore the effect of repeated evocation of situational interest on individual interest.

Students' Concept Achievement

Some studies have shown the usefulness of inquiry-based learning for supporting students' interests, conceptual development, and self-perception in science learning (Raes & Schellens, 2012; Suduc et al., 2015). Exploring the effects on students' concept achievement by adjusting the task order was verified, with data from the study indicating that participants in the DO-D model had more significant conceptual achievement gains than those in the D-DO model. Although no studies have explored the effects of task order on students' concept achievement, the results of this study can be explained by some previous studies. Students' concept achievement is significantly increased when the teaching sessions are properly sequenced (Bybee et al., 2006).

According to Bybee et al. (2006), inquiry is a fundamental component of primary science education that helps students assess their responses, allows them to communicate clearly, and supports their answers with evidence. In terms of the specific components involved, in the DO-D model, the doing task phase is ahead of the discussion phase. Building scientific knowledge based on hands-on practice emphasizes the bridging role of hands-on work in inquiry learning, whereas the D-DO model emphasizes effective discussion prior to the hands-on component. Students have enough time to organize hands-on practice during the discussion phase. Both models effectively build students' scientific concepts about the refraction of light, but the task order of the DO-D model is clearly more appropriate for teaching the content of this unit. The appropriate order of tasks should be used for different content to promote students' concept achievement, which needs to be concluded by a great deal of practice over time.

Conclusions and Implications

In science education, a large number of inquiry learning models have been proposed and proven to be effective for developing student interest and subject knowledge. Previous research has focused on creating and summarizing new inquiry learning models, but few studies have focused on the impact of subtle adjustments to task order within the models. In order to accommodate different learning content, the task order in inquiry learning should be appropriately adapted to promote students' learning interest and their concept achievement. It is important to note that subtle task order adjustments are controllable in teachers' instruction. Therefore, this study adjusted the order of DO and DISCUSS, two common and important educational sessions of inquiry-based learning, and designed the D-DO and DO-D models to explore the effects of adjusting task order on students' individual and situational interests, and concept achievement. Research results show that there was a significant difference in situational interest and concept achievement between the two models, with participants using the DO-D model showing a more significant increase than those using the D-DO model. In addition, there were no significant differences in individual interest between the two models.

Theoretically, the overall results of this study suggest that when students practice the DO-D learning model, they can effectively increase their situational interest and promote the development of their concept achievement in science. Thus, the findings point to a mechanism whereby it is feasible to influence students' interest and concept achievement by adjusting the task order. This provides theoretical support for task-order adjustments and teacher instructional dynamics in inquiry learning, and expands the forms in which inquiry-based learning can be

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conducted. From a practical point of view, to increase primary school students' interest and concept achievement in science learning, we propose to implement the DO-D learning model. At the same time, rationalizing the task order not only facilitates innovative educational processes, but can also be adapted to the needs of other different subjects. This model and other task order models deserve to be tried and tested in more schools and subjects.

Improving students' learning in science education is the theoretical and practical pursuit of global science education in the 21st century. The conclusion of this study can provide some implications for science instructors from all over the world for improving students' learning in science education. Instructors can adjust the task order to help enhance students' interest and concept achievement. The study of the DO-D model showed that the adjustment of the task order was effective in terms of enhancing students' situational interest and concept achievement. Therefore, it is recommended that teachers use the DO-D model in science courses to enhance students' interest and conceptual learning. In addition, there are still many possibilities for exploring task order. In science teaching, teachers often teach multiple classes. During the instructional design phase, teachers can differentiate teaching for different classes by adjusting the task order and making long-term observations of students' individual and situational interests to conclude a more appropriate inquiry model.

Limitations and Future Studies

A shortcoming of this study is that the time of the two groups' learning was relatively short, and the learning content was limited to one learning unit. Therefore, the applicability of the DO-D model to other content or more participants is uncertain. Further studies with participants from different contexts and for longer periods of time are necessary to explore the development of interest. In addition, this study significantly enhanced students' situational interest through the DO-D model, but there was no clear analysis of how the task order affected the "triggering" and "sustaining" phases. Thus, the specific stages of situational interest should be further investigated.

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Declaration of Interest

The authors declare no competing interest.

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Appendix

Appendix 1: Individual interest questionnaire (IIQ).

1. I am very interested in Science.
2. Outside of school I read a lot about Science.
3. I always look forward to my Science lessons, because I enjoy them a lot.
4. I have been interested in Science since I was young.
5. I watch a lot of Science-related TV programs (e.g., Discovery channel).
6. Later in my life I want to pursue a career in Science or a Science-related discipline.
7. When I am reading something about Science, or watching something about Science on TV, I am fully focused and forget everything around me.

Appendix 2: Situational interest questionnaire (SIQ)

1. I want to know more about today's topic.
2. I will enjoy working on today's topic.
3. I think today's topic is interesting.
4. I expect to master today's topic well.
5. I am fully focused on today's topic; I am not distracted by other things.
6. Presently I feel bored.

Appendix 3: The items of the light reflection test

Choice questions

1. When light hits the mirror or the curtain wall, the light will return; this phenomenon is called ( ).

A. the straight lines of light B. the reflection of light C. the refraction of light

2. Almost everything reflects light, and ( ) the surface, the better.

A. the flatter B. the rougher C. the smoother
3. ( ) is the best reflector.
A. a plane mirror B. a convex lens C. a concave lens
4. The image in the mirror is ( ) to the actual object.
A. upside-down B. heterochiral C. similar
5. The smaller the angle between the two mirrors, ( ) the image.
A. The bigger B. the smaller C. the same as
True or false
1. Only mirrors can reflect light.
2. The fact that a mirror can display an image of an object shows that light does not travel in a straight line.
3. Light can be reflected.
4. A convex lens is needed to make a periscope.
5. The image in the convex mirror is upright and of the same size as the real thing.

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