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Preparing Student Teachers to Integrate Science Content and Pedagogical Strategies in Instructional Activities

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ABSTRACT

Teachers' content knowledge and their skill in teaching concepts are key research findings for effective teachers. Collaborative learning is also found to be a way to improve teachers' subject-matter and pedagogical knowledge. Taking this into account, the practicum course in the second semester of the academic year 2013 at Udon Thani Rajabhat University was designed to prepare professionals in teaching for 4th year Thai student teachers. There were six stages of learning that the students had undergone in order to develop these professional skills. In this research, the following steps were followed. First, student teachers' misconceptions in specific science contents were diagnosed and discussed. Second, the students were made to participate in learning activities using those concepts. Third, a peer review of science lesson plans was analysed, focussing on an appropriate teaching method to teach specific science content and learning tasks. Peer discussions and reflections were conducted from Stages 4 through 6: collaborative lesson preparation; peer observation of teaching; and reflection. It was found that the student teachers held common misconceptions in science as revealed in the research findings. The preparation process was effective in that it gave a sense of ownership to student teachers working in collaboration with their peers to plan and implement instructional activities.

Keywords: Instructional activities, pedagogical strategies, science content, student teachers

INTRODUCTION

In today's world, the product of scientific inquiry has become necessary for everyone. In addition, science is viewed as a subject of life-long utility to all students, whether or not they enter science-related careers. Therefore, everyone needs to

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have scientific literacy to make decisions and debate scientific issues (Tasakorn & Pongtabodee, 2005). In Thailand, science education has been engaged in educational reform since 1997. Consequently, science is taught as a compulsory subject from primary education through secondary education in the Basic Education Curriculum. Therefore, all learners from Grade 1 to Grade 12 are offered science content, running from simple to more complex for higher grades. A success of the development of the national science curriculum in Thailand began around 1980, undertaken by the Institute for Promotion of Science Teaching (IPST), in Bangkok, and it attempted to implement science curriculum for schools (Fensham, 1986). The science curricular strands consist of: Living Things and Living Processes; Life and the Environment; Substances and their Properties; Force and Motion; Energy; Changing Process of the Earth; Astronomy and Space; and the Nature of Science. All learners are expected to learn the subjects with emphasis on connecting scientific knowledge with scientific processes, acquiring essential skills to search and construct knowledge through investigative processes and acquiring diverse problem solving experience, all of which create opportunity for student participation in all stages of learning. Also provided for are various hands-on activities suitable for learners in each level (IPST, 2008).

At the primary-education level, students are expected to integrate science content as follows: understand principles, concepts and theories of basic science; understand the nature of science; understand the inter-relationship and impact of science, technology, humanities and the natural environment; demonstrate applications of science and technology in daily life and society; promote the process of learning science and research in science and technology; and promote an open-minded, rigorous attitude towards science. At the lower-secondary level, general science courses are offered as core-compulsory and elective classes. At the upper secondary education level, students are divided into science and non-science streams. Physics, chemistry, biology and environmental science are offered as compulsory electives and free elective courses for science-stream students. Various units (modules) on physical and biological science are offered for non-science stream students. In order to achieve science literacy goals, the education system needs to be changed. Reform of the learning and teaching process is at the heart of the education reform. The IPST has emphasised that the aspects for quality science teaching should include the following: inquiry-based teaching/learning processes; higher-order thinking processes; scientific processes; communication and decision-making strategies; project-based skills; and using Information Technology for teaching/learning. However, there are limitations such as class size, lack of science equipment and a shortage of qualified teachers, and these affect the outcomes for students (Boonklurb, 2008).

There are many factors that are considered to influence student achievement such as: the appropriateness and currency of the curriculum; the availability and quality of textbooks; the appropriateness of the assessment system; the availability of laboratories and scientific equipment; the school environment in which learning takes place; and the quality of the science teacher (Ware, 1992). The teacher is generally viewed as the person who plays a key role in schools and classrooms. It is widely believed that the quality of teachers and teaching positively impacts student academic achievement. Across the educational systems of the world, the problems of teaching/learning management are all involved with hiring adequately qualified teachers (Ingersoll, 2007). Concern about the quality of teaching is related to the quality of teacher preparation programmes. Thus, there is a great deal of interest in ensuring that the teacher education programme is as effective as possible.

In Thailand, the Teachers Act of Buddhist Era 2546 (2003), Section 44, has enacted the qualifications of persons who are able to apply for a licence to practise a licensed profession, which consists of: being of age twenty years or older; having an education degree or equivalent or other educational qualification accredited by the Teachers Council of Thailand; and having completed practical training in an educational institution in accordance with an educational curriculum of not less than one year and having passed the practical training requirements in accordance with the criteria, procedures and conditions as established by the Teachers Council of Thailand Board.

Most recently, there were two teacher preparation systems for five-year education programmes. The first system, the Bachelor of Education Programme, requires student teachers to study course work for four years and spend one year in schools to gain teaching field experience. This programme is normally provided by the regular school programme at a Faculty of Education. The second teacher preparation system, the Graduate Diploma Programme in the Teaching Profession, requires students who already hold a tertiary degree to pursues the Diploma Programme in Teaching Profession at a Faculty of Education for one year. All teacher preparation programmes have to meet with the criteria, procedures and conditions set out by the Teachers Council of Thailand Board and the Thailand Qualification Framework (TQF).

Promoting the skills in teaching/ learning management is an important domain of the teaching profession preparation provided by the TQF. The ability of new teachers to incorporate and teach environmental concepts in their classrooms requires both content knowledge and skill in teaching the concepts (McDonald & Dominguez, 2010). The integration of content and pedagogical strategies in instructional activities is appropriate for the professional preparation of pre-service teachers. Researchers find

positive statistical relationships between student learning gains and teachers' content knowledge (Ferguson & Ladd, 1996) and skill (Ehrenberg & Brewer, 1994; Ferguson, 1991). In a context of science education, research findings have revealed that not only children, but teachers and student teachers, hold various misconceptions in science (Wandersee, Mintzes, & Novak, 1994; Chang, 1999). Many student science teachers, specifically, prescribe to numerous misconceptions, so the misconception on subject matter knowledge that these science teachers hold is likely to be transmitted to their students (Sheehan & Childs, 2013). Consequently, teachers must have sufficient knowledge to be able to know how to teach and organise a subject for their students (Shulman, 1986). Therefore, teachers' subject matter knowledge and skill expertise do affect student achievement.

Issues within science education focus attention on teacher's professional development in the science area and improving professional experience practice for pre-service teachers (Jones, 2008). No teacher education programme can prepare teachers for all the situations they will encounter (Liakopoulou, 2012). In teacher preparation programmes and professional development opportunities, models of good teaching to assist student teachers in developing their content knowledge and subject-specific knowledge should be provided and should be ongoing. Likewise, the integration of pedagogical strategies with subject matter and learning standards are continual. However, managing the complexity of the teaching process is not easy to shape. Research indicates that student teachers' development of pedagogical content knowledge can be fostered if they are supported in reflecting on teaching experiences individually and cooperatively (Huppertz, Massler, & Plötzner, 2005). Successful teacher education programmes should assist the student teachers to link the methodological theory and teaching practice. There are various models being developed to prepare teachers. A collaborative approach is viewed as the most effective of undergraduate teacher preparation programmes; many universities use this approach to prepare pre-service teachers (Junor, Clarke, & Kinuthia, 2009; Henry, Patterson, Campbell, & Yi, 2013). In addition, reflection on practice is also considered necessary for student teachers because it enables them to assess, understand and learn through their experiences (Ho, 1995; Liakopoulou, 2012).

Student teachers need to be well-grounded in the content that they are expected to teach and they also need to understand how knowledge is constructed, how the processes of inquiry are applied, and how learning standards and pedagogical strategies are analysed to create instructional activities that are appropriate for their students' level of knowledge and understanding. This study aimed to encourage student science teachers to integrate science content and pedagogical strategies in their instructional

activities, which can be aligned with science content areas that are constructed as well as with the learning standards and levels of the students. In order to prepare student science teachers to deliver knowledge and to assist in honing their professional skill in teaching science, a model for preparing them was constructed. In this study, collaborative learning was also found to be a way to improve student teachers' subject-matter and pedagogical knowledge.

RESEARCH QUESTIONS

The research questions examined in this work are: (1) How do student teachers understand science concepts? (2) How do student teachers integrate science content and pedagogical strategies in their instructional activities? (3) How do student teachers learn and perform through the model of the teacher preparation programme?

METHODOLOGY

Participants

The participants involved in this study were 4th year student teachers at Udon Thani Rajabhat University who enrolled in the school practicum course in the second semester of the academic year 2013. There were 29 students involved in this study.

Teacher Preparation Programmes

The teacher preparation programme was designed for student teachers to assist them to make the move from being the learner to being the teacher in the classroom. Collaborative learning and teaching was conducted on the practicum course designed for collaborative work and was reflected upon by the university advisor and the student teachers' peers. The student teachers underwent six stages of learning to develop professional skills. The stages were: (1) diagnosis and discussion of student teachers' conceptions of specific science content; (2) participation of the student teachers as learners in learning activities using those concepts; (3) analysis of peer review of science lesson plans, focussing on an appropriate teaching method for specific science content and learning tasks; (4) creation of lesson plans by the student teachers in a small group for field teaching experience in schools; (5) classroom teaching by student teachers while being observed by peers; (6) reflection on own and peers' performance by student teachers. All six stages of the process are detailed in following sections of this paper.

Identifying student teachers' science content knowledge. The participants in this study were undergraduate physics teachers. Three physics concepts that researchers have found to be difficult concern the topics of force and motion, electric circuits and astronomy phenomena. These topics were used to diagnose student teachers' science concepts. At the end of the programme, student teachers could identify their misconception.

Participating in learning activities. Learning activities related to the three topics were designed and implemented. The three topics were presented sequentially,

based on the nature of the subject matter. All learning sequences were based on inquiry and the inductive approach. Students derived general principles of the concepts from the data collected through observation. Because of time limitations for this stage, each learning activity took four hours. After the learning activities, all misconceptions regarding the three concepts were analysed and the teachers discussed how these misconceptions were connected through cause-and-effect relationships for the pupils they taught.

Reviewing the peer review of science lesson plans. Before having the student teachers create their own lessons, they were given peer reviews of science lesson plans from the Teacher Leadership for Science and Mathematics Instruction Change programme, a project created by the Institute for the Promotion of Teaching Science and Technology (IPST). IPST plays a major role in establishing standards for teaching and learning science. The student teachers analysed the lesson components, focussing on the learning activities and learning tasks and whether or not they were aligned with the nature of the content and the students' ability.

Creating their own lessons with their peers. All the student teachers created their own lessons and then implemented them in the classrooms. In preparation for field experience, the student teachers worked in small groups of five to six members. Before creating the lesson, a Content Representation Tool (CoRe), which consisted of eight questions (Loughran, Mulhall, & Berry, 2004) was presented to the student teachers followed by discussion to orientate them to the lessons. Then, the students had to answer the eight questions: (1) What do you intend the students to learn concerning this idea? (2) Why is it important for the students to know this? (3) What else do you know about this idea that you do not intend students to know yet? (4) What difficulties/limitations are connected with teaching this idea? (5) What do you know about student thinking that influences teaching about this idea? (6) Are there any other factors that influence your teaching of this idea? (7) What teaching procedures would you use, and why, for this idea? (8) How would you ascertain student understanding of, or confusion about, this idea? The members in each group helped each other to create a CoRe template. After completing the CoRe on the topics they planned to teach, they also helped each other to create the lessons. All the CoRe lessons received feedback from their peers, as well as from their university advisor.

Doing and observing the lesson implementation. The peer lessons were conducted by the student teachers in a primary school made up of students from Grades 1-5. While the student teacher conducted his or her lesson, the other members observed what happened in the classroom. All actions of the student teachers and the pupils were video-taped.

Reflecting on teaching/field experience. After teaching, all the student teachers would observe their class lessons via video tape. Then, the student teachers

read through all the reflection reports on what group members and the university advisor thought of their classroom management. Finally, the student teacher reflected upon the classroom practices that were observed.

Data Collection

For science concepts, three physics concepts held by the student teachers were analysed. The data were analysed using mean, standard deviation, percentage and the dependent t-test. For teaching skills, classroom observation, reflection after teaching and a collection of related documents were recorded as data.

RESULTS

According to the research questions, student teachers' understanding of subject matter, peer lesson plans, reflections on themselves and examining others' classroom practices were studied through both quantitative and qualitative data relevant to the questions. Based on the data collection, the research findings were compiled and reviewed.

Student Teachers' Science Concepts

Three physics concepts that were used to design the learning activities in this study consisted of force and motion, electric circuits and astronomy phenomena tests. Each of these subject areas was administered to the student teachers before and after implementing the learning based on inquiry and the inductive approach. The student teachers' understanding of science before and after participating in the three learning activities was also examined (see Table 1).

Student teachers' common misconceptions of force and motion. Twenty multiple-choice questions from the Force Concept Inventory (FCI developed by Hestenes, Wells, & Swackhamer, 1992) and the Force and Motion Conceptual Evaluation (FMCE developed by Thornton & *Sokoloff*, 1998) were used to evaluate the student teachers' understanding of force and motion concepts. It was found that the student teachers had similar common misconceptions about force and motion, as supported by science education research findings (Clement, 1982; Halloun & Hestenes, 1985). The force and motion concepts used in this study centred on Newton's laws of motion. The student teachers had difficulty with Newton's first law of motion, which states that an object remains at rest or in uniform motion in a straight line unless acted upon by an external force. Almost 70% of them believed that a moving object always exerted applied force i.e. no force, no movement.

For Newton's second law of motion, over 40% of them believed that heavier objects moved faster than lighter ones in free-fall motion, but that heavier objects moved more slowly than lighter ones on a horizontal path. More than half of them believed that a moving object would move following the path of an applied external force after it was kicked, no matter which direction the object moved in before.

For projectile motion, they believed that there was always force from a shooting source exerted on an object after it was shot because the object kept moving forward in a horizontal direction. However, for a package falling from a plane's luggage compartment, while the plane flew along a horizontal direction, 73% of them believed that the path of the package would lie behind the plane, where the package would drop. They did not think that the package followed a parabolic path and remained directly below the plane at all times. For Newton's third law of motion, applied to a case of collisions between a car and heavier trucks, 70% of the student teachers believed that the faster car exerted greater force on the slower or stationary truck. However, in the case of both moving at the same speed when they collided, 40% of the student teachers believed that the truck exerted a greater amount of force on the car than the car exerted on the truck.

Student teachers' common misconceptions of astronomy phenomena. There were 20 multiple-choice questions about astronomy phenomena used to evaluate student teachers' understanding of astronomy phenomena concepts. Based on the student teachers' answers, most of them knew that the rotation of the Earth caused the day-night cycle; however, 62% of them did not know why the sun is seen rising in the east and setting in the west. Of those responding, 76% believed that seasons are caused by the Earth's changing distance from the sun. Therefore, 90% of them did not know when the four seasons occurred in the northern and southern hemispheres. Of those responding, 76% did not know moonrise and moonset times. All of them did not know the reason why the eclipses occurred an average of one or two times every one or two years.

Student teachers' common misconceptions of electric circuits. The Determining and Interpreting Resistive Electric Circuits Concepts Test (DIRECT) developed by Engelhardt and Beichner (2004) with 29 multiple-choice questions was used to investigate the student teachers' understanding of electric circuits. Of those responding, 72 % believed that charges were used up in the production of light in a light bulb. Most of them (over 90%) were unable to answer how the power delivered to one resistor changed when one more resistor or a battery was added to the circuit. Of those students, 97% were unable to identify the schematic diagram of circuits. Almost 30% of them believed that a bulb would be equally as bright as when connected individually to an equal number of batteries, no matter how the battery was connected in a circuit. In addition, 62% of them believed that two batteries connected parallel to one another would make a bulb shine brighter than two batteries connected in a series. Of those responding, 50% were unable to identify the diagram of a complete circuit, and 86% were unable to identify a short circuit.

TABLE 1
Mean Scores (M), Standard Deviations (SD), Percentage and p-Values of the Pre- and Post-Test Results of the Test (25 Items) of the Student Science Teachers

Science Concepts		$\overline{X}$	S.D.	%	t	*p* (Sig.)
Force and motion	Pre-test	6.72	2.84	33.60	5.12	0.00
	Post-test	10.86	2.97	54.30		
Astronomy phenomena	Pre-test	7.31	2.50	36.55	5.00	0.00
	Post-test	9.97	3.13	49.85		
Electric circuit	Pre-test	8.93	2.23	30.79	4.56	0.00
	Post-test	11.65	2.35	40.17		

According to the student teachers' responses to the test, it was notable that their performance on the science test was significantly better after participating in the three learning activities ($p < 0.01$). The post-test mean scores were greater than the pre-test scores at a significance level of $\alpha=0.01$. It is suggested that the student physics teachers who participated in the learning activities had a better understanding of science concepts after participating in the learning activities based on inquiry and the inductive approach.

Student Teachers' Lesson Plans

All the student teachers' CoRe and lesson plans were presented and reflected on by the university advisor and peers. Firstly, the student teachers were divided into groups of five to six members and the group was tasked with creating their lesson plans together. The student teachers started to present their CoRe individually and received feedback recommendations from their group members.After they had all completed their CoRe, they created lesson plans, which were presented to their group members again. Next, their CoRe and lesson plans were presented to the whole class for feedback recommendations from the university advisor and peers.

Group 1. The core content for Grade 1 pupils consisted of materials used for making toys and common objects. These materials were used as criteria classification: The sun, the moon and the stars are in the sky. Four lesson plans were developed, each lasting one hour. To meet the requirements of their learning objectives, three teaching sequences i.e. introducing, teaching and summarising, were used to design the activities in all four lesson plans. Three lesson plans with material concepts were developed, then students were divided into small groups with four to five members to classify the provided materials into groups as their criteria set. After that, they summarised all the data. One lesson was with the stars in the sky, and the pupil was to observe and draw the stars in the sky. Questions were used throughout all the teaching sequences. Their instructional activities aligned with their learning objectives.

Group 2. The core content for Grade 2 students consisted of forces originating from a magnet, applications of magnets, electrical forces resulting from rubbing some materials together, electricity as a form of energy, household electrical appliances and the importance of the sun. Five lesson plans were developed with one hour allocated for each. For pedagogical strategies, the 5E's learning cycle was used to teach the forces originating from a magnet, applications of magnets, electrical forces resulting from rubbing some materials together and the importance of the sun. Five teaching sequences of the scientific method were used to teach the form of energy. Five teaching sequences of the experimental teaching method were used to teach about household electrical appliances. Students were divided into small groups with four to five members each, to work with provided materials as mentioned in the learning objectives in all the lesson plans. Questioning techniques were used throughout the learning activities.

Group 3. The core content for Grade 3 students consisted of effects of forces acting on objects, the Earth's force of attraction upon the objects, natural energy sources utilised for producing electricity, the importance of electrical energy and safe methods of electricity utilisation, rising and setting of the sun, the moon, cause of day and night and determining directions. Six lesson plans were developed with one hour for each. For pedagogical strategies, the 5E's learning cycle and a small-group activity, along with questioning techniques were used to conduct the learning activities in all lessons. Observations and data collected from experiments that were provided for teaching the effects of force acting on objects, along with the Earth's attraction force upon the objects, were shared. Videos and information sheets were provided to the students for learning about natural energy sources utilised for producing electricity, the importance of electrical energy and safe methods of electricity utilisation, the rising and setting of the sun, the moon, cause of day and night and determining directions.

Group 4. The core content for Grade 4 students consisted of functions of vascular bundles and stomata of plants and the factors essential for plant growth and photosynthesis. Five lesson plans were developed with two hours allotted for each lesson. For pedagogical strategies, the 5E's learning cycle and a small-group activity and questioning techniques were used to conduct learning activities in all the lessons. Observations and data collected from experiments were provided to conduct learning activities in all the lessons.

Group 5. The core content for grade 5 students, which consisted of the generation and propagation of sound, the generation of high-pitched and low-pitched sound, loud and soft sound and directions and the rising and falling phenomena of stars were created. Six lesson plans were developed with one hour provided for each lesson. For pedagogical strategies, the 5E's learning cycle and a small-group activity, along

with questioning techniques, were used to conduct learning activities in all the lessons. For the sound lessons, observations and data collection data from experiments were provided to conduct learning activities. For astronomy phenomena, demonstrations and star charts were used.

Student Teacher Reflections on Field Experience

Reflections from in-service teachers, the student teachers' group members and themselves were considered after all the student teachers had finished their teaching practice. All the student teachers observed each other's actions when learning activities were conducted. Then, they all analysed how they had acted, while conducting learning activities from video tapes and they also read each other's reflections on what others thought about their classroom management, based on feedback from the teacher and other group members. Finally, all the student teachers reflected on how well they had done in relation to their lesson plans as self-reflection. Based on the data collection, the reflections are shown below.

In-service teacher's reflection. Due to time limitation, a teacher who was teaching science in this school was unable to observe how all the student teachers conducted their lessons in class as she was the only science teacher in the school and taught science to Grades 1-5. Her reflections on how the student teachers did in the classroom were positive but general. She reported that the student teachers were well prepared to teach as they had all come equipped with their own lesson plans, which included worksheets and equipment for the activities. However, their classroom management skills were problematic, especially when it came to questioning as they proceeded without allocating wait time, and their methods of controlling the class while the students did their experiments.

Members' reflections. All the student teachers in each group observed how their peers had done in their classroom practice. The common reflection that all the student teachers reported was that they were well prepared to teach. They had worksheets, equipment, pictures, videos and questions geared towards students' interests. However, the common problems they reported about their peers' skills were: they could not control the class, especially when students started to talk with each other; and some did not answer students' questions. Examples of the members' reflections include:

She did well engaging of students' interest and well prepare lesson. However, while students make noise she was unable to manage this point.

She did a well start. She cannot control students while they are doing experiment with materials. She should wait time after raising questions. Students seem to talk much at the end of her lesson.

She did well engaging of students' interest and well prepare lesson. To do two hours teaching is too long for grade 2 students.

Self-reflections. The student teachers analysed their classroom teaching after viewing a video and reviewed feedback from their group members and considered the teachers' reflections, as well as their self-reports. All the student teachers mentioned that this had been a good, new experience for them and it helped them be prepared before going in to teach in their fifth year as students. They began to realise how primary school students thought, what their interests were and how they behaved. They began to know their limitations in content knowledge and teaching strategies. They had to prepare more material before teaching again.

DISCUSSION AND CONCLUSION

The study aimed to study student teachers' content knowledge and their skill in teaching science concepts by examining key research findings for effective teachers through the implementation of six stages of a teacher education preparation model. The research findings revealed that the student teachers held common misconceptions in science. The common misconception about force and motion for the student science teachers were: Motion is always caused by force; if there is no force acting on the object, it does not move; force is proportional to velocity of motion; gravitational force exerts on the object only when it moves down a sloping plane but on an upward slope, it needs external force to move; heavier objects take a shorter time to fall than lighter ones. These common misconceptions about force and motion that are shared by the student teachers are also reported in other research to be the common misconceptions among student teachers (Clement, 1982; Halloun & Hestenes, 1985). The common misconception about astronomy phenomena were: The sun rises exactly in the east and sets exactly in the west every day; the phases of the moon are caused by the shadow of the earth on the moon; the earth is farther away from the sun in winter and closer in summer. For concepts related to electric circuits, the common misconceptions were: Current is used up in circuits; one battery makes a bulb shine with a certain brightness, regardless of the configuration; the bulbs connected in the same branch are equally bright. These common misconceptions regarding electric circuits were also common among student teachers studied in other research (Shaffer & McDermott, 1992; Engelhardt & Beichner, 2004). The student teachers in this study had studied these three science concepts in high school and university courses, but they still held on to the misconceptions. It might be that these concepts are relevant to students' daily experience but not a focus in textbooks and traditional. The preparation process was effective, in that it gave a sense of ownership to the student teachers while working in collaboration with their peers to plan and implement instructional activities. Their science content knowledge was considered an important factor that affected their classroom management skills because each content area was constructed in specific ways by the scientists who used reasoning data and evidence to explain

natural phenomena. Therefore, if teachers hold misconceptions in science, they will transmit them to their students. One constructivist learning theory states that all knowledge is constructed from a base of prior knowledge, so the pre-knowledge of students should be considered in preparing learning activities. After the student teachers had participated in the learning activities based on inquiry and the inductive approach, they had a better understanding of science concepts. In addition, they had learnt the importance of creating their own lesson using inquiry as a base to help students overcome difficulties in science.

Analysing peer review lessons was seen as an important stage of the process because it helped student teachers to develop a deeper understanding of the relation of teaching/learning components, especially how to teach the specific content before they constructed their own lessons. Creating and implementing their lessons in class helped them to experience how students learnt, regardless of what they thought or how they prepared to help students learn. Reflection helped them to take note of what they did in the classroom that made their teaching more effective. Reflection supported the students in gaining meaningful insight on teaching and how to apply what they had learnt more effectively (Huppertz, Massler, & Plötzner, 2005; Junor, Clarke & Kinuthia, 2009; Liakopoulou, 2012; Henry, Patterson, Campbell & Yi, 2013). However, the student teachers seemed to see learning to teach as problematic. They frequently saw themselves as novice teachers who learn through trial and error in the practicum classroom. This process informed them that teaching as a professional must include providing different contexts for different students. Preparing student teachers to integrate science content and pedagogical strategies in instructional activities through these six processes can help them add to their knowledge base and professional skill of teaching science because this model was designed to assist student teachers in developing both their subject-specific knowledge and how to teach specific concepts. This is an important domain of the preparation for the teaching profession as provided for by the TQF and other research findings (Ehrenberg & Brewer, 1994; Ferguson & Ladd, 1996; McDonald & Dominguez, 2010).

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