An Insight into Constructivism and Discovery Inquiry in the Teaching of Science by Secondary School Trainee Teachers during Practicum

by

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ABSTRACT

This study investigates the Post Graduate Diploma (KPLI) secondary school science trainee teachers' conceptions of constructivism and discovery inquiry and their related practice in the classroom during practicum. The study involved four KPLI participants undergoing practicum. Two of the participants taught science in the same school and did team teaching in Form four class. The third participant taught science in a Form one class while the fouth participant taught a Form two class in different schools. The participants' conception of constructivism and discovery inquiry were revealed through interviews and espoused mental models. Classroom observation of their science teachings revealed how the participants intergrated constructivism and discovery inquiry in the class. The findings showed that participants had a fairly clear understanding of constructivism and discovery inquiry in theory. However, in practice, the participants carried out confirmatory inquiries from the textbooks. Although the participants had perceived that they had conducted a constructivist lesson, in reality the main features of constructivism were not observed in their lessons. This study also included some recommendations like reviewing the role of college lecturers to improve the situations and some suggestions for future studies.

Introduction

The current trend in teaching and learning of science is to synergize constructivism and discovery inquiry towards thoughtful learning in the classroom as suggested in the curriculum (Kementerian Pendidikan, 2001). Science trainee teachers enrolled for the Post Graduate Diploma in Teaching (KPLI) are very familiar with terms associated with science teaching and learning strategies, namely, discovery inquiry, guided inquiry and constructivism methods. These teaching strategies and cognitive theories are exposed by science and education lecturers during their first semester for 15 contact hours. During the second semester, KPLI trainee teachers undergo practicum in schools for 10 weeks. It is while in schools that the trainee teachers put into practice what they have learned in the college.

Can our trainee teachers integrate constructivist teaching and discovery inquiry in the teaching of science? From the constructivist's perspective, we construct our own understanding of the world by reflecting on our experiences. The most important element of the constructivist theory is that each person builds knowledge himself actively by comparing the new information with the existing understanding (Driver, 1989).

Scott (1987) says a constructivist in science as one who "perceives students as active learners who come to science lessons already holding ideas about natural phenomena, which they use to make sense of everyday experiences…Such a process is one in which learners actively make sense of the world by constructing meaning". The recent emphasis on hands-on science has put constructivism as one of the learning theories relevant for teaching and learning science. Students involved in discovery inquiry perform certain mental processes, such as observing, classifying, measuring, predicting, describing, and inferring. I believe science trainee teachers who always think of constructivism and discovery inquiry in their practices are likely to produce effective science teaching in the classroom. How are the trainee teachers assimilating and accommodating discovery inquiry with constructivism?

Through mental models of trainee teachers, we can get an insight into their minds concerning discovery inquiry and constructivism. According to Norman (1983), mental models are internal representations that humans develop of themselves and the objects they interact with in the world. Norman said mental model formation depends heavily on the conceptualizations brought to a task and includes our views, beliefs, and attitudes concerning: (a) world (b) ourselves as learners or teachers, (c) our capabilities and prior experiences (d) the tasks we undertake, (e) the issues we confront, and (f) the strategies we employ.

The main purpose of this study is to investigate the Post Graduate Diploma (KPLI) secondary school science trainee teachers' conceptions of discovery learning and constructivism and their related practice in classroom teaching of science.

Context

The Conceptual model of Teacher Education is based on the Philosophy of National Education (PNE) and the Philosophy of Teacher Education (PTE) which emphasize the importance of three fundamental aspects of education: knowledge, skills and values. The curriculum of the Post Graduate Diploma In Teaching (January, 2001) is designed to interpret the three aspects, that is knowledge, skills and values, in an integrated manner. Knowledge encompasses the general knowledge and the content knowledge of specialized subject matter. This includes the knowledge of Integrated Primary School Curriculum (KBSR) and Integrated Secondary School Curriculum (KBSM) as well as professional pedagogical skills. On other hand, skills encompass professional knowledge which aims towards developing communication, thinking, information technology and pedagogical skills. Finally, values refers to the formation and practice of positive values and qualities befitting a teacher, such as being caring, noble, resilient, patriotic, innovative, creative, competent, of high credibility and committed to the profession. One of the objectives of the science major curriculum is to apply the elements of constructivism in various methods and strategies of teaching and learning of science and to plan and prepare lesson plans that focus on the integration of knowledge, scientific skills and moral values.

In the first semester, trainee teachers are exposed to science curriculum, scientific skills and implement science teaching through micro and macro teaching (Table 1). Cognitive learning theories like Piaget, Bruner, Ausubel and Gagne and the Constructivist approach are exposed in main topic 2, that is, Science Teaching and Learning Strategies.

In the second semester, KPLI trainee teachers are attached to schools for 10 weeks during practicum. During practicum, the trainee will put his/her knowledge and pedagogical skills into practice under the guidance of a college lecturer and a cooperative teacher in school.

Practicum is the prime time for researchers to view trainee teacher's beliefs, values and his understandings regarding the nature of science. Does the curriculum prepare the trainee teachers with sufficient skills for them to teach science with a constructivist approach? The researcher believes the trainee teachers performance during practicum in the classroom will be the yardstick of the skills and knowledge gathered from the college.

Table 1 Topics and time allocation in the science curriculum.

Topics	Credit	Hour
Semester 1		
1. Science Curricula in Malaysia	1	15
2. **Science Teaching and Learning Strategies**	1	15
3. Scientific skills	2	30
4. **Planning and Implementing of Science Teaching and Learning**	4	60 15
5. Organization and Management of Science Laboratories	1	
Semester 2		
1. Evaluation	1	15
2. Smart Science Learning Package	1	15

PERSONAL INTEREST

I have taught the component of Planning and Implementing Science Teaching and Learning to the KPLI secondary school science trainee teachers for almost four years. The other topics were taught by different lecturers. In the topic 2 of Science Teaching and Learning strategies, trainees are exposed to cognitive development theory by Piaget and cognitive learning theories like Bruner's inductive thinking, Ausubel's deductive thinking, Gagne's mastery learning and Constructivism. The constructivist approaches using Needham's Five Phase model, Generative model and Interactive model were also exposed to the trainees.

In my class, the trainees prepared daily lesson plans that contain among others, teaching-learning activities based on models of constructivism and discovery inquiry. Needham Five Phase Constructivist model was commonly used by the trainees. The five phases in the Needham's constructivist model are similar to Driver's (1989) model as a general teaching sequence to provoke conceptual change. The phases are orientation, elicitation of ideas, restructuring ideas, application of ideas and reflection or review change in ideas.

During macro teaching in the college, the trainee teachers planned teaching-learning activities and carried out the activities according to the phases. In fact, in constructivist lessons using Needham's model, the teacher can infuse inquiry-based activities. I had discussed many ways the trainees could carry out inquiry based activities in a constructivist lesson. I believe trainees having a clear conception of discovery inquiry and constructivism are able to plan and put into practice teaching-learning activities that are based on constructivism theory and have elements of inquiry.

Trainees' mental models can reflect their conceptions of constructivism and inquiry. Johnson-Laird (1983) stated that mental models are cognitive representations of the external real environment. If the learner's model is elaborate and accurate enough, it permits him to try out various alternative actions and react by using knowledge from past experiences in order to handle successfully the current situation. At the same time, holding an inappropriate mental

model can lead to ineffective learning, or worse, no learning at all (Jih & Reeves,1992). A theoretical framework as shown in Fig 1 was derived from these theories for this study.

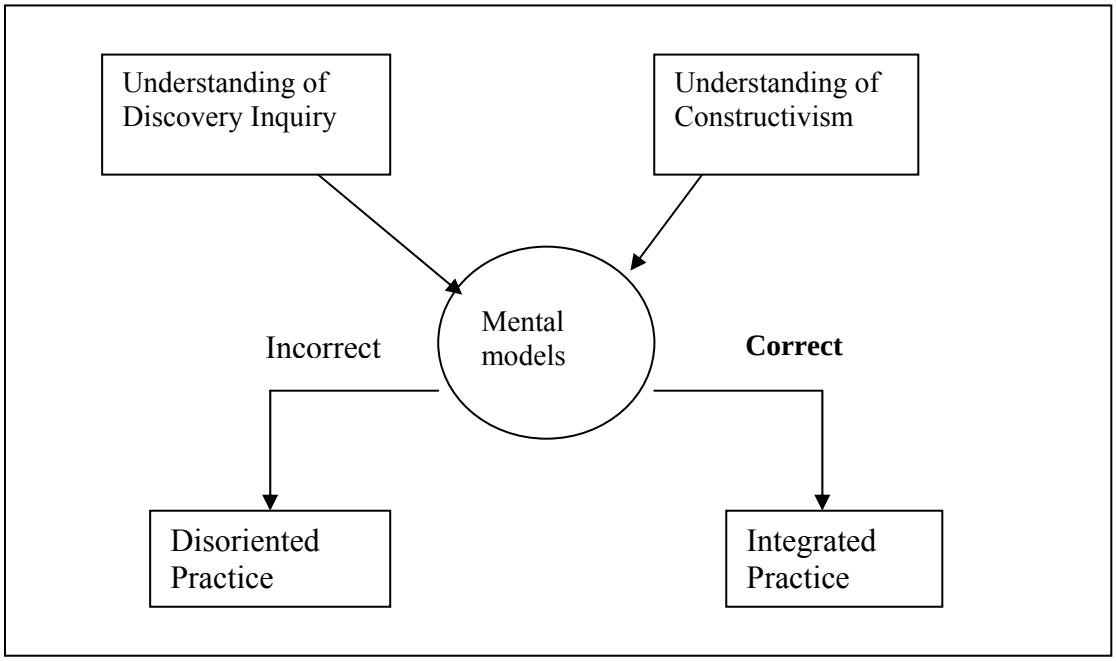
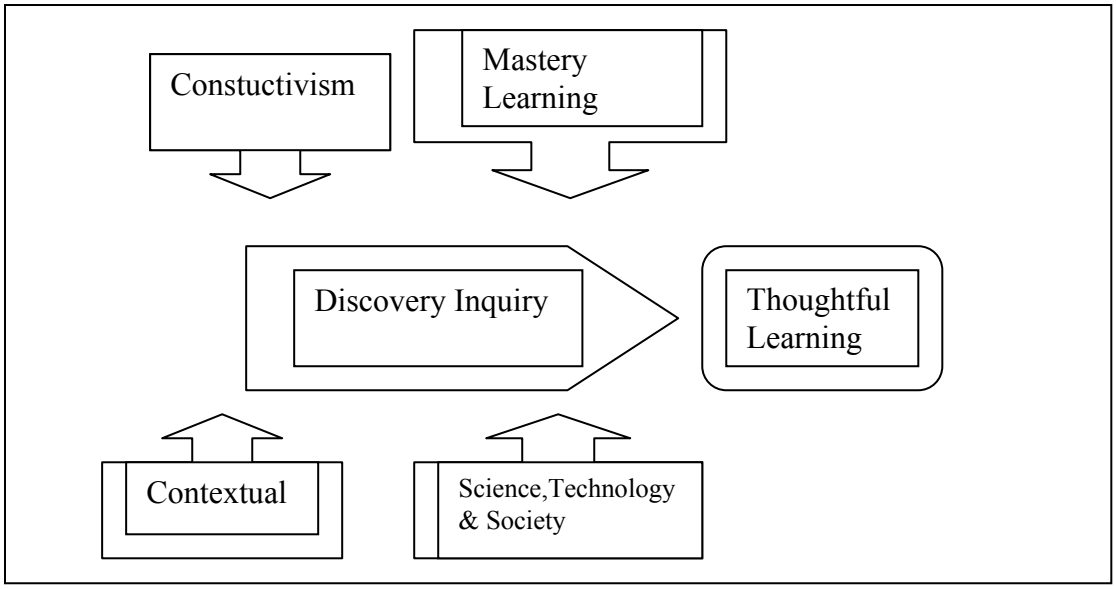


Fig 1. Theoritical framework connecting mental model of trainee teachers and their practice in the classroom.

The Malaysian Curriculum Development Centre (2001) came up with an overall framework as shown in Fig 2 that the teaching strategies use a discovery inquiry approach towards a thoughtful learning outcome. Fig 2 shows there are many strategies a teacher can employ using discovery inquiry towards thoughtful learning. Constructivist strategy is only one of the strategies in teaching science via discovery inquiry. Therefore, by investigating the mental model of these KPLI secondary school trainee teachers and their related practice in the classroom, we can understand their actions in the classroom.



Source: Malaysian Ministry of Education, 2001. Knowing the Science Curriculum. Curriculum Development centre: Kuala Lumpur
(*Kementerian Pendidikan Malaysia, 2001. Menghayati Kurikulum Sains. Pusat Perkembangan Kurikulum: Kuala Lumpur)*

Fig 2. Relationship between teaching strategies and thoughtful learning

Objectives of this study

The objectives of the study are as follows;

(i) To explore the understanding of KPLI Secondary School Science trainee teachers on constructivism and discovery inquiry.
(ii) To determine the mental model of the KPLI secondary school science trainee teachers concerning constructivism and discovery inquiry.
(iii) To investigate how the KPLI secondary school science trainee teachers relate teaching and learning activities they plan with constructivism, and discovery inquiry.
(iv) To investigate how the KPLI secondary school science trainee teachers implement teaching and learning activities based on constructivism and discovery inquiry.

Research Questions

This research is guided by the following questions:

1. What do constructivism and discovery inquiry mean to the KPLI secondary school science trainee teachers?

2. What is the mental model of KPLI secondary school science trainee teachers' conceptions of constructivism and discovery inquiry?

3. How do the KPLI secondary school science trainee teachers relate teaching and learning activities they plan with constructivism and discovery inquiry?

4. How are the KPLI secondary school science trainee teachers implementing teaching and learning activities based on constructivism and discovery inquiry?

Significance of the Study

By understanding the mental model of the science trainee teachers concerning constructivism and discovery learning, educators get an insight into the knowledge perceived by trainee teachers. Trainee teachers having a poor understanding of constructivism and discovery inquiry may find it difficult to plan activities that involve students on hands-on activities. Thus, teacher educators can help them by scaffolding, modeling and coaching. The Teacher Education Division can revise the KPLI secondary school curriculum to promote better understanding and creative ways of integrating constructivism and discovery inquiry in the science classroom, so that more effective science trainee teachers can be produced. A more coordinated effort can be taken by teacher training colleges and schools involved in practicum to assist the trainee teachers to integrate constructivism and discovery inquiry in an effective manner.

Definition of terms

(i) **Constructivism**
A learning theory that states learners construct knowledge as they attempt to bring meaning to their experiences. In this study, constructivism is the learning theory that explains the conceptual change in science learning among students using a model.

(ii) **Discovery Inquiry**
Conceptually, discovery inquiry is a set of behaviors involved in the struggle of human beings for reasonable explanations of phenomena about which they are curious. In this study, discovery inquiry is a teaching strategy that involves students in investigative process like investigating problems, designing experiments and the use of mental process of assimilating concepts and principles of science.

Limitations of the Study

This study is confined to the context of one teacher training college and therefore the findings cannot be generalized to other colleges. Due to time constraints and logistics, only 4 participants were studied, hence only a small portion of the actual situation as seen by the respondents was discussed in this study.

METHODOLOGY

This study has been conducted within a constructivist context. Inquiry into science teaching as described in this study was best addressed using a dialectical methodology in which individual constructions are elicited by interactive dialogue between the researcher and the participants. The researcher acknowledges that an individual's constructs are influenced by his or her environment and are subject to influence by prior knowledge, peers, learning experiences, and other social interactions (Monk, 1995). The teacher trainees' conceptions of discovery inquiry and constructivism were investigated using mental models. Examination of

curriculum material, literature and interviews with the college lecturers resulted in the identification of seven plausible models.

Instruments

In this study, structured interview questions, a list of seven mental models concerning constructivism and discovery inquiry and a observer's checklist formed the main data gathering instruments.

Structured Interview Questions

The interview questions were designed to elicit learner's mental model using the Interviews-About-Events (IAE) approach. This approach was prescribed by Gilbert, Watts and Osborne (1985) in which learner's preferred mental models were probed using the interview protocol. The five questions to elicit teacher trainees' mental models is shown in Table 2

Table 2 Interview Questions Used in the Inquiry

(a) What do you understand by (i) constructivism (ii) discovery inquiry
(b) Do you see any relationship between constructivism and discovery inquiry?
(c) Which model shows the relationship you have said? *(A list of seven drawn models was shown)*
(d) Do you have any other model in mind? (In *case, participant cannot choose any one of the drawn models)*
(e) How do you explain the model you have chosen or drawn?

List of Mental Models on Constructivism and Discovery Inquiry

A list of Suggested mental models on constructivism and discovery inquiry is given in Appendix II. This list of models were derived after detailed examination of curriculum material, lecture notes, reference books used by teacher trainees combined with informal interviews with the college lecturers involved in teaching the teacher trainees. The models express a number of relationships between constructivism and discovery inquiry; from no relationship (Model 1) to constructivism as subset of Discovery Inquiry (Model 7). In case, participants have other mental models, they were asked to draw on the space given.

Observers' Checklist on Teaching-Learning Activities.

An observation checklist as shown in Appendix III was used to identify teaching-learning activities in the participants' lesson plans with constructivism and discovery inquiry. The participants were asked whether the teaching-learning activities planned in their lesson plan involved discovery inquiry, constructivism or both.

Field notes were taken while observing the participants teach science in the classroom. Field notes were focused on the implementation of discovery inquiry and constructivist teaching.

Participants

In this study, four KPLI secondary school science teacher trainees from Sultan Abdul Halim Teacher Training College took part in the study: Mas, Fane, Ravi and Roger (not real names). They are from a class of 22 secondary school science teacher trainees undergoing the Postgraduate Diploma in Teaching Course, Session 2003-4. Two of the participants were females and the other two participants were males. The female participants had degrees in chemical engineering and were teaching in the same school for practicum. One of the male participants has a degree in Physics while the other participant majored in biochemistry. The male participants taught in different schools during practicum. All of them did not have teaching experience before joining the college. I chose these teacher trainees for this study because they could articulate well and express their ideas clearly.

Data Collection

About a month before data collection, permission was sought from the Ministry of Education to embark on this study. Two weeks later, the researcher got the approval from the Planning and Research Department of the Ministry of Education to conduct the study. The approval letter is given in Appendix IV. The researcher then contacted the Kedah state education department and the schools concerning the study. The researcher was given the green light to conduct the study in the schools.

Data collection was done in three stages. The first stage was interviewing the participants to find out their understandings of constructivism and discovery inquiry. Then the participants choose a mental model that reflects their conceptions of constructivism and discovery inquiry. The second stage consisted of checking the lesson plan and relating the teaching-learning activities using the observation's checklist. After that, observation of classroom teaching was done using and field notes were taken while observing. Finally, the third stage involved interviewing the participants again to clarify researcher's interpretations and observations made. The preferred mental models of the participants were asked again after teaching.

The participants were placed in secondary schools in Kulim and Kuala Muda / Yan districts in Kedah for a duration of 10 weeks practicum. A week before practicum, the researcher informed the participants about the objectives of the study. They were told to prepare an inquiry lesson plan based on a Constructivist model.

When the researcher visited the school, firstly, he stressed to the participant that no evaluation will be done and then briefed the code of ethics (Appendix 1). The participants felt relief when they knew they won't be assessed. This could be seen when they communicated freely and confidently to the researcher. When the participants felt easy to communicate, the researcher interviewed them using the structured questions as shown in Table 3.1. The interview session was recorded with the participant's permission.

After the interview, the researcher observed the classroom teaching by the participant. Field notes were taken during the lesson. The observer' checklist for lesson plan was used to note the activities carried out in the classroom. After the observation, the researcher interviewed

the participant again to verify some incidents and activities carried out during the lesson. The participant was asked for reasons why he/she has related a particular teaching-learning activity with constructivism or discovery inquiry. The researcher also asked for the participant's preferred mental model after teaching.

Pilot Study

A pilot study was conducted on two teacher trainees a week before they went for practicum. The interview questions were focused on the teacher trainees' mental models concerning constructivism, discovery inquiry and thoughtful learning. The participants found the explanation for the three conceptions were tiring and a strain on them. Also thoughtful learning is seen as a product of constructivism and discovery inquiry, rather than a another construct. After consultation with the supervisor, the researcher probed the participants' conceptions of constructivism and discovery inquiry only. They were asked to draw a model that reflected their understanding on these conceptions. The researcher found the participants difficult to relate these conceptions through drawing. Hence, instead of asking the participants to draw in a short time, the researcher gave a list of plausible mental models relating constructivism and discovery inquiry for them to choose. A prepared science lesson plan was used for participants to relate the teaching-learning activities with constructivism and discovery inquiry. Both the participants did not have much problem in relating teaching-learning activities to discovery inquiry and constructivism. The participants' comments on the interview questions were considered and changes were made to improve it.

Through this pilot study, the researcher made two modifications. The first modification was to reduce the participants' mental model conceptions of constructivism, discovery inquiry, thoughtful learning to constructivism and discovery learning only. The other modification is the way the mental model is derived. Instead of asking the participants to draw, they will choose a mental model from a list of plausible mental models or draw one if not found in the list.

Interpretation and Data Analysis

The structured interviews on participants' understanding of constructivism and discovery learning were transcribed. Statements that revealed participants' views on constructivism and discovery inquiry were inspected. The participants reasons in relating the teaching-learning activities to constructivism and discovery inquiry were discussed. The preferred mental models of the participants on constructivism and discovery inquiry were highlighted with reasons. Finally, the implementation of constructivism and discovery inquiry by the participants during classroom teaching were discussed.

FINDINGS AND RECOMMENDATIONS

Introduction

In this section, the findings of the study are discussed followed with the implications and recommendations based on this study.

Understanding of Constructivism and Discovery Inquiry

This section discusses the findings on research question 1 which reads as "What do constructivism and discovery inquiry mean to the KPLI secondary school science trainee teachers?

Analysis of the interview data shows that even though the trainee teachers have various explanations for constructivism, but all of them do have some similar ideas about constructivism. All of them have focused constructivism based on students' approaches towards learning through doing experiments, experience, student thinking and student questions. They have emphasized student's learning rather than teacher's teaching. The trainees had identified the teacher's role as a guide in the science classroom. One of the trainees talked about students constructing using their mind and relating what they have learned to daily life. This implied the trainees perceived the students as active learners and science learning should be meaningful to them by seeing its use in daily life. These ideas are similar to Scott (1987) who says a constructivist in science as one who perceives students as active learners who come to science lessons already holding ideas about natural phenomena, which they use to make sense of everyday experiences. It is obvious from the explanations that the trainees have understood constructivism quite clearly from the practical aspects, that is, emphasizing the importance of student learning.

However, a broader outlook of constructivism like students holding prior ideas and their ideas evolve as a result of experience and socialization as stated by Driver et al (1994) would be more appropriate to understand the dynamics of constructivist lesson. The conceptual change and misconceptions of students on a particular topic should be addressed by the teachers in the classroom.

The trainee teachers seem to have narrow views on discovery inquiry. Doing activities and doing experiments and asking questions were considered inquiry by the trainees. Merely asking questions cannot be considered as inquiry. Trowbridge et al (2000) talks about guiding questions that are planned and should direct students' thought processes. Although, doing experiments is an important aspect of inquiry, discovery inquiry should be seen as an investigative process involving mental processes too. According to Trowbridge et al (2000), discovery inquiry involve investigative operations that include observing, questioning, experimenting, comparing, inferring, generalizing, communicating and students identifying the principles and concepts through thinking. Curiosity is also important aspect of inquiry (Novak, 1964). Thus discovery inquiry involves activity, process skills, mental processes and the focus is on active search for knowledge.

Relationship between Constructivism and Discovery Inquiry using Mental Models.

In this section, the findings on participants' mental models relating constructivism and discovery inquiry are discussed. This is also the findings for research question two that reads as "What is the mental model of KPLI secondary school science trainee teachers' conceptions of constructivism and discovery inquiry?"

The findings indicate that trainee teachers perceived some sort of relationship between constructivism and discovery. At the beginning everybody had their own interpretations between constructivism and discovery inquiry which differed from each other. These can be

seen from the various models they chose. This is in agreement to Norman (1995) who said that mental models represent personal constructs and are unique to the observer.

Mas viewed constructivism as a subset of discovery inquiry. This implied that when a lesson is conducted using discovery inquiry, constructivism is implicitly carried out too. The teacher trainee with this mindset may not stress constructivist teaching but more may focus only on discovery inquiry methods in teaching science. The trainee may assume that she need not stress constructivism when using the discovery inquiry methods since it is already imbedded in discovery inquiry. However, her mindset changed after teaching into overlapping relationship (Model 5) between constructivism and discovery inquiry. She had realized that constructivism and discovery inquiry are two different identities with some similarities. The similarities between constructivism and discovery inquiry like both stress on student learning and teacher acting as facilitator had changed her mind. As Park and Gittelman (1995) pointed out mental models are fluid and can change as learner's expertise change, thus, trainee teachers changing their mental models after teaching were expected.

On a similar situation, Fane who saw a two-way relationship between constructivism and discovery inquiry changed into overlapping relationship (Model 5) after teaching like Mas. Initially, Fane thought that any teaching-learning activity inclined towards discovery inquiry has constructivism and vice versa. This is a wrong conception and may lead the teacher trainee to emphasize one of it, either constructivism or discovery inquiry in teaching science.

In contrast, Ravi and Roger had chosen the same mental models before and after teaching. Ravi felt that discovery inquiry should be carried out first and then constructivism. Therefore, he perceived one way relationship from discovery inquiry to constructivism (Model 3). It is clear that Ravi did not perceive any similarities between constructivism and discovery inquiry and he firmly believed discovery inquiry preceded constructivism. This is quite worrying because teacher trainee may carry out discovery inquiry first and then carry out other activities as constructivism. In fact, inquiry- oriented teaching reflects the constructivist model of learning (Osborne & Freyberg, 1985) and mediated inquiry is used in constructivist teaching. However, Roger viewed discovery inquiry as a part of constructivism (Model 6). By holding to this view, he fails to see constructivism as learning theory and discovery inquiry as an investigative process and this view may affect his teaching science in class. He may focus on the constructivist teaching without emphasizing the inquiry aspect of discovering the nature of science.

The various mental models displayed by the trainee trainers only indicate the different ways they understand constructivism and discovery inquiry. Constructivism and discovery inquiry are closely linked as shown in model 5. Haury (1993) explains the relationship between constructivism and discovery inquiry well by saying "inquiry-oriented teaching engages students in investigations to satisfy their curiosities, with curiosities being satisfied when individuals have constructed mental frameworks that adequately explain their experiences"

Planning teaching-learning activities based on constructivism and discovery inquiry.

The findings based on research question three that reads "How do the KPLI secondary school science trainee teachers relate teaching and learning activities they plan with constructivism and discovery inquiry?" is discussed in this section.

The researcher has highlighted some pertinent issues that have arisen in relating teaching-learning activities to constructivism and discovery inquiry by trainee teachers.

Firstly, the findings show that all the participants had thought of science process skills to be incorporated in their lessons before teaching by writing it on the lesson plans. This showed the trainees gave importance to content as well as the science process skills. Science process skills are stressed in constructivist teaching through inquiry and mastery of these skills is product of this teaching. Trowbridge et al (2000) stress the need for hands-on activities in inquiry lessons and the science process skills developed through these activities. In constructivist teaching too, hands –on activities and science process skills are important. In teaching science through constructivism, Saunders (1992) talked about involving students with hands-on activities that promote science process skills and to help students to utilize their own schema to formulate expectations about what to be observed during the activities.

Secondly, all the trainee teachers in the study viewed the five phases in the lesson plan as important for constructivist teaching. This clearly shows that the trainee teachers knew the phases are connected and leads that to constructivist teaching . Martin et al (2002) described the teacher's activities in a constructivist teaching model are closely linked. At orientation phase, teacher provides opportunities for students to explore through all appropriate senses and to be fully involved. At elicitation phase, teachers interact with students to discover their ideas. At the restructuring of ideas phase, teachers help students develop their ideas further through additional physical and mental activities. At the application phase, the students apply their new knowledge to answer questions and solve problems. Finally, at reflection phase, teachers evaluate students' conceptions by examining changes in students' ideas and by their mastery of science process skills

Thirdly, the participants perceived any hands-on activities or doing experiments involved both the constructivism and discovery inquiry because they perceived the students are thinking while doing the activities. This assumption may not be so right. Students may do activities by following the procedures without thinking the science concepts behind these activities. Suchman (1966) says inquiry is a purposeful activity and raises questions in the inquirer's mind. Thus, teachers must make sure students are thinking by asking probing questions (Trowbridge, 2000).

Finally, all the participants had viewed any questions planned in the lesson plan were linked to discovery inquiry. This is a false assumption by the trainees. In fact, not all questions lead to inquiry. Questions that promote inquiry and lead to conceptual discussion are important for the success of inquiry teaching and learning (Dantonio, 1987). Teacher acts as problem poser asking questions that stimulates idea formation, idea testing and concept construction through observation.

Implementing Teaching and Learning Activities based on constructivism and discovery inquiry

The findings in this section will answer the fifth research question which says "How are the KPLI secondary school science trainee teachers implementing teaching and learning activities based on constructivism and discovery inquiry?".

Even though the trainee teachers taught different classes and levels, there are some common issues concerning constructivist teaching of science that will be addressed here.

Firstly, all the three science lessons were controlled fully by the trainee teachers. Ironically, the trainee teachers were aware that constructivist science lessons should be student centered. The trainee teachers directed all the teaching-learning activities from the beginning of the lesson till to the end following the lesson plans strictly. The researcher sees the trainee teacher as the authority who has fully control of the activities in the classroom rather than a guide in the classroom. The teacher trainee conforms to the old orientation of teaching (Anderson, 2002) in which the teacher becomes the dispenser of knowledge, explains conceptual relationships and directs student actions. This role hampers student's creativity and puts them at the back seat to become passive receiver of teacher's information.

Secondly, the conceptual change (Driver, 1989) that should take place in a constructivist lesson was not clear in all the lessons. The conceptual change was not obvious because trainees did not stress the elicitation of ideas phase and reflection phase. None of the trainee teachers identified the misconceptions or the alternative framework of the students on the topic during the elicitation phase. Thus, at the reflection phase, they cannot evaluate students' understanding by examining the changes in students' ideas. The reflection phase was not carried out well. Thus what the students construct was not clear to the researcher.

Thirdly, the experiments done by the students are closely guided by the teacher. The procedures were coached and the students carry out the activities to confirm some science concepts are correct. They were doing some confirmatory inquiry which is the lowest of inquiry considered by Windschitl (2003). The students should be given more freedom to try out ideas using various materials (Suchman, 1966). The hands-on activities were data driven and the data was discussed in the classroom. Only one trainee used the multimedia presentation to stimulate inquiry in the class. The stimulation was interesting and the questions posed involved inquiry. The students have to predict the outcome of the observation using science concepts. Thus, it is clear the trainee teachers can use multimedia to conduct inquiry lessons but must complement with hands-on activity to master the science process skills.

Finally, text books are not used creatively by the trainee teachers in this study. It is fine to use the textbook in the science classroom but it should be inquiry oriented. The students use the textbook directly without any explanation or challenge posed by the trainee teachers. The trainee teachers should make explicit the connections between textbook explanations and student misconceptions for effective use of textbooks (Trowbridge, 2000).

As a summary, trainee teachers are quite competent in carrying out confirmatory inquiry activities in the classroom. However, the constructivist teaching by the trainees is not very clear even with using five phase constructivist model. The main reasons for this poor constructivist teaching is the trainees are unable carried out the activities at the elicitation of ideas and at reflection phases well and rigid control by the teacher.

Summary of the study

In this section, the overall summary of the study is described. Table 4 shows the summary of the findings of this study.

Table 4 Summary of the findings of the study

Aspects	Mas	Fane	Ravi	Roger
Understanding Constructivism	**A**ll the participants had clear ideas about constructivism. They focused on student's learning. Students learn by constructing own ideas/meaning through experience			
Discovery Inquiry	Although their approaches differ, they agree that students get new knowledge/discover through experiment/ activities			
Mental model	Model 7 to Model 5 after teaching	Model 4 to Model 5 after teaching	Model 3 (no change after teaching)	Model 6 (no change after teaching)
Relating activities with constructivism and discovery inquiry	Doing experiment linked to constructivism and discovery inquiry. Questions linked to discovery inquiry		Activity through multimedia presentation has constructivism and discovery inquiry. Questions linked to discovery inquiry	Doing an experiment has constructivism and discovery inquiry.
Classroom practice	Teacher centered teaching. Alternative ideas and misconceptions of students were not identified. Students in groups carried out activities to confirm a theory. Questions based on text book. Constructivism was not obvious while inquiry was conducted in the form of experiment.		Teacher followed closely the multimedia presentation. Alternative ideas and misconceptions were not identified. Inquiry based questions were given. Constructivism not clearly seen.	Teacher directed all the teaching and learning activities. Misconceptions and alternative ideas not noted. Students carried out hands-on activities. Inquiry was clearly carried out but constructivism.

The Table 4 clearly shows the trainee teachers in this study understand constructivism and discovery inquiry quite well in theory. They understand the main concepts of constructivism and discovery inquiry. Although they perceived that they have conducted a constructivist science lesson the researcher thought otherwise. The researcher through his classroom

observation, felt that the trainees did a inquiry based teaching rather than a constructivist teaching of science. The teacher centered approach and the inability of trainee teachers to show the conceptual change which is the crust of constructivism, had occurred among the students indicated that the trainee teachers are still far from constructivist approach towards science teaching.

These findings also seem to contradict the theoretical framework (Fig 1) of this study that shows that trainee teachers with the correct mental models on the understanding of constructivism and discovery inquiry should be able to integrate them in their practice. The researcher agrees with Martin et al (2002) who said applying constructivist teaching is much more difficult. The constructivist teacher must fill many roles and largely functions as a facilitator of knowledge construction which is rather difficult for a trainee teacher in a large classroom. In the next section there are some recommendations that could improve the trainee teachers' practice in the classroom.

Implications of the study

This study has several implications to the teacher training division and teacher training colleges to consider in training the science secondary school trainee teachers.

(i) The trainee teachers need more exposure and practice in conducting lessons using constructivist model. The trainees are still weak in helping students to elicit their ideas and identifying the misconceptions and alternative ideas of the students on the particular topic. Trainee teachers should use open-ended questions, problems and discrepant events for students to elicit their ideas. Trainees need to show at the end of lesson that the students have learned by correcting their misconceptions at the reflection phase. The trainees need more practice in conducting the reflection phase which is often neglected.

(ii) The trainees need more coaching in carrying out discovery inquiry using constructivism. Both the concepts are complex for the trainee teachers. Hence, teacher educators should give more practice to trainees to enable them to mediate inquiry in constructivist lesson. The essence of constructivism should be stressed and at the same time the scientific processes during inquiry need to be mastered.

(iii) The teacher trainee should act as a facilitator or a guide in the classroom rather than a giver of information. More freedom should be given to students to voice their views in planning and carrying out an investigation. Trainees should take risks by asking open-ended questions and sharing all ideas from the students.

(iv) Lecturers need to understand the dilemmas of trainee teachers conducting constructivist lessons and should encourage and guide them closely by scaffolding, as well as giving them alternative ideas for them to try.

(v) There must be close collaboration between college lecturers and cooperating teachers so that they can constantly guide the trainees to conduct constructivist teaching of science throughout the practicum.

(vi) Trainee teachers must know how to use the science text books wisely so that the students' curiosity in science, creativity and investigative skills are not hindered.

Questions in textbooks seldom have students apply knowledge to everyday experiences. Teachers should construct alternative representations of textbook explanations.

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Appendix I

Code of Ethics

1. Your identity will not be revealed and remain anonymous.
2. All information given will be treated with the strictest confidentiality.
3. You will have the opportunity to verify statements when the research is in draft form.
4. You can have a copy of the final report if you wish to have it.
5. You are free to withdraw consent and to discontinue participation in the research at any time without prejudice.

I understand the above code of ethics and would like to take part in the research voluntarily.

…… ……..

( ) (Thangavelo Marimuthu)
Participant's Name Researcher's Name
Date: …….. Date:……..

Appendix II

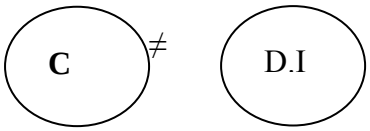
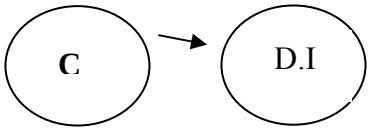
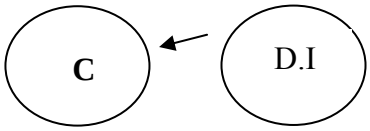
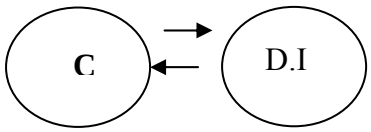
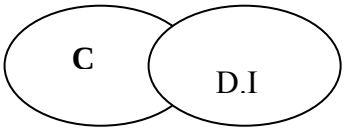
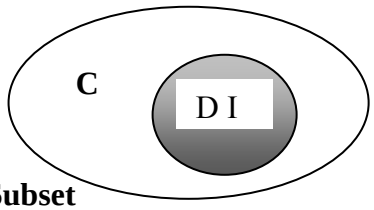
Observer's Checklist For Lesson Plan
Participant: ……..
Topic: ……. Form:…….

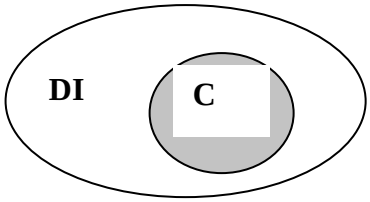
Phase	Teaching –Learning Activities	Const*	Dis.Inq*	Remarks
Orientation				
Eliciting Ideas				
Restructuring Ideas				
Application of Ideas				
Reflection				

Key: Const* - Constructivism
Dis.Inq* - Discovery Inquiry

Appendix III

Mental Models of Constructivism and Discovery Inquiry in Teaching Science

Models	Explanation	Remarks
 **Not related**		
 1 way relationship		
 1 way relationship		
 **2- Way relationships**		
 **Overlapping**		
 **Subset**		

 **Subset**		
My Model		