A Suggested Integrative Model for Pedagogical Courses in Science Teacher Education

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Abstract

Science methodology courses based on a model of pedagogical science knowledge maximize the effectiveness of the teaching and learning of science. A properly conceptualized science methods course can have the potential to familiarize student teachers with pedagogical subject knowledge and thus improve science education. Courses which integrate content and pedagogy can be very effective in preparing teachers with pedagogical content knowledge. Colleges of education should observe a number of important matters in order to make science pedagogical courses more effective and advantageous to student teachers.

Introduction

Grossman and Richert (1988) argue that teacher education courses do influence prospective teachers and that the possibility for that influence will grow as they develop the understanding of the broad and complex knowledge base for teaching. They add that the curriculum of teacher programmes needs to reflect the knowledge base of the profession in order to affect educating student teachers.

The literature review also indicates that this domain of knowledge is crucial to promote effective learning and essential for equipping prospective teachers with concepts needed for effective teaching (Al Salmi, 1996; Al-Tobi, 2002; Kelly, 2000; Manouchehri, 1997; Smyth, 1987 and Peterson & Treagust, 1998). Al Salmi (1996) indicates that theoretical courses play a crucial role in the teaching and learning process. Without them it is difficult to understand, for example,

adolescent development, the way they think and the way they learn. Teaching theories are needed to accommodate learning styles and teaching strategies that fit the individual needs of students.

In investigating the effectiveness of the professional courses, Fullan (1991) argues that most student teachers will say that they get too much theory that it is irrelevant and a waste of time. In addition, there is a little impact of these components on educating prospective teachers, whereas, many professors of education, especially those in the social science disciplines, will argue that student get too little theories of education and teaching. Al-Tobi (2002) and San (1999) argue that the pedagogical courses in the colleges of education are not given enough consideration. Bekalo & Welford, (1999) also indicate that pedagogical knowledge in teacher education is not given sufficient attention. Shulman (1986, 1987) also says: ''pedagogical content knowledge'' is not seriously considered. Thus, this paper sheds light on how the effectiveness of the science methodologies courses could be maximised at the Colleges of Education. More emphasis is given to the science methodologies course and an integrative model of pedagogical science knowledge is presented.

a) Linkage between pre-service teacher courses and school curriculum:

It is crucial that the science methodologies courses at the colleges of education are linked to the school education. Bekalo and Welford (1999) indicate that teacher-training courses often suffer because they lack congruence with both the school curriculum and the realities of typical classrooms. Jong and Brinkman (1999) also state that pre-service teacher education programmes still experience difficulties in bridging the gap between theories taught in these programmes and the classroom reality. Blanton, 1992; Calder, 1990; Didham, 1991; Landers & Weaver, 1991; Murphy, 1990; Pugach, 1988, cited in Strawderman and Lindsey (1995) all indicate that the competencies most teacher education programmes identify do not facilitate the kind of knowledge base both regular and special education teachers need to function effectively in today's schools. Thus, it is clear that institutions of higher education are not preparing future teachers to meet the demands of schools.

So, reforms of teacher education programmes must go hand in hand with school reforms. As Manouchehri (1997) states: simultaneous

reform in teacher education must accompany efforts toward school reform, lest they should become futile. Calderhead and Shorrock (1997) say that the quality of initial teacher training programmes should be improved to meet the increasing quality demands of the schools and teachers. New teachers need to be able to implement the new vision of the school's curriculum as Coble and Koballa, Jr (1996) argue that teachers are directly responsible for implementing the changes associated with the new reform of science education in the classroom. They demand that science teacher programmes play a major role in preparing effective teachers in order to enact the changes that accompany the new vision of science education.

Thus, in order to prepare effective teachers who are able to cope with the reformed science curriculum, the colleges of education programmes should be related to, and accordant with, the demands of the new reform. The philosophy and aims of the reform, the structure of the new system, the design of the reformed Education Curriculum, and the characteristics of this reform should be important components in the college's courses. Aspects of a science education of the reform should be essential and integrated components of these programmes. To mention some, these are (Ministry of Education, 1995, 1999a, 1999b): the objectives of science education, theoretical and practical materials of the teaching methods such as experiential learning approaches, hands-on activities and experiments, problem-solving method, out-of-school trips and visits, collaborative learning, self-learning, Information, Communication and Technology (ICT), games and so on. Assessment strategies such as observation, tests, performance assessment, self-assessment, reports, measurement of higher cognitive skills, interviews, and so on should be also included and integrated in training programmes. Kahle and Boome (2000) also suggest educators and policy makers need to be certain that the integral components, instruction, curriculum and tests of the science education reform, are aligned, and links across these components need to be made in pre-service teacher education.

b) Integrating theoretical and practical aspects:

Integrating theoretical and practical aspects is an important aim for development of the college programmes. Fullan (1991) stresses that the *integration* of theory and practice is a desirable goal for effectiveness of

pedagogical courses. Rask (1995) identifies several important issues concerning the linkage between theory and practice, school experience and taught courses. These are:

- the use of simulation experience and group tasks during the taught course; to be effective they must be made real;
- the value of group work with fellow students on the taught courses;
- the importance of developing personal theories throughout the taught courses and how important it is to be aware of underpinning principles of practice;
- a written assignment might be shaped to draw upon issues arising out of practice or taught sessions built around observations and samples gathered in schools together with selected personal readings (pp. 52-53).

c) Teaching and learning environment:

Usually, educators in the colleges of education do not use different teaching and assessment methods (Al-Tobi, 2002). This might be due to many causes. For example, the nature of courses, which have huge theoretical content, and the available time, obligate the tutors to deliver the content by lectures. Thus, other teaching methods such as discussion, workshops, and research are omitted. Therefore, educators can only use exams to assess the memorisation of this huge content. Another factor might be the insufficiency of resources in the Colleges which limits the use of a range of teaching methods. Another reason might be that the tutors themselves do not know how to use the other different teaching and assessment methods.

The limited use of different teaching and assessment methods affects student teachers' abilities to use these methods in their own teaching. Fullan and Stiege (cited: in Kelly, 2000) confirm that teachers would teach science the way they were taught; in schools or in teacher education institutions. Hewson, Tabachnick, Zeichne and Lemberger (1999) indicate that prospective teachers' positive views of knowledge and transmissionist views of teaching are influenced by the university model of teaching they experienced in their courses.

The use of variety of teaching and assessment methods is a desirable goal to help improve delivery of the College programmes.

This, of course, would help student teachers in their teaching, by modelling good practice. As Alshannag (1998) confirms, student teachers who experienced a wider variety of instructional and assessment strategies in their teacher training courses, such as small group discussions, teaching group projects, group work, and cooperative learning, could use these teaching methods in their teaching.

In addition, as schools use a range of teaching and learning methods (Al-Tobi, 2002), it is sensible that student teachers should be taught using the same methods. Manouchehri (1997) states if teachers are to choose the visions offered by a reform, they must be convinced of their values and have exposure to a similar learning environment first-hand as learners. Thus, it is appropriate to recommend that educators at the colleges of education should use a range of teaching methods, and assessment and evaluation tools.

d) Effectiveness of the science methodologies course (Suggested Integrative Model):

In science education, the major responsibility for assisting prospective science teachers to be pedagogues rather than scientists lies on the science methods course (Coble, and Koballa Jr, 1996). This opinion is also shared by Kelly (2000) who states that there is an increasing evidence that to prepare individuals who will be better, more effective teachers of science, different learning methods are necessary. Science methods courses play an important role in the education of the student teachers. They provide them with techniques and skills of teaching that will help them to teach in schools.

Coble & Koballa Jr (1996) and Kelly (2000) confirm that science methodologies courses are a central element in science teacher preparation programmes for educating pedagogically effective science teachers. Raizen and Michelshon (cited in: Kelly, 2000) also believe that many of the pedagogical strategies employed in science methods courses have limited value because teachers cannot connect the scientific content with the appropriate teaching strategy. The lack of pedagogical content knowledge occurs because the relationship between science subject courses, which emphasise science content, and science methods courses, which focus on pedagogy and process is not made explicit. Thus, more attention needs to be paid to integrating science content with pedagogical knowledge. This is called "pedagogical content knowledge" (Shul-

man, 1987). The College courses need to provide student teachers with this kind of knowledge because it is crucial for meaningful learning and effective teaching (Coble and Koballa Jr, 1996; Geddis, 1993; Grossman, 1989; and Kelly, 2000).

To integrate science and pedagogy, a model or framework of pedagogical content knowledge is very important. Cochran, DeRuiter and King (1993) argue that such a model is effective to educate teachers pedagogically. According to Yager, Hidayat and Penick (1988) the methods course in a teacher education programme serves as a vehicle for content and pedagogy integration (pedagogical content knowledge). Thus, this Course should be designed to provide student teachers with strategies of pedagogical content knowledge that would help them to work effectively in the reformed schools. Kelly (2000) states that there is no single model of a science methods course that will be appropriate for all situations, but there may be some general guidelines emerging from several recent initiatives to effect improvement in science teacher education.

Courses and course experiences, and models that could be considered as frameworks for the pre-service teacher programmes have been described in the literature review (e.g. Cochran, DeRuiter and King, 1993; Kelly, 2000; Manouchehri, 1997). For example, a Science methods course was designed at the Texas Christian University to assist pre-service teachers in gaining content knowledge, pedagogical knowledge, and pedagogical content knowledge for the teaching of science while preparing them for a life-long process of teacher learning. This course has the following goals (Kelly, 2000):

- assume the constructivist perspective and integrate science content with pedagogical strategies to engage pre-service teachers in active, inquiry-based explorations that provide opportunities to build upon previous knowledge and enhance the personal understanding;

- promote interest and attitude in science through exploration and by relating the content to relevant, real-world concerns and issues;

- empower teachers to create and develop the curriculum for use in their own classroom;

- encourage the use of unique learning environments that capture the essence of science. In this particular instance, a local museum of science and history was chosen as the informal learning site;

- provide practice teaching experiences in different learning environments (p. 757).

The mentioned course demonstrates effective constructivist teaching practice, and requires development of curriculum units and learning centres. A variety of approaches, including modelling for the pre-service teachers' constructivist teaching strategies, involving them in exploratory and reflective collaborative activities; requiring them to seek resources and develop their own teaching materials; and having them explore and teach science in the context of formal and informal learning environments, are employed. In addition, this course provides student teachers with opportunities to observe and reflect upon the learning styles of elementary students.

Results of the application of this course have shown that the methods course had a positive impact on most students. There is evidence that students gained new insights and understanding. Most expressed more positive attitudes towards science and science teaching and expressed greater confidence in their abilities to teach science. The results also show that there are indications that experiences gained from the course are influencing the way in which course participants who are now in-service teachers teach science. Some of them designated and developed several other science units for their schools. Kelly (2000) concludes that the success of the study adds to the growing body of evidence that even a single science methods course based on an holistic, constructivist approach can reform and enhance teacher knowledge, confidence and attitudes. This may lead to the utilisation of constructivist strategies in teaching science.

Cochran, DeRuiter and King (1993) stress the importance of providing pre-service teachers with a coherent and integrated set of skills of Pedagogical Content Knowledge (PCK) through professional/ pedagogical courses. They reviewed the related literature of teacher education and suggested a model of PCK that can serve as a framework for pre-service teacher programmes. This model is based on the *constructivisit* view of learning and its application to teaching and

teacher education. PCK model includes four integrated components of "*pedagogy, subject matter, student characteristics, and the environmental context of learning*" (p. 266). This model represents the following ideas:

- the changes in a pre-service understanding in each of the four components because development in each area begins with a limited focus and becomes more elaborate through programme experiences and reflective activities;
- the growth of pedagogical content knowledge;
- the simultaneous integration of four PCK components, which theoretically become so integrated and so interrelated: these integration processes should result in conceptual change and conceptual integration;
- the four components should not be acquired first and then somehow put together, but rather preparation programmes must promote integration by having teachers *simultaneously* experience the PCK components;
- the transformation occurs simultaneously in all four components they become integrated to form PCK;
- the developing of all the components of teacher understanding will be symmetrical. The relative contributions of the four components to PCK development will vary during students' pre-service programmes.

To apply PCK model to teacher preparation, Cochran *et al* (1993) suggest a series of ideas. These are as follows (pp. 269-270):

- *PCK development requires* **conceptually integrated instruction** across liberal arts, pedagogy and subject area courses for these types of knowledge to develop concurrently;
- developing PCK in teacher preparation programmes may depend on the level focus of these programmes;
- the construction of pedagogical content knowledge results from multiple opportunities to teach, observe and reflect on ones own teaching and that of others in content area;

- development of PCK requires early, continued and authentic field experiences with opportunities for real teaching and follows up reflection and feedback;
- the development of PCK occurs through repeated experiences that deliberately promote simultaneous learning of the components;
- case studies, peer coaching, cooperative classroom methods, hypermedia, microteaching, and team teaching, promote PCK development. In addition, these methods should involve students in realistic, active contexts and through appropriate inclusion in teacher preparation programmes;
- competent beginning teachers continue to develop toward more integrated PCK with experience. So, in-service professional development training should be designated to enhance this process throughout teachers' careers.

Based on the aspects mentioned earlier and the model presented above, this paper suggests an integrative model of pedagogical science knowledge. It is illustrated in the following figure:

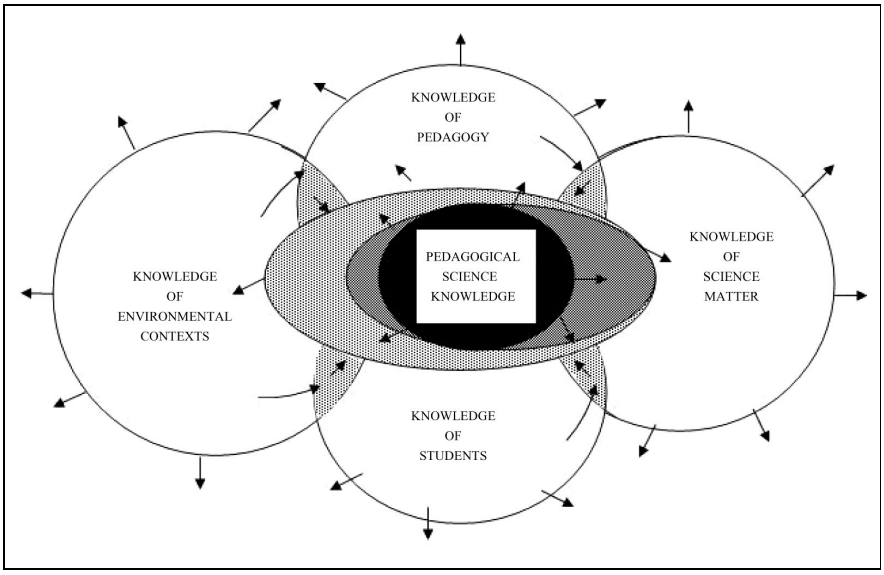

Figure 1: A Developmental Model Of Pedagogical Science Knowledge (PSK) as a Framework for Science Methodologies Course, based on Cochran, DeRuiter and King's (1993) Model

It is important to provide pre-service teachers with a coherent and integrated set of skills of Pedagogical Science Knowledge (PSK) through the Science Methodologies Course. So, the suggested integrative model can serve as a framework for integrating the knowledge of science, pedagogy, environmental context of learning and student characteristics in pre-service teacher programmes. This holistic, constructivist model can reform and enhance science teacher knowledge, confidence and attitudes. This may lead to the utilisation of constructivist strategies in teaching science. Therefore, this would help teachers to work effectively in the schools.

To build such a course that combines science content and pedagogy, Alshannag (1998) suggests increasing the communication and collaboration between the science departments and educators through small group discussions. Thus, a collaborative committee formed from the Science Department, the Department of Educational Studies in the Colleges of education and experienced science teachers from the schools and science supervisors could design a constructive science methods course.

To accomplish the suggested model successfully, Cochran *et al.* (1993) stress that pedagogical experts, subject area specialists and experienced teachers should cooperate in the delivery of teacher training programmes. Substantial and innovative course development, closely linked to field experience, are essential. In addition, the effectiveness of methods and procedures in these programmes should be evaluated and revisited. It must be acknowledged that such accomplishments require time, money and commitment.

In conclusion, it is supposed that building a science methodologies courses based on the mentioned model would maximise the effectiveness of teaching and learning science. Abell and Bryan (1997) confirm that there is evidence that a properly conceptualised science methods course has the potential to familiarise student science teachers with pedagogical subject knowledge and thus improve science education. The key to successful science methodologies courses is in design, organisation, integration and implementation of them. Courses, which integrate content and pedagogy, can be very effective in preparing teachers with pedagogical content knowledge. Thus, it is appropriate to recommend that:

1 - in order to make science methodologies courses more effective and advantageous to student teachers, the Colleges of Education should restructure these courses and aspects to be in accordance with the requirements of the general Education. Policy makers and curriculum planners need to be certain that the philosophy, objectives and characteristics of the reform, integral components, teaching and learning methods, curriculum and assessment and evaluation tools of the science education reform, are made explicit and objectives in pre-service science teacher education.

2 - A co-operative committee between the Colleges of Education and the Ministry of Education should be formed to encourage collaborative efforts in planning and designing the components of science teacher education programmes. Accommodations should be made so that the content of the science curriculum of the schools is reflected in the college courses.

3 - Teacher preparation programmes should not just focus on preparation in theory, but should also deal with a more practical approach to the nature of classroom teaching. In other words, the methodologies courses should increase the time and effort spent in translating teaching theory into actual practice.

4 - Integrating theory and practice by using simulation experience, group tasks and written assignments.

5 - Handouts, handbooks, booklets, or other sorts of written materials with complete descriptions and a clear picture of the philosophy of the general education should be distributed to the student teachers and college staff. This will be done co-operatively with the Ministry of Education.

6 - The teaching methods, and assessment and evaluation tools used in the Colleges of Education in all the three components: the subject-matter courses, the professional courses and the practicum, would require modification and improvement. Student teachers should be taught by using a range of developed teaching and assessment methods that are used in the reformed schools. Varying these

methods is a desirable goal to develop the delivering of the College programmes. This, of course, will help student teachers in their teaching.

7 - More attention should be paid to the Science Teaching Methods Course. This course should be designed as a model or framework of pedagogical content knowledge. This could be done based on the model addressed in this study. Communicative and collaborative committees formed from science specialists, pedagogical experts, and experienced science teachers and supervisors should be co-operative to design such a course that better combines scientific content and pedagogical aspects.

8 - Reviewing the frameworks of the science methodologies courses from time to time.

9 - Teacher education programmes should also actively involve current research going on in the field of programmes' evaluation in order to improve them.

نموذج مقترح لتكامل المقررات التربوية في إعداد معلم العلوم

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ملخص

إن مقررات طرق تدريس مادة العلوم التي تقوم على نموذج تربوي للمعرفة العلمية يمكن أن تزيد من كفاءة تعليم و تعلم هذه المادة. كما أن الرؤية السليمة لمثل هذه المناهج يجعلها قادرة على تزويد الطالب المعلم بالمعرفة التربوية المرتبطة بمادة العلوم وهو ما يؤدى إلى تطوير تدريسها. وعندما توجد المناهج التي يتآزر من خلالها المحتوى مع الأساليب التربوية (البيداجوجيا) نتمكن من الإعداد الفعال للمعلم المزود بالمعرفة التربوية المتخصصة. وعلى كليات التربية مراعاة العديد من الأمور الهامة حتى يمكن تفعيل مثل هذه المناهج بما يعود بالفائدة على الطالب المعلم كإعادة صياغة مقررات طرق تدريس العلوم ويمكن الاستفادة من التوصيات الواردة في هذا البحث كتشكيل لجنة من المختصين في التربية العلمية من كليات التربية والمواد العلمية والمشرفين والمعلمين المتمرسين من اجل ربط هذه المقررات بالتعليم العام والعمل على تكامل الجوانب النظرية مع الجوانب العملية على أن تكامل هذه المقررات كذلك بين المحتوى العلمي، المعرفة التربوية، المعرفة التي يمتلكها الطلبة المعلمون وبيئة التعلم.

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