Constructing Conceptions about Science, Science Teaching and Science Learning in Initial Teacher Education

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Abstract

This Action Learning Project aimed to improve the quality of teaching and learning of science in the initial teacher education programme. The project provided opportunities for student teachers to restructure their conceptions of science and science learning. The design of the project engaged student teachers in activities related to scientific investigations, such activities being very different from the typical science education courses. The theoretical basis of the project is an intervention using a pedagogy which facilitates the conceptual development of the nature of science, science teaching and science learning. Student teachers' conceptions were revealed during interviews before and after their active learning experience. The findings indicated that student teachers were just beginning to develop an awareness of different concepts of science teaching and learning. The project facilitated in student teachers an initial realisation of an alternative approach to teaching, i.e. to construct understandings of science which were different from those constructed as a result of the commonly used didactic approach. The effectiveness of this alternative approach was manifest in terms of an improved understanding of the nature of science, science teaching and science learning. Student teachers also stated that they were aware of the benefits gained in the learning process, particularly the benefits gained from being an active participant in the learning process. They also acknowledged that their existing ideas about science, science teaching and learning were challenged. The findings of the project demonstrated that both Institute lecturers and student teachers developed an understanding of the experiences of student teachers' learning of science.

Introduction

In most teacher education programmes, more time is devoted to substantive study in the discipline than to professional education (Seddon, 1991). The initial teacher education programme in Hong Kong is no exception, with the academic studies modules including discipline-based studies which utilise about two thirds of the curriculum time allocated to student teachers specialising in science. The design and content of the academic studies modules claims to provide student teachers with the conceptual basis and in-depth knowledge required to teach science. However, the teaching of academic studies modules alongside the traditional subject disciplines, i.e. physics, chemistry and biology, only serves to extend students' subject knowledge, but not to provide opportunities for student teachers to get into the inside of science, i.e. to be able to engage in exploratory studies of science. Such an approach to the design of the academic studies modules in the existing teacher education programme cannot enhance student teachers' broad understanding of science, science teaching and science learning, which ultimately affects the practical teaching competence of student teachers. The feedback of previous cohorts of student teachers indicated that they felt the academic studies modules had not fully equipped them to teach science at primary level.

The Constructivist View of Teaching

Beliefs about science teaching point to a predominantly didactic - and discovery-oriented approach (Smith, & Neale, 1989). The constructivist view of learning and teaching, which has recently gained attention, contrasts with the view of science teaching which believes that the transmission of objective facts from teacher to children is best achieved using a didactic approach (Ritchie, 1995). Researchers have identified powerful preconceptions about phenomena brought by students to the classroom and commented that these ideas affect the receptivity to new information (Stofflett, 1994). In the constructivist view, learning involves the active construction of meaning by students, which is not imparted by teachers (Driver, & Oldham, 1986). Evidence points to the potential benefits of adopting constructivist approaches to science teaching in both and primary and secondary schools (Smith, & Neale, 1989; Appleton, & Asoko, 1994; Ritchie, 1995). The emphasis on constructivism and hands-on inquiry-oriented instruction to promote students' conceptual knowledge, by building on prior understanding, active engagement with the subject content, and applications to real world situation, has long been advocated in science lessons (Stofflett, & Stoddart, 1994); while Smith, Blakeskee, & Anderson (1993) believed that teachers need to focus on students' ideas and pursue class activities that engage students in using scientific conceptual schemes to describe, explain or make predictions about the world around them.

The Student Teachers' Conception of Teaching and Learning Science

It has been argued that student teachers bring to the teacher education programme preconceptions about science teaching and learning. These preconceptions, which are primarily didactic in origin, are formed after years of experiencing a didactic science pedagogy in their schooling prior to the teacher education programme. Student teachers commonly view science as a body of facts that are proven or verified by scientists with this view impacting on their views of science teaching (Aguirre, Haggerty, & Linder, 1990). Stofflett and Stoddart (1994) hypothesised that the pedagogy through which student teachers learn science and science teaching is a primary determinant of how they understand and teach science. Student teachers from traditional academic studies modules which emphasise the teaching (i.e. giving) of science facts and principles, may not be able to construct the conception of the nature of science, science teaching and science learning. It was demonstrated in a study by Stofflett and Stoddart (1994) that student teachers had to be exposed to, and experience as learners, a constructivist approach to learning if they were to consider using such an approach in their teaching. They found that student teachers who experienced a constructivist approach in the learning of science were able, as teachers, to develop and implement the same pedagogy in the primary classrooms. In a recent issue of Science Teacher Education, the editors Zaman and Nott (1998), encouraged further debate about the efficiency and effectiveness of constructivism in the education of teachers of science, the present status of constructivism in science in initial teacher education, its limits and appropriate applications. A newly designed science studies module in the initial teacher education program at the Hong Kong Institute of Education, which encourages student teachers to undertake science projects, is an attempt to engage in the debate. The rationale is to promote in student teachers the development of pedagogical conceptions.

The Action Learning Project

An Action Learning Project was conducted to study the effectiveness and concerns of the application of a constructivist view of teaching in the academic studies module in changing student teachers' conceptions of teaching and learning science. It was based upon the work of Kember and Kelly (1994) who proposed that an Action Learning Project consists of a number of phases which include initial reflection, planning, action, observation and reflection. They also advocated that where possible, most projects should go through several cycles, or spirals, of the

basic phases. Because initial planning was not perfect and the action in the first phase revealed the need for further planning, this study went through two phases. An account of each phase is provided separately in the following discussion which describes the action research process.

Description of the Project

This study drew data from a science academic studies module undertaken by a class of pre-service teachers in the initial teacher education programme. The module took one semester to complete. Student teachers were organised in small groups to undertake open-ended science projects. These science projects were pertinent to the teaching context and represented the first opportunity for student teachers to 'get inside of science' and to experience the actual practices of science (Ryder, Leach, & Driver, 1997). In the process of undertaking the science projects, student teachers were required to explore how science knowledge is constructed, and to structure their own understanding, recognise challenges to their existing ideas and adapt cognitive frameworks using new ideas or evidence. The teaching approach employed in the delivery of the module was based on a constructivist view of learning which involves the orientation, eliciting, restructuring and reviewing phases, which Ritchie (1995) found to be a practical and effective taxonomy. The project began with an introductory session discussing the nature of the science and the science process skills, followed by the four stages of learning: orientation, eliciting, restructuring and reviewing.

- Orientation

Orientation to the science projects involves considering the problems posed to student teachers and an introduction to the areas to be investigated. The aim is to arouse the learner's interest and curiosity.

- Eliciting

Eliciting is the stage where learners are helped to determine and clarify their existing conceptions. An interview with the student teachers was conducted at this juncture. This initial interview aimed to explore the student teachers' existing ideas about science - including their understanding of science, their beliefs about the nature of science, science teaching and science learning. The context of student teachers' science projects formed the backdrop for the initial interview. Student teachers were encouraged to talk about their conceptions about the nature of science with reference to their preconceptions of their particular science activities.

- Restructuring

Restructuring of one's own conception within the science projects was the soul of the intervention. This was the stage where the importance of practical activities and the inextricable links between process, knowledge and understanding were reinforced. Throughout the project, student teachers were encouraged to take individual responsibility for their own learning by testing ideas to extend, develop and finally to replace their existing conceptions. They were also allowed to work at their own pace on areas of science relevant to their particular needs. Lecturers gave responses to individual needs, and there was an exchange of ideas between themselves and / or lecturers. Pomeroy (1993) suggested that this might help to bring student teachers closer to a more contemporary, constructivist view of science.

- Reviewing

Reviewing was the stage of helping student teachers clarify changes in their conceptions. In the context of the assigned science project, a second interview was performed towards the end of the activities. During this interview student teachers were encouraged to talk about their conceptions of the nature of science, science teaching and learning with reference to particular activities in their science project. They were also encouraged to identify changes in their

conceptions of science, including the possible influences from their science projects. In spite of the lack of test-based empirical evidence to confirm teachers' improved understanding of the nature of science, science teaching and learning, the effectiveness of the module was evidenced by changes in student teachers' conceptions of science compared with their prior preconceptions. There were also obvious areas of development resulting from the input and the process of working on the science project.

Method of Evaluation

It is believed that student teachers' receptivity to further input of science knowledge and pedagogy in the teacher education programme is influenced by previous conceptions of science resulting from their prior science education experience. The initial conceptions of the nature of science, science teaching and learning held by student teachers were revealed through interviews, which focused on their understanding of science, beliefs regarding the nature of science, science teaching and science learning. Discussion with student teachers in the first and second interviews about the image of science, science teaching and science learning utilised questions which underpinned studies conducted by Aguirre, Haggerty, and Linder (1990), and Gustafson and Rowell (1995). The interview was designed to encourage student teachers to address the following four broad research questions:

1. What are the changes in student teachers' conceptions of the nature of science at the end of the module?
2. What are the changes in student teachers' conceptions of science teaching at the end of the module?
3. What are the changes in student teachers' conceptions of science learning at the end of the module?
4. What are student teachers' gains and concerns at the end of the module?

Preliminary Trial of the Teaching Approach

The preliminary trial of the teaching approach was conducted in the academic year 1997-98. It consisted of a 45-hour module undertaken by a class of 27 student teachers in the initial teacher education programme where science was an elective subject. The project required the student teachers to work in small groups on some science investigative activities during a 5-month period under the supervision of science lecturers who were also project members. These science investigative activities facilitate active learning and provide opportunities for student teachers to have their first experience of the learning of science through the constructivist model. In the process of science investigative activities, student teachers were required to structure their own current understanding, recognise challenges to their existing ideas and adapt cognitive frameworks in the light of evidence or new ideas.

Topics of student teachers' investigation included:

- The amount of vitamin C in food;
- The amount of chemicals in fertilizer and plant growth;
- Food additives; The nutrient value of vegetable and fruit;
- The environmental impact to plant growth;
- Preservatives in food;

- Making bean curd;
- Waves; and
- Electric circuits.

Learners' Gains in the Learning Process

During the science project work, student teachers were required to decide on a topic which they wished to investigate and to determine the procedure for the investigation. This was considered to be a good learning experience for them. After the completion of the project, student teachers expressed their appreciation of the autonomy they enjoyed in choosing of topics, arranging procedures for investigation and using different experimental techniques. Such freedom allowed them to learn at their own pace, and to become more serious about, and responsible for, their work. They also managed to develop improved scientific skills during the process. The open learning structure of the module allowed student teachers to choose when and where to work. Such an arrangement resulted in them obtaining information not only from their experimentation and the lecturer, but also from library books, the Internet, and the supporting laboratory technicians.

Education practitioners have reported that co-operative learning results in high academic achievement and provides a vehicle for students to learn from each other (Hassard, 1990). The opportunities to work with peers in this study resulted in the student teachers reporting that this was a major gain. The majority of them believed that they learned science better through interaction in group-work since the sharing of views motivated them to learn. This echoed one of the key aspects of the constructivist approach to learning in science. The shift from a teacher-centred approach in teaching and learning, to co-operative group-work was essential for learners to experience the constructivist way of learning science.

The opportunities for student teachers to present their interim report was identified as another gain in this science project. During presentations, student teachers had the opportunity to display their well organised data and feedback collected from peers and lecturers. The relevant feedback gave them the impetus to further their investigation. Generally speaking, student teachers enjoyed the experience and hoped such a method of learning would be the method of learning science in the initial teacher education programme.

However, not all student teachers found a significant learning gain after completing their science project indicating that different learners might learn in different ways. It is important then that teacher educators should be aware of individual differences in the students and be prepared to use different theoretical and practical approaches in their teaching (Woolnough, 1998).

Learners Concerns: The Mode of Teaching

Although many student teachers favoured this way of learning, some were still reluctant to learn in a way that was so very different from their past learning experiences. They indicated that they favoured the teacher-centred approach to which they had previously been exposed.

Although most of the student teachers recognised the specific role undertaken by the lecturers, some tended to compare it with the mode of teaching in other modules in the teacher education programme as well as with previous learning experiences. They expressed discomfort with the seeming lack of structure of the module and an apparent paucity of contact with the lecturers throughout the module. Nevertheless, there were student teachers who realised that the teacher was engaging in the role of facilitator rather than that of a dispenser of knowledge or information.

Another concern raised by student teachers about the science project was the lack of relevance to the local primary school curriculum. Owing to their freedom to decide on their own project topics, most of the topics were relevant to adults but not to children. Though most of them expressed satisfaction with the knowledge gained in the learning process and the writing of the report, quite a number of student teachers queried its application in future teaching in primary school. They suggested that the topics for exploration should be in line with science topics in the primary curriculum so that what they gained in the process, both in terms of knowledge and development of pedagogy skills, could be used in their future teaching.

Action to Improve the Teaching Approach

In planning the module for the second cycle of the study in the 1998-99 academic year, student teachers' concern over the lack of structure of the learning process and the insignificance of the science projects to the local primary curriculum was acknowledged and considered. Modifications, therefore, to the organisation and content of the module were made to accommodate their concern. Investigations, however, were still central to the module.

Again there was an introductory session discussing the nature of science and science process skills, followed by a guided investigation identifying the factors affecting the melting of ice. The guided investigation was designed to encourage student teachers to become involved in an activity but they were guided by the lecturer. This was in response to student teachers' request for more than one phase of activities. Student teachers could therefore review the whole learning process prior to the next phase of activities where they received less guidance from the lecturer.

At the end of the guided investigation activity, student teachers worked in groups and decided on a topic for investigation from four main science themes in the primary curriculum:

- Electricity and electromagnet;
- Light;
- Expansion and contraction; and
- Heat conduction.

Selecting a theme, student teachers undertook investigations to modify and improve the activities commonly found in primary textbooks related to scientific theories. They then were required to design a practical guide for activities detailing and supporting scientific theories**.** Students, upon evaluating each experiment from the perspective of the primary school pupils, gained a more in-depth understanding of the subject (MacMahan, & Stevens, 1993). The next phase involved student teachers designing a science investigation of one of four themes. The topics being investigated included:

- Conduction of heat;
- The transmission of light;
- The expansion and contraction of the three states of matter; and
- The different effects of electricity.

The following phase required student teachers to design investigative activities according to the interests of primary school pupils. This phase served to illustrate how a tertiary-level investigation could be reshaped for use in primary-level learning. This included activities relating to:

- The rusting of iron;

- Floating and sinking; and
- Light and colour.

The module ended with students' presentation of their work.

Findings and Discussion

Categorisation of student teachers' responses in the two surveys provided preliminary information which enhanced lecturers' understanding of the existing conceptions held by individual student teachers. The findings were similar to those of Gustafson and Rowell (1995). Some student teachers were able to articulate their ideas while others admitted that it was difficult to describe what they truly believed during the interviews. Nevertheless, most of them tried to integrate their ideas and experiences into the science projects.

The second cycle of the study examined how the engagement of the 18 student teachers in the science project work helped to improve their understanding of science. All their responses to the interview questions were analysed and compared before and after their involvement in science projects. The range of images on the nature of science, science teaching and science learning raised by the student teachers were examined. The interview results indicated that student teachers were able to recognise benefits associated with the constructivist approach adopted for the module. The areas of benefits again included the learning process. This was similar to that expressed in the first cycle, while one of the concerns expressed by the student teachers related to time constraints.

Change of Views on the Nature of Science

Students enter the classroom with a range of conceptions of science. These are the result of past experiences and opportunities related to science (Hassard, 1990). Science teacher educators should consider the repertoire of conceptions brought by student teachers during the training programme (Aguirre, Haggerty, & Linder, 1990), since student teachers have their own views of what science is. In the first cycle, student teachers could be classified into four categories according to their views on the nature of science: a) a superficial conception of science, b) the process conception of science, c) the inquiry conception of science, and d) the technological conception of science.

A superficial conception of science envisions science as something abstract and a mystery; science is about daily phenomena; science needs thought; and science is a body of knowledge. In this portrayal, there is no apparent difference between science and non-science (Aguirre, Haggerty, & Linder, 1990).

The process conception of science includes observations and explanations of natural phenomenon; science is ever changing; and science is something related to something else.

An inquiry conception of science describes science as an organisation of data obtained from experiments; science as a process of inquiry; and science as an investigation.

The technological conception of science perceives science to be activities which contribute to the advancement of mankind; and science is related to technological advancement.

We attempted to examine the responses of student teachers about the nature of science based on the four categories derived from the first cycle of the study, i.e. the preliminary trial of the project. Initially only three of the above categories of conceptions were identified with no student teacher holding the technological conception of science. After engaging in those

activities the number of responses of student teachers with the superficial conception and inquiry conception slightly dropped and the change in their responses to the questions related to the process conception was quite apparent. This was particularly significant in that the module, which modeled a constructivist and inquiry approach for science teaching, resulted in a positive influence on student teachers' concepts of the nature of science.

When student teachers were asked to express their views on ways of acquiring scientific knowledge, more than half of the student teachers responded that knowledge could be acquired by investigation. The majority perceived that hypothesising, performing experiments, and inferring were the means for developing a body of scientific knowledge, however, some responded that scientific knowledge could only be acquired by making observations. Another quarter of the student teachers believed that it could be acquired by an accumulation of daily experience. Student teachers' initial beliefs about the acquisition of scientific knowledge tended to be unchanged from the views held as a result of their prior education. However, after active involvement in science projects, the response "accumulation of experience" in the process of acquiring science, declined. Most of the student teachers stated that scientific knowledge was accumulated through investigation. Such views remained unchanged in the second interview with responses such as the following being given:

> Human curiosity drives people to explore more science knowledge; and
>
> People are interested to explore.

This reflected that student teachers were geared to the humanistic side of science, and it appeared that the constructivist approach enabled the student teachers to rethink their views of the nature of science.

Changing Views about the Nature of Scientific Work

When discussing the ways in which good and bad scientific work could be distinguished, a few student teachers initially found that there was no clear distinction between good and bad work, but there was no such response in the second interview. In the initial interview, some student teachers mentioned "the experimental evidence" including "sufficient data analysis to support the discussion", "the experimental results", "a clear experimental procedure and accurate data collected" were important factors to be aware of when considering the quality of scientific work. It was apparent that student teachers had to collect repeatedly, experimental data to verify and support the hypothesis they had tested in their project work.

It is interesting that student teachers put more emphasis on the humanistic side of good science work after the activities, indicating that they were more aware of the value and the benefits of the scientific work instead of just evaluating the works in terms of provision of data and appropriateness of procedures. This shift of view was illustrated in the following extracts from the data:

> Works that are useful and beneficial to people in the world were good; and
>
> Works that are not against ethics and moral were good.

In discussing how conflicting ideas were resolved in the scientific community, in both interviews all student teachers stressed the importance of obtaining evidence through inquiry and experimentation. In the first interview, many of the student teachers believed that conflicts could be resolved by discussion, but some student teachers shifted to the belief, in the second interview, that having evidence to support one's point of view was sufficient to resolve conflicts. Through engagement in science projects and in spite of discussing and negotiating with each other,

student teachers were more aware of needing evidence to settle the conflicts of ideas among their peers.

Changing Views about Science Learning

When discussing the ways that would help children to learn about science, there were a variety of responses including the need to apply science to daily life, the need to demonstrate the fun side of science, the mystery of science and the creativity in science. The following transcriptions illustrate the views of student teachers about science which they thought would be useful to help pupils to learn science:

> Things that are related to daily life and are useful to children;
>
> Interesting things will be more appropriate for children to learn;
>
> Mysterious things that arouse pupils' curiosity to learn; and
>
> Creative things that require pupils' thinking.

However, in the final interview, student teachers concentrated on two areas indicated in the following statements:

> Interesting things will be more appropriate for children to learn; and
>
> Things that are related to daily life and were useful to children.

This reflected the need to appreciate the importance of the fun side of science. The conception of student teachers focused on that particular side because of their active involvement in some interesting science investigations.

Furthermore, student teachers also expressed their views on the ways of science learning. In the first interview, student teachers suggested that students should do experiments, read more reference books, observe more, do the worksheets provided by the teacher, and listen carefully to what the teacher taught. However, in the second interview, there were responses such as:

> Pupils should be actively involved in investigation;
>
> Pupils' should learn actively through project work; and
>
> Pupils should be active in asking questions.

It was found that student teachers realised the importance of the learner's active role in learning and began to consider that learners should take more control over their learning about science. In fact, discovery, inquiry and constructivist approaches are all learner-centred and involve active learning (Ritchie, 1995). The findings provided student teachers with an array of teaching strategies intended to consider students' prior knowledge (Aguirre, Haggerty, & Linder, 1990).

The above conceptual development of science learning was important as it was believed that students' views of science learning was critical in determining how they would view science teaching in primary schools (Hand, & Peterson, 1995). It appeared that the approach used in this science module had enabled the learners to re-think the way they learned, and they recognised that science and the nature of science was not just a body of knowledge.

Changes in Views of Science Teaching

The data so far have related to students' experience of the acquisition of science knowledge. This next part discusses students' experiences of the different teaching strategies in the module which were used by the lecturers. The majority of the student teachers conceived the teacher's role to be a guide to trigger off thinking and investigation by students, some even said that a teacher was responsible for raising questions. With the constructivist learning experience of performing investigations independently, student teachers changed their views about the teacher's role to being a provider of opportunities for learners to investigate, and, when necessary, a student support.

After experiencing a semester-long module which encouraged learners to take responsibility for their own learning and allowed lecturers to respond to individual needs, it can be seen that the student teachers began to change their views about the teacher's role in students' learning. They now considered that the teacher should employ a learner-oriented approach in their teaching. They could also relate this to their experiences of the role of their lecturers in their science projects. This recognition of the teachers' alternative roles might well enhance the possibilities of re-defining what counted as school science teaching.

Student teachers were also asked to give account of the effective teaching strategies in teaching children science. In both interviews, most of them considered inquiry and investigation to be effective. A few more student teachers believed in the final interview that "guiding pupils to learn from different ways" was effective in science teaching. Student teachers began to realise that there was no one single way of effective teaching and pupils could benefit from the variety of learning experience provided by the teacher. Though few changes in student teachers' conceptions of science teaching were identified after the semester's work undertaking science projects, this was a good beginning for student teachers to experience constructive teaching, which was different from the didactic teaching experienced in their prior education.

Gains in Learning: The Learning Process

Student teachers' concerns were taken into account in the planning and designing of the module in the second cycle of study, hoping that they would benefit from improvements in the module design. When student teachers were asked what they had gained through the learning process, almost half of them stated that they had had valuable experiences during investigations. Such statements included:

> I learned to consider factors and difficulties in carrying investigations and doing experiments;
>
> I knew the ways to search for useful information to support the investigations; and
>
> I had chances to design the investigation by myself.

Others focused on the teaching of science. Student teachers mentioned that this module provided more opportunities for them:

> I learned about the difficulties and problems that might challenge our future teaching;
>
> and
>
> I gained knowledge to create some innovative way of teaching science.

Development of pedagogical skills was another benefit reported by students in the study with the use of constructivist teaching and learning approach (Hand, & Peterson, 1995). Some also mentioned the gain in personal growth and that this learning process enhanced their self-

learning techniques. A majority of student teachers recognised that they had developed an understanding of the science topics they had investigated.

Student teachers were invited to compare this learning experience with previous ones in their Sixth Form education. The great difference was that there was no concrete instruction for this investigation. Student teachers also mentioned that though there was more freedom in the process, more thinking was involved. They also said that the emphasis of the previous work was on the product while this investigation emphasised the process.

The majority of student teachers seemed to be comfortable with this learning experience. Only a few felt uncomfortable with the different roles undertaken by both the lecturers and students stating:

> The procedures of the experiments in the previous experiences were more detailed and I could gain more knowledge from the previous experience.

Student teachers also found a significant change from their experience of science learning in secondary school. The reasons they preferred the learning experiences provided in this module are exemplified in the following statements:

> There was more room for creativity;
>
> There was fun in self-investigation; and
>
> The learning process was simple and less intensive.

The various responses on the special features of this module included:

> There were opportunities for free investigation;
>
> We could carry out self-investigation and discovery;
>
> I was glad I have more time for thinking;
>
> I realised the role of teacher and the different ways of learning science; and
>
> I realised the possible problems and difficulties in my future teaching.

All these reflected the benefits of this learning experience to student teachers. It also helped to prepare the student teachers for the way children manipulate and work when exposed to inquiry work.

Learners' Concerns: Time Constraints

Taking the concerns of learners from the first cycle of the study into consideration, the design of the module paid more attention to the teaching role, the relevance particularly to the primary curriculum, and experiencing more than one investigation. However, fewer concerns were expressed by student teachers in the second cycle of the study. Some of them were concerned about the time allocation given to each component of the module. They suggested conducting investigations related to other themes. It seemed that student teachers were very ambitious. Nevertheless, it also showed student teachers' desire and eagerness to learn.

Having more than one investigations in the second cycle of the study provided opportunities to explore two different topics, enabling student teachers to review the whole learning process (Hand, & Peterson, 1995). Prior to starting the second topic, students could review the

investigation processes, reflect on their own roles in the investigations and examine the learning conditions necessary for better learning.

Conclusion

Pre-service student teachers hold a variety of conceptions about science, science teaching and children's learning. These conceptions could affect the teaching approaches the student teachers eventually take in the classroom (Gustafson, & Rowell, 1995). This project considered these conceptions of teaching and learning and gave students an opportunity to construct new ideas in the light of their own experiences (Fischler, 1999). The aim of the project was to provide an opportunity for student teachers to learn about the nature of science in a learner-oriented way, and to raise their awareness about the nature of learning. This was the first time that the student teachers had engaged in this type of teaching pedagogy, independently investigating selected science topics. It is also an approach which encourages learners to take responsibility for their learning, and allows lecturers to respond to individual needs and differences (Ritchie, 1995). The findings showed that student teachers were able to refine their ideas and began to develop an awareness of different ways of teaching and learning. The authors are interested in finding out if the student teachers are able to apply this active way of teaching and learning in their practice, since Aguirre, Haggerty and Linder (1990) found that a teacher's conception of teaching and of learning influences his / her approach to teaching. Although the project only serves to provide student teachers with an initial realisation of an alternative approach to teaching, i.e. to construct understandings of the nature of science, instead of experiencing the traditional didactic approach, the effectiveness of the alternative approach has been evaluated in terms of student teachers' improved understanding of science after being involved in the active learning of science.

Most of the student teachers' comments indicated that they had developed an awareness of the benefits to be gained in the learning process when the learner took an active role. They also indicated that their existing views of science, science teaching and learning were challenged. Although these student teachers enjoyed the learning experience, some failed to appreciate 'getting inside of science' and subsequently became 'lost'. They were uncertain of their roles in the learning process.

Bearing in mind that an Action Learning Project involves the five phases of planning, acting, observing, reflecting and evaluating, the authors analysed the practice, modified the design of the module, and finally evaluated these changes based on a framework set by the findings of the first cycle. In tackling the problems encountered, student teachers suggested modifying the module so that they could be given an opportunity to recognise their own learning process by undertaking more than one phase of investigation. Moreover, student teachers suggested that they should investigate issues related to the science topics in the local primary curriculum, which in effect would draw their learning closer to their future teaching. MacMahan and Stevens (1993) suggested "devising ways to get the materials across to children helps to clarify the future teachers' understanding of difficult scientific concepts" (p.90). The accommodation of student teachers' suggestions in the second cycle of the study resulted in an increased gain in the learning process. This reflects the success of the Action Learning Project. On one hand, it has provided opportunities to explore student teachers' learning through two cycles of study. On the other hand, it has provided opportunities to design and redesign the module to help student teachers to teach elementary pupils science in full confidence (MacMahan, & Stevens, 1993).

All in all, the findings of the study will help lecturers, as well as the student teachers themselves to gain a better understanding of their perceptions of science, science teaching and science learning. The results also help to identify areas of the teacher education programme in

which student teachers' images of science might be developed, thus better preparing them to teach science at primary level with better preparation.

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