

Modeling of Science Teacher Professional Development

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Abstract

Educators, policy makers, parents and others are concerned with student attainment, which is in part linked to the initial competencies of teachers and their ongoing professional development. This research paper was set out to critically present the key aspects of science teacher professional development, such as teaching excellence, the advancement of learning, critical thinking and meticulous and thoughtful assessment of students. In particular, the research paper envisions a way forward to present the best science-training model that develops teacher competencies and effectively prepares students for the 21st century. The methodology included a mixed method approach using the TPD questionnaire with close and open-ended items with 283 science teachers. The study employed an analytical literature review along with the use of questionnaire technique. Major results indicated examples of effective science teacher professional development. Finally, it presents a Science Teacher Professional Development (STPD) model that is based on the educational and socio-cultural contexts that allows for teacher growth, and consequently, positively influence student learning.

Keywords: Professional development, science education, model of professional development.

I. Introduction

Free, publicly provided education has been a central tenet of the social contract in every country in the Middle East and North Africa since independence. Post-independence governments have significantly expanded their education systems, driven by rapidly expanding youth populations, and the need to build nationhood and to establish political legitimacy and popular support for new regimes through making education a fundamental right of citizenship [1]. It is well known that population growth in Arab countries is among the highest in the world, which makes providing basic education a major challenge [2]. Teacher identity is also important in recognizing teacher realization of strengths and weaknesses which may encourage intrinsic motivation in teachers to seek PD. Seeking PD is also dependent upon how teachers view themselves and the environments in which they work [1]. Although much research focuses on the development of teacher identity in beginning teachers as they combine their past and their expectations into their professional lives, teacher identity is never linked to professional development. However, education systems in many developing countries, with a few exceptions, now provide basic education to most children [3].

In particular, this study presents key aspects of the STPD and how effective and sustainable are they. Additionally, it suggests a model for the best STPD that advances traditional ways of providing teacher training and further incorporates new approaches appropriate to developing countries. The authors' own experience in planning and providing many science professional development activities are included. Data drawn from the questionnaire that developed specifically to elicit teachers' and administrators' perceptions regarding PD. The questions worth pursuing in relation to STPD are as follows:

- What can be considered as effective examples of science teacher professional development (STPD)?
- What are some examples of recent professional development sessions that you've attended?
- Who initiates plans for professional development activities?
- What types of professional develop you need in your area of teaching?
- What aspects of professional development do science teachers feel assist them in their practice?
- What is your most preferred professional development delivery style?

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- What are the challenges that are encountered in STPD?
- To what extent do teachers have the opportunity to be professionally developed, with or without governmental support?

Exemplary models of professional development, e.g., organizational partnership models and small or individual models [5], [6], which will be used as a frame of reference to compare examples of science professional development. In relation to the content of professional development based on these models, two dimensions are used: (1) personal, social and professional; and (2) a continuum from transitive to transformative. Teachers' personal interest in advancing their abilities, coupled by the cooperative, social and professional needs are found to be key sustaining and transforming the content of professional development. Additionally, this paper envisions a third dimension, the instructional continuum from expository to independent [7]. Therefore, this research paper aims to describe examples of STPD using blended research methods and employing an analytical literature review along with the use of questionnaires and interview techniques. It also aims to provide a STPD model that is appropriate for developing countries. Science literacy, standard-based education, guided-inquiry instruction, effective assessment and other important new directions have been the focus all over the world for several years now (such as in the US, UK, Canada, Australia, and Singapore). These directions provide substantive frameworks for curriculum development and policy making to better educate children to be future citizens. In order to meet the challenge of instituting and implementing such new science frameworks, teachers are expected to keep up-to-date with the advancements in science and technology and to continue transforming themselves from technicians to professionals. They will move from merely delivering textbook knowledge to students, to intellectual professionals who are capable of facilitating student active learning and making decisions on curricular, instructional, and assessment issues to effectively impact their students. To help teachers grow professionally in this new context, there is a pressing need for developing and instituting a new model for professional development that can foster the growth of teachers from technicians to professionals [8].

Teacher shortages have become a global concern. Similarly, there has been an acute shortage of Emirati male teachers in schools in general, but especially in the public sector, as the Knowledge and Human Development Authority [9] revealed that although 90% of female teachers in Dubai's girls public schools are Emirati, only 4% of male teachers in the boys schools are Emirati. This is a major concern as Dubai is the second largest Emirate. There is such a heavy reliance on expatriate teachers which may create, on one hand, a major concern with regard to educational reform and 'Emiratization' of jobs. On the other hand, this situation of the lack of Emirati male teachers, especially for boys' schools, raises the need for professional development of teachers to help familiarize them with the UAE educational system and further assist them to implement the new curricula. Science, mathematics, and English are regarded to be of paramount interest in the reform agenda of the UAE. While there has been a growing debate on striking a balance among school subjects, especially Islamic and Arabic studies, the emphasis is still on English, science, and mathematics. This is unique to the country and differs from global reform which still has major emphasis only on reading, writing and maths (e.g. No Child Left Behind, USA). In particular, several ambitious initiatives were launched to improve students' science attainment. Yet, teachers are still the cornerstone for any improvement that may be foreseen for students.

Education is a profession that is based on systems, philosophies, and standards for instruction which are all reflected within teacher professionalism. Initial teacher qualifications can potentially have a significant effect on the quality and impact of the educational system. More importantly teachers should continuously be developed to be presented with up-to-date strategies and the new pedagogical content knowledge in order to positively impact students' learning experiences. The government is continuously attempting to improve public education, which is considered to be lagging behind private education, by building new schools, institutes, colleges and universities in all the seven emirates in the country. It is also investing in teacher preparation and qualification, teaching quality, staffing salary, and the upgrading of technology.

I. Background

A. Science Teacher Professional Development

Professional development, in a broad sense, refers to the development of a person in his or her professional role. More specifically, teacher development is the professional growth a teacher achieves as a result of gaining increased experience and examining his or her teaching systematically [10]. Extensive research is conducted on in-service teacher professional development [2], [11], [12]. A key aspect for teacher growth is to conduct the professional development by using models that call for learner-centred approaches. In a longitudinal study by [13], series of curriculum units were developed to constitute the entire science curriculum for grades 3-5 which replaced the district-adopted curriculum in the six participating schools in the US to support (a) teacher knowledge of science content, (b) teaching practices to promote scientific understanding, (c) teaching practices to promote scientific inquiry, and (d) teaching practices to support English language development.

Teachers tend to practice their craft as well as learn about their profession in isolation from their colleagues [8]. Traditionally, teachers plan and teach their students in individual classrooms with the doors closed and without the involvement of others. “Historically, schools have been structured so that teachers work alone, are rarely given time together to plan lessons, share instructional practices, assess students, design curriculum, or help make administrative decisions [12]. Teachers may still need to set in the collaborative direction and this may ultimately need to be the culture of the school. Changing the culture of a school is not an easy task, though, especially if the existing school culture and structures favour privacy and isolation [1]. Isolation reduces the quality of the individual classroom teacher. One of the problems with working in isolation is that an individual teacher is not exposed to different ways of teaching and school dealings. In this regard, the teacher may begin to believe that his or her way of teaching and assessment is the only way or the best way of doing things [13]. Another potential problem is that a teacher does not get to share the successes and struggles of his or her own experiences or learn from the experiences of the other teachers in the school. Therefore, such a problem is determined by the level of collaboration and the type of school system.

Most development relates to an aspect that can be done only by and for oneself. Therefore, it can be said that in order to develop professionally, teachers should feel a continuous desire to learn more about themselves as professionals and about their profession. According to Soleimani and Khaliliyan (p. 363) “Self-directed professional development is defined as the professional development arising from the teachers’ own initiative, i.e. the process is internally determined and initiated.” Self-directed professional development has several advantages, such as allowing teachers to determine their own goals for professional development, the types of activities presented, strategies followed and timing and scheduling that best fit their interest and preference. Such PD opportunities are rare though, due to many inhibiting factors, such as school systems, workload, leave issues, and limited PD offerings. However, the benefits exceed the challenges when teachers develop their cognitive ability and metacognitive awareness as they focus on developing their own areas of shortcoming and become reflective practitioners. Self-directed learning is based on attitudes that encourage teachers to explore their own context and construct their own knowledge and understanding of what takes place in their classroom.

The major problem that professional development has encountered is that it is usually developed as an isolated requirement, with no real connection to daily teaching and with almost no teacher input [15]. For US teachers, the new teacher evaluations and accountability procedures mean that teachers must demand high quality professional development – development that helps mentor, nurture and enhance their professional repertoire. The reasons for professional development, however, vary in degree and kind. There is no clear accountability requirement except the hiring and firing process, based on contracts that lessen any motivation to seek professional development. Other obstacles as reported by teachers’ questionnaire responses are: 1) heavy workload which does not leave room for professional development, 2) disconnected professional development activities, 3) a lack of embedded practices of the professional development, and 4) an absence of differentiated professional development experiences, as they are largely planned for all teachers, beginners and veteran, with the same objectives.

II. METHODOLOGY & DATA ANALYSIS

The questionnaire was developed by [17] to measure participating teachers’ perceptions regarding professional development issues. Several sources were incorporated Teaching and Learning International Survey TALIS and TIMSS. The Teacher Professional Development Questionnaire (TPDQ) consisted of 20 Five-Likert scale items and 5 open-ended questions written in English language for familiarity of teachers with English language. The Questionnaire was piloted with 26 science teachers, not included in the study sample, to test for reliability [16], which was found to be high, 0.85. The validity was also checked using a panel of five teachers who pursue master degree studies. The results of the questionnaire revealed several interesting perceptions that are considered a direct reflection on science teachers’ experiences and challenges regarding professional development and the map of the reality of the hopeful model that is developed in this study to better suit the needs of science teacher PD. First, the demographics of participating teachers are presented. A total of 283 UAE representative science teachers responded to the online TPDQ during its two rounds of call. Ninety-eight participants were male (35%) while 185 were female (65%), including 19% elementary (cycle 1), 46% middle (cycle 2) and 35% high school teachers from the total respondents. The majority of participants, that is, 58% of participants, were from governmental schools, while 42% were from private schools. Twelve nationalities were recorded, including Emirati, Indian, Egyptian, Jordanian, Syrian, Algerian, British, and Pakistani. The years of experience indicated by the majority of the participants were in the range of six to ten years; some had more years of experience and a few had less than four years of teaching experience. The second largest experience group was for those with more than 15 years of teaching experience.

As for their ages, half of the participants fell between two age groups, 31-40 and 41-50. Equally, a small number of their ages fell beyond these ranges. The reported degrees held by participating teachers included bachelors (67%), masters (21), and higher diplomas (19%) with different majors ranging from general science, biology, physics, chemistry, earth science, and others. General science and biology comprised the majority of teacher majors, 36% and 29% respectively [13].

Table 1 below presents a summary of the participating teachers' responses in the main items of the questionnaire. The majority is calculated by the higher mean of total strongly agree and agree or strongly disagree and disagree which is found to be appropriate for this study being first in the UAE. The neutral/do not know percentage is dis-regarded (subtracted) of calculation of each questionnaire item.

Not surprisingly that the majority of teachers (60%) indicated that there is an acute shortage of professional development opportunities presented to them. Despite that, most participating teachers indicated the importance of professional development in improving their content and abilities to maximize student learning. Overwhelmingly, teachers (96%) indicated the importance of professional development opportunities that offered to them by the schools and the ministry of education in advancing student learning. However, only 25% of participating teachers take advantage of such limited opportunities. This explains why teachers have indicated, in the interviews, several obstacles to having and attending PD activities, such as the heavy workload and long school days. In addition, in another questionnaire item, only a small number of participating teachers (19%) stated that their schools have a professional library that can assist in their development and teaching quality; in spite of the fact that half of the participating teachers have regular and equal access to professional development programmes, forms, publications, etc. Such access was further explained, in the interviews, by the teachers' personal means such as the internet, and affiliate universities at which they are pursuing their higher degrees. While schools generally determine the professional development that teachers may have, the majority of teachers do not indicate any notable discussion of professional development that is going on in their schools (5%). Only 10% of the teachers indicated that they can get release if they apply for their own professional development activities that they mostly pay for themselves, and that the schools only grant them time release to attend, without financial support. This is a challenging issue facing teachers in the UAE, that there are limited opportunities and that there is a lack of support from authorities on professional development. Male teachers in the government schools are the most affected by this lack of professional development, as they may need it the most, due to the fact that they tend to be expatriate teachers who are usually get hired from neighbouring countries with different educational systems. Most participating teachers (65%) preferred PD activities in multiple subject areas such as science content, teaching strategies, assessment, motivation and classroom management. They did not entertain taking professional development in only one area, e.g. content or strategies, as they preferred to take the PD in multiple areas collectively. This view relates to what the research suggests that teachers prefer comprehensive PD [2]. Along the same lines, teachers overwhelmingly seemed to confuse their participation in developing curriculum and designing committees and see them as professional development.

Over half of the participating teachers (57%) attested that their schools include both short-term and long-term goals of professional development in their annual plans. However, a large percentage indicated that their school links short-term goals for PD in their planning. This result can be explained by the fact that with the limited PD opportunities, schools connect such PD opportunities to only short-term goals usually related to teacher evaluation or classroom-linked immediate issues, e.g. upgrading the content or use of technology for certain teachers for particular problematic grades. Such PD activities are viewed by teachers, in the interviews, as a way to retain their jobs rather than to satisfy their interests and needs for appropriate PD. Also, there is a need for long-term goals for PD as supported by research [2], [13]. It is clear that both short- and long-term goals are needed for the appropriate planning of professional development. Expectedly, most respondents (92%) see their professional development to be through training and workshops provided by experts, while engaging in developing curriculum and designing programmes were seen as types of professional development. Despite presenting these invariant results, the majority of participating teachers (90%) still attest to the need for more professional development. Finally, some teachers reported that they have master degrees (21%) yet more teachers see this as a direction that they independently would like to follow to upgrade their professional growth.

Table 1. Teachers' Responses Of The Science Pd

#	Item	Response Rate %
1.	There are enough opportunities offered to me by school or the Ministry to have professional development	40%
2.	I participate in the professional development provided to me	25%
3.	Professional development activities should be related to need of teachers in maximizing student learning	83%
4.	We have a professional library, in the school or accessible to us, stacked with professional books, magazines, video& audio tapes	19%
5.	Teachers can get release by the school/zone to attend if we submit proposals for individual professional growth	10%
6.	Our staff has ongoing discussion groups on professional development issues	5%
7.	Teachers have regular and equal access to professional development programmes, forms, publications, etc.	50%
8.	Our professional development approach has both long-range and short-term goals tied to our school improvement plan	57%
9.	Our professional development approach has only short-term goals tied to our school improvement plan.	67%
10.	Our school/zone has an annual plan that includes teacher professional development	41%
11.	The professional development activities I had focused only on content	24%
12.	The professional development activities I had focused only on teaching strategies	25%
13.	The professional development activities I had focused on content and teaching strategies, assessment, classroom management, &resources	65%
14.	Our school/zone establishes regular meetings and annual training for new members	56%
15.	I see my professional development through engaging in developing curriculum and designing programmes	61%
16.	I see my professional development through training and workshops provided by experts	92%
17.	Teachers and administrators set yearly professional development goals.	57%
18.	I model continuous upgrading of my own professional development and leadership skills.	38%
19.	I pursue a higher education degree to assist me to professionally develop myself	21%
20.	Would like to undertake more professional development activities	90%

A. Qualitative Responses

The open-ended section of the TPDQ included three questions regarding professional development expectations:

What are some of your expectations in getting professional development activities?

How do you relate such expectations to your teaching subject area and students?

Can you add any additional comments regarding your understanding of teacher professional development?

The responses to the open questions at end of the questionnaire were transcribed, prepared and analyzed (Ryen, 2002) to highlight the following main results:

- 1- Many expectations were stated for effective professional development, however the most common one were, e.g., improving science content knowledge, teaching strategies, assessment techniques, classroom management, critical thinking, ICT utility.
- 2- The PD on classroom practices, and not the theoretical ones, sought to be the appropriate PD activities. Therefore, a strong need for exemplary lessons and synopsis of activities of science instruction is indicated.
- 3- Physical science is found as one of the major areas of need for the PD.
- 4- Many believe that the content of the staff development programs will increase student learning and that any professional development should ultimately influence student attainment.
- 5- Participants indicated need to be involved in planning and deciding on the professional development activities by determining the topics and content.
- 6- Science education experts or department leaders can be the PD facilitators to credibly provide the PD activities.
- 7- Need to share teacher best practices regarding guided-inquiry instruction with specific inquiry topics and examples.

- 8- Elementary, middle and high school science teachers are equally be provided with few opportunities for PD during the school year, with focus on content and instructional strategies.
- 9- Instructional supervisors provide on-going, one-on-one support during the year, especially for high school science teachers.
- 10- The interdisciplinary approach for such PD activities should be planned to include integration of sciences as well as science and other subject areas.
- 11- It is suggested by the participating teachers that first of all the financial difficulties of schools should be resolved and the physical conditions of schools should be improved in order to sustain school improvement and teachers' professional development.

III. DISCUSSION AND CONCLUSION

To discuss these responses in light of the paper's framework that the PD is necessary activities for teachers to improve content [18], instruction [4], assessment and varied and comprehensive workshops [2]. Such workshop opportunities are beneficial if science educators and senior department managers deliver them. An interesting response, however, that is different than what previous research has indicated is the 'financial difficulty' that permit teachers for taking PD workshops and training. As for the interviews, selected participants to further explain the study's results that shown in the following examples provided several responses:

- Mainly hands-on activities, discussion, and collaborative grouping, or a mixture of them are among the most preferred PD delivery styles. 'I mostly prefer several delivery styles, such as hands-on, collaborative, online or/and a mix of practical types, rather than theoretical.'
- Interviewees briefly described some of the best professional development sessions that they have had. They included: 'implementing AP curriculum which was rich in hands-on activities and lab applications.' 'CPD course in Learning Disability as it helped to understand the difficulties of the students and what can be done for them.' 'Having fun with your parachute was the best, because it incorporated many practical activities and provided me with innovative ideas to apply.' '...I attended many workshops, but one I remember the most was a workshop that gave tips on how to teach mitosis and meiosis divisions through play, games and kinesthetic movement. I'm using them in my classes since that day, and my students, boys and girls, adore them.'
- When participants were asked what are some reasons for you not to attend and take professional development, responses included; '...if the PD activities are irrelevant, impractical or do not meet my interest,' '...overloaded with work commitment, time constraint, and family commitment.'

Most of the interview responses above indicated the reasons for the successful PD activities as well as some challenges that may prevent science teachers from taking them. The best workshops are thought to be those which provide applicable ideas and real classroom situations, as supported by [11]. Particularly, they are the workshops that provide more strategies and techniques that the teacher can apply with the students.

B. The Science teacher professional growth (STPG) model

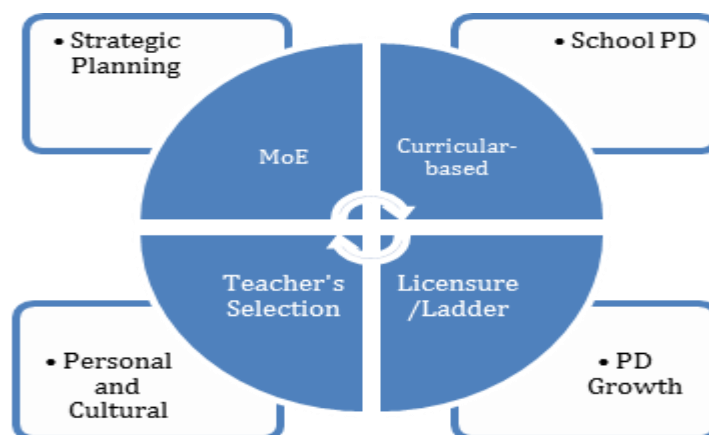
Based on the results of this study and the extensive review of the literature of science teacher PD, the model for science teacher professional growth is presented as effective, comprehensive, and student-centered model. In this regard, the following steps are suggested:

- Strategic planning for overall K-12 science education that rests on the scientific literacy, inquiry instruction, and moral education.
- Development and implementation of in-school professional development.
- Participation of research-based professional development.

Teachers need a wide variety of ongoing opportunities to improve their skills. The science teacher PD model rests on the specific instruction provided to teachers to promote their development in a certain area of science curriculum and leadership. Such a model can be used as a tool by which policymakers' visions for change are planned, disseminated and conveyed to teachers. Several layers, as presented in the figure below, encompass the Science Teacher Professional Growth Model (STPG model) to appropriately lead to teacher ongoing development that is measurable, sustainable, and meaningful. The STPG model (Figure 1 below), developed by [17], has three possible modes of planning and delivery: train-the-trainer, school-based, and self-directed. Train-the-trainer is more of standardized mode where a certain set of goals for professional development are chosen to be presented by experts in the area who will train/lead teachers or supervisors who in turn cascade the activities to other teachers. The school-based mode involves long-term goals set by the school as part of its continuous process of improvement (CPI).

The personal, cultural, and self-directed professional development component involves the sole individual teacher's initiatives on growth that is planned for short-term goals by the teacher through different avenues, such as ongoing workshops, follow-up, case studying, reflective practice, observations, assessment of the teacher as learner, and utility of methods and activities that are likely to lead teachers to improve their practice as professionals. These models echo the need the importance of teachers' personal, collaborative, growth needs in selecting the appropriate PD as presented the previous literature review. In our opinion these three modes should lead to an ultimate professional growth that is linked to several incentives, based on local needs, such as licensure, ladder upgrade, employment promotion, etc. This is important in the context as the hiring authority, the Ministry of Education (governmental schools) and private schools, are in control of teachers' employment and that by linking such PD to incentives, teachers can benefit the most, yet get rewarded on any choice of available PD opportunities. The proposed model takes into consideration the fact that there are limited PD activities teachers are allowed or asked to do. In conclusion, this shared responsibility can itself be the force and motivation for greater growth. The idea of growth is also unique in the sense that any activity taken by teachers ought to lead to their growth, and consequently impact their students' learning and growth.

Figure 1. Science Teacher Professional Growth Model (STPG) [17]



This paper sets out to critically present the key aspects of science teacher professional development (STPD), such as teaching excellence, advancing learning, critical thinking, and meticulous and thoughtful assessment of students. In particular the paper envisions a way forward to present the best science training model that develops teacher competencies, and effectively prepares students for the 21st century. Educators, policy makers, parents and others are concerned with student attainment which is directly linked to teacher initial competencies and their ongoing professional development. Indeed, sustained professional development for teachers is a central focus in improving the quality of teaching [4].

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