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The effects of an in-service professional development course on Acehnese science teachers' perceived pedagogical knowledge and skills

Eng Tek Ong
Sultan Idris Education University, Malaysia

This study aimed to determine the effects of a four-week in-service professional development course on Acehnese science teachers' pedagogical knowledge and skills. A triangulation mixed-methods research design was employed: The participants' self-perceived level of pedagogical knowledge and skills in pretest-posttest, and their written responses on what they have learnt constituted the quantitative and qualitative data respectively. The participants consisted of 26 Acehnese science teachers and were selected by means of a stratified purposive sampling. The quantitative data of pretest-posttest differences were analysed using a paired samples t-test, while the qualitative data were analysed recursively to uncover emerging themes. The findings indicated that the Acehnese science teachers perceived that their pedagogical knowledge and skills have elevated as the outcome of the professional development course. The significant gains observed were further supported by the participants' self-written responses which upon analysis, crystallized into two major themes, namely "pedagogical knowledge gained" and the "applicability of the pedagogical knowledge gained". A reflection on the course implementation was provided; ending with some recommendations should similar course be conducted in the future.

Keywords: Science education; in-service, professional development; pedagogical knowledge and skills; Aceh.

Introduction

Aceh has been inflicted by natural disasters such as earthquakes and tsunamis in the recent past and these obviously have impacted negatively on Aceh in all spheres of life, particularly in terms of human capitals. For example, in the 2004 Tsunami, an approximately 128,000 people in Aceh perished; among those who perished were some 500 university lecturers and 2,876 teachers (Deakin University, 2009). Hence, the urgency of continuous social rebuilding programs in Aceh. One of the ways in rebuilding Aceh is the providence of quality education, specifically in science, mathematics and technology education to the people of Aceh.

Student achievement which demonstrates students' construction of knowledge and understanding of school science is one of the key goals of science education. Student achievement, in turn, is affected by many factors. Through a comprehensive review on the factors which contribute to student achievement, Hawley and Rosenholtz (1984) concluded

that, “In virtually every instance in which researchers have examined the factors that account for student performance, teachers prove to have greater impact than program” (p.3). This conclusion underscores the impact of science teachers on student achievement.

While many reforms in science education have been initiated throughout the past two decades and these reforms advocated the use of certain science teaching approach such as the use of inquiry-based instruction (American Association for the Advancement of Science [AAAS], 1993; National Science Teachers Association, 1998), Capps, Crawford, and Constas (2012) reported that little has changed regarding how science is taught in majority of the US classrooms and subsequently, recommend that the key to the desired changes in the way teachers teach science is to provide innovative professional development for both pre-service and in-service teachers.

The review of literature on the effectiveness of professional development shows a mixed outcome. On a negative note, Smylie (1996) reported that, based on a national survey, teachers ranked in-service training as their least effective source of learning, while Guskey (1986) summarised that nearly every major work on the topic of staff development sneered at its effectiveness. Supovitz and Turner (2000) contended that the development of educators is a much “maligned enterprise” (p. 963) although staff development lies at the heart of nearly every educational effort to improve student achievement. On a positive note, by contrast, research findings indicated that the quantity of professional development on inquiry-based teaching in which teachers participate is strongly linked with both inquiry-based teaching practice and investigative classroom culture (Supovitz & Turner, 2000) and that highly intensive (160 hours), inquiry-based professional development changed teachers' attitudes towards reform, their preparation to use reform-based practices, and their use of inquiry-based teaching practices, and that these changes have long-term effects in that they persisted several years after teachers concluded their experience (Supovitz, Mayer, & Kahle, 2000).

In order to ensure positive impact of professional development for science teachers, researchers look at the prevailing format of professional development in a critical manner, research on the characteristics of effective professional development, and put forward their findings on what constitute effective professional development in the form of guidelines. For example, Blunck (1993) criticizes the professional development format which legitimizes the training format whereby "teachers were ‘trained’ to faithfully implement the various innovations" (p. 23), and views such format as akin to a metaphor of “vessels to be filled rather than lamps to be lit” (p. 24). Blunck (1993) reckons that the major problem with such training paradigm is its view of teachers as passive recipients of knowledge and its prescription from the top down.

The realization of the limitations of the “teacher training” model has led to many formal studies which characterise effective format of professional development. For instance, Berman and McLaughlin (1978) found that the programs that made a lasting difference in schools were characterized by in-service activities that had a local focus, allowed teachers to experiment with and customize the innovation to suit the local context, had active support from the administrators, and involved extended opportunities and ongoing support for teachers to implement the innovations. Meanwhile, Van Driel and Berry (2012) recommend that professional development programs aimed at the development of teachers’ pedagogical content knowledge (PCK) should be organized in step with teachers’ professional practice, providing opportunities to enact certain instructional strategies, and to reflect on their experiences individually and collectively. These research studies culminated in the development of various guidelines on science teacher professional development (e.g., Evans, 1986; Klein, 2001).

As such, following a request to provide a professional development course by Aceh Parliament through a letter dated May 24, 2012 (Ref: 422.5/1255) on research-based teaching strategies to a group of science teachers, the limitations outlined by Blunck (1993) were viewed with deterrence while the recommendations by Berman and McLaughlin (1978) and Van Driel and Berry (2012) were taken into consideration while customising the four-week professional development course. In particular, the training format that prescribes the knowledge on pedagogical skills into empty vessels were viewed as deterrence while beneficial recommendations such as the importance of providing opportunities where teachers were actually taught about a certain strategy through the use of the strategy itself were taken into account in the planning.

This paper aims to establish the effect of a provision of an in-service professional development course for Acehnese science teachers on the pedagogical knowledge and skills, measured by means of a questionnaire that elicits teachers' self-rating and personal written responses. More specifically, this study aims to seek illumination to the following research question: What are the effects of an in-service professional development course on Acehnese science teachers' self-perceived pedagogical knowledge and skills?

Aceh professional development program

The four-week professional development course, 'Research-Based Science Teaching Strategies", was conducted from 27 August to 22 September 2012: the first three weeks in Banda Aceh, while the final week in Sultan Idris Education University. The main reasons for having the final week at Sultan Idris Education University were to capitalise on the computer interface failities available; to oberve the teaching and learning process as well as to interact with the teachers in the Cluster Schools of Excellence in Malaysia; and to visit Petronas Science Discovery Centre and National Science Centre. The course outline of the Aceh Professional Development Course is shown in the Appendix.

The course began with uncovering participants' personal philosophies, making these philosophies explicit for comparison and subsequent restructuring in light of active learning experiences (Loucks-Horsley, Hewson, Love, & Stiles, 1998) while undergoing the course and personal sense-making of a plethora of research-based research-validated science teaching strategies incorporated in the course. Research indicates that the personal philosophy or belief that one holds about teaching and learning is key to reforming science education (Crawford, 2007; Jones & Carter, 2007). A teacher's beliefs about science, teaching and learning virtually influence every aspect of his/her pedagogical practice because beliefs serve as a filter through which actions are viewed and decisions are made (Sampson, Grooms, & Enderle, 2013). Philosophically and metaphorically, Ong and Yeam (2003) argue that teachers' personal beliefs about teaching and learning seem to constitute the genetic coding that underpins and guides teachers' decisions and actions in the classrooms. Accordingly, if a teacher believes that all students are teachable, s/he will most probably plan lessons which are suitable for, and appropriate to the cognitive levels of his/her students. Conversely, if a teacher believes that only certain students are teachable, s/he will probably not teach to the best of her/his ability when dealing with slow learners or bottom-set students, believing that it is a waste of time teaching the un-teachable (Ong & Yeam, 2003).

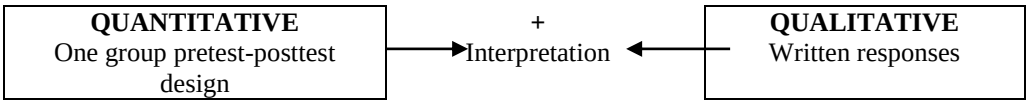
Generally, the facilitators have been briefed about the pedagogical (or rather, andragogical) approach when facilitating the sessions: providing hands-on and mind-on activities which would be reflected upon when summing up. For example, when participants were familiarized with Student Teams-Achievement Divisions (STAD), facilitator would simulate a STAD lesson using an unfamiliar content, walking through each of the five

phases in STAD, namely Teaching, Team Study, Individual Test/Quiz, Improvement Point Calculation, and Team Recognition (Slavin, 1995). Such an approach to professional development has been found to be effective (Ong, 2007). In summing up, facilitator inductively invoked upon the participants each of the phases that they have experienced and by putting these phases as a whole, it was envisaged that they would understand how STAD was enacted in the science classroom, and subsequently, in groups, they chose a topic and outlined lesson ideas on how to enact STAD in the chosen topic. Likewise, for Inquiry-Based Learning, participants were provided with a novel context to which they posed questions, identified questions of their choice to investigate, planned and designed experiments, used data, and connected the data with explanations (Capps, Crawford, & Constas, 2012). Having walked through the inquiry process as "students", the participants then chose a topic and outlined the lesson ideas on how to enact inquiry-based teaching in the chosen topic. This inquiry-based approach in professional development has also been found to be not only effective, but its effect is also long-lasting (Supovitz, Mayer, & Kahle, 2000). In training of trainers, the output envisaged was that each participant would prepare a working paper to conduct a professional development program within their respective workplaces, schools or districts. The working paper incorporates, among others, the rationale for professional development, the topics to be covered, proposed training schedule, facilitator(s) involved, proposed dates and venue, resources to be provided, and estimated budget.

Methodology

Research Design

This study employed a triangulation mixed-methods research design (Creswell, 2005; 2009), in which both quantitative and qualitative data were collected at about the same time and given equal emphasis, combining the strengths of each form of data and using the results of analyses simultaneously to understand and to establish the impact of the In-Service Professional Development Course on Acehnese science teachers' perceived pedagogical knowledge and skills. Such a triangulation of quantitative and qualitative data would provide a fuller and deeper understanding of the phenomenon at hand (Bogdan & Biklen, 2003; Denzin & Lincoln, 2000). Specifically, in view of the exploratory nature of this research to determine the impact of the In-Service Professional Development Course, the "one-group pretest-posttest design" (Gay & Airasian, 2009, p.389) was deemed appropriate. This design involved a single group that was pretested, exposed to a treatment, and posttested. Additionally, qualitative responses in terms of written responses were gathered so as to illuminate what participants say they have learnt. Figure 1 depicts the triangulation mixed-methods research design used in this study.



Legend: + = concurrent or simultaneous

Figure 1. Depiction of triangulation mixed-methods research design

Sampling

The participants of this course comprised 26 science teachers from Aceh. While the selection was done by the Aceh Institute of Human Resources Development (AIHRD), it could, however, be safely inferred from the geographical areas of the participants indicated in the list that the sampling technique employed was a stratified purposive sampling. It was stratified given that the science teachers selected were drawn from different parts of Aceh, including north, south, east, west, east-west, south-east of Aceh, and that the participants have generally not attended any intensive, more than two-week long of in-service professional development.

Instrumentation

A 26-item pretest (and posttest) instrument was developed for this Aceh In-Service Professional Development Course. The instrument was essentially a full list of 26 topics which were covered in the professional development course and it measured participants' self-perceived level of knowledge and skills using Liker-type responses: 1 = Low; 2 = Below Average; 3 = Average; 4 = Above Average; 5 = High. This instrument has sufficient content validity in that every single item subsumes within the content coverage of the Aceh In-Service Professional Development Course (Sireci, 1998). Using the dataset of 26 participants, the Cronbach's alpha for the instrument was measured at 0.96, suggesting that the instrument has high internal reliability (Nunnally, 1978). While the pretest and posttest were basically the same instrument, there were four additional questions eliciting free responses from the participants in the posttest. The first question asked participants to list three science teaching strategies which they will try to enact in their classrooms upon returning to their respective workplaces. The second question sought to capture their experiences while undergoing the four-week professional development course. The third question required a metacognitive thinking from the participants, reflecting on what knowledge and skills that they had learnt which they did not know or did not fully understand prior to the course. Finally, the fourth question asked for suggestions for improvement, if any, for the course and/or any particular facilitator(s) should the course be conducted again in the near future for other cohorts of Acehnese science teachers.

Data Gathering and Analysis Procedures

At the beginning and at the end of the course, a similar evaluation questionnaire was administered to the participants as pre- and posttest respectively, so as to obtain feedback on their perceived level of pedagogical knowledge and skills before training and after training on each of the 26 topics incorporated in the course using a five-point Likert Scale. However, for the posttest only, additional 4 questions were posed to get participants' self-reported views on the pedagogical knowledge and skills acquired, and also on other matters meant for course/facilitator improvement. The pretest-posttest differences were analysed using a paired-samples t-test, while the qualitative data were analysed recursively to uncover emerging themes (Patton, 2002).

Results

Table 1 shows the means of self-perceived level of a group of 26 participants' on each of the 26 main topics "before training" (pretest) and "after training" (posttest), and the results of the analysis using a dependent samples t-test. Based on Table 1, it was heartening to note that the participants had indicated that their knowledge and skills had statistically

significantly increased ($p < .001$) across all the topics as the results of the four-week In-Service Professional Development Course on "Research-Based Science Teaching Strategies".

Table 1. Results obtained from t-test for paired samples

No	Topic	Pre-Training Mean	Post-Training Mean	*t*	*p*
1	Personal Philosophy	2.15	4.35	12.49	.000*
2	Current trends & issues in science education	1.88	4.12	13.95	.000*
3	The nature of science	1.69	4.19	12.38	.000*
4	Johnson's Conceptual Approach	1.73	4.04	10.83	.000*
5	Kagan's Structural Approach	1.62	4.08	13.87	.000*
6	Curricular Approach.	1.85	4.04	11.40	.000*
7	Multiple Intelligences (MI)	1.81	4.31	12.88	.000*
8	Constructivism in science	2.35	4.46	10.86	.000*
9	Needham 5-Phase Approach	1.73	4.54	15.99	.000*
10	Generative Teaching Model	2.23	4.27	9.05	.000*
11	Role Play and Simulation	2.35	4.31	10.01	.000*
12	5-E Learning Cycle	1.88	4.15	9.76	.000*
13	Science Process Skills	2.04	4.15	9.44	.000*
14	Inquiry learning	2.50	4.42	8.69	.000*
15	Problem solving in science & technology	2.27	4.23	9.29	.000*
16	Predict-Observe-Explain (POE)	1.88	4.31	15.28	.000*
17	Concept Map	2.08	4.19	10.08	.000*
18	Concept cartoon	2.08	4.35	10.05	.000*
19	Problem-based learning	2.23	4.31	11.33	.000*
20	Teaching thinking	2.04	4.23	10.56	.000*
21	Questioning techniques	2.00	4.31	12.68	.000*
22	Facilitation techniques	1.81	3.92	11.33	.000*
23	Technology-enhanced project-based learning	1.81	4.12	10.16	.000*
24	Action research	2.15	3.92	9.93	.000*
25	The use of ICT in science teaching	2.12	4.15	11.35	.000*
26	Training of trainers	1.92	3.77	9.73	.000*

* Significant at $p < .001$

The self-rating results are further triangulated by participants' written responses when asked to provide additional comments on the course. Two resounding themes emerged from the qualitative data analysis of participants' responses, namely the pedagogical knowledge gained/acquired, and the applicability of the knowledge gained.

Theme 1: Pedagogical knowledge gained

The participants indicated the course/training materials were indeed beneficial in terms of pedagogical knowledge gained. While some of the pedagogical knowledge gained was relatively new and contemporary, others were gained in a restructured manner where previous misconceptions of certain theories and teaching methods have been better

perceived in pedagogical sense in light of such training as evidentially supported by the following excerpts from the participants' written comments:-

> *The teaching strategies which I have learnt in this course are extremely beneficial. In the past, I did not know how to implement these strategies in my classroom teaching.*
>
> (P1)

> *Through this course, I got the experience of how to use these teaching models.*
>
> (P4)

> *My pedagogical knowledge on how to use science teaching strategies has increased tremendously.*
>
> (P5)

> *After going through this course, I come to the realisation that before attending this course, I actually did not know about so many teaching strategies and that those teaching strategies that I knew before the course were in fact very vague or misunderstood.*
>
> *(P6)*

> *I have now discovered some teaching strategies, models of learning, and learning techniques which are so variative (sic) and innovative.*
>
> (P7)

> *There were so many teaching strategies which I misunderstood in the past.*
>
> (P8)

> *So many experiences which I gained from this training, such as knowing how to implement so many teaching strategies and also improving my English language. ... Earlier, I didn't know about problem-based learning and POE (Predict-Observe-Explain). After undergoing this training, my knowledge has increased so much and I now know how to use so many methods of teaching.*
>
> (P10)

> *After undergoing this course, I now have a solid grasp of how to use concept map, concept cartoon, POE and so many other teaching strategies which I had never received in any previous training in Aceh.*
>
> (P17)

> *I have gained so many experiences in using models of teaching which I previously didn't know anything about [these models of teaching].*
>
> (P22)

> *Through this training ... I have gained so much knowledge, understanding, and competency to employ these teaching strategies and approaches, which are good and effective and will make learning more joyful and meaningful.*
>
> (P23)

Theme 2: Classroom applicability of the knowledge gained

The second theme that emerged from the analysis of participants' written comments through a recursive process was the classroom applicability of the pedagogical knowledge gained. Specifically, the participants noted that they were able to apply/integrate the pedagogical knowledge and skills acquired in their respective classrooms or educational contexts in Aceh. They attributed such classroom applicability to the way in which the training was conducted. Instead of a didactic, lecture, and facilitator-centred mode, the training was conducted in a constructivist and simulative manner where a particular teaching method was espoused in a simulative way in which the participants acted as students while the facilitator played the role of a classroom teacher. Such simulative training instead of facilitator-centred lecturer has also contributed to better retention of the pedagogical methods acquired, and more importantly, the feasibility to practise in their classrooms upon returning to their respective schools in Aceh. The following quotes from participants' comments, when cohere together, seem to support such contention.

> *There were so many new things which I can take away from this course, and among them are various teaching strategies which prior to the training, I only know them theoretically. But now, through this course, the facilitators directly simulated the teaching strategies and such an approach really sticks on to my brain forever and I can use these strategies in my class.*
>
> (P15)

> *I have gained so much knowledge and experience especially in how to incorporate teaching models. Before this training, I came to know about these teaching models but only in theory; however, through this training, I have the opportunity to actually practise them.*
>
> *(P19)*

> *My knowledge and skills have increased especially in using the methods of teaching upon returning to my school after this training.*
>
> *(P20)*

> *From this training, I have gained new vision on how an effective science teaching strategy could be implemented in my classroom using the available infrastructure, particularly the ICT.*
>
> (P23)

> *I can now use the various teaching strategies and also cooperative learning models such as Jigsaw, STAD, Mix-and-Match which can really help me to teach effectively in school.*
>
> (P25)

Conclusion, reflection and recommendations

The findings of this study indicated that the Acehnese science teachers perceived that their pedagogical knowledge and skills in each of the 26 topics have been elevated as the outcome of the four-week In-Service Professional Development Course, evident in the differences of

pretest and posttest scores across the board which were all statistically significant. The significant gains observed were further supported by the participants' self-written responses which, when qualitatively analysed, gave rise to two major themes, namely "pedagogical knowledge gained" and the "applicability of the pedagogical knowledge gained".

This course was co-facilitated by six lecturers from the Sultan Idris Education University over four-week duration. Even though the schedule was tight and that the participants had to make sense of a number of research-based science teaching strategies within a limited time frame, there was no sign of boredom among the participants. This could be attributed to the employment of simulative and participants-centred hands-on, minds-on, hearts-on, and reality-on activities in the training where the underlying pedagogical principles were illuminated at the plenary after the participants have had their hands-on and minds-on tasks.

This group of 26 science teachers showed great enthusiasm and interest in the course, which was evident in their notes taking, discussion, and involvement in all the class activities. This was made possible because, as commented by many participants, the Malay language was used as the medium of instruction. It was felt that the pedagogical messages could be conveyed more easily in the Malay language rather than the English language because the participants, generally, were less proficient in the latter. Although there was some confusion in the use of language (e.g., eliciting children's pre-instructional ideas in which "mencungkil" was an appropriate translation for eliciting in the Malaysian context, the Acehnese teachers wittingly clarified that it was more appropriate to use "menggali" which, in Malaysian context, invokes digging task), the confusion had in fact triggered amusement which ultimately sustained participants' attention and facilitated further on-task discussion.

While the participants echoed that they have mastered the pedagogical knowledge and skills through the simulation and also from the planning of lesson ideas using the teaching strategies which they have acquired, such effectiveness has yet to be supported by actual trialling in the classroom. Therefore, it is recommended that in future training, an actual Aceh classroom trialling should be incorporated so as to provide teachers with evidential proof for classroom effectiveness and being mindful of the time constraint, the trialling could be done in pairs or in groups of 3-4 teachers and enacting only a preferred research-based science teaching strategy. Alternatively, participants upon returning to their respective schools, have to plan, execute (teach), reflect, re-plan, and re-teach certain science concepts using a particular teaching model such as one of the cooperative learning models like Jigsaw-II, Student Teams-Achievement Divisions (STAD), or Teams-Games-Tournaments (TGT). It would be equally beneficial if the lesson is recorded to create a pool of teaching resources which could subsequently be made available to other science teachers in Aceh for vicarious learning. Apart from creating a pool of teaching resources, such planning and teaching would ensure that the participants have sufficient time to assimilate or/and accommodate the theoretical and practical bases of the particular teaching model acquired in the training. This in turn will also provide the participants with a good grasp of the cooperative learning model. Such skill and knowledge acquired will prepare them to be better science teachers who have the cascading multiplier effect when they conduct in-service training in their respective schools or educational contexts.

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APPENDIX

Aceh Professional Development Course Outline

COURSE SYNOPSIS

This course aims to enhance the pedagogical content knowledge of science teachers in light of the recent development in theory, research and practice in the teaching and learning of science. Accordingly, through this course, teachers are familiarised with the research-based and research-validated science teaching approaches that are aligned with the current learning theories and technological advances.

COURSE OBJECTIVES

At the end of this course, the course participants should be able to:

1. discuss intelligibly the various effective and research-based science teaching strategies;
2. plan, assess, and implement effective, research-based science teaching; and
3. adopt changes and innovations in the teaching and learning of science so that they become effective science teachers.

COURSE CONTENT

This course emphasises a good grounding of theory, research and classroom practice in the teaching and learning of science. Hence, emphases are given to hands-on, minds-on and hearts-on activities that help participants make sense of the effective and research-based strategies in the teaching and learning of science, and subsequently, to cascade the pedagogical knowledge and skills gained to other science teachers in Aceh.

The major areas include:

- Current trends and issues in science education
- Cooperative learning in science
- Constructivism in science
- Inculcation of science process skills
- Inquiry learning
- Problem solving in science and technology
- Problem-Based Learning
- Critical and creative thinking in science
- Integrating ICT in science teaching
- Role play and simulations in science teaching
- Assessment in science
- Action research in the classroom
- Training the Trainers
