THE INFLUENCE OF AN IN-SERVICE TRAINING PROGRAMME ON LIBYAN BIOLOGY TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE (PCK)

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Science, Faculty of Education, School of Science and Mathematics at the University of the Western Cape

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Declaration

I hereby declare that: 'the influence of an in-service training programme on Libyan biology teachers' pedagogical content knowledge (PCK)' is my work, that it has not been submitted for any degree or examination in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

Tarek Abdalla **August 2020**

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"He who does not thank the people is not thankful to Allah."

Prophet Muhammad

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'Thank you is more than good manners. It's good spirituality.'

Alfred Palmer

Abstract

Libya, as one of the third world countries, is struggling to address the issue of transformation and various institutional reforms (**including the education system)**. For example, it has been observed that many biology teachers are faced with challenges relating to both subject matter knowledge (SMK) and pedagogical content knowledge (PCK) yet the expectation of the new curriculum is that biology teachers demonstrate professional efficacy in their work regardless of the challenges they face. In light of this, a group of Libyan secondary school biology teachers was investigated in Tripoli through a participatory action research process. The study was underpinned by the Shulman theory of PCK using a mixed-methods design to generate an understanding of the theory of basic knowledge of teaching. This investigation examined the influence of an in-service training programme consisting of three components of PCK namely: teachers' subject matter knowledge (SMK); use of instructional strategies; and understanding of learners on a group of Libyan biology teachers' instructional practices. On the one hand, the investigation considered their theoretical knowledge, and their experiences during the professional development programme aimed at designing new teaching and learning activities and materials while on the other hand, it considered their practical knowledge in terms of their professional skills or their practical use of what has been learned during their pre-service training as well as what they learned during the professional development programme. Specifically, the study focused on biology teachers from the Hai Alandalus District (Libya). This representation enabled me to unveil the PCK components held to some extent by the Libyan teachers in general. Moreover, the PCK representation has also enabled me to clarify the category of the teachers' PCK in the Libyan context especially as their PCK was unknown at the commencement of the study.

The findings have shown that the professional development used in the study facilitated the biology teachers' ability in several ways such as increased their PCK and SMK; improved their ability to organize activity-based lessons; increased their desire to use a variety of instructional strategies; increased the understanding of their learners' needs; improved their awareness that their learners' performance is not unrelated to their socio-economic background; and so on. Overall, the findings suggest that designing and implementing new teaching and learning activities and materials based on the teachers' knowledge, experiences, and needs, in a workshop context could provide an enabling learning environment for them as well as facilitate their potential to provide a powerful means for increasing their PCK, SMK and understanding their learners. The study also reveals that there is a great necessity for designers to mount professional development programmes that take

into consideration the teachers' PCK to meaningfully promote their professional development and instructional practices.

Keywords:

1. Pedagogical content knowledge (PCK).
2. subject matter knowledge (SMK).
3. Teachers' understanding of learners.
4. Instruction strategy.
5. Teaching-based on activities.
6. In-service biology teachers.
7. Teaching biology.
8. Professional development programme.
9. Libya context.
10. Participatory action research.

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List of Abbreviations

1.	**BSCS**	Biological Sciences Curriculum Study
2.	**CK**	Content knowledge
3.	**INSTP**	In-Service Training Trogramme
4.	**LTTC**	Libyan Teachers' Training Centre
5.	**ODDT**	Osmosis and Diffusion Diagnostic Test
6.	**PCK**	Pedagogical Content Knowledge
7.	**PD**	Professional Development
8.	**PK**	Pedagogical Knowledge
9.	**SMK**	Subject Matter Knowledge
10.	**UOT**	University Of Tripoli

Chapter 1: Context and Introduction of the study

1.0 A Point of Departure

At the outset, I wish to mention that I am passionately concerned about teaching and in particular the teaching of biology as a school subject. I have noticed that in Libya, my home country, the way biology as a school subject is addressed is experiencing difficult challenges in terms of students' poor performance in biology; the dominance of traditional talk-and-chalk instruction; poor assessment strategies; the stranglehold effect of examination on the education system; the prevalence of rote learning; inadequate teaching resources; inadequate professional training programmes for biology teachers; large classes; and others. In light of this, it is apposite for me to explore the educational and environmental concerns that necessitated this study. I hope that the discussion that follows will create a better awareness among the stakeholders about the state of biology education in Libya as well as create further research interest in the area.

One of the primary goals for teaching biology or any school subject is to enable students to gain knowledge from their daily life experiences. But even before doing this, it is necessary to first determine the biology teachers' Pedagogical Content Knowledge (PCK) especially considering the influence of teachers on their students' knowledge of any subject matter they teach. Otherwise, the students' understanding of biology would be a corruption of what they are expected to know. By knowledge, I mean the substantive and procedural knowledge of biology. The substantive knowledge deals with the well-established facts, concepts, and generalizations of a given subject matter namely, the hypotheses, laws, and theories while the procedural knowledge deals with the modalities, the protocols, and the methodologies used to establish such knowledge (Ogunniyi, 2006).

This chapter comprises the following sections: the background and rationale of the study, the context in which the study is conducted; in this case, Libya in terms of its history, geography, climate, education system, initial teacher training, continuing teacher development opportunities, challenges in teacher training and its curriculum reforms. The following sections present the research problem and the research questions, the significance of the study, the research methodology outline, and the study outline. Having provided my motivation to conduct this study, I shall now present the background and rationale of the study.

1.1 Background and rationale of the study

In 1998, the Libyan educational system was reformed to respond to one of the eight UN Millennium development goals proposed in 2000 to combat illiteracy and to achieve universal primary education by 2015. Although that goal is far from being accomplished particularly in Libya, great strides have been made not only to achieve universal primary education but to increase scientific and technological literacy in the whole society. In recognition of the critical role that teachers play in education, the Libyan government, through its Ministry of Education, established a National Teacher Training Centre (NTTC) in Tripoli to guide and supervise teachers' development in the country.

To ensure that the reform is complete and brings something new, the Ministry of Education adopted the Singaporean science and mathematics curriculum for use in Libyan schools. The adopted Singaporean curriculum is considered as the best curriculum due to its unique design based on active learning to motivate students in problem-solving and thinking development. Therefore, the Libyan Ministry of Education in its endeavor to improve Libyan students' capacity has preferred this curriculum that has been implemented and found adequate and efficient in many other countries over the world.

One obvious problem though is that the activities and tasks designed in this science curriculum were originally planned for Singaporean students in their natural environment without any serious attempt made to contextualize it to the Libyan environment. For instance, instructional materials that are commonplace in Singapore are not easy to come by in Libya. The implication of course, is that the success of the new curriculum would depend on the importation of equipment and that in the face of the current economic and political crisis in Libya.

According to educational regulations in Libya, the first nine years of schooling are compulsory. During the foundational phase, basic education includes the study of the Arabic language besides other local languages such as Tuareg, Toubou, and Berber. The first six years of schooling constitute the primary level and the remaining three years constitute middle school. Secondary school consists of grades 10, 11, and 12 and allows students to choose subjects among the sciences and arts that focus on their prospective professions. Apart from secondary schools, the education system also provides vocational training for children whose interest is to pursue technical careers. For example, 44 different types of programmes are available in the vocational field, which covers a vast range of subjects such as architecture, agriculture, and general science. There are thirteen universities in Libya that provide tertiary education in different fields.

Despite all the strides Libya has made in education, the same cannot be said regarding training for bringing about changes in the initial teacher training programmes. New curricula have been adopted, but no training courses or modules complementing the adopted curriculum have been provided. The lack of teaching resources has resulted in serious challenges facing the education system that has further been impacted by a lack of proper planning of education. This implies there is a big gap between the prospective teachers' training programme and the current curriculum. It also means that teachers would not be able to implement the adopted curriculum because they lack practical knowledge. Consequently, to improve teaching effectiveness and to enhance the implementation of the adopted curriculum, they need to be enriched with professional development training or workshops. Thus, given the new curriculum, I proposed conducting an in-service training workshop as one of the immediate solutions to the problem. Hence, in this study, I would like to assess the influence of such a workshop on Libyan secondary school biology teachers' PCK.

Most observers agree that competent teachers draw on specialized knowledge in their instructional work with students. Therefore, identifying, describing, and improving this experience is likely to enhance their professional development. In the same perspective, Shulman (1987) has identified one specific issue that distinguishes between teachers' subject matter knowledge and general pedagogical knowledge. This distinction has externalized teaching basic knowledge, including the PCK as the highest rank of basic knowledge. For instance, in the present context after having adopted the new science curriculum, the teacher training programmes have not been revised in Libya to implement teachers' ideas and practice to integrate their understanding of the content they are teaching with their knowledge of methodologies.

Shulman's (1986, 1987) seminal work on teachers' PCK or their professional knowledge identified and clearly distinguished between the teachers' knowledge of the subject matter and their general knowledge of pedagogy. In his opinion, PCK is a form of practical knowledge that is used by teachers to guide their movements in highly contextualized classroom settings. This type of practical knowledge requires their orientations and practice.

As stated earlier, teachers' PCK is critical to their professional growth, and ignoring it, is to produce teachers with a generalized knowledge in the fields of their professionalization where a deeper conceptual understanding is called for. For the same reason, this study construes biology teachers' PCK as a reference point for designing and conducting their professional development programmes. According to Schmelzing, van Driel, Jüttner, Brandenbusch, Sandmann, and Neuhaus (2013), "Teachers' PCK should be analyzed as one of the essential components to evaluate professional development programs" (p. 1369).

1.2 Context of the study

1.2.1 Geographical information

Libya is a North African country that is limited on the north by the Mediterranean Sea, on the east by Egypt, on the south-east by Sudan, on the south by Chad and Niger, and finally on the west by Algeria and Tunisia. Tripoli is the capital of Libya and is the largest city in the country in terms of landmass. It is followed by Benghazi which is another city located in the eastern part of the country. Libya is a multi-ethnic country. Even though other languages are used in the foundation phase, Arabic remains the official and the language of education all over the country.

At this junction, it is important to mention that approximately 97% of the Libyan population is Arab. Islam is the state religion. Libya is regarded as one of the driest countries in the world due to the desert climate prevailing over the major Southern part of the country. The overall rainfall quantity is generally very low. It has a Mediterranean Sea climate with rain during winter and sunny and drier weather during summer. The main source of revenue is the oil that contributes to approximately 95% of exports. This situation makes Libya dependent on oil revenues (Esterhuysen, 2013).

The local time equals +2 GMT. Libya is deemed to have two bodies that politically influence its existence: the Council of Deputies and the nonconformists. The Council of Deputies is considered to be the legitimate government, however, it does not hold sway over the whole country. While the nonconformists are seen as revolutionaries. Hence, this situation impacts on the education system. This means that the education system is polarized. Each region has its own Minister of education who is responsible for the formulation and implementation of education policies. This polarized education system affects negatively the education plan and the implementation of the decisions and educational policies. To illustrate, the minister of education in the Western part of Libya had reduced the number of biology lessons from 9 to 3 lessons per week, while the minister of the Eastern part did not reduce the number of lessons. For this reason, in the Western part of the country, biology teachers have to skip some lessons and units to be able to finish the syllabus based on the time allocated. However, in the Eastern part teachers, the teaching practices, the teachers' planning, the time table, and the biology curriculum were not affected.

Figure 1-1: Geographical Map of Libya in Africa

According to the latest United Nations estimates, Libya is the 4th largest country on the African continent with a current population estimated to 6,458,448 inhabitants (Congress, 2010). It has a total landmass of nearly 1,759,541 km^2.

Italy colonized Libya from 1911- 1942, and from 1942-1951 it was under the interim of the British military ruler. It became independent in 1951 after 40 years of European occupation (Clark, 2004). Since its independence in 1951, Libya has gone through various political changes. On December 24, 1951, it declared itself ***'The Kingdom of Libya'*** and opted for the hereditary regime under King Idris (Esterhuysen, 2013). It was governed by the monarchy until September 1st, 1969 when the king was dethroned by a military coup which was led by Muammar Al-Qaddafi.

In 1977, Al-Qaddafi and his military regime changed the official designation of the country from ***'The Kingdom of Libya'*** to the ***'Great Socialist People's Libyan Arab Jamahiriya.'*** He ruled the country for forty-two years until 2011. His reign ended due to the so-called "Arab spring" which was an uprising that took place in the country following other revolutionary movements that occurred in other Arabic counties of the region, more particularly in Tunisia and Egypt. The protests started in Benghazi, the second biggest city of the country (Libya), where protesters, mostly young people, called for an end to the Al-Qaddafi regime (Khaled, 2014). The movement spread to most Libyan cities. Following this protest, many people were inhumanely killed. This brought about civil unrest in the country, and since then, the UN has been trying to foster peaceful relations between Tobruk (the Eastern region) and Tripoli (The Western region). Thanks to political unrest, the education system was negatively affected.

1.2.2 The features of the teaching culture in Libya

Studies have widely documented how the educational process is affected by socio-cultural factors in any society (Canagarajah, 1996; Coleman, 1996; Shamim, 1996). Teachers and instructional staff operate within a sociocultural setting, and the standards of that particular environment influence their opinion regarding teaching science and having expectations. When teachers arrive at school, they bring with them diverse beliefs, an abundance of knowledge, and have expectations about what happens inside the classroom, how students think about the content, and what and how to teach.

Libyan students usually assume that their role in the classroom is to sit quietly and to record or memorize the information delivered by the teacher. It is considered impolite to argue with, or interrupt the teacher. Therefore, students are requested to be quiet most of the time to show respect for their teachers. If one has a question, he/she has to raise up a hand to get the teacher's permission to ask that question (Orafi, 2008). As to the classroom organization, students are seated at school desks, arranged in straight rows facing the teacher who stands at the front of the classroom. When required, they participate in classroom tasks and activities if they are allowed.

Teachers are often considered to be the source of knowledge when it comes to school curricula. Their main role is to transfer the knowledge they have acquired to their students. For example, it has been observed that when teaching biology, most biology teachers focus mainly on increasing students’ theoretical knowledge by memorizing concepts and content. Very often, practical activities are considered extra work.

These activities seem to be extra work for teachers because they have not been well prepared to conduct such activities. They need to be trained to do so. The rationale behind this training is on improving teachers’ knowledge of teaching biology. If they are well prepared with the awareness of the biology goals, they will be well placed to transfer the knowledge of biology to their students. This reflection comes from profound ideas in the culture of Libyan teachers about the processes of knowledge transmission. According to this culture, teachers are viewed as the only authority in the classroom who should not be questioned or interrupted at all. Therefore, this belief requires them to be well-informed because their inability to answer questions, for instance, would be understood as a blemish on them, or that they are not sure about the content and not well equipped to address its specific aspects.

The education process, as mentioned above, is influenced by the sociocultural factors that are widespread within this particular context. Based on this, to understand teachers' behavior and professional development, the socio-cultural factors should be considered as one of the important issues for this development. This means that the way teachers manage their classrooms is culturally driven. A child cannot talk in front of an adult if not given permission even if he/she has reason to. This cultural belief empowers teachers to maintain discipline in the classroom. Even though it stops students from disrupting activities, it can be mentioned that it also reduces teacher-student interaction considerably.

As indicated earlier, Libya is a highly traditional Islamic society, and many of the cultural standards that are common in society originate from the principles of Islam (Deeb & Deeb, 1982). In families, strong emphasis is placed on the importance of listening attentively to adults and respecting their opinions. Very often, children are not encouraged to participate in adults' discussions or conversations. Libyan culture emphasizes the value of saving face over maintaining a conversation to the extent that, even if one disagrees with someone's point of view, it is considered impolite to show such disagreement publicly. Also, within Libyan culture, there is always a gender-based segregation tendency.

Learning within Libyan society is traditionally observed as a set of truths not open to disagreement and discussion. Students are provided with textbooks about diverse school subjects and are expected to master and understand their content without questioning their credibility. Within the Libyan institutional culture, the Ministry of Education reported that education has a unique traditional character in teaching methods. On the one hand, it is interested in providing students with the knowledge, while on the other hand, it does not care much for reliable scientific thinking methods. Indeed, the assurance of information learning must be the core criterion for which the learner is given high scores. This is one of the difficulties of innovative thinking and preparing students to produce knowledge (The Libyan National Commission for Education, 2005).

The community habits, cultural and religious issues that are inherent in society play a significant role in defining what goes on in the classroom. As previously mentioned, Libya has thirteen universities, several technical schools, and a well developed secondary and primary education system. Moreover, most of the people residing in the country are either Arabs or influenced by Arab culture. As all Libyans are guaranteed the right to seek and provide education to different minority communities such as Greeks, Italians, and Maltese established schools in Libya, but these schools were further influenced by the established education system. The observed influence on the minority educational system established in Libya has affected what happens inside the teaching space and what types of behaviors are acceptable. On the basis of the findings of this study, the discussion chapter addresses these impacts in detail.

1.2.3 Characteristics of the teaching process in Libya

As indicated by Shakuna, Mohamad, and Ali (2016), the characteristics of teaching in Libya comprises both non-linguistic and contextual elements that affect the learning process. They are considered to be significantly the critical part of the learning process, which needs to be considered by teachers and professors engaged in the teaching profession. As mentioned earlier, in Libya, education is free for all citizens at primary and high school as well as for undergraduate university programmes. Consequently, classes are overcrowded with a large number of students ranging from 35-45 students per class (Elkaseh, 2015).

Secondary education, the central concern of this study, is divided into three broad streams, namely, Arts, Science, and Technology. The delivery of science education is made possible by specialized secondary schools that cater to subjects such as engineering, basic science along with the modern sciences, agricultural science, medical science, economics, social science, and others. Studies in these streams last for three years in high schools as well as in vocational centers (AM Elkaseh, Kok & Chun, 2015). After attending comprehensive high school, learners interested in pedagogy are further trained for four years in teacher training institutions. The attention is not only given to teacher education and the teaching process but also the teacher's beliefs and knowledge.

Hawedi (2015) indicated that research conducted on craft knowledge had implied the acknowledgment of the context-specific nature of teaching contribution to the empowerment of teachers to enhance the status of instruction taken up as a profession. Moreover, the concerned field of science education provides expectations for the development of understanding for the students engaged in the relevant subject. The educational activity in both secondary and elementary phases aims to introduce new enhanced formats that further make the learning and teaching methods to be simple for both teacher and students.

1.2.4 Teaching method

The success of any teaching practice is based on the teaching methodology used by the teacher. All teaching methods are useful to some degree, but they are not all adequate for every lesson. However, a good selection of teaching methods tends to enhance learning better than the mere transmission and delivery of the content (Hamurcu & Canbulat, 2019; Demirdöğen, 2016). A well-prepared teacher is likely to make the right choice of teaching methods that can help him/her address his/her students' needs and challenges. However, as early as the 1960s, Johnson and Seagull (1968) assert that teachers were too often educated by means of theoretical lectures, and in some environments like Libya, this is still the practice even today. Consequently, most teachers fail to use adequate techniques and procedures to conduct their teaching practice. In other words, teachers tend to teach in the way they were taught. This diminishes their array of maneuvers in the classroom when it comes to the practical selection of an adequate teaching process.

Grippin (1989), referring to the above-mentioned situation, argued that teachers need to receive regular reinforcement. This implies that teaching practice is about one doing in practice what he/she expects students to do rather than delivering information about innovative teaching practices and students' engagement through traditional 'ex-cathedra' methods, which discourage students' participation in the learning process, as well as any initiative on their part. In this case, designing teachers' INSTP (In-Service Training Programme) serves the purpose of equipping teachers with good teaching practices based on active teaching methods (Kalande, 2006).

Since the emergence of constructivist theories of learning, different new teaching approaches have come into the educational arena (Harasim & Harasim, 2018). Libya is one of the nations interested in these new instructional innovations. For the same reasons, students are being encouraged to participate more actively in classroom activities by contributing to classroom discourse and to reach collaborative consensus and decision making on assigned cognitive tasks (Kinnucan-Welsch & Jenlink, 1998; Terwel, 1999; Vermunt, 1998; Von Glasersfeld, 1988).

Students' active participation in the classroom as encouraged by the constructivist instructional approach is intended to motivate students to obtain new knowledge through individual discovery or in groups as well as use authentic materials under the assistance of their teachers. In other words, active teaching approaches motivate students to conceptualize knowledge by means of practical and relevant activities representing real-life problems that can be tackled individually or in groups. Constructivist teaching, therefore, strives to encourage students' active participation in the classroom to solve a given problem in an attempt to reach a specified goal (Jacobson & Mark, 1995; Meyers & Jones, 1993; Silberman, 1996; Tenenbaum, Naidu, Jegede, & Austin, 2001; Struyven, Dochy, & Janssens, 2010). Therefore, Libya, as one of the countries which care about quality education for all its citizens, has adopted a new science and mathematics curriculum that necessitates the training of teachers to plan and organize their upgrade in using effective teaching methods.

1.2.5 The education system in Libya

Although Libyan regulations fully support and finances the education system at all stages, the quality of instruction is still a significant concern, particularly for those qualifying in science and technology subjects regarded as the foundation of the development of the country (Alhmali, 2007). In order to gain a better understanding of the educational system, a brief history covering the period from 1551-1951 is added here. During this period, different political changes and regimes have greatly influenced the development of the Libyan education system. From the seventh to the twentieth century, this means that the Ottoman Turks followed by the Italian military forces and the British Mandate have left their mark on the Libyan education system (Congress, 2005). During the Ottoman rule from 1551-1911 education was oriented towards religion. The educational institutions were nearly self-containers of local communities based on the teaching of Qur'anic sciences, Arabic language, and Islamic principles (Obeidi, 2013).

During the period of Italian colonization (1911-1942), during the early years of Italian occupation, Libyan citizens fought against the education system and the policy of Italianisation (Obeidi, 2013). After the collapse of Italian rule in 1943, the French and British governed the country from 1945 - 1951. The education system followed the British-French administrations: for example in the Fezzan area; the French-Tunisian curriculum was used, whereas in Cyrenaica the Egyptian curriculum was adopted and the curriculum chosen in Tripoli was the one used in Palestine throughout the British Mandate. During 1945-1951, the British administration created vocational schools distinct from religious institutions.

Under the monarchy of King Idris (1951-1969), all Libyans were given a real opportunity to educate themselves. All levels of primary and secondary education were established throughout the kingdom, and old Qur'anic schools that had been closed were reopened

(Congress, 2005). The total school enrollment rose from 34,000 during the year of independence (1951), to approximately 150,000 in 1962 and 1,700,000 in 2010 (see Table 1.1 below). However, the education system has faced some difficulties such as the complexity of the curriculum and lack of well-trained teachers, especially science teachers (Congress, 2005).

Table 1-1*: Growth in Education in Libya*

Growth in Education in Libya		
Years	**Number of students**	**Literacy**
1951	**34000**	**population literacy < 20%**
1962	**150000**	**female literacy ~6%**
1977	**980000**	**51% male, 31% females**
1986	**1245000**	**literacy 54% male, 46% female**
2004	**1477000**	**literacy 92% male, 72% female**
2010	**1700000**	**overall literacy 89.2%**

(Source: (Alhmali, 2007)

The military coup in 1969 brought about several revolutionary changes at the political level as well as in the education system. All the names of ministries and administrations were removed, and principals and staff were replaced. For example, the Ministry of Education has renamed the General People's Committee for Education (GPCE), which is considered the highest executive power for education. It consisted of two levels: (1) the centre of the administration, where educational policies and plans were executed, and (2) the local administrative sub-divisions, which worked on the implementation of education policy discussed by administrators, inspectors of education, and supervisors.

Under the slogan *'Education For All'* Libyan law required citizens to register all children, male and female for basic education, which is compulsory up to Grade 9. There are five educational stages in Libya. The first stage is the kindergarten, where children aged 4-5 years old are enrolled for a maximum of two years. The second stage is the primary education phase, which consists of 6 years of primary school and 3 years of middle school. Students are awarded the Basic Education Certificate after successful completion of nine years of primary education (Congress, 2005).

Secondary education is the third stage and lasts for 3-4 years that cater to specialized high schools -chemistry, physics, biology, economics, art, media, engineering and social sciences, technical and occupational training centres and institutes- (Library of Congress – Federal Research Division, 2005). Students who pass the final examination are awarded the Secondary Education Certificate (Congress, 2010). The fourth stage is the higher education phase that consists of two main sections: university, that lasts 4 to 7 years, and higher vocational and technical learning that lasts 3 to 5 years (Rhema & Miliszewska, 2010). The fifth and final stage is the post-graduate studies, namely Masters (MA or MSc) degree, Ph.D. degree, and the higher diploma in several different areas of specialization (Khaled, 2014) see Figure 1.2.

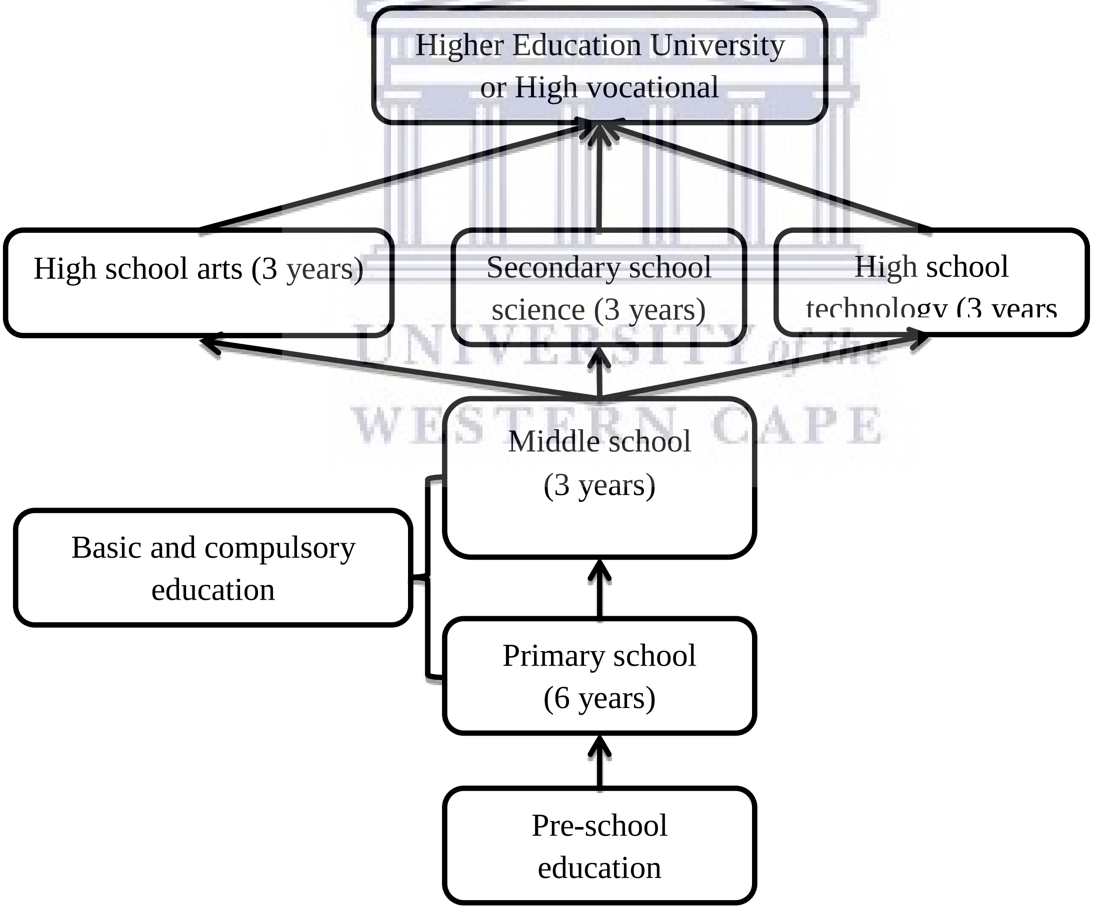


Figure 1-2: Education system in Libya

1.2.6 Factors contributing to teaching development in Libya

Libya is a country that promotes efforts to occupy a suitable standing in the international community. Therefore, the youth taking university courses ranks quite high. As indicated by Haneda and Alexander (2015), much emphasis is placed on the infrastructure of universities and schools so as to keep students focused on the curriculum activities. Moreover, different institutions are further established in partnerships, so that the concerned education boards can provide students and teachers with appropriate facilities enhanced with technologies of teaching and learning.

The development of technologies results in a proper structure and procedure to enrich students with relevant knowledge. Higher education is now made available in both vocational colleges and universities and only students who excel qualify for higher education. As the higher education system contains a variety of institutions, the development of teaching techniques is quite noticeable. The implementation of e-technologies is adopted to enhance the education system by utilizing the internet in every possible manner. Previously, the teaching methods that were used by biology teachers in their teaching practice were mainly based on the students' textbooks directives.

However, as mentioned by Daw, Shabash, El-Bouzedi, and Dau, (2016), the modern world and advanced technologies have influenced and raised the standard of teaching methods in Libya for all students. Therefore, at present, the method of teaching science does not only provide students with the theoretical sources, but it also shows the practical assumption and practices in the safely guarded science laboratories. In addition to the above, the focus of teachers lies in the very fact of providing their students with the relevant information related to the topics of Chemistry, Biology, Physics, Earth science, and other subjects they are teaching (Abbar, 2016).

It is also worth to mention that factors such as enrollment procedure, general objectives, and contents as well as efficient teaching staff tend to affect the entire education process in Libya. Teachers are considered the core of the school system, which provides institutions and universities with the opportunity for further professional development. They thus train and help them to develop pedagogical skills in their relevant field of study. Thus, the role of teachers is vital enough to enlighten and guide their students. However, Elferjani (2015) thinks that the development of teaching in Libya must be separated from regular training so as to set up a suitable education system that can be followed and implemented. Thus, with better teacher training and qualifications, professional development in the field of the entire teaching system is developed. These changes are further noted regarding the factors mentioned above. Therefore, the effectiveness of the changes influences the overall teaching process in Libya.

Moreover, the publication of scientific research is required to support the social development of developing nations, along with the economic factors influencing the same. The introduction of a training programme, especially in science education, will help to enhance the teaching system in a developing country such as Libya. The involvement of cultural and social aspects also must be taken into consideration when providing training of pedagogy, as science education itself demands practical application; the utilization of training would be more beneficial if operated with efficiency.

1.2.7 Curriculum adaptation and science teaching effectiveness in Libya

As stated earlier, almost two decades ago, the Libyan government, via its Ministry of Education, adopted for Libyan students the science and mathematics curriculum used in Singapore. This new curriculum was translated without prior and adequate changes related to local realities. Besides, it has been put directly to use in schools without prior training of teachers. It is worth to mention that the expectations of this new curriculum pose significant challenges to teachers and students alike. This implies that most of these expectations are not immediately reached. Teacher's competency in using the curriculum material is imperative in ensuring teaching effectiveness.

As indicated earlier, the Singaporean science curriculum is considered to be one of the most advanced and holistic curricula, where certain mental attitudes such as creativity, curiosity, integrity, open-mindedness, objectivity, responsibility, and perseverance are advocated (Long & Bae, 2018). When the Libyan educational authorities adopted this curriculum, they did not consider the differences in teachers based on their initial training, ability, and skills for the implementation of the curriculum. In Singapore, prospective teachers are normally trained on the basis of the curriculum they will be using. Meanwhile, teachers in Libya have not been trained on the basis of the curriculum they are currently using for teaching. Besides, as pointed earlier, the materials to be used in different practical activities are the ones that are related and easily found in the Singaporean environment. They are a little bit scarce to be found in the Libyan surroundings. This scenario certainly poses a challenging situation for most of the Libyan biology teachers.

Apart from professionalism in the curriculum implementation, it seems expedient for science teachers, and in particular biology teachers, to be able to "analyze, modify and enact curriculum materials in a principled, reform-based manner for effective science teaching" (Schwarz et al., 2008). This reform calls for a shift in teaching methodology from the teacher-based to student-centered approach and inquiry-based learning techniques. At this juncture, it is important to mention that Libyan science teachers (mathematics, biology, physics, and chemistry) were given notions of general didactics relying on theoretical teaching in forms of magistral lecturers during their pre-service training. These notions did not take into account practical activities. There were no specific efforts to enhance teachers teaching skills. This pre-service training programme and procedure were negatively impregnating the preparation of prospective teachers and were consequently impacting negatively on the adequate implementation of the curriculum.

To promote activity-based learning in science, teachers are encouraged to actively adapt the curriculum materials in order to facilitate student accessibility to the materials for learning effectiveness. This agrees with Beyer and Davis, (2009) who state that:

> … Curricular resources are typically designed for a broad audience and general context, limiting the ability of teachers to address specific learning goals and student needs. Therefore, teachers need to use materials in flexibly adaptive ways to meet their specific contextual needs and anchor their students' learning in productive ways (p. 518).

In this perspective, professional development programmes should be conceived to enhance teachers' knowledge and skills so as to adapt possible changes in their teaching practice. "The concept of change itself denotes a "disruption in the status quo" (Yarden, 2011, p. 81). Individuals possess a natural tendency to remain in a steady-state, so any changes that disrupt this status quo are viewed with caution and are only accepted if the perceived outcomes add value to the individuals (Hanley, Maringe & Ratcliffe, 2008).

Scholars have suggested that adequate professional development programmes need to engage the teachers' experience and awareness that can guide them to make decisions related to the new curriculum and teaching practice issues as they mirror the connections between theory and practice (Parke & Coble, 1997). In this way, to design an adequate professional development programme, the designer needs to take into consideration both the teachers' PCK (Magnusson et al., 1999) and their teaching beliefs (Henze, van Driel, & Verloop, 2008; Henze, van Driel, & Verloop, 2009). Each constituent of PCK has a different impact on the further development of that constituent due to changes in the quantity of knowledge that every teacher holds in each constituent. Besides, there are various ways or different pathways for PCK development. However, further discussion on teachers' PCK is addressed in the literature review chapter.

1.2.8 Initial teacher education in Libya

During the last forty years, the education system has been changed many times. This has led to the poor manner in which the science curriculum has been implemented. With the haphazard manner in which the curriculum has been implemented, science teachers (including biology teachers) tend to be confused. Besides, the top-down approach adopted by the policymakers and curriculum planners, with little involvement of teachers, has further exacerbated the instability of the curriculum implementation process (Elferjani, 2015; Ogunniyi, 2004). Currently, however, the training of teachers in Libya is based on supplying all schools with skilled teachers capable of delivering good teaching. The institutions tasked with teacher training are the education faculties at all universities in Libya. The duration of teacher training, also known as the pre-service teacher education, is four years, and on completion, students are awarded a certificate in education and qualify as novice teachers. During their four-year course, students typically study 35-41 modules depending on their field of study. In the fourth year, they are required to embark on a three-month practice to be done at local schools.

1.2.9 Continuing teacher development opportunities in Libya

The need for quantitative and qualitative change and improvement in education has been felt in Libya for a long time. The rapid spread of this change required an improvement in training organizations for educators. Consequently, in 1998, a national committee intended for teacher training organizations was established to improve and evaluate the existing curricula and teacher training programmes. The purpose of the committee was a renewal of educational principles, such as the need to adopt modern educational technologies, the requirement for professional and scientific training programmes for teachers, and their position in the educational process.

In the same domain, the Libyan Secretariat of Education established qualified professional centres for in-service training of teachers, to produce skilled teachers. The teacher training programmes institutions emphasized teachers' development by insisting on three main types of subjects: (a) general culture preparation, (b) vocational and pedagogical development, (c) specialized and academic preparation. Prospective teachers for kindergarten are required to take at least 30% more of their course subjects in educational psychology and occupational sciences. Creating opportunities for science teachers to participate in professional development programmes help them to improve themselves personally, socially, and professionally (Gilbert & Bell 1996). Achieving quality education is possible with well-trained, qualified, and motivated teachers, and the rationale behind teacher development opportunities is to be more efficient in their classroom practice.

There are different in-service teacher training programmes, namely, the improvement courses for science teachers whose performance is weak, the enhancement courses for the motivation of academic teachers', cultural knowledge and vocational experience, the methodological courses, which relate to innovations introduced in teaching subject material and the qualification courses for teaching at secondary school levels. In addition, there are specific courses to support teachers who take up new occupations such as science lab keepers, and others.

Equally important is that specific measures have been instituted to support professional development opportunities through workshops and temporary orientations. Apart from being rare, these professional development opportunities are often planned in such a way that 2-3 teachers per school are trained and required to succeed during the training programme. Theoretically, it is believed (assumed) that teachers who attended such programmes would pass on to other teachers the knowledge, experience, and skills that they have acquired during the training programme (Reddy, 2004). These workshops are organized in a one-size-fits-all approach where the same information is given to all participants (Loucks-Horsley, Love, Stiles, & Mundry, 2010).

I am inclined to believe that it is essential for a teacher-development programme to enhance teachers' ability to enact a curriculum more confidently than otherwise. This will help them to adequately handle the adopted curriculum. The Singaporean biology curriculum that served as a model to Libyan educational authorities is designed, taking into account active learning through activities so as to help teachers develop their knowledge of teaching biology based on practical activities. As a matter of fact, they need to go through such experience to enhance their depth understanding of the concept and deliver it adequately through activities to their students. Therefore, this study, as an investigation into biology teachers' professional development, it seeks to understand what can be done to help teachers in their pedagogical endeavor, their in-depth understanding of the content, their understanding of instructional strategies, in terms of the "5Es" which mean (Engaging, Exploring, Explaining, Elaborating, Evaluating) as well as know their students' ability and prior knowledge. At this juncture, I want to mention that the essential components of teachers' PCK are fully addressed in the first section of the literature review chapter.

1.2.10 Significance of training in the pedagogical context

As indicated by Tynjälä, Virtanen, and Klemola (2016), the efforts made by the teachers to attend the workshops helped them to structure their teaching techniques according to the prevailing teaching system. The series of workshops conducted to enhance pedagogical skills has been met with enthusiasm, and they have been immensely beneficial for teachers to enhance their teaching methods. However, some information gathered from the professional development workshops suggests the need to structure workshops' preparation more comprehensively than has been the case (Ogunniyi, 2004; Van Manen, 2016). Thus, the influence of training has contributed to the teachers' instructional practices. They are now able to access more websites and resources for science education, its related subjects, and current affairs. The above-mentioned capacity makes teachers capable of providing their students with correct information related to the science they are studying and teachers are also likely capable of enhancing the background knowledge their students are required to have on a given topic (Rhema & Miliszewska, 2010)

In keeping with the above statement, I am inclined to believe that the appropriate training on how a teacher can integrate his/her understanding of the content he/she is teaching with suitable instructional strategies as well as his/her students' prior knowledge and ability can develop the teacher's PCK. Thus, a teacher can select suitable techniques that are enriched with crucial arguments and awareness related to science education and its topics (Estelami, 2016).

In the same vein, it should be acknowledged that with good knowledge of pedagogical instructional strategies such as the 5Es model and teaching experiences, teachers can try to stimulate students by organizing and conducting group debates or experiments. The confidence gained can help them to carry on the teaching session in a most efficient manner. Instruction is said to be successful, only when the teachers can engage in arguments with their students on the topic that has been previously discussed in the classroom. This is in stark contrast with the traditional pedagogical experiences based on the chalk-and-talk teaching method that reduces students during classroom activities to mere spectators or listeners.

A plethora of literature has pointed out the importance of teacher training in the implementation of any curriculum. Indeed, the quality of teaching practice and output depends on the seriousness of the teachers' in-service training (Yarden, 2011). But the decrease in the expenditure by the Libyan National Education Department has severely limited the goals that can be achieved with the implementation of teachers' practical knowledge and teaching practice such as the use of discovery approaches by means of hands-on activities. The significance of teachers' practical knowledge thus assists teachers in Libya to implement the new curriculum based on the reality of the environment. This means that the practicability of teachers' practical knowledge can help them to be efficient teachers.

1.2.9.2 Secondary School in Libya

After successful completion of the basic education level, students may proceed to secondary school (high school) where they will complete their studies and prepare for higher education. Secondary schools are organized into general high schools, specialized high school (Science, Technology and Arts sections), and intermediate vocational centres. The duration of studies at secondary schools usually lasts for three years (IAU, 2000).

Students are required to pass each year successfully. In the final year, they write a national examination under the supervision of the Ministry of Education. Secondary school is thus a decisive stage in the student's future career prospects. Therefore, this study focuses on how secondary school biology teachers' PCK can be developed by means of in-service training (INST) programme so as to respond to the educational requirements.

1.2.11 Challenges in secondary school teacher's education in Libya

Libya, like many other countries, is trying to reform and develop its education system and enter the next generation of education. However, as mentioned earlier, the biggest challenge is the quality of education, namely teaching efficiency, because of the significant gap between how teachers have been trained to teach and how they are actually teaching the new curriculum. This makes the implementation of the new curriculum a challenge for most teachers, as they have never been trained about it.

It can also be observed that opportunities for teacher development are rare in the country and that the majority of teachers remain unqualified. Moreover, teacher training and teacher practices are not adequately funded and are lacking in human resources. This indicates that it is not possible to rely only on training programmes. In this regard, Spillane, Reiser, and Reimer (2002) assert that reform cannot be made by having teachers taught only the surface form of improvement practices. It requires grappling with the underlying ideas that may need a profound conceptual change, in which they rethink an entire system of interacting attitudes, beliefs, and practices. For the above reason, I provided biology teachers with development opportunities to help them meet the requirements of the new curriculum and develop their PCK in biology. More will be said about this in the methodology chapter.

1.2.12 Researcher's perspective

Given my position as a biology teacher and science teachers' trainer, I have observed that teachers tend to teach and act in the same way they were taught. Even if they know teaching strategies and have good knowledge of subject matter structure, I clearly see the difference between their thinking and their behavior (action). It cannot be overemphasized that apart from practice, teachers must have in-depth knowledge of the subject matter such as knowledge of related concepts/notions, skills of designing and conducting activities using local material, ability to provide examples from the students' environment. They must also have a good understanding of their students' prior knowledge as well as their way of thinking about the concept. Lastly, they must have the ability to use different pedagogical instructional strategies advocated by the 5Es and also be able to use techniques such as argumentation to build their PCK as well as apply effectively their ideas to teach biology.

In light of the above discussion, one can see that biology teachers are facing substantial challenges on how to access the curriculum and to analyze and teach the subject matter effectively. In order to make a determination on these challenges, one of the strategies adopted in this study is to revisit strategies used by these biology teachers to transfer the content to decide on the appropriate one that could help teachers to suitably address the content they teach in a way to make it understandable for students.

Most challenges arise when while preparing their lessons teachers think and anticipate possible questions for which they do not have plausible and convincing answers. Preparing a lesson means to foresee and anticipate interactions between the teacher and the students and also among students themselves. It is also preparing activities that can help learners acquire new knowledge. However, even though the majority of the schools have functional biology labs, most teachers find it challenging to handle and implement the adopted curriculum effectively in these labs. Therefore, to escape from this incapability, most teachers prefer teaching science theoretically in the classrooms. As a result, it has been observed that biology is poorly taught in most schools.

In relation to the above-mentioned challenges, the identified causes were the lack of subject matter knowledge and pedagogical skills. Lessons were abstractly presented that do not relate to students' daily life experiences and are not based on or supported by practical work as advocated in the objectives of teaching biology in Libya. This clearly illustrates that the ability and skills required to access the new content and implement it effectively in the classroom are insufficient. For instance, to effectively teach osmosis and diffusion, the central concern of this study, the teacher needs to accompany the students to the lab and conduct practical experiments. It is, for this reason, I designed an in-service training programme for biology teachers to enhance and improve their teaching practice by using the 5Es strategy through the teaching of osmosis and diffusion.

1.2.13 Biology teachers' PCK in Libya

Teachers PCK differs from one subject to another due to the structure and nature of the content it relates to. For example, the PCK of biology teachers must be reliable, based not only on theoretical knowledge but also on practical activity and experiments. Schmelzing et al., (2013) conducted a study on biology teachers' PCK and concluded that it correlates with the student's achievement as well as with teaching effectiveness. The PCK of biology teachers needs to be analyzed as one of the principal components in evaluating professional development programmes. Moreover, McConnell, Parker, and Eberhardt (2013) assert that one of the characteristics of an effective biology teacher is a deep understanding of biology concepts. They also maintain that the ability to identify, explain, and apply concepts is critical in designing, delivering, and assessing instruction. According to Abdalla (2007), Libyan biology teachers at secondary schools had difficulties in achieving specific lesson objectives and that they lack the necessary skills in using experiments to enhance students' understanding of the subject.

1.3 Research Problem

As stated earlier, the present study is concerned with finding an informed solution to the problem that has emerged since the Libyan government, through its Ministry of Education, adopted a new science and mathematics curriculum from Singapore for use in Libyan schools. As a consequence, the new curriculum appears to be a dumb, black, and opaque teaching material that cannot help for the teaching of the subject it has been adopted. This implies that there are no courses or modules available to demonstrate how to teach the new curriculum, and no in-service training has been organized around such a critical issue. The implication is that there is a big gap between what prospective teachers are being trained to teach and what they encounter as professionals in the workplace. This means they are not adequately prepared to teach the new curriculum effectively.

Specifically, it means that the present study seeks how to improve teaching effectiveness and to enhance the implementation of the new curriculum. One of the possible ways is to determine how sufficient in-service training programmes support can help science teachers and more specifically biology teachers to develop their PCK and enhance their performance. This problem is based on the premise that biology teachers are facing difficulties to deal with content instruction. This is easily noticeable in terms of the difficulties they encounter when to: plan lessons adequately; to access the content and to present the subject matter using the appropriate strategies accompanied by practical activities; and to understand the students' thinking about the biology content they are learning; as well as to connect that content to their daily lives. In sum, the research problem lies on difficulties faced by biology teachers on how to teach effectively due to their lack of understanding of the subject matter, and their incapacity to clarify it in new ways to make it relevant to the life world of their students.

1.4 Aim of the study

This study aims at determining the effectiveness or otherwise of an in-service training programme in enhancing biology teachers' PCK. More specifically, the study aims at: determining: 1) the effect of the in-service training programme on biology teachers' in-depth understanding of the subject matter they are teaching; 2) their ability to access the curriculum materials for effective teaching; 3) their ability to develop effective teaching strategies; 4) their effectiveness in the implementation of the new biology curriculum in their classrooms, and finally 5) their skills to integrate their understanding of the subject matter with their understanding of teaching strategies.

In pursuance of this aim, answers would be sought to the following questions:

1. What is the nature of Libyan biology teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK)?
2. How effective is an in-service programme in enhancing their SMK and PCK?
3. To what extent has an in-service programme enhanced their instructional practice and the way their learners learn biology?

1.5 Theoretical framework

Without a theoretical framework, a researcher has no frame of reference and all he/she does is dependent on his/her instincts or a trial and error approach. Nevertheless, with a framework to work with, a researcher has a better platform to tackle a given problem and to corroborate or disconfirm findings in earlier research studies in a given area. It is apposite to state, however, that when there is no handy theory, a study can still be situated within or draw inspiration from the context of the extant literature (Ogunniyi, 1992). For instance, although Shulma's (1987) categories of basic knowledge such as PCK, SMK, content knowledge (CK), knowledge of the curriculum, knowledge of the aims of education, knowledge of learners, and other big ideas have great appeal to practical/professional wisdom, the whole construct is still in need of greater refinement to meet the requirements of a strong theoretical framework. For the same reason, the present study drew on a number of socio-constructivist theoretical frameworks as espoused by a number of scholars (e.g. Bybee, 1997; Magnusson, Krajcik & Borko, 1999; Shulman, 1987). These will be further elaborated in chapter 2. The study was carried out in the context of a newly implemented biology curriculum in Libya. Further, the study attempted to explore the effectiveness or otherwise of a training programme on their instructional practice. This is because the implementation of a new curriculum invariably demands professional development and the ability to implement an activity -and learner- based on the Singaporean curriculum adopted in the Libyan context.

The present study is underpinned mainly by a number of theoretical/conceptual frameworks as espoused especially by Shulman (1987) under his general rubric of curriculum content knowledge, subject content knowledge (SCK), pedagogical content knowledge (PCK), knowledge of learners, knowledge of educational context and knowledge of educational ends. The study also draws on the frameworks proposed by Magnusson, Krajcik, and Borko (1999) particularly in relation to the domain of in-service training programme, teachers' practices, their beliefs, and their PCK and Bybee's (1997) instructional model in terms of the 5Es namely, engaging learners, exploring phenomena, explaining phenomena, elaborating scientific concepts and abilities, and evaluating learners.

However, it suffices it to state that although professional development programmes do stimulate change and promote the development of PCK among teachers, nevertheless, it is necessary to point out that the teaching-learning endeavor is a dynamic process governed, a congeries of factors, not least the teacher's personality, modes of delivery of instruction, learning environment, and other intervening variables as well as the students' predisposition to learning. In other words, the changing PCK does not form the sum of its parts, rather, it represents an integrated whole of diverse factors at play in a given context.

What the above indicates is that professional development programmes should not be construed only in terms of teachers' instructional practice but also in terms of other intervening variables. This is because contextual factors other than the teacher have an important role to play in the teaching-learning process and do impact the outcomes of an instructional episode. Ultimately, a teacher's beliefs and ability to perceive the need for change do play some role in what or not is achieved in practice. More details about the theoretical frameworks underpinning the study will be provided in the next chapter.

1.6 Significance of the study

In general, the outcomes of this research could have diverse impacts on science education, and especially on the teaching of biology in Libya. The study will also provide informed knowledge of the effectiveness of in-service training intended to improve the PCK of biology teachers based on the curriculum in the Libyan context. This implies that the study could:

1. Shed some lights on teaching biology in the Libyan context.
2. Provide some insight into the PCK challenges facing biology teachers in Libya.
3. Provide a comprehensive description of an intervention programme to address the PCK challenges of biology teachers and attempt to delineate the successes, limitations, and challenges of implementing such programmes.
4. Provide baseline data for further studies on the PCK improvement of biology teachers.

Finally, the proposed in-service training could serve as a foundation for future research in the field of teaching biology in Libya.

1.7 Outline of the study

This dissertation consists of the following six chapters.

The first chapter presents the introduction, background, rationale of the case under investigation, the context of the study, the aim of the study, the research questions, the significance of the study as well as the study outline.

The second chapter presents a review of the comparative literature in which it presents the theoretical framework underlying the study and analyzes the relevant studies in the field of the PCK of biology teachers, professional development programmes and finally the in-service training programme.

The third chapter describes the research methodology, research procedures, and the methods of data analysis.

The fourth chapter exhibits the findings of data analysis, which are quantitative data and qualitative-based findings.

The fifth chapter discusses the findings of the study.

The sixth and final chapter sets forward the conclusion and implications and recommendations emerging from the research as well as my informed reflection.

1.8 Summary of the chapter

This chapter has presented the underlying research problem as well as the research questions and the background. It has also presented the context of the study, including the overall description of Libya, its geography, climate, history, cultural teaching features as well as educational regulations. The curriculum reform and initial teacher training have been discussed. It has been demonstrated that classroom realism in Libya is dominated by traditional didactic methods. The chapter has also introduced key arguments about secondary school biology teachers’ PCK that are thoroughly discussed in the following chapter.

Having introduced this study, the following chapter reviews the relevant literature considered as the existing answers to the research questions and related to teachers' pedagogical content knowledge “PCK” and professional development.

Chapter 2: Literature review

2.0 Introduction

This study considers teacher professional development (PD) as a multi-faceted process where different factors interact to equip teachers with the necessary knowledge and instructional skills to perform their daily tasks. In view of the current explosion of scientific and technological information has come a feeling of the need for science teachers to possess adequate knowledge of the discipline as well as the skills to disseminate that knowledge effectively and efficiently. For the same reason, it has become mandatory for science teachers to move away from a single mode of instruction. This implies that they need constant training, retraining, and upgrading of their knowledge of the discipline or content of the subject matter they teach and knowledge of pedagogy they use (including the variety of technological tools they use) to facilitate their students' learning.

The literature reviewed in this study is divided into two main sections. The first section deals with Pedagogical Content Knowledge (PCK) and the second deals with professional development. Both sections aim at describing: (a) the biology teachers' teaching-learning practical knowledge development for classroom activities; (b) the nature of pedagogical knowledge and its components; (c) the nature of content knowledge for teaching biology. This means that these sections reviews and discusses around issues of the teachers' teaching practice skills, their capacity to use appropriate instructional strategies as well as their knowledge and understanding of the concepts they teach, their understanding of the learners' thinking about the biology content, which thinking makes these learners' learning understandable.

It should be noted that although this literature review presents several scholars' point of view on basic teaching knowledge, it does not assume that all areas on teacher pedagogical practices have been treated. In other words, it espouses what teachers need to know for better and effective delivery of the content to their students. It addresses this aspect not only by investigating the role of teachers' knowledge, their in-deep understanding of the concepts they are teaching, their efficacy of using the instructional pedagogical strategy such as the 5Es to deliver the concept to their students but also by examining the role of students' prior knowledge and ability in the understanding of the concepts they are learning. In addition, it provides insights into developing and integrating PCK components by focusing on its most practical components. Finally, it provides informed insights on how PCK can be developed by means of professional development.

2.1 Pedagogical content knowledge (PCK)

Pedagogical content knowledge (PCK) is a description of knowledge that distinguishes teachers and is based on the design according to which they link what they know about pedagogical knowledge to what they know about the subject matter. According to this understanding, teachers' PCK is constituted of both pedagogical knowledge and their subject matter knowledge. Shulman (1986) maintains that PCK:

> . . . embodies the aspects of content most germane to its teachability. Within the category of pedagogical content knowledge I include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others. (p. 9).

Based on the above, Gudmundsdottir, (1987) believes that PCK is that specific familiarity with the subject content, which makes teachers, teachers rather than scientists. There is a clear distinction between scientists and teachers in that their difference does not necessarily reside in the quantity or quality of their subject matter knowledge but in the organization and use of that knowledge. Stated differently, the scientific knowledge of an expert teacher is coherent and logical from a pedagogical point of view, which is used as a foundation for helping students to comprehend specific concepts. On the other hand, the knowledge of a scientist is coherent and logical from a research point of view, and it is used as a foundation for innovation of knowledge in the field (Bayram-Jacobs, Henze, Evagorou,, Shwartz, Aschim, Alcaraz-Dominguez & Dagan, 2019).

2.1.1 Teachers knowledge

Teachers are the most significant factors in student learning and achievement (McCaffrey, Lockwood, Koretz, & Hamilton, 2003; Rivkin, Hanushek, & Kain, 2000; National Research Council, 1997; Sanders, Wright, & Horn, 1997). They determine students' learning through the extent of their knowledge. Instructional knowledge, on the other hand, is determined by mastery of content knowledge (CK), command of basic pedagogical knowledge (PK) or knowledge of teaching methods, and finally by the mastery of PCK (Shulman, 1986).

As far as how the content knowledge is concerned for better representation of a topic to meet students' needs in the classroom, Shulman, (1987) has researched teachers' knowledge regarding what they need to know about effective teaching. He found that to be an expert, teachers need to identify the sources of knowledge, know-how to organize and absorb the scientific material, and know their impact on teaching. In this context, to meet students' needs in the classroom, teachers should make the notions they are teaching understandable to their students so as to help them deal with scientific content they are exposed to. They should also know how to use their understanding of the concepts taking into account their students' understanding to process their teaching. In the same vein, Shulman (1986, 1987) suggested that for his/her content knowledge a teacher should distinguish different categories of content knowledge namely the subject matter knowledge, the PCK, and the curricular knowledge as summarized in the following Figure 2.1.

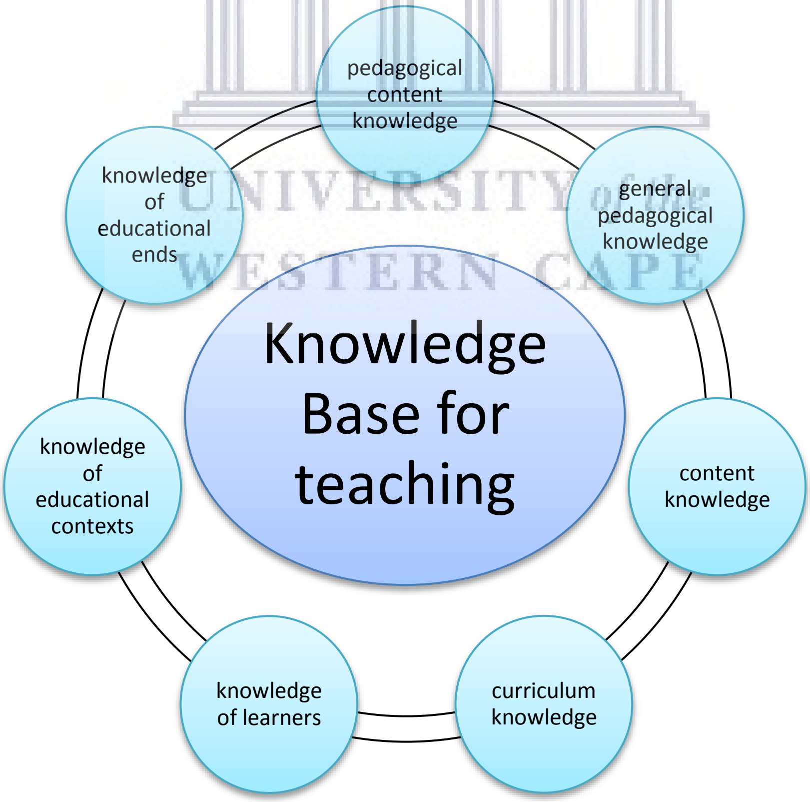


Figure 2-1: Categories of the knowledge base for teaching (Source: Shulman, 1987)

Relating on how teachers' command of basic pedagogical knowledge (PK) as well as their pedagogical content knowledge (PCK) work for better representation of a topic to meet their students' needs in the classroom, Shulman (1987) presents a deep and broad view of aspects that need to be respected. Taking into account this view, PCK is defined as "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8).

The definition above suggests that PCK embodies the effective integration of the teacher's deep understanding of content and pedagogical knowledge (i.e., a teacher's deep understanding of how the content should be organized, represented, and delivered to learners who have dissimilar interests and needs). This implies that discussing PCK is in one way or another addressing the PK. Therefore, meeting students' needs in the classroom depends on teachers' flexibility in their understanding of the subject matter. This ability to adapt to new understanding is essential for teachers to provide different explanations of the same concepts, generate various but similar activities and procedures to help learners who have learning difficulties.

In keeping with the above, McConnell, Parker, and Eberhardt (2013) assert that "effective science teachers are characterized by a deep understanding of scientific concepts" (p. 717). Similarly, Ozden (2008) indicates that teachers' mastery of content knowledge influences their teaching practice. Loewenberg Ball, Thames, & Phelps, (2008) on the other hand, mention that as a concept, PCK, with its emphasis on representations and conceptions/misconceptions, extended ideas about "how knowledge might matter to teaching, suggesting that it is not only knowledge of content on one hand, and knowledge of pedagogy, on the other hand" (p. 392).

Additionally, Shulman (1986, p. 8) stated that: "Mere content knowledge is likely to be as useless pedagogically as content-free skill." This justifies why biology teachers should effectively integrate their understanding of the subject matter with their understanding of how this should be taught (methodologies). Studies support that through activities, the reciprocal relationships between components of PCK are more clearly delineated, rather than placing them in a hierarchy (Wischow, Bryan & Bodner, 2013).

PCK is the content knowledge, knowledge about learners, as well as "the ways of representing and formulating the subject that make it comprehensible to others" (Shulman

1986, p. 9). This kind of knowledge has a high possibility to impact how biology teachers prepare and teach for the comprehension of others (Hashweh, 1987).

Taking into account the above-stated points of view one can understand that poor or faulty PCK is the key cause of failure in most classroom teaching-learning practices. It is no exaggeration to suggest that a teacher possessing a robust PCK is likely to be an outstanding teacher. He/she knows what to extract from the textbook and how to transform those complex or difficult ideas into concepts that students and or any novice in the field can easily grasp. This means that PCK plays a tremendous role in teachers' interpretations and transformations of the subject matter knowledge into digestible information likely to facilitate students' learning activity. Though as indicated earlier, the actual learning outcome is a combination of the teacher's PCK as well as the effort put by the learner and the contribution made of those supporting him/her. Though the contribution by the latter is important, it is outside the scope of this study. In light of this, biology teachers should encourage their students to pay close attention to what they are learning in the classroom as well as encourage them to seek information from other sources outside the classroom.

Further, Shulman (1987) talks about teachers' representation of instructional materials in terms of tailoring the materials to specific students in one's classroom rather than students in general. It also means considering the relevant aspects of their ability, gender, language, culture, motivations, or prior knowledge and skills that will affect their responses to different forms of representation and presentation. The interactive biology teaching techniques are not available to biology teachers when they do not understand the topic to be taught (Shulman, 1987), the appropriate strategies to be used, and the student's thinking about the content.

PCK has been described differently in many studies by means of using terms such as integration, transformation, combination, and amalgam to describe it. It means that PCK is not knowledge that can only be searched for in the teaching-learning context (Nelson, 1992).

Talking about teachers' knowledge without referring to their beliefs is like talking fire without explaining what it is capable of. The following section discusses the connexions that exist between teachers' knowledge and their beliefs.

Teaching-learning practices cannot be separated from teachers' perceptions and understanding of the subject matter they teach. In this context, teachers' perceptions of teachers' beliefs play a vital role in education. Since one's beliefs can be different from what stands to be the true knowledge, both knowledge and beliefs need to be considered to improve, shape, adapt or reform and change the content of the curriculum to avoid subsequent problems. It is in this perspective that many researchers see beliefs as the roots of change (Kim, Kim, Lee, & Spector, 2013; Troop-Gordon & Ladd, 2015; Verdolin, 2006; Yildirim & Tezci, 2016; Zheng & Borg, 2014). In that regard, what teachers believe about teaching, becomes the reference point or gateway towards change. What precedes, is not surprising since numerous researchers suggest that beliefs may create stumbling blocks in the reform of classroom instruction.

It is apposite to mention here that there is a difference between beliefs and knowledge. Therefore, I am inclined to agree with Nespor (1987) who on the one hand supports the notion that beliefs are very personal, stable, and hide behind individual control or knowledge while on the other hand, he believes that central beliefs are more powerful and much more resistant to change. However, some researchers do not share that view. According to some scholars, knowledge is a belief that satisfies two requirements: (1) the truth of what is believed and (2) the justification that someone has for believing it (Hoy & Murphy, 2001). As a matter of fact, this study considers reform and change as a way of adjusting teachers' beliefs to the content they are teaching so as to increase their PCK and improve their performance for adequate results.

Hence, the process of investigating teachers' practical knowledge has become part of professional development programmes that attempt to improve and change beliefs (Richardson, 2003). For instance, terms such as attitudes, values, opinions, ideologies, perceptions, judgments, conceptions, conceptual systems, implicit theories, internal mental processes, dispositions, action strategies, perspectives, and rules of practice are used and introduced as beliefs (Gutsalo, 1995). Ultimately, beliefs are sourced in vivid memories of earlier experiences. In this respect, Richardson (1996) suggests that these previous experiences consist of personal experience, experience with formal knowledge, and experience with schooling and instruction.

The earlier section has discussed teachers' knowledge and beliefs about teaching. It has shown that teachers' knowledge and beliefs play a critical role in their teaching practice in the classroom and therefore contribute to the development of their PCK. Considering the fact that the existing literature presents the teachers' beliefs as their mental process influenced by their knowledge increment, their teaching practice performance, and their understanding of the subject matter (Buehl 2015, George & Ogunniyi 2016) the investigation of their beliefs can provide insights underpinning the issue under investigation as well as provide informed answers to the main research question of this study. The following section, therefore, discusses how the result of teachers' knowledge and beliefs about teaching can be considered relevant to the development of their PCK.

2.1.2 PCK measurement

When looking at teachers' knowledge and beliefs as a strategic component in their development, it is necessary to measure and observe them in order to decide whether there is a need to increase these components. Their content knowledge and beliefs form a critical component of their overall teacher development. However, due to the numerous and diverse factors related to PCK, it is challenging to determine how to assess or observe it in individuals. According to Seung Ho Chang (2014), there could be two approaches to assessing and measuring it. The first way is to test it by using written tests that provide a situation or case linked to their misunderstanding. The other way of measuring it is direct measuring by observing their teaching practices and PCK components.

Using direct observation to measure PCK needs firstly a clear definition, then a decision on which variables can best represent it. In this study, the variables are biology teachers' in-depth understanding of the concept and curriculum context, their pedagogical knowledge and understanding of learners as well as their thinking process about content. All these variables were tested in the study by means of an analytic scale in terms of not observed, observed but not performed well; and observed and performed well to determine teachers' understanding. Many studies have observed and measured PCK directly (Kirschner, Borowski, Fischer, Gess-Newsome, & von Aufschnaiter, 2016); others by paper-and-pencil test to measure PCK (Jüttner, Boone, Park, & Neuhaus, 2013) and still, others are using surveys (Rowan & Mille, 2001).

In brief, this first section of the literature review has discussed the biology teachers' PCK on the basis of the relationship between their knowledge and beliefs, PCK measurement, their knowledge of the subject matter of the curriculum, their knowledge of the instructional strategy, and their knowledge of learners.

After having discussed one of the main concerns of this study, namely, PCK, in the next section I continue with the second concern known as professional development.

2.2 Professional development (PD)

2.2.1 Components of PCK

The PCK concept was introduced into the discussion of teacher education by Shulman (1985) in the American Educational Research Association. However, it was determined as "the second kind of content knowledge" (Shulman,1986, p. 9), which means teachers should have a deep understanding of the subject matter, tested and approved by means of an analytic scale as mentioned above for them to be considered good professionals. In other words, they must have sound knowledge and understanding of the content and other contextual factors influencing the teaching-learning process.

Many scholars have used different PCK domains (e.g., knowledge of content, pedagogical knowledge, learners' knowledge, educational context, curriculum, and so on) by emphasizing one or two of its components to expand on their views of it. It is obvious that Shulman's concept of PCK could have contributed to the further distinction between PCK, subject matter knowledge (SMK), and other types of knowledge. The latter has been used by many investigators to conduct research related to PCK as a conceptual framework in real life. Also, the use of various conceptualizations of PCK has led to the uncertainty of the construct, which implies that some authors have viewed it differently and they are not often referring to the same concept (Amade-Escot, 2001). Despite the fact that Shulman's construct of PCK has revealed some weaknesses, it remains the most frequently referred to in the science education literature worldwide. It was for the same reason (and in the absence of a better construct) that I have adopted the construct as being applicable to some extent in the present study. At the same time, I was aware of some of its limitations in terms of diverse contextual variables that might be at play in the teaching-learning process not adequately captured by Shulman's (1987) PCK categories.

This study would suggest that the value of PCK depends on the strength of its components, as well as the coherence among them. Shulman's (1987) view of PCK has been widely used among educationists. Consequently, it has resulted in various models of PCK (Appleton, 2003; Friedrichsen et al., 2009; Hashweh, 2005; Magnusson, Krajcik, & Borko, 1999; Nelson, 1992; Park & Steve Oliver, 2008). It states that as teachers perceive and replicate on student's learning in the classroom, the choices they make are not only subjective because of what can be considered as the well-established knowledge base but also because of the real-time experience in the profession. This implies that a high level of PCK is essential for competent teaching practice.

PCK models differ in their conceptualizations of the relationship between its components such as SMK, PK, understanding student thinking of the content, and other basic knowledge. For instance, Cochran, King, and DeRuiter (1991), Magnusson et al (1999) as well as Nelson and Grossman (1990) separated SMK from PCK as basic knowledge for teaching, whereas Marks (1990) included it within PCK. Despite these divergent views, one common feature of the PCK models is that they explain and extend Shulman's concept by adapting and modifying the key components or including new components based on empirical indications or the researchers' beliefs (Park & Chen, 2012; Chan & Hume, 2019). Furthermore, to clarify the scholars' components of PCK, Jing-Jing (2014) summarized its components as shown in Table 2.1.

In this regard, many types of research have been undertaken on the nature of PCK: the nature of its components, how this knowledge is developed, the manner in which its components integrate into the teacher's mind, and so on. The following selected constructs are remarkable and consistent studies on the field of PCK that have provided an overall understanding of teaching-learning practices.

Table 2-1 indicates that Gudmundsdottir and Shulman (1987) and Grossman (1990) are closer to each other than the other categories. Similarly, Shulman (1986) Gudmundsdottir, and Shulman (1987) are also closer to each other than other categories. This means that different scholars have based their studies on Shulman's (1986) have either confirmed his points of view or rejected them. However, I am inclined to believe that even though these scholars have highlighted some divergent points of view they seek the same reality. In other words, the divergence of their points of view might be to the fact that in different environments teachers face different realities that influence their points of view. Besides, the teaching-learning process is a complex process in which many variables exert different levels of influence. This process happens in rapid succession that even the expert teacher might not be aware of.

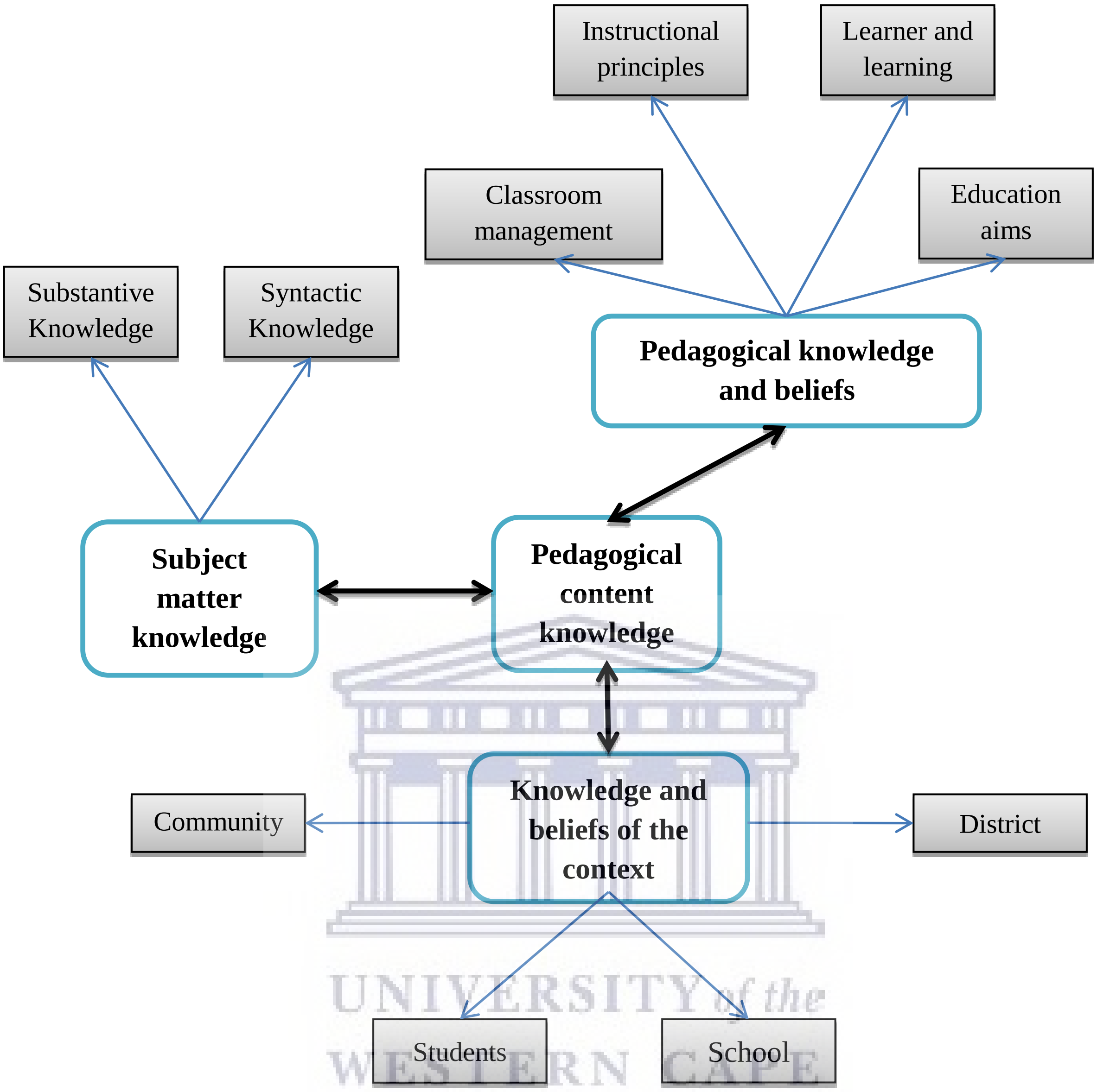
Table 2-1*: Summary of PCK components from different authors*

Components and sub-components \ Scholars		Shulman (1986)	Gudmundsdottir & Shulman (1987)	Grossman (1990)	Tamir (1998)	Magnusson et al. (1999)
Subject matter knowledge		A	A	A	A	A
General Pedagogical knowledge		B	A	A	A	A
General knowledge of curriculum		A	A	A	B	B
Knowledge of Context		B	A	A	B	A
Knowledge of students		B	A	A	B	A
Knowledge of instructional strategies for teaching the subject matter	Representations (analogies, similes, examples and metaphors)	PCK	PCK	PCK	PCK	PCK
	Activities	B	B	B	PCK	PCK
Knowledge of curriculum in specific subject areas	Selection of	PCK	PCK	B	B	B
	Teaching materials	B	B	PCK	B	B
	organization of content	B	B	PCK	PCK	B
Knowledge of students' understanding of the subject matter	Students' conceptions of learning the subject matter	PCK	PCK	PCK	PCK	B
	Students' learning interest in the subject area	B	PCK	B	B	PCK
	Students' learning approaches	B	B	B	B	PCK
	Students' difficulties in learning	PCK	PCK	B	B	PCK
Knowledge of the goals for teaching a subject		B	B	PCK	B	PCK
Knowledge of assessment of students' learning of the subject matter		B	B	B	PCK	PCK

(Source: Adapted from Jing-Jing, 2014).

PCK: The author placed components as PCK components. A: The author placed this subcategory outside PCK as a distinct basic knowledge for teaching. B: The author did not discuss this subcategory explicitly.

This study has adapted the PCK model from (Magnusson et al., 1999) as shown in Figure 2.2. It has been able to reveal not only some of the major strengths and weaknesses of Shulman's (1986, 1987) PCK construct but also its suitability in regard to teachers' knowledge, the relation between teachers' beliefs and knowledge as well as the measurement of PCK, the teaching-learning practices, and the teaching-learning objectives.



Source: Adapted from Grossman (1990)

Figure 2-2: A model of the relationships among the domains of teacher knowledge

Since the present study investigated the influence of an in-service training programme on what are considered to be the main components of PCK, the reviewed literature permits me to provide informed and acceptable answers to my research questions on the basis of the convenience, the achievability, and the attainment of procedures and data sources.

2.2.1.1 *Teachers' knowledge of curriculum*

2.2.1.1.1 Knowledge of Biology Curriculum

Teachers' knowledge of the biology curriculum is considered one aspect of PCK, which is considered the main component in subject matter and involves two categories: (1) specific curricular programmes and (2) materials construction and instruction goals and objectives. Shulman and colleagues initially considered curriculum knowledge to be a separate domain of the basic knowledge for teaching (Wilson, Shulman, & Richert, 1988). Following the lead of Grossman (1990), Walter, (2013) I have included it as part of PCK, because it represents the knowledge that distinguishes the content specialist from the pedagogical issue.

2.2.1.1.2 Knowledge of Specific Curriculum Programme

This category refers to the familiarity with programmes and suitable materials necessary for teaching practical concepts of certain topics in the biology course, for example, an effective way of teaching osmosis and diffusion. The familiarity of teachers with the biology curriculum implies knowledge of the biology curriculum in general. Knowing different curricula does not mean having general knowledge only, but also knowing the teaching goals, the appropriate activities to conduct, and the relevant materials to use in order to be successful in teaching practice.

2.2.1.1.3 Knowledge of instruction goals and objectives

Even though the familiarity with the curriculum involves knowledge of teaching goals and activities, the familiarization with specific instruction goals and teaching objectives remains important. This category refers to the familiarity with a specific component of PCK. It includes familiarity with the interaction of goals and objectives in order to help students in the section they are learning, and also the capacity to spread these instructions to all units intended to be taught for the year. With regard to the general knowledge of the curricula, knowledge of teaching objectives also includes curriculum vertical knowledge of different sections (cross-sectional knowledge). This means, teachers should have a good knowledge of what students have learned previously, what they are expected to learn now and what they will learn later (Grossman, 1990).

This category of knowledge is acquired through the use of national education policy documents, which design the frameworks considered by stakeholders when deciding about new perspectives for the science curriculum and teaching practice (e.g., teacher's guide of teaching in Libya). For practical use, some schools and districts may also have the adapted version of these documents stating specific courses or programmes and specific concepts that should be addressed to achieve the prescribed objectives. As such, competent biology teachers are well-informed about the existence of these documents.

Several studies that depict the general state of biology education in Libya have reported that the vast majority of teachers surveyed were not knowledgeable about nationally-funded curriculum projects relevant to their teaching (Abdalla, 2007; Mohamed, 2010).

There is also evidence that those who are knowledgeable about programmes may not agree with their learning goals and as a result may substantially modify them or reject important parts of the materials (Cronin-Jones, 1991; Anderson & Mitchener, 1994). This point of view provides some evidence of the issue of coherence with respect to the components of PCK, in this case, the lack of coherence of their orientations toward biology teaching and the focus of the curricular materials (Magnusson, Krajcik, & Borko, 1999).

Obviously, it is important to mention that the examinations or the way students are tested are very decisive and tremendously influential for the curriculum and the instructional practices in Libya and over the world. It drives teachers' teaching practices and learners' behavior and their learning commitment. Teachers deliver to prepare their learners to be successful in examinations while learners are making great efforts to master concepts for the test. The teaching-learning process that is based on such principles is temporary and cannot be of importance for the educational system.

2.2.1.1.4 Teachers' in-depth understanding of Biology concepts

2.2.1.1.4.1 What are Concepts?

Concepts are like mental images which, in their simple forms, can be represented by a single word, such as alive, dead, table or chair, plant or animal, apple or orange, good or bad. Concepts may also be described as a set of ideas that can be explained with a few words. Within the use of language, individual concepts can be combined to build more complex structures of ideas. Through the use of language, therefore, people can create new independent concepts. Moreover, complex concepts such as "osmosis and diffusion" can express a whole idea. Thus, within a particular structure, concepts help us to produce thoughts and also to explain more complex ideas. Concepts can, therefore, act as building blocks for more complex or abstract representations (Zirbe, 2006).

2.2.1.1.4.2 What is Deep Understanding?

The term “deep understanding” generally relates to how concepts are “represented” in the teacher’s mind, and most significantly, how these concepts are linked with each other (Grotzer, 1999). Representation is usually made in the form of images and becomes more complex in abstract situations. Deep understanding then indicates that the concepts are well represented and properly connected with other concepts in the learner’s mind where every single concept holds a deep meaning in itself. Therefore, a deep understanding of thinking can make additional connections between the networks of concepts. Also, deep understanding always depends on what the teachers already know. In this way, it is very important to confirm that the most basic concepts are deeply understood and rightly connected. This then gives the teachers the feeling of having a thorough understanding of what they are teaching.

According to Zirbel (2006) the main difference between expert teachers and non-experts “is in how they deal with information. An expert has a much better overview of the whole subject i.e., he sees the connections between the concepts” (p. 3). Professional teachers in biology do not only have more knowledge, but the knowledge they have is connected in a logical and meaningful manner, which includes the student’s thinking about the concept. This is necessary for biology teachers because when they see all the connections between various concepts, they can link them in the students' minds effectively, specifically when they are able to identify the learner's prior knowledge of these concepts.

The teacher’s in-depth understanding of subject matter is very important, as Shulman (1986) reminds us “the teacher needs not only understand that something is so; the teacher must further understand why it is so” (p. 9). The teacher's in-depth understanding of subject matter is thus considered a reference point to develop his/her PCK. Moreover, his/her empowerment of the subject matter gives him/her time to think about the student's learning and pedagogical issues.

Borko, Bellamy, and Sanders (1992) mentioned that (a) drawing on subject matter knowledge, PCK, and teaching experience to represent lesson content in several ways, (b) making connections between classroom activities and students’ lives, (c) understanding of potential student learning difficulties, and (d) monitoring their learning through questioning and observation during lessons are evident patterns in teaching practice. Hence, biology teachers need to possess an in-depth understanding of fundamental biology concepts, understanding of the learners' thinking about the content, and knowledge of instructional strategies to effectively transfer the content knowledge to their students. These components of their knowledge make it possible for them to present concepts to students in multiple ways, and address their difficulties with content more efficiently (Borko et al., 1992; Nilsson & Vikström, 2015).

Subject matter knowledge is a platform for the teacher's knowledge of teaching. After all, if teaching involves helping others to learn, then knowing what is to be taught is a fundamental requirement of teaching. The multiple tasks of teaching, such as selecting important learning activities, giving helpful explanations, using student-centred approaches, asking productive questions, and assessing their learning, all depend on the teacher's in-depth understanding of what should be taught. This is in agreement with Buchmann (1983) who argues that:

> It would be odd to expect a teacher to plan a lesson on, for instance, writing reports in science and to evaluate related student assignments, while admitting that the teacher is ignorant about writing as well as science, and does not understand what student progress in writing science reports might mean. (p. 9)

Subject matter knowledge that is required to teach extends beyond the specific topics of the curriculum. This is why Shulman (1986) argues, "teachers must not only be capable of defining for students the accepted truths in a domain. They must also be able to explain why a particular proposition is deemed warranted, why it is worth knowing and how it relates to other propositions" (p. 9). This kind of understanding includes an understanding of the intellectual foundation and essence of the subject matter itself and makes the teachers transfer knowledge easily and also supports them in the teaching process (de Sá Ibraim & Justi, 2019).

2.2.1.2 Knowledge of Instructional Strategy

Biology teachers' knowledge of appropriate teaching strategy sequences of specific content helps them to develop their PCK during practical teaching in the classroom. Magnusson, Krajcik, and Borko (1999) divided their knowledge of teaching strategies into two categories: knowledge of topic-specific strategies and knowledge of subject-specific strategies. On the other hand, their beliefs about efficient ways of teaching would determine their use of student-centred and teacher-centred approaches to instruction (Chan & Elliott, 2004).

Teacher-centred approaches tend to highlight the activities that a teacher employs to promote teaching; while student-centred approaches tend to highlight the activities in which students are engaged. The correlation between these two methods is a continuum from structured, directed learning environments to unstructured, open-ended learning environments. For instance, "if a teacher believes that teaching is about letting students search around for answers rather than explaining the answers directly, he/she may use a relatively open-ended approach" (Kim et al. 2013).

Furthermore, several studies show that the ability to use subject-specific strategies and special sequences is dependent on the knowledge of other domains such as subject matter knowledge, pedagogical knowledge, and their understanding of students (Hewson, Tabachnick & Zeichner, 1999; Smith & Neale, 1989). The most significant aspect of their beliefs has affected their use of reform-oriented instructional practices involved in their opinions of their roles as teachers.

A lack of knowledge of topic-specific teaching strategies may result in ineffective lessons, as well as difficulties in responding to questions, which require explaining different representations of the concept. Furthermore, their knowledge of topic-specific activities based on their knowledge of activities, in general, can be used to support the students' comprehension of concepts or relationships between them. There is no guarantee that an experienced teacher will know conceptually strong and powerful activities otherwise (Bartos, Lederman & Lederman, 2014; Berg & Brouwer, 1991). However, their knowledge of topic-specific strategies develops from participating in long-term or short-term enhancement programmes (Bartos, Lederman & Lederman, 2014). For instance, Smith and Neale (1991) found that teachers who were participating in their programmes showed increased knowledge of topic-specific strategies, even though there were differences related to their subject matter knowledge. Similarly, observation has been made by (Bayram-Jacobs et al., 2019; Muijs & Reynolds, 2017).

Another important teaching strategy, besides the specific strategies, is the 5Es teaching model that was introduced in the 1980s by Rodger Bybee through the Biological Sciences Curriculum Study (BSCS) (Bybee et al. 2006). When it was first conceived, the model involved three original learning phases known as exploration, invention, and discovery

(Atkin & Karplus, 1962). Later, these learning phases were renamed Explore, Explain, Elaborate, and restructured into five phases adding 'Engage' and 'Evaluate.'

Explore, Explain, Elaborate can be used to help students by (1) challenging their misconceptions (explore); then (2) introducing them to the scientific explanation (explain); and then (3) applying it in a new form in multiple contexts (elaborate). Therefore the concept becomes believable, intelligible, and productive. The 5Es technique is regarded as a successful strategy for engaging students in scientific inquiry since constructivism emanated from how learners learn, whereas biology classroom inquiry developed from teaching science in a way that is similar to how scientists do their work (Sickel & Friedrichsen, 2015). Furthermore, the National Research Council (NRC) in the USA highlighted that science students' inquiry in classrooms should be made to engage in scientifically oriented questions, give priority to evidence, explain and connect to scientific knowledge as well as justify and communicate explanations.

The 5Es model was built on daily life thinking and can also be viewed from two perspectives: teaching biology based on classroom inquiry and constructivism. Moreover, the model can also be regarded from a conceptual change perspective of constructivism (Midigo, Mwanda, Odundo & Midigo, 2017; Posner, Strike, Hewson & Gertzog, 1982). Figure 2.3 presents the 5Es instruction model developed by Rodger Bybee.

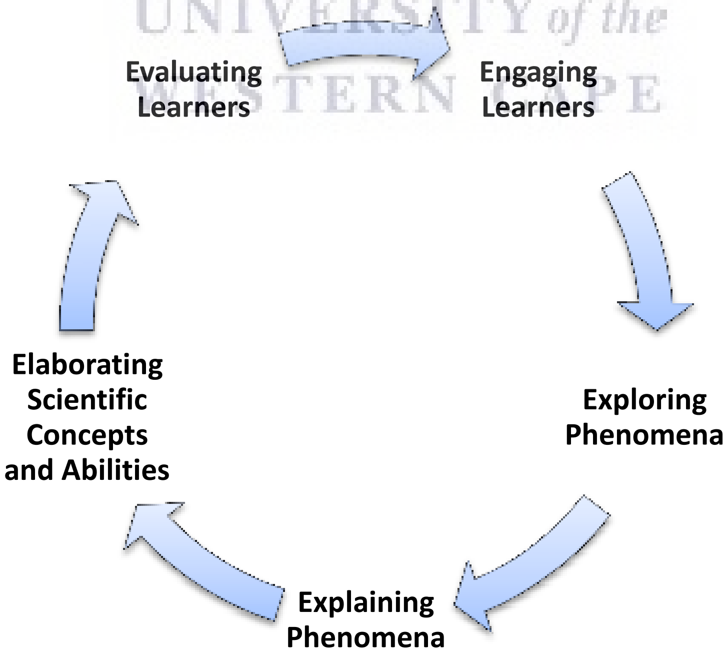


Figure 2-3: 5Es instruction model developed by Rodger Bybee 1997

First stage: Engaging Learners

Engaging learners involves gaining their attention, interest, and motivation about the topic or the concept. This means getting them focused on an event, a situation, a demonstration, or a problem that involves the concepts that teachers are going to deliver. From a teaching point of view, introducing a problem, asking a question, or presenting various events, are all examples of techniques to engage learners in a lesson. “If students look puzzled, expressing ‘How did that happen?’ or ‘I have wondered about that,’ and ‘I want to know more about that,’ they are likely engaged in a learning situation.” (Bybee, 2014, p.10)

Usually, students have some ideas or preconceptions when they go to the biology classroom for the first time. However, the use of these preconceptions may not be scientifically accurate and fruitful. According to Bybee (2014), two things are involved in this phase. First, the engagement needs not to be a full lesson; nevertheless, it should be used to bring to the surface and to assess their prior knowledge. It may be as short as a question or a brief explanation. For instance, teachers might provide a concise description of a natural phenomenon and then ask students about their opinion or how they would explain the event or situation. The reference point is that: “the students are puzzled and thinking about content related to the learning outcomes of the instructional sequence” (Bybee, 2014, p. 11). Secondly, this phase presents opportunities for teachers to determine misconceptions informally expressed by the students (Brown, Friedrichsen, & Abell, 2013).

Second stage: Exploring Phenomena

In the exploration phase, students have opportunities, through activities, to resolve a misconception or develop their idea. The exploration phase provides direct learning, which involves hands-on experiences where students try to express their current conceptions, pick up explicit and implicit knowledge and demonstrate their abilities, as well as try to clarify the puzzling aspects of the preceding stage (Engaging phase). Designing exploration experiences should be included at a later stage during the introduction and representation of the concepts, skills, and practices, of the instructional sequence (Brown et al., 2013; Lankford, 2010; Sickel & Friedrichsen, 2015).

In the exploration phase, the teacher’s role is to initiate the activity, provide adequate equipment and materials, and describe the relevant background. Following this, he/she steps back and becomes a coach with the tasks of observing, listening, and leading students as they clarify and reconstruct their understanding of scientific concepts and developing their thinking and abilities (Bybee, 2014).

Third stage: Explaining Phenomena

The scientific explanation of events is visible in this phase. The practices, concepts, and abilities with which students were initially engaged and afterward explored, now are comprehensible and transparent. The teacher directs their attention to the key aspects of the previous phases and then asks them for their explanations. Using their comments and experiences, the teacher should introduce scientific concepts or phenomena briefly and explicitly. Here, prior experiences should be used as contexts of the explanation of the concepts (Brown et al. 2013; Bybee, 2014).

Fourth stage: Elaborating Scientific Concepts and Abilities

After students have been involved in learning experiences that expand, extend, and enhance the concepts and abilities, which developed in the preceding phases, they can then move on to elaborate on those concepts. The main point, at this phase, is to use activities that are challenging but achievable by them. Thus, in the elaboration phase, the teacher challenges them through new experiences. The process is that they extend their knowledge deeper and broader, gaining more information and sufficient skills to implement their understanding of the concept by carrying out further activities (Bybee, 2014; Lankford, 2010).

Fifth stage: Evaluating Learners

Students should receive feedback on their explanations and abilities. Apparently, the evaluation will occur at the initial stage of the instructional phase. However, in practice, teachers need to assess and report educational outcomes after the evaluation stage that addresses the issue of assessment (Brown et al., 2013; Lankford, 2010). Therefore, the teacher should involve students in experiences, which are understandable and consistent with those of the previous stages and compatible with their explanations. Hence, he/she should determine the indication for student learning and achievement by obtaining that evidence as part of the evaluation phase (Bybee, 2014).

2.2.1.3 Teachers' knowledge of learners

One of the key components of PCK is the understanding of learners. This involves teachers' knowledge and beliefs about prerequisite knowledge such as making student thinking visible by hands-on activities, questions, explanations, and any reaction from them to provide feedback on their thinking and abilities. Moreover, teachers need to know how to expose prior notions and bring together students' thinking concerning the learning results of the activities in progress (Bybee et al., 2006). In addition, Magnusson et al. (1999) indicate that their knowledge should include learners' needs for learning particular content, their understanding of variations in learners thinking, learning manners and developmental levels within specific subject domains, and concepts that they find difficult to absorb due to the degree of abstraction, alternative conceptions, or big challenges with problem-solving (Dani, 2004).

Thus teachers should remain aware of students' prior knowledge of the topic that will be the starting point of the lesson, which results from understanding and personal sense-making of the natural world of students. Therefore, they can continue to change and develop their ideas conceptually, whereas if they deliver the concept without linking it to their prior knowledge and clarifying preconceptions, this might not affect the students' cognitive abilities. Hence, there could be a high likelihood that learning did not effectively happen and students' misconceptions remain unaltered.

Few researchers have studied teachers' PCK of students' understandings of science, and none of them has paid attention to their knowledge of the students thinking about content (Creasy, Whipp, & Jackson, 2012; Khishfe, Alshaya, & BouJaoude, 2017). Other studies that directly assessed teachers' knowledge of students' understanding showed them having knowledge of students' difficulties, but lacking the knowledge to help them overcome these difficulties (Berg & Brouwer, 1991). For example, Liu and Li's (2017) study found that some middle school Biology teachers have more or less incorrect or incomplete understanding of the key concepts in Biology. Teachers' and students' misconceptions display some similarities, and the teachers' misconceptions are likely to be the source of the students' misconceptions.

Several researchers believe that teachers' knowledge of students' misconceptions increases with enhancement programmes (Smith & Neale, 1989, 1991). However, this increase in knowledge does not necessarily go hand in hand with knowledge of ways to address the alternative conceptions. Instead of probing students' reasoning, a lot of teachers address these alternative conceptions by providing them with more detailed explanations of the concepts at hand. Moreover, Magnusson et al. (1999) as well as Smith and Neale (1989) suggest that the independence of the PCK components implies that changes in some of the components may not accompany changes in one of the components. Therefore, an interpretation of the relationship between the components of PCK is needed.

Biology teachers' PCK is a worldwide phenomenon, although capturing it is still not enough as an educational concept. However, many researchers identify that teachers’ PCK comes from knowledge and practice. This raises a question about the knowledge they need to have to be able to deliver the concepts to their students effectively. Indeed, the researchers, as mentioned in the PCK components previously, described many domains of PCK components. In this discussion, I present what teachers should know about students’ thinking about the content, their abilities, and prior knowledge to improve their PCK Gess-Newsome, Taylor, Carlson, Gardner, Wilson, & Stuhlsatz, (2019). Therefore, the following section presents what knowledge teachers need to understand regarding students’ thinking about the content.

2.2.1.3.1 Teachers’ understanding of students’ thinking about the content

When teachers present a concept to their students, they need to know at which level they are. In other words, they need a starting point (the prior knowledge students have) to link old concepts to new ones. Indeed, this point depends on the teacher’s experience, knowledge, and beliefs with practice. Understanding students’ thinking about the content requires making thinking visible. Generally, thinking happens in our heads, it is abstract and invisible to others and even to us. Many studies mentioned that teachers need to know about making students’ thinking visible (Delvin & England, 2016; Goldman, Duschl, Ellenbogen & Williams, 2003; Kassissieh & Tillinghast, 2016; Konopásek, 2007; Miller & Calfee 2004; Perkins 2008; Ritchhart, Church & Morrison, 2011).

Effective teachers make their students’ thinking visible namely, by externalizing their thoughts through hands-on activities, speaking, writing, drawing, or some other methods. Then teachers can understand, direct, and improve students’ thoughts about a particular concept. In addition, visible thinking emphasizes documenting students’ thinking processes for later reflection. Moreover, looking at students’ thinking protocol through their behaviors (e.g., body language) and their work using documentation of their thinking, guides teachers through closely observing students’ responses, reflections, raising questions, and exploring implications for teaching (Gess-Newsome 2019 and Perkins 2008).

Equally important, some teachers have used mind mapping to make their students’ thinking visible. There is not a specific way of doing this. Any teacher, who has a deep understanding of the concepts, can design a mind map to put together his/her students' understanding to make them visible and help other students to understand. In doing so, the teacher follows the (1) questioning, (2) listening, and (3) documenting strategy based on the eight fundamental thinking skills such as (a) observing closely and describing what is there; (b)building explanations and interpretations; (c) reasoning with evidence; (d) making connections; (e) considering differences; (f) capturing the heart and forming conclusions; (g) wondering and asking questions; and (h) uncovering complexity and going below the surface of things (Ritchhart, Church & Morrison, 2011).

In addition, teachers must have a window into their students' thinking about the content. This means they must have a general idea about what students understand about the concept and how they understand it. It is only when they have this information that they can help students to move to the next level in their thinking and to link the concepts effectively. I shall elaborate on this in the next section.

2.2.1.3.2 Teachers' understanding of how to make students' thinking visible

As mentioned above, teachers cannot understand students' thinking about the content without understanding how to make it visible first. The method consists of following the three primary ways suggested by Ritchhart et al. (2011).

The first way is by questioning. Teachers can ask questions in three different ways:

1. Questions to model the interest in the ideas being explored: these questions include authentic questions for which the teacher does not already have a given answer. For example, "I am wondering how the water gets to the top of the tree" this kind of question comes at the beginning of the lesson to open the discussion before getting to the heart of the lesson.
2. Questions to help students construct understanding: These questions move away from asking review questions or eliciting their prior knowledge, but serve to move their understanding forward. Without questions that develop their thinking about the content, the exercise just becomes a fun game, unless it is aimed at developing their thinking about the content.
3. Questions to help students clarify their thinking; rather than transmit what is already in their heads about the content, teachers should try to draw out what students think about the concept. Examples of this type of questioning include,

> "What makes you say that?" "What do you think you were basing that on?" and "I'm not quite following, can you say what you are thinking in a different way?" (Ritchhart et al, 2011; Ritchhart & Perkins, 2008).

The second way is by listening. Through listening, teachers can learn about students' thinking about the content, but only if they truly know how to listen. For instance, when they ask the right question at the right time, then they should carefully pay attention to the students' responses, especially with short answers or their confusion. Without listening, it is difficult for teachers to follow up with an appropriate response. Furthermore, listening conveys respect and interest in students' thinking about the concept, which encourages them to share their thinking in the future, even though it is time-consuming.

The third way is by documenting. This tool makes students' thinking visible by means of notes on a whiteboard, photographs of their work, audiotapes of class discussions, or written notes of their contributions. There are many ways, especially in biology, to capture their thinking about the content. However, it is important to note that in order to enhance teachers' understanding of their learning of concepts; the documentation must include more than simply capturing the learning. Teachers must be able to use the documentation to reflect on and monitor their students' progress (Tishman, 2005; Kassissieh & Tillinghast, 2016; Ritchhart et al. 2011). According to Shulman (1986) teachers' knowledge of learners and their characteristics, for instance, their abilities, their thinking about the content, is a critical issue for the effective teaching of biology.

The above discussion on teachers' knowledge of learners provides a deep understanding of the nature of students' thinking about the content. The discussion also clarifies how teachers understand students' thinking about the content by making it visible.

At this juncture, I would like to mention that when I link the main research question of the present study to its specific objectives, the study aims to: enhance biology teachers' understanding of the curriculum they are teaching. The study bases itself on the unit related to osmosis and diffusion. Second, it aims to enhance teachers' knowledge of instructional strategy more specifically the 5Es strategy. In keeping with the above claim, I would like to mention that during the workshop with teachers this instructional strategy was implemented. Third, it aims to enhance teachers' understanding of learners. So, I can say the study aims to discover the impact of the teacher professional development programme to be designed on teachers PCK. Stated differently, the present study aims at how teacher professional development could combine and enhance teachers' knowledge of curriculum, instructional strategy, and learners through the specific unit (Melo-Niño & Mellado 2017).

The preceding section explored a number of factors that justify poor performance in teaching practice in general and in teaching biology in grade 10 secondary schools in Libya in particular. Based on the above, some studies have revealed that some gaps observed between teaching goals and teaching realities are due to various causes, among others: unqualified and under-qualified teachers; teachers' inadequate PCK; lack of adequate teaching resources; and materials. It has also been found that sometimes even qualified teachers experience similar problems with PCK, because of the lack of training received at university and teaching realities (Council & National Academies of Sciences, Engineering, and Medicine, 2016). In order to improve students' performance in biology, these teachers need support through professional development to enhance their PCK.

The literature reviewed in this section explores pertinent characteristics that make professional development more effective. It aims to scrutinize and develop a model of teacher change based on the study's theoretical framework as espoused by Shulman (1987) as well as Magnusson, Krajcik and Borko (1999) and associated models alluded in the chapter. The main domains of concern in this framework are (1) in-service training programme, (2) teachers' practices, (3) teachers' beliefs, and (4) teachers' PCK.

It should be noted that professional development programmes stimulate change and promote the development of PCK. However, PCK does not form the sum of its parts, rather, it represents an integrated whole. This indicates that professional development programmes should be based on their actual practice, mainly because contextual factors present an important role in PCK development and translate it into practice. Ultimately, their beliefs represent a lens through which new knowledge is obtained, and integrated into classroom practice. Beliefs are a significant aspect of this change and it is used to guide this investigation on teachers' change, beliefs, and knowledge in the process.

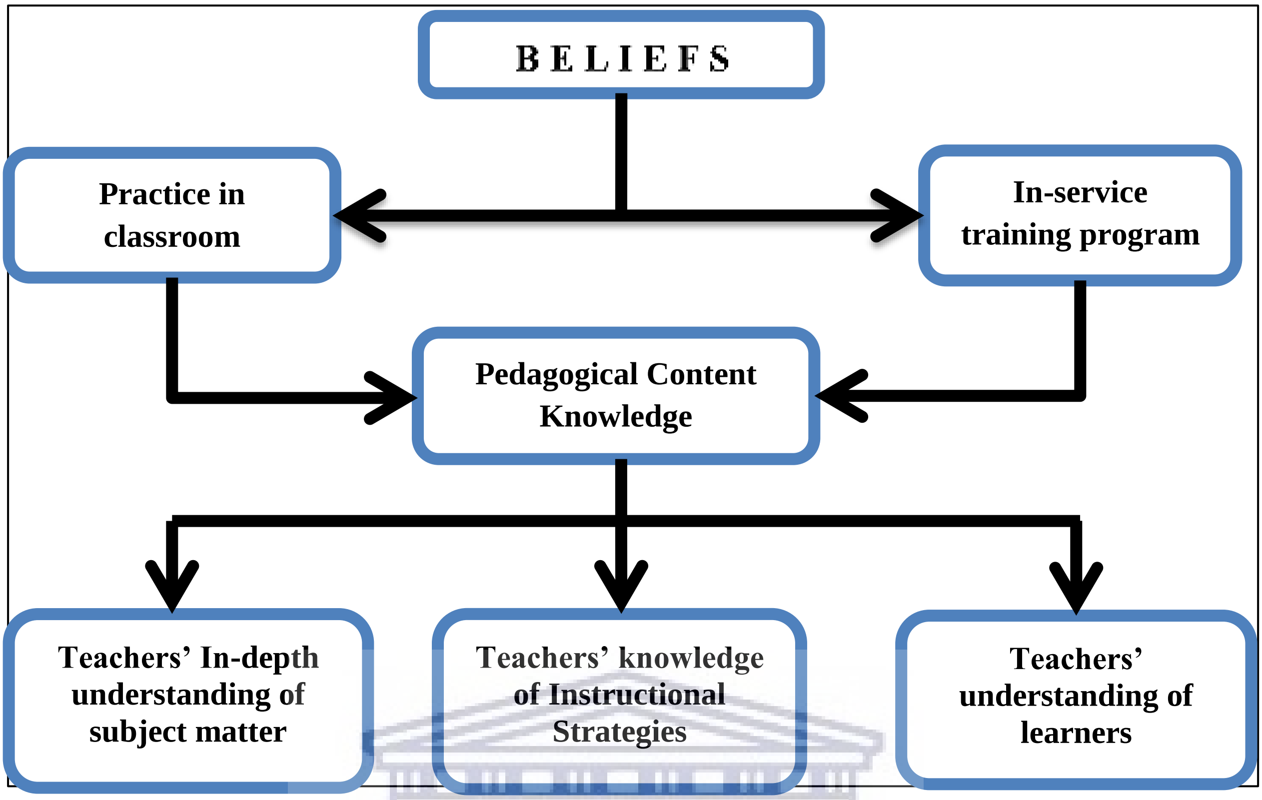


Figure 2-4: Holistic context for teachers' instructional practice standing for a model of teacher change: Adapted and modified from Magnusson, Krajcik, and Borko (1999).

The claim according to which theoretical framework supports the researcher to categorize and circumscribe problem areas, determine research questions that need to be responded, and the relevant design that can be used in conducting the study (McMillan & Schumacher, 2006). The holistic context for teachers' instructional practice standing for a model of teacher change represented above (see Figure 2-4) facilitates the researcher to link this study to the immersed base of knowledge to which other researchers have contributed, to determine gaps in teachers' PCK as well as how different components are interrelated so as to provide recommendations in order to solve the teaching-learning issues in Libya.

Regarding the issue of teachers' change, Guskey (2002) maintained that the majority of programmes fail because they do not take into account two crucial factors:

- What motivates, and enhances teachers to engage in professional development and;
- The process by which change in their behavior and attitudes typically occurs.

Most professional development programmes are based on the assumption that change in attitudes and beliefs needs to come before the implementation of a new practice or strategy. Guskey (2002) suggests that success is not professional development itself, but the experience of successful implementation that changes teachers' attitudes and beliefs. He also believes that professional development programmes will be more efficient and powerful only if the following principles are considered:

- The recognition of the fact that changing is difficult to process for teachers learning. Being proficient at something new requires time and effort as well as extra work, especially at the beginning.
- The assurance that teachers receive frequent feedback on students' learning programmes.
- Providing continued follow-up support and peer support, which are essential for maintaining educational improvement.

Teachers' successful professional development must be seen as a process and not as an event. Hence, throughout this section, careful attention is devoted to activities that can effect change in teaching practices according to Guskey's (2002) point of view this will likely contribute to filling the gaps observed between teachers' performance and teaching requirements.

2.2.2 Effective teachers' professional development characteristics

Professionalism is the key to quality and efficiency. For this reason, any profession requires distinctive knowledge that defines it clearly and distinguishes it from others. The principle of professionalism is the same, even for the teaching profession. Shulman, (1986) asserts that a considerable amount of distinctive knowledge also known as PCK is one of the professional characteristics and effective teachers possess. This knowledge fills the gap and links between pedagogy, learners, and content as shown in the following figure 2.5.

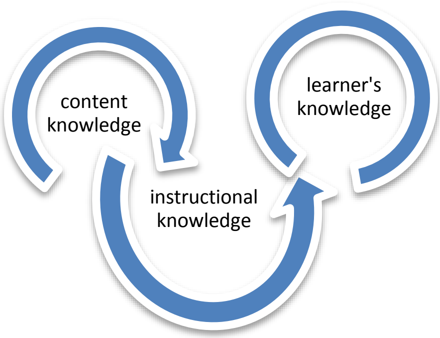


Figure 2-5: A Knowledgebase of the teaching profession

According to teacher development specialists, for more than three decades, from the 1960's to the mid-1980's pedagogy emphasized most on teaching research, involving general knowledge, beliefs, and skills. Detailed general knowledge extended over knowledge and beliefs of learning and learners, over knowledge of principles of instruction, over knowledge and skills associated with classroom management and knowledge as well as beliefs concerning the objectives and reasons for teaching (Cohen & Doyle, 1986; Grossman, 1990).

A discipline's essence is a viewpoint of knowledge of that discipline based on the scope and profundity of the content (Shulman, 1986). It is the comprehension of the internal order of notions and body of instructions of a subject (related to the discipline to be taught) and the methods within the subject to develop new knowledge. Shulman (1986) is of the view that this field of teacher knowledge was ignored until the 1980s. With regards to Shulman’s contention above, Borko and Putnam, (1996); Darling-Harmond, (2008) have stated that having an extensible, manageable theoretical comprehension of the discipline is basic for competent teaching.

In sum, PCK relates to how teachers mix the essence of discipline and teaching methods to decide about the most competent methods to teach particular lessons or issues in conformity with the students’ benefit and aptitude (Shulman, 1986). It is necessary for teachers to be well-informed about lessons that are difficult for students (Shulman, 1986; Wilson, Shulman & Richert, 1987). The latter admits that teachers need processes to examine the discipline through the learners’ eyes, hearts, and minds. Their role is to change the essence of the discipline in ways that render it accessible to students (Wilson et al., 1987) without altering its integrity (Ball, 1993; Lampert, 1992). Furthermore, as knowledge develops, with time and circumstance, so teachers need to find a way to readjust themselves to developments.

A significant contribution to their professional development and advancement is grounded in their desire to discover new things. Borko and Putnam (1996) and Loucks-Horsley et al. (2009) hold that to be an expert teacher, the education programme should view them as learners in following approaches that agree with the student's view of learning. This means that they need to be granted experience with teaching approaches resembling the ones that are used in teacher-learning contexts. As an illustration, if the programme demands them to teach using the learner-centred method, then it needs to expose them to this teaching method. Further, Borko and Putnam,1996; and Magidanga, 2017) maintain that according to contemporary cognitive theories, learning occurs in a specific context and that it is an active, constructive process, which is mainly affected by different existing knowledge and beliefs. Studies conducted in the teacher-training field reveals that the knowledge they have and their beliefs are important in designing what and how they are informed from their own educational experiences. In this way, Borko and Putnam, (1996) argued that the knowledge and beliefs of prospective and experienced teachers function as a sieve through which they learn new ideas. This means that they use their experiences as the foundation of new practices Mavhunga & Rollnick (2016).

2.2.3 Basics for professional development

Professional development has an important function in the success of education reform. It serves as a link between teachers' current knowledge and the future in meeting new instructions so as to guide students to reach a significant level of learning and development. In order to understand the basics of professional development, the next section tries to introduce and address its principles in clear terms.

Scholars have differed in their attempt to describe professional development. According to Fullan’s (2001) point of view, professional development is the embodiment of conventional and unconventional learning experiences spanning one's profession, from prospective teacher training through in-service teaching activities to retirement. Loucks-Horsley et al. (2010) also view professional development as the advantages presented to teachers to enhance new experiences, capacities, methods, and dispositions to redress their expertise in classrooms and organizations.

For his part, Guskey (2000) believes that professional development is like any other technique and remedy conceived to develop professional knowledge, capacities, and points of view of teachers so as to enable them to improve the learning experience. Besides, he agrees that the process concerns learning how to renovate pedagogical frameworks and cultures. Taking into account these different views, it is clear that professional development concerns all processes and preconceived remedies intended to enable teachers to gain experience, capacities, points of view, and behavior, developing their skill to perform effectively in the classroom. The next section addresses essential principles, emphasizing the views that affect the design of professional development programmes.

2.2.4 Essential principles of professional development

General beliefs of learners and learning, teachers and teaching, the nature of the content, and principles of successful professional development programmes collectively affect the design of professional development programmes.

2.2.4.1 *Conceptions of learners and learning*

Educators' perceptions of learners and learning shape the type of guidelines they suggest (Bruner, 1996; Loucks-Horsley et al., 2010). People have various considerations of learners; one such consideration perceives the student as a creative learner and concentrates on passing on capacities and 'know-how' by means of illustrations and representative action. This consideration is based on the behaviorist theory of learning, and it perceives the learner's mind as an empty board that needs to be decorated. The supporters of this consideration emphasize talent, skills, and expertise, rather than knowledge and action (Bloom, 1956; Gagné, 1967).

In certain circumstances, behaviorism is used interchangeably with 'objectivism', because of its conviction of the objectivist epistemology. The objectivist approach in learning is convinced of the persistence of trustworthy knowledge about nature, and the learner's objective is to obtain this knowledge as it is conveyed by teachers (Jonassen, 1991).

In contrast, current theories emphasize the power of students' prior knowledge, beliefs, and attitudes on their learning (Cobb, 1994; Kieren & Steffe, 1994). This consideration is identified as constructivism, which claims that learners actively create a message through cooperating with prior knowledge and notions provided by their peers and teachers. Constructivists perceive them as coming to the classroom with pre-established beliefs, ideas, and experiences that impact the way they comprehend and look into new materials.

Students cooperate with others to make sense of experiences and phenomena, and then think through this method of reconceptualizing their prior knowledge systems. This makes learning to be considered as a social mechanism in which cooperation with peers is of great significance (Nicolini, 2016; Wenger, 1998). By means of cooperation with peers and teachers, they make their own experiences visible to others, the reconceptualizing of their prior knowledge systems occurs. Their comprehension of new knowledge significance relies on the context of the phenomenon. In this view, their social and cultural contexts become significant components of the teaching and learning method.

Professional development specialists are inclined to believe that strengthening their teaching in a constructivist way demands teachers to use new teaching techniques (Loucks-Horsley et al., 2009; Putnam & Borko, 2000). After having discussed the conception of learners and learning, the following section introduces the conception of the teacher and teaching in the constructivist theory.

2.2.4.2 Conceptions of teachers and teaching

This conception plans the way professional development programmes are conceived. In order to help students to create their personal knowledge, teachers are required to stop assuming their traditional responsibility of conveying knowledge. According to a constructivist approach to teaching, the teacher's task is to assist learners in the conception and creation of understanding, contrary to the traditional mechanical transmission of knowledge (von Glasersfeld, 2012). Teaching is not to merely deliver knowledge, but to provide opportunities to students and to motivate them to further develop it (von Glasersfeld, 1996). According to the constructivist point of view, teachers are required to use a teacher-student cooperation approach of instruction by simulating and encouraging a learning environment that permits students to go deeper into learning activities while teachers act as facilitators (Gergen, 2012). For constructivist teachers, problem-solving activities are central to teaching; intentional activities proceed from problem situations that demand creative thinking, discovering, inventing, communicating, testing ideas as well as gathering and applying information.

Teachers are required to comprehend the complexity of teaching practice. They should understand that teaching takes place in questionable circumstances and demands everlasting decision-making. It encloses profound, manageable knowledge and the aptitude to assign that knowledge to students, content, the programme, instruction, and the educational institution and the society (Hargreaves & Fullan, 1992; Loucks-Horsley et al., 2010; Shulman, 1987; Doyle, Sonnert, & Sadler, 2018). However, it is hypothesized that teachers can perform in the following two ways: first, by building on their own classroom experience and, second, by learning from the wisdom extracted from others (Loucks-Horsley et al., 2010). This way of performing, sooner or later, can help them become successful teachers. Being a successful teacher is eventually considered in terms of releasing knowledge and values that students can understand and learn from.

According to Stephens and Crawley (1994), and Loucks-Horsley et al., (2010) successful teaching embodies the following:

- Making the subject motivating and related to students' everyday life issues;
- Openly loving the subject and helping the students to know that they love it;

- Making intricate issues comprehensible;
- Avoiding a lot of talking and writing activities by listening to the students, carefully and very often;
- Setting realistic and achievable tasks for students;
- Believing that initial teacher training is only one phase of long-term professional development.

In sum, Swafford, Jones, and Thornton (1997) believe that teaching in a constructivist way is subject to teachers' understanding of teaching in helping students to learn. Teachers have a different understanding of the constitution of the branch they teach. The following section presents these views with specific reference to biology.

2.2.5 Views on principles of professional development

Many research studies have been conducted on professional development. For example, professional development for science teachers was reviewed by Sikula (1996) while Clarke (1994) revised it for mathematics teachers. These research studies aimed to discover principles that could inform professional development. Loucks-Horsley et al. (2010) present a general conception of professional development in science and mathematics by investigating attempts to develop criteria to guide reform. Their conception was accepted by a number of institutions and it contained seven principles to address successful professional development experiences:

i. Based on a well-defined image of successful classroom learning and teaching.
ii. Providing occasions for teachers to construct their knowledge and capacities. For example, helping teachers to develop extensive knowledge of their subjects as well as their PCK; helping teachers in selecting and mixing curriculum and learning practices.
iii. Modeling with teachers strategies they will use with their students. For example, starting and building from where teachers are; providing enough time for extensive investigations, collaborative work, and reflection; and connecting formally with teachers' professional development experiences and activities.
iv. Building a learning community. For example, rewarding and encouraging teachers to learn and share knowledge with others, because continuous learning is part of school norms and culture,
v. Supporting teachers to serve in leadership roles such as supporters of other teachers, as agents of change, or as promoters of reform.

vi. Providing relations to other parts of the education.

vii. Ensuring continuously a positive influence on teachers' success, students' learning, leadership, and the school community (Loucks-Horsley et al., 2010).

To be successful, professional development attempts should consider the principle according to which teachers' collaboration, their mutual co-operation, and the creation of learning communities are some of the most indispensable elements targeted in the principles of successful professional development. These elements imply the need for the teacher's cooperation to promote their professional development. The next section presents a discussion about supplementary materials.

2.2.6 Supplementary activities and materials

It has been observed that standard materials play an important role in teacher professional development because they fulfill the role of a subsidiary tool for those struggling to adjust their teaching practice (Ball & Cohen, 1996; Gray, 1997).

Curriculum materials, mentioned by Loucks-Horsley et al. (2010) as 'curriculum replacement units' can be used in a diverse manner in professional development:

1. They can be used to encourage teacher reproduction and debate on existing knowledge with the innovative teaching process.
2. They can assist in the development of shifting the curriculum by permitting teachers to acquire the content and a different strategy of teaching progressively.
3. They can assist to encourage teachers to co-operate with contemporaries in formal, as well as informal techniques.

Many studies that have been piloted in both developed and developing countries have indicated that the practice of innovative curriculum materials is understood as a cause for the instructional revolution if they provide activities and material about the teacher's responsibility in presenting a lesson. These activities and instructions can be offered through 'procedural terms': precise how-to-do-it advice, intensive on essential, but seemingly weak elements of the curriculum (Ball, 1996). The use of procedural terms has been required by four implementation problem areas several teachers encounter (Voogt & van den Akker, 2009). Lesson planning, which is habitually time-consuming and challenging, subject matter knowledge, which several teachers tend to lack, lack of pedagogical knowledge, and assessment of learning which is also considered difficult.

Studies conducted by van den Berg (1996) and Ibrahim (2015) showed that using procedural terms improves the effects of in-service training on the execution determinations of teachers. They mentioned that the combination of materials with procedural terms in an in-service course encourages teachers to try different things and deliver them with fruitful first-time experiences. Besides, she found that procedural terms render lesson preparation less complex and time-consuming in comparison to preparing a lesson without them. Likewise, many studies have been conducted in developing countries, and more particularly in South Africa to decide the appropriateness of standard materials with procedural terms in helping science teachers in their professional development (Gray, 1997; Stronkhorst, 2001).

The outcomes from these studies indicated that the tools had helpful effects in supporting teachers' determinations to implement learner-centred learning, though in variable levels of usefulness. The activities and materials could afford them with a perfect representation of how the revolution can be applied in a real environment and support them throughout their first teaching practice trials (Ibrahim, 2015). Also, the materials could propose a motivation for the revolution, stimulating peer associated activities. Conclusions from Ibrahim (2015), and Stronkhorst, (2001) agree with the remarks by van den Akker (1988) according to which the materials to be used should comprise procedural terms on how to implement modernization.

Van den Berg and Thijs (2002) warn about the importance of the choice of the subject and theme for developing the materials. They think that it is very crucial to consider relevant themes. They recommend that the materials should look at subject topics that are elements of the syllabus, but not sufficiently highlighted in standard textbooks. The topic should also be suitable for the organization of the teachers' practice.

From these conclusions, it seems evident that programme materials are of great significance for teacher professional growth. Among other things, they can motivate the teacher's teamwork, which is extremely significant for teacher knowledge. Likewise, programme materials combined with teamwork can help teachers professional growth in circumstances where they have the opportunity to meet frequently in school on a formal or informal basis. The following section introduces the significance of topic-based teacher professional growth, whereby the role of guidance is emphasized.

2.2.6.1 Topic-based professional development

According to some experts in teacher growth, topic-based help is highly considered in both developed countries and developing countries (Borko & Putnam, 1996; Fullan, 2001; Van den Berg & Thijs, 2002). The topic-based background is seen as sustainable, continuing, and allowing teachers to exchange ideas with their colleagues regarding modifications and perfections in their practice (Guskey, 2000; Powell, Goldenberg & Cano, 1995). This background encourages and considers teachers as being both students and teachers.

Guskey (2000) observes that topic-based strategies offer a number of benefits. One is that, because the conclusions about professional growth objectives, content, and prototypes, are prepared at the school level, determinations are more probable to be contextually significant. The other is that the unanimity on subjects interconnected with professional growth is easier to achieve since not many individuals are engaged. To support work successfully in this background, there must be reassuring guidance in schools that recognizes the significance of teacher professional growth.

First, such guidance must allow the reorganization of the school so that teamwork among teachers becomes possible (Van den Berg & Thijs, 2002). The study conducted by Anderson and Sumra (1995) indicated that participation of school management in a teacher professional growth plan, especially in preparing events, is an important aspect of creating a climate of confidence among teachers. Moreover, they claimed that the events should be separate from the assessment. Also, as part of management at the school level, there has to be established knowledge and concrete involvement in the area of interest (Loucks-Horsley et al. 2010). These pedagogical specialists help as instructors or helpers (either formally or informally).

It is apposite to state that the quantity of in-service training programmes is not essentially linked to the quality of the operation, but it can be if merged with pre-operation exercise, accompanied with help during the operation (Fullan, 2001). Borko and Putnam (1996) argue that teachers need significant and continuous help in integrating the didactic content information and principles they learn from in-service programmes into their present teaching practices in the classroom. The quintessence of helpers is to solidify teachers' help on a regular basis every time they experience problems through the operation. It is said that teachers learn best from other teachers, but research illustrates that they cooperate with one another irregularly (Lortie, 1975). Having helpers in the schools may encourage and render their collaboration probable by being the foundation of motivation, where they can benefit from day to day help. When teachers are educated as staff developers, they can be very active in working with other educators (Fullan, 2001).

2.2.7 General overview of professional development

Teacher education creates a significant part of teacher professional growth and continuous development. It comprises active construction processes that are deeply influenced by an individual's prevailing awareness and opinions and are placed in a specific situation. Teachers' current knowledge and opinions are important in modeling what and how they learn from their educational experiences. This chapter has investigated what probably helps in organizing teachers' knowledge. It has been said that to be an expert teacher, one is requested to own an extensive amount of educational content information. This information, which is a connection of subject matter and pedagogy, allows teachers to identify what to teach and how to teach it successfully to a given group of students.

In order to develop and strengthen teacher knowledge, teachers need reinforcement by means of professional growth programmes. The chapter shows that there exist different types of teacher professional growth. Certain types focus on individual teachers such as individually conducted professional growth programmes. In spite of their assistance, these programmes have restrictions, such as the acceptance of teacher isolation. They are not reliable with the existing techniques of teacher professional growth methods, which underscore teacher teamwork and collaboration. Therefore, there are types that underscore their teamwork either in or outside the classroom.

In the classroom teachers can cooperate through mentoring, classroom observation, or team teaching. Outside the classroom, they can cooperate by means of study groups, action research, or by being involved in the growth/enhancement practice. Studies by Little and Lieberman (1990); Durksen, Klassen and Daniels (2017) indicate that the cooperation of colleagues has the capacity to improve teacher professional growth and continuous development. It has been discovered that working together could help teachers to develop the necessary capacity to build the needed confidence, passion, and willingness to participate in research and to develop a greater sense of effectiveness.

In order to motivate more effective practice and take the external information into the teachers' practice, teachers need to be supplied with curriculum resources and strategies that address issues in a new manner, and that is suitable for their organization of work. To encourage and stimulate the use of local materials, topic-based backgrounds are to be more applicable since teachers can receive on-the-spot help, provided that there is helpful management support.

2.3 Implications

In light of the literature discussed above, before addressing the implications of the in-service training programme (INSTP) based on PCK, it is important to make a point on **Participatory Action Research (PAR),** which is the foundation in the type of this research. According to Steinberg (2014), the 'descriptions of educational reality outside the boundaries of socio-economic contexts; hold little meaning for educators concerned with social justice and ethical action' (p.7). There are several definitions and understanding supplied for PAR in literature. In the present study I have considered only two:

- On the one hand, PAR is about jointly producing knowledge with others to produce critical interpretations and readings of the world, which are accessible, understandable to all those involved and actionable. (Paul Chatterton, Duncan Fuller & Paul Routledge, 2007)
- On the other hand, PAR is a form of action research in which professional social researchers operate as full collaborators with members of organizations in studying and transforming those organizations. It is an on-going organizational learning process, a research approach that emphasizes co-learning, participation and organizational transformation. (Greenwood, Whyte & Harkavy, 1993).

From the perspectives presented above, the focus of PAR is the social construction of realities. It is apparent that stakeholders should engage in a collaborative process of collective understanding in order to engage in a social process of transformation. When engaging in PAR, the commitment to change is implicit. So action research implies adopting a deliberate openness to new experiences and processes, and, as such, demands that the action of educational research is itself educational.

The process of implementing a PAR approach in this research process was informed by the cyclical process which aimed to combine the elements of action, reflection, theory and practice.

It was imperative for the researcher to engage in a process that would facilitate transformation through collaborative research processes hence the participatory action research (PAR) methodology was deemed appropriate for the purposes of this study.

Taking into account the principle of PAR and the literature reviewed above a variety of questions have been raised for the in-service training programme (INSTP) based on PCK.

First, considering the capacity for the development of peer cooperation that supports teachers' professional growth and constant evolution, the INSTP should take into account peer cooperation as a principal element in professional growth programmes intended at improving biology teachers' PCK. As mentioned previously, context analysis has shown that biology teachers in Libya have difficulties related to content and pedagogy because of poor preparation they received in colleges or insufficient experiences to teach in a given grade. In this way, there is a serious need to help them improve their PCK by means of professional growth.

Second, it has been observed that PCK consists of pedagogy and content, which are both, very significant for teachers. The INSTP examines the opportunities for assisting biology teachers, thanks to professional growth programmes to increase their PCK. The method should emphasize the constructivist notions of the learner and learning, the teacher and teaching, and the nature of biology notions.

Third, the significance of the course resources for teacher professional growth has been approved. As earlier indicated in this review, the availability of material resources is critical to teachers' professional development. It has been found that Libyan schools lack the implementation of appropriate course resources. The existing ones and generally used, contain a lot of writing errors and misconstructions. They contain irrelevant materials instead of pedagogical support Mohamed (2010) Thus, in planning the in-service training programme (INSTP), resources should be considered absolutely necessary. More explicitly, they should be increased and assimilated into the course to support teachers' understand and identify what to teach and how to teach it successfully. The resources should reflect the curriculum desires for biology, as well as be appropriate to the teachers' organization of work (Abdalla 2007, Mohamed 2010)

Fourth, for course resources to be more effective in encouraging cooperation, the topic-based background should be applied, because the rigorous practice of resources is made within this background. It has been acknowledged that a topic-based background is more encouraging for peer cooperation in that it supports and guarantees viable and continuing help for teachers who use this background. Consequently, in planning the INSTP, the topic-based background needs to be taken into consideration to help all biology teachers. In conclusion, it has been found that topic-based cooperation and course resources by themselves do not assure achievement in assisting teachers. Teachers also need significant and constant help, as well as occasions to execute their pedagogical content and principles. There exists a real necessity for guidance aptitudes among selected teachers to classify and help their peers in a topic-based teacher growth programme (Mohd Yusof, Ahmad Helmi Syed Hassan, Zamry Jamaludin, & Farida Harun, 2012).

2.4 Summary of the chapter

Since the present study is concerned with the effect of a professional development programme on the PCK and practice of biology teachers, its emphasis is mainly on their PCK and teaching practice. This chapter has been subdivided into two main sections. The first section looked at the relevant research studies conducted on PCK and their outcomes. The second section examined professional development programmes and their impact on teachers. In sum, the reviewed literature has revealed that professional development efforts within the normative-reductive perspective result in important changes in teachers' knowledge, beliefs, and teaching practices in classroom instruction. This suggests that in many cases professional development activities contribute to significant growths of both teachers' PCK and their roles as teachers. Also, while many studies on teachers' PCK have been carried out in the last four decades worldwide not much has been done in the area in Libya and hence, the present study. It is hope that the outcomes of the study would provide useful information and insights about the nature of professional development programmes especially for biology teachers in Libya. Having discussed the relevant literature to this study, the next chapter will present and discuss the research methodologies adopted for the study.

Chapter 3: Research design and methodology

3.0 Introduction

Taking into consideration that the present study is concerned with determining the effectiveness or otherwise of an in-service training programme for Libyan biology teachers' PCK development, this chapter lays out the design and methodology of the study. Specifically, the chapter describes in detail the research site, the sampling procedure adopted, the process of instrument development, and the method used to collect and analyse the data. The last section deals with ethical considerations.

It is important to mention that the present study is underpinned by a socio-constructivist theoretical framework as espoused by Shulman (1987), Magnusson, Krajcik, and Borko (1999) as well as Bybee (1997) regarding the importance of the teacher's pedagogical content knowledge (PCK) and subject content knowledge (SCK), knowledge of the students and the contextual factors influencing classroom transactions. As far as the development of constructivist theories of learning is concerned, it has generated different new teaching approaches. In this perspective, an investigation based on teaching and learning practices should be conducted by considering the constructivist theories and principles of learning according to which "knowledge is sustained by social processes and that knowledge and social action go together" (Young & Collin, 2004. p. 2).

It was in light of the above perspectives that the study adopted a socio-constructivist framework. I was convinced that a socio-constructivist framework as proposed by the above scholars would enable the Libyan biology teachers involved in the study to interact with each other, learn from each other and as a result gain a better insight into the complexity and the dynamism of the teaching-learning process than was otherwise the case before participating in the study. Likewise, I believed that the multiplicity of realities expressed by the participants and my own subjective stance could enable the construction of a more nuanced understanding of teaching biology in Libya. This point of view is congruent to Crotty (1998), who believes that "All knowledge, and therefore all meaningful reality, as such, is contingent upon human practices, being constructed in and out of the interaction between human beings and their world, and developed and transmitted within an essentially social context" (p. 42). In sum, this chapter addresses all the issues that pertain to the overall design of the study. In the following first section, I state the research questions of my study.

3.1 Statement of the research questions

As indicated earlier, Shulman's (1986 and 1987) and other scholars' notions of instructional practice (e.g. Bybee, 1997; Magnusson, Krajcik, & Borko, 1999; Young & Collin, 2004) have helped me to construe the in-service programme as one of the ways to facilitate the professional development of the Libyan biology teachers involved in the study. I find for instance Bybee's 5Es (i.e. Engaging learners, Exploring phenomena, Explaining phenomena, Elaborating scientific concepts and abilities and finally Evaluating learners) instructional model to be particularly fascinating in that it is easy to implement and assess in the classroom setting. Consistent with this view, one can expect the in-service programme to provide insights on how to engage teachers for their professional development, to develop their engagement with teaching-learning practices by actively working to understand the subject matter in the curriculum, to develop their skills so as to successfully teach this subject matter as well as to consider and use their students' background knowledge.

In light of the aforementioned scope, the central concern of the study was to determine the influence of an in-service training programme on Libyan biology teachers' PCK.
In pursuance of this aim answers were sought for the following questions:

1. What is the nature of Libyan biology teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK)?
2. How effective is an in-service programme in enhancing the teachers' SMK and PCK?
3. To what extent has the in-service programme enhanced their instructional practice and the way their learners learn biology?

The research questions above form the central concern of the study. It was my hope that the method adopted and described in the sections that follow would assist me to find answers to these questions. The first question aims at determining the status of Libyan biology teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK) as well as their knowledge of the curriculum. The second research question seeks to find out whether or not the in-service programme was effective in enhancing the teachers' SMK and PCK. The third and last research question is concerned with finding out to what extent the in-service programme has actually enhanced their instructional practice and the way their learners learn biology. The following section describes the research design adopted for the study.

Research Design

The study used a mixed-method involving a combination of quantitative and qualitative approaches as espoused by Creswell, Shope, Plano, Clark, & Green (2006) and Dornyei (2007). These researchers and other researchers who value a mixed-method approach argue that often the set of data emerging in the research process could evince different aspects of a given phenomenon some might be quantifiable while others may be less or so. Whatever the case, it is not always easy or advisable to present educational outcomes involving test measures or other forms of assessment measures solely in terms of quantitative or qualitative data alone. For instance, certain data are better represented by nominal, ordinal, interval, or even absolute scale while others are not amenable to such numerical scales and yet could prove very valuable (Ogunniyi, 1992).

Even though, I have used the mixed methods approach in the present study, in nature it remains predominantly a qualitative one. A fundamental concern in the use of mixed methods is that it "provides a rationale for hypotheses/theories / guiding assumptions to compete and provides alternatives" (Niaz, 2008, p. 64). In light of this, I collected substantial information about the influence of the professional development programme used to enhance Libyan biology teachers' PCK and instructional practice.

The incorporation of the quantitative and qualitative approaches in data collection is mostly used in mainstream social science and research in education (Creswell, 2009; Teddlie, 2003; Ivankova, Creswell, & Stick, 2006), the main reason being that "neither quantitative nor qualitative methods are sufficient, by themselves, to capture the trends and details of a situation" (Ivankova et al., 2006, p. 3). Thus, using a combination of quantitative and qualitative approaches allows for "a more robust analysis, taking advantage of the strengths of each" (Ivankova et al., 2006, p.3).

A mixed-method design has some advantages such as the enhancement of data, collection of data in creative ways, and the confidence that a researcher could gain from the findings (Johnson, Onwuegbuzie, & Turner, 2007). Despite these advantages, however, it has been criticized by the supporters of qualitative interpretive research for various reasons. For example, according to Howe (2004), the quantitative approaches tend to dominate the quantitative component thus relegating the qualitative component to a secondary status (Creswell et al., 2006). In keeping with the above-stated claim, it does not mean that researchers with an inclination for interpretive design offer qualitative research a primary role in their mixed methods design (Creswell et al., 2006). Yet, it agrees with Mason's (2006) belief according to which the mixed methods design can enhance and extend 'the logic of qualitative explanations about the social life' (p. 2).

In keeping with the above, I have decided to conduct the present study like the one that should be explanatory and descriptive in nature. The exploratory facet of this study can help provide an in-depth qualitative and quantitative exploration of the in-service programme activities, the observation, and the interviews conducted to inform this study, while the descriptive one examines quantitatively and statistically the Wilcoxon signed-rank test (p-value variables), the result of paired samples t-test for teachers' scores on ODDT, and the combined ODDT pre and post results as well as the percentages of teachers' selection of the desired content choice and the combination of content choice to determine whether the change occurred. Without this quantitative aspect of the study it could not be possible for me to make a viable conclusion about teachers' growth. Nevertheless, this requires a "lengthy time and feasibility of resources to collect and analyze both types of data" (Ivankova et al, 2006, p. 5).

3.2 The population of the study

The term 'population' refers to a group of people who have the similarity of characteristics accordingly to the study objectives and research plans to draw inferences (Hart, 2002). As mentioned previously, the current investigation is about Libyan biology teachers' PCK, the ideal population would have been all the biology teachers in secondary schools in Libya. However, there are seven districts in Tripoli, but the project took place in the Hai Alandalus district. The reason for selecting Hai Alandalus is that it is in the centre of Tripoli. Moreover, it has a teachers' training centre, which provided its facilities and supported me to conduct the workshop. Also, there are many secondary schools in the area and additionally, I could not consider all the seven districts due to financial and time constraints.

For convenience, I selected schools and participants that are very close to the training centre for ease and safety of travel due to the security concerns in Libya at the time. From these schools, I had chosen grade 10 biology teachers who were willing to participate in the project as shown in Table 3.1 below presents the demographic information of the participants in this study. The data shows that all teachers who participated in this study were females working in public schools. It is important to mention that in the 90ies, the national ministry of education had attempted according to the Islamic culture prevailing in the country, to establish the feminization of school teaching. This attempt has significantly influenced educational personnel in the country, to the point that the number of female teachers in most schools is very high. This implies that, the selected population of this study is the microcosm of the large body of Libyan biology teachers.

Table 3-1: Demographic information of the participants in the INST programme.

Items	Chooses	Teachers
Gender	Male	0
	Female	22
School Type	Private	0
	Public	22
Academic/Professional Qualifications	BSC	19
	BED	3
	MSC	0
Area of Specialization	Biology	21
	Chemistry	1
	Physics	0
	Others	0
Teaching Experience	0-2 years	2
	2-5 years	3
	Over 6 years	17

One might be curious to know why this study does not have male participants. As said earlier, education in Libyan is culture driven. According to Islam, the nature of a woman is to educate. In light of the above-stated claim, the teaching (education) carrier is mostly done by females. Based on an investigation conducted by Sarhan (2014) “of Libya’s working women, 73% choose careers in education or medicine”. As mention before this study a mixed methods approaches and the finding from quantitative data are background for participants to generate qualitative data findings.

Among the participants in this study, 19 teachers had a bachelor's degree in science and three teachers had a bachelor's degree in education. 21 teachers were specialized in biology and one teacher in chemistry. Moreover, 17 teachers had a teaching experience of more than six years, three teachers had between 2-5 years’ experience and two teachers had less than 2 years’ experience. All of the participants were female as this is very common in Libya, and also because males are not willing to work as teachers in schools. However, it should be noted that there is a very low percentage of males working in schools. The truth is that the majority of them do not necessarily work as teachers. They are either managers or they occupy other administrative and managerial positions.

Sampling procedures

The sampling technique is essential in any study, and participants must be carefully chosen (Quinn, 2002). They need to communicate and have no objections to the intended activities to be performed (in-service training programme in the case of the present study) for data collection. Besides that, Cohen, Morrison, and Manion (2017) offered a good contrast between the different types of sampling:

> There is a little benefit in seeking a random sample when most of the random sample may be largely ignorant of particular issues and unable to comment on matters of interest to the researcher, in which case a purposive sample is vital (p.115).

In keeping with the above claim and considering that sampling in mixed studies is complex, for the present study, I have chosen the purposive sampling technique and the probability sampling technique. The nature of the investigation and Cohen's point were reflected regarding the selection of participants for this investigation. Quinn (2002) argued that: "The logic and power of purposive sampling lies in selecting information-rich cases for in-depth study. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the inquiry" (p. 230). While the probability aspect of my sample was to achieve the representativeness, which is the degree to which the sample reliably represents the entire population (Teddlie & Yu, 2007), a purposive sample does have some merit.

Accordingly, purposive sampling deals with particular purposes and small populations. So this investigation "could provide a springboard for further research or allow links to be forged with existing findings in an area" (Bryman, 2004, p. 100). The primary variable used in choosing the participants was their experience in teaching osmosis and diffusion in grade 10 in secondary school.

I had thus invited teachers through the administration of schools to volunteer in the programme at the beginning of the school year. On the 10th, October 2017, 22 from a total of

113 grade 10 biology teachers attended the in-service training programme in Hai Alandalus. All the teachers were requested to practice and implement what they had learned during the workshop when they get back to their respective schools. Five teachers were selected for further observation at their schools for the second phase of data collection, interview, and observation.

3.3 Data collection procedure

Before the start of the in-service training programme workshop, all 22 teachers who had accepted to be part of the study, were administered the Osmosis and Diffusion Diagnostic Test (ODDT) (see Appendix E) to check their prior knowledge on these notions. They were administered a questionnaire (see Appendix A) subdivided into two sections. The first section contained the background information, their perspective on biology curriculum context, and support at school while the second section dealt with the subject matter context in Libya.

After the teachers participated in the workshop, they were asked to complete section (B) of the questionnaire (see Appendix A) and the Osmosis and Diffusion Diagnostic Test (ODDT) (see Appendix E). Their responses to these two instruments were the first phase of data collection. Thereafter they went back to their schools to practice what they had leaned. The second phase of data collection took place, which were interviews and observations as presented in Figure 3.1.

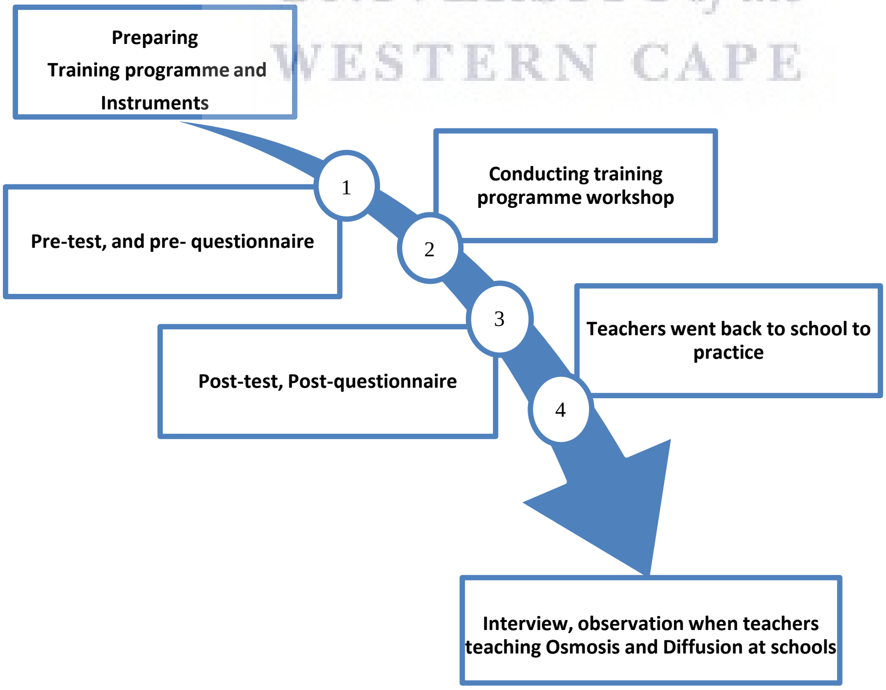


Figure 3-1 shows data collection steps

Data collection instruments

This study involved the use of a mixed-method (Figure 3.2). Based on the INST programme conducted with subjects, the study involved the development of a questionnaire, an interview schedule, and a classroom observation scheme. A combination of these instruments helped in the concurrent collection of both quantitative and qualitative data (see Figure 3.2 below) from the Libyan biology teachers' regarding their PCK and their practices in the classroom in a secondary school context.

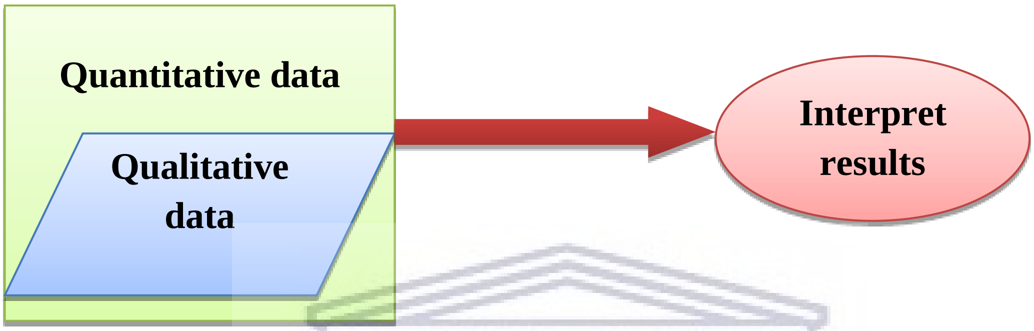


Figure 3.2: Concurrent designs

I could have based my study objectives on the use of qualitative research designs as phenomenology and narrative inquiry because these methodologies also allow the in-depth investigation of the participants' views and their stories regarding the research problem. Despite this, I believe that in the current research study a mixed-methods study design would be seen as a useful methodology to triangulate the findings in order to investigate teachers' knowledge and practices about teaching biology. Moreover, this allowed me to merge both qualitative and quantitative data and to provide a more complete picture of the phenomenon under investigation.

Furthermore, in the context of this study, I believe that the mixed methods methodology is an appropriate choice when taking into account the unexpected circumstances the present research can experience. Whereas narrative inquiry and phenomenology need access to the field of investigation where I have the opportunity to spend enough time with the participants, but, that was impossible at the time of data collection due to the Libyan revolution that started in 2011. It was unsafe for the teachers and education staff. Despite these exceptional circumstances, they guide me to adopt the graphic sequential mixed methods research design so that I could achieve a thorough understanding of the phenomenon under investigation by using a combination of qualitative and quantitative methods sequentially.

The aforementioned assisted me to explore teachers' content knowledge, their understanding of learners, and their knowledge of the subject matter they were teaching. Therefore, I used the questionnaire to gain a preliminary opinion of what the participants believed. The data so collected provided me with the necessary information on the phenomenon under investigation. Using in-depth interviews and an observation scheme assisted me to understand the social embeddedness of experience and practice in light of my communication with the participants.

As indicated earlier, the study attempted to achieve the following aims:

a. The teachers' in-depth understanding of the content they are teaching.
b. Their ability to access the curriculum materials for teaching effectiveness.
c. Their ability to develop effective teaching strategies.
d. Their ability to integrate their understanding of the content with their teaching methodologies.
e. Their ability to promote teaching/learning effectiveness.
f. Their ability to implement the curriculum effectively.

As mentioned above, to succeed the above aims concurrent quantitative and qualitative approaches were applied on the basis of the following instruments to answer the main and sub-research questions stated previously.

3.4 The INST Programme

Based on insights gained from the context analysis (Chapter One) and the review of the literature (Chapter Two), I designed and developed a professional development programme. It was labeled as the INST programme and aimed at improving grade 10 secondary school biology teachers' PCK. Throughout the following sections, I propose to formulate the programme's design guidelines to highlight its aims and development process. Thus, I describe and justify the preparation of the curriculum material, which is one of the key elements in the programme. After this, I present activities elaborated in the preparation of the workshop, which is another important element of the programme. Then, I describe the teachers' collaboration, a part that plays a central role in the programme; lastly, I present a summary of the section.

3.4.1 The INST programme design guidelines

In this section, I describe the strategies that helped me to prepare the programme. These strategies were founded and based on context analysis facts (Chapter One) and literature review schemes (Chapter Two). This implies that the context analysis provided a rich representation of the features of biology teachers in Libya and their learning requirements. The chapter also emphasized on in-service education programmes intended to increase teachers' professional growth, besides their possible limitations in meeting their learning requirements. The literature review provided a general idea of the essential characteristics of the professional growth programme. It also emphasized the fundamental role that teachers' collaboration accomplishes in the process.

The combination of information from Chapters One and Two has formulated the following primary strategies for the INST programme:

1. Keeping in mind the profundity of the issues and needs of Libyan biology teachers' experience in terms of pedagogy and content, it is important to take small steps and cautiously express the aims of the programme that could help teachers in improving their PCK.
2. As explained in Chapter One and Two, increasing teachers' PCK in biology teaching practices is looked at as a significant fact, as it has the possibility to encourage and help teachers' education. This should also emphasize different collective activities. To motivate teacher's work, curriculum materials are looked at as a significant strategy, because they can motivate teachers to cooperate with colleagues both in conventional and unconventional ways. The objective of the material should not only help them with subject matter knowledge, but it should also introduce them to learner-centred teaching practices. In a practical way of doing this, the materials should consist of specific assistance in combination with the 5Es strategy as follows:
   - Engaging learners.
   - Exploring phenomena
   - Explaining phenomena
   - Elaborating phenomena
   - Evaluating learners (Bybee et al., 2006).
3. A workshop is seen as an important way for ample cooperation in the use of programme materials. The workshop's objective is to familiarize teachers with the

core characteristics of the programme materials and the 5Es strategy phases. For its materialization, the workshop should involve the following modules:

- Demonstration of the Osmosis and Diffusion unit, which was conducted by the researcher using the activities and materials (textbooks); this permits teachers to expand their knowledge of the subject matter and gained new insights on how to conduct teaching in an activity-based way.
- Group work where teachers debate the unit, point after point, to improve activity-based teaching skills and perception into the subject matter knowledge.
- The co-planning of lessons by means of which teachers get the chance to share ideas on how to organize lessons with the materials in combination with the 5Es strategy.
- Micro-teaching sessions through which teachers exercise the teaching of osmosis and diffusion in a training situation and get feedback from me and from their team-mate and colleagues who were attending the training session with them.

To further encourage biology teachers, in student-based settings, the local background is judged significant. Teachers are required to help and inspire their students to run more activities via the use and implementation of 5Es strategy (Demirdöğen, 2016; Hoskins, 2013; Sickel & Friedrichsen, 2015)

3.4.1.1 Development of the INST programme

This section relates to the extensive expansion of the INST programme before describing the programme and its different elements in detail. It provides an impression of the activities incorporated into the development of the programme and discusses its principal objectives.

a. Overview

The development of the INST programme was centred on the project strategies and was made up of the following key elements:

- Curriculum materials (Osmosis and Diffusion Unit).
- 5 days workshop.
- 5Es strategy guidelines.
- Facilitator (researcher).

The elements of the programme were developed concomitantly based on the project strategies. All phases of development comprised formative evaluation to define the realism of the programme, to identify its weaknesses, and to conceive ideas for upgrading (Nieveen, 1999). Throughout the process, during each phase, one of the programme materials was tested, and I participated in all the activities. Figure 3.3 below provides an overview of the improvement of different elements of the programme and the formative evaluation activities.

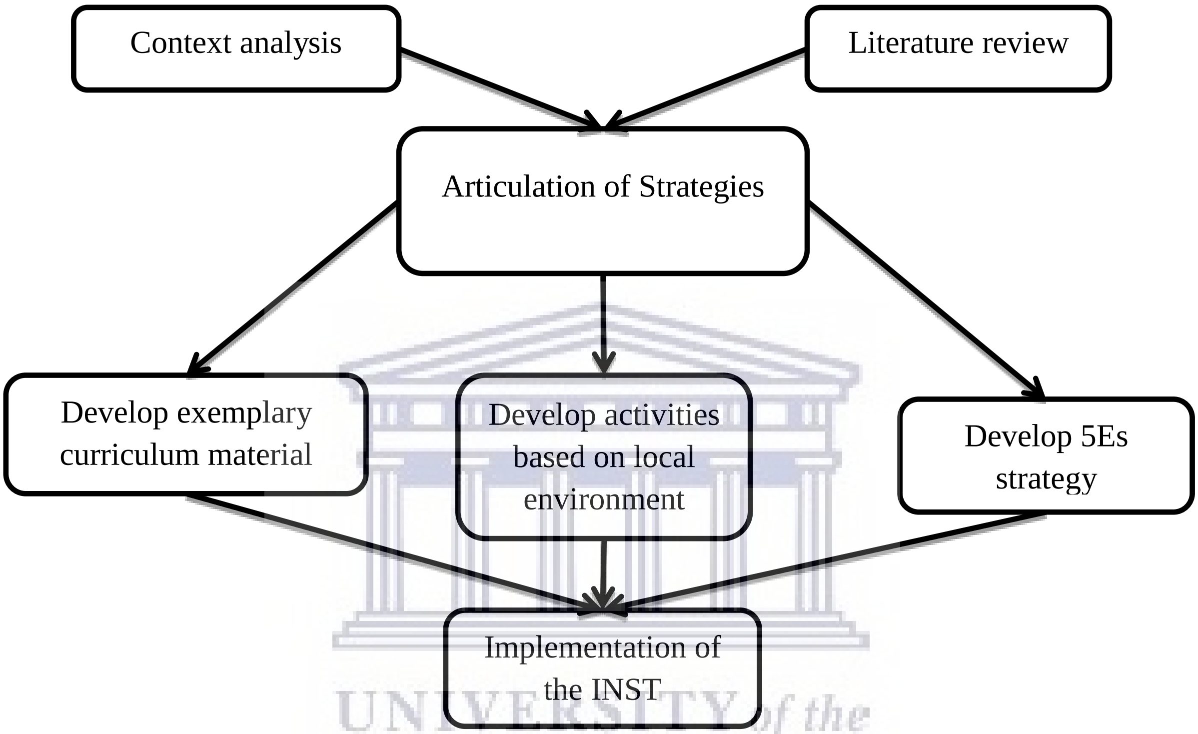


Figure 3.3: Schematic development of the INST programme

The programme was conducted to meet the needs of biology teachers' in Libya in terms of the effectiveness of biology teaching-learning requirements. The key motivation for including teachers in the programme activities was based on the fact that they are directly involved in the implementation of the curriculum and that they could assist to develop materials for use in the classroom (Loucks-Horsley et al., 2010).

They have quite a good knowledge of what materials are practical in the classroom and what would meet their students' needs. Another motivation for including them was to remain faithful to school-based professional development, which emphasizes that teachers should take possession of the programme and become accountable for the value of their teaching practice (Pugach & Johnson, 1995). By playing an active role in the materials development workshop, it was anticipated that these teachers could improve their comprehension of both content and pedagogy (Loucks-Horsley et al., 2010). Consequently, they would be in a better place to implement the core ideas of the programme.

The established INST programme involved five days of activities based on the osmosis and diffusion unit and involved three lessons. Each day was devoted to practicing one of the 5Es strategy levels. Therefore five days were considered adequate for the programme. The topics of these lessons were carefully selected as they were regarded as the most significant in biology concepts and challenging to be taught in grade 10. As they were teachers in different schools, they could provide a good idea as to how the INST programme could be appropriate and compatible with their respective schools' programmes and schedules. Considering helping teachers in piloting peer collaboration, I prepared a framework of work strategies. In trying to ensure that the strategies would work as anticipated, there was constant cooperation between myself and the biology teacher participants. After having discussed the overview of the INST programme, in the following section, I present the aims of the programme.

b. Aims of the programme

Supporting grade 10 biology teachers to improve their PCK was the main aim of the INST programme. In order to achieve this objective, a five-day workshop and peer-cooperation were the main foundations of the process. With reference to the design guide, the INST programme was projected to take small steps and cautiously express the aims that could enhance the teachers' PCK. In this regard, to properly support the teachers, the programme emphasized mainly on subject matter knowledge, because it is based on learning needs assessment. Many teachers in Libya showed a need for help in this area and it was estimated that it would be easy to help teachers if they have adequate subject matter knowledge in terms of pedagogical knowledge.

The grade 10 syllabus contained many potential errors, which if not confronted would become totally embedded. It was thus significant to assist the teachers in handling these errors so as to enable them to become better teachers. To assist them in teaching Osmosis and Diffusion in a learner-centred way, the grade 10 secondary school syllabus of biology in Libya (referred to above) indicates that the INST programme should emphasize activity-based techniques of teaching. The activity-based techniques would be used to support teachers/students to grow an interactive understanding to conceptualize knowledge and biology concepts.

In order to realize these activity-based techniques of teaching, the following practices were followed:

- ***Hands-on activity:*** it is supposed to persuade teachers to practice biology–experimenting first, using physical items available in their surroundings while having solid knowledge. This means that teachers are expected to practice what would help them in their teaching practice and help them clear the misunderstandings that are linked to it.
- ***Authentic activity:*** it is supposed to allow teachers to practice Osmosis and Diffusion activities that are directly connected to real-life situations and to employ local or available material. In order to permit the use of different techniques during the practical process, it was decided to equip them with a number of teaching and learning activities.

During these activities disagreement between teachers is welcomed and highly encouraged as the above support the subject matter knowledge and activity-based teaching involved within the curriculum materials.

After having presented a detailed picture of the design, the development of the INST programme's key elements are presented in the following sections:

c. Development of the activities and material

In this study, curriculum material was seen as a key element in helping biology teachers to improve their PCK in the teaching practice of osmosis and diffusion. The main objective was to increase teachers' self-reliance and aptitude to use local materials in teaching these topics in particular, and other topics in general. This section presents the materials preparation workshop; organization and elements of the first draft of the materials as well as the formative evaluation of the materials, which comprised expert opinion and experiment.

d. Material development workshop

I had organized a 5-day workshop in order to offer the teacher participants an advantageous environment to model materials. The objective of the workshop was to elaborate on the first set of programme materials likely capable of helping biology teachers to develop their PCK on the Osmosis and Diffusion unit and various topics of the discipline in general.

e. **Plan and organization**

It would be very difficult to evaluate teachers' success and preparation if there are no well-defined objectives. Consequently, examples of well-defined objectives were proposed and the participants were asked to define objectives that were weighed in terms of their adaptability and practicability to the situation. Emphasis was also placed on how to plan classroom activities. In keeping with the above, they were requested to plan activities that would mirror students' everyday lives, as well as their abilities.

In preparing the materials, it was decided to follow the main headings and sub-topics under the three themes in the Osmosis and Diffusion unit syllabus. Teachers were asked to prepare different lessons based on these subtopics for their practice. This means that lessons were prepared and discussed in groups. Then, at the end of each day, the four groups would meet for the demonstration of the lessons and activities prepared earlier. After each demonstration, the participants and I discussed the lessons by providing feedback and suggesting corrections. This technique was used throughout the workshop. The five days spent on the workshop were considered adequate to prepare intensive lessons.

After their initial information was gathered, the participants were divided into four groups. These groups were carefully selected so as to have balanced groups where active disagreement about lessons could easily be observed. For a good mixture of participants, teachers representing the same school were placed in different groups. These groups were maintained, without any change, until the end of the workshop.

f. **Outcomes of the workshop**

As a result of the workshop, four lessons on Osmosis, Diffusion, Active transport, and Surface area to volume ratio were prepared and argued as indicated in Table 3.2.

After the workshop activities, I collected the teachers' opinions about the workshop by means of a post-workshop questionnaire. In general, the majority of participants indicated that the workshop was very useful. They stated that it facilitated an exchange of expertise among them about the teaching of Osmosis and Diffusion. They also found that preparing lessons in a team was beneficial and enriched their subject matter knowledge and their capacity to teach through activity-based techniques.

Table 3-2: Lessons participants worked on during the five-day workshop

Unit	Lessons	Title [Topic]
Osmosis and diffusion	Lesson 1	Osmosis
	Lesson 2	Diffusion
	Lesson 3	Active transport
	Lesson 4	Surface Area to Volume Ratio

Furthermore, they maintained that preparing the activity-based lessons with local material taught them how to make students fully participate in the teaching and learning practice. They further stated that the materials necessitated being revised to meet the needs of the current learner-centred approach. Additionally, through casual discussion, it was observed that the exercise was beneficial and that it should be employed for other areas of the curriculum and also for a larger group of teachers.

g. **Formative evaluation of the activities and material**

i). Expert evaluation

After the programme has been developed, compiled and typed, it was submitted to two experts (a biology lecturer from the Department of Science Education at the University of Tripoli (UOT) and the head of the teachers' training unit at the Libyan Teachers' Training Centre (LTTC) for comments and additional views. Their task consisted of suggesting ways to improve the organization, and the validity of the content of the materials, based on Libyan classroom realities. During the interview, the experts were asked to provide criticisms and ideas that could enhance the quality of the programme.

The experts were further requested to consider whether the aims were realistic; the significance of the content and the proposed classroom activities were reasonable in terms of content coverage and use of local materials. They commented that the programme adequately covered the biology content for the target sample and also that the issue related to the comprehension of the content was resolved. They further commented that teachers seeking development and making use of the document could easily teach Osmosis and Diffusion without any problems resulting from misconceptions and misunderstanding of the concepts and their applicability.

Since these experts were aware of the problems many teachers were experiencing in teaching because of their deficient knowledge, they approved the idea of the INST programmme to help teachers. They stated further that the materials were significant and would meet the teachers' needs. Also, they estimated that teachers should familiarise themselves with teaching the topic by means of the new activity-based techniques, which should help them prioritize student-centred teaching and learning practices. They proposed that the materials should be embedded in a workshop to help teachers acquire sufficient information that can help them teach the topic much easier.

The experts also recognized that the goals of the workshop were achievable and the activities were concrete and useful for classroom presentation. In general, they agreed that the materials were basically learner-centred and that they covered the syllabus requirements and the biology curriculum objectives. They did not suggest any major improvements to the objectives, teaching activities, or content. After this evaluation and feedback from the experts, the programme was reviewed and all the amendments and ideas were incorporated into the final document. Lastly, the activities and materials were tested to check its efficacy.

ii) Trial of activities and materials

The preliminary exercise involved two biology teachers in two different secondary schools. The purpose of the exercise was to explore the practicality of the material and hands-on activities, that is, to observe whether teachers would be competent enough to use the proposed materials and activities (Nieveen, 1997). Each teacher used activities and a technique as the trial coincided with their teaching of Osmosis and Diffusion. However, only one observation for each teacher was conducted, whereas events focusing on teacher-student interaction as well as activity-based teaching suggested in the programme with the activities textbook materials were recorded. At the end of the trial, the participating teachers were interviewed so as to get their opinions about the usefulness of the exemplary materials, in general in terms of the aims, content, classroom activities, and the proposed exercises.

The teachers claimed that employing the activity-based approach was fairly new, considering that they were accustomed to the chalk-and-talk method. They also noted that some of the suggested experiments like using egg and dye to observe Osmosis were unfamiliar to the students. This observation was revealed to be a problem related to exposure, rather than the programme activities. Although the teachers could not carry out the activity-based lessons effectively, as the method was very new to them, they thought that the programme materials were suitable for biology teachers, because of their potential benefit. They commented that the materials could help guarantee students' participation in the classroom and reverse the lesson from being teacher-centred to student-centred. They also commented that a sense of collaboration could be developed among students, because of the activity-based nature of the lessons. This perception of collaboration could be facilitated by means of group activities from which learning could be a mutual practice rather than a personal one. The perception of collaboration could also be promoted among students and teachers especially if teachers happen to understand that their students can practice by themselves if provided with appropriate guidance. They might, in turn, develop a comprehension of teaching and learning as a process, rather than a teacher-centered activity only.

About the teaching aims of the 5Es, the teachers stated that they were suitable and achievable and the lesson contents were pertinent. They also maintained that the lessons could meet the teacher's organization of the work. They further noted the number of students in the classes could hinder the proper implementation of the lesson activities. Regarding the exercise and assessment ideas, they observed that they contained no prepared answers. They argued that this could restrict their practice of the materials and if the materials were to assist teachers to develop their knowledge of Osmosis and Diffusion, in that way they should have the answers to the problems, which would allow them to make sure whether they are correct or incorrect. These revisions were considered in the programme.

h. Workshop programme

In order to help biology teachers improve their PCK through content knowledge, pedagogical knowledge, and understanding learners in the teaching of Osmosis and Diffusion, the 5-day workshop was considered as a significant element of the INST programme. The objective of the preparation of this workshop was to familiarize teachers with the materials on Osmosis and Diffusion as well as the activity-based teaching approach. It was estimated that through the following, teachers would have the chance to develop their PCK:

- demonstration lessons,
- hands-on activities using local materials,
- group work,
- co-planning of the lessons,
- Micro-teaching sessions.

In terms of learning, teaching, and professional growth, it was valued that the workshop would succeed to increase teachers' understanding of osmosis and diffusion on how to demonstrate it; give them time away from the classroom and the chance to reflect, debate alternative justifications, cooperate with their peers and exercise new ideas and methods and thus get help from their peers (Joyce & Showers, 2002; Showers, 1985).

The researcher prepared the framework of the 5-day activities-based workshop. The choice on time allocated for each activity in the framework depended on the significance of the activity. The framework involved the following:

- A demonstration of the 5Es strategy more particularly on the meaning of activity-based teaching in connection to the learner-centred or teaching-learning approach.
- A subject matter demonstration and deep discussion of all the lessons.
- An argument based on how lessons are taught.
- A micro-teaching seance from which all participants would prepare teaching activity-based on Osmosis and Diffusion lessons by planning short 20-minute lessons.
- A comprehensive report of the 5-day workshop is provided under the workshop programme strategy.

i. Workshop design

The in-service training programme that was planned for the biology teachers, aimed to help them comprehend how to use the 5E's model and to facilitate them how to teach, Osmosis, Diffusion, and Surface area volume ratio. As a result, the training enhanced biology teachers' PCK of the selected unit. The training programme was planned to conform to the objectives of the biology course in the Libyan curriculum and to render a more realistic biology teaching practice. The 5Es instruction included the comprehension and practice of the following steps Engage, Explore, Explain, Elaborate, and Evaluate. The sessions were conducted through dynamic and profound discussions based on each of these steps. Different activities conducted during this training programme were intended to help the teacher participants in preparing, executing, and conveying competently the knowledge of biology to students.

j. Objectives of the in-service training programme workshop

It was anticipated that by the end of the in-service training workshop, participants would:

1. Have a deep understanding of Osmosis and Diffusion.
2. Use the 5Es model to deliver the notions of Osmosis and Diffusion.
3. Be able to generate multiple-choice questions as well as short answer questions, and structured questions related to the unit.
4. Be able to represent the unit using different methods.
5. Understand how to make visible what students think about the content.
6. Be able to select assessment methods consistent with the functions the examination is to serve.
7. Be able to link the unit to the students' everyday life.

k. Training programme methodologies

The in-service training was collaborative and participants were introduced to the options of using different teaching methods. They were also presented with new information and skills that could assist them to improve as competent biology teachers. In this way, the training did not only give them an occasion to think critically on their current teaching practices but also to practice other strategies to improve their action plans for achieving excellence in their schools. The methods below were used throughout the training programme: Arguments, presentations (both individually and in the group) and demonstrations. The 5-day workshop involving all the participants was organized to introduce: the biology programme, the new model materials; demonstration of lessons, group discussions, preparation of the lessons in groups, designing of activities related to local materials, and micro-teaching sessions as indicated in Table 3.3.

Table 3.3: Timetable for the first day of the workshop

TIME	DURATION	EVENT	NOTE
9:00	90 minutes	• Welcome. • Registration.	Researcher explaining the aim and the procedure of the workshop and answers any other questions
10:30	**30 minutes**	**Break and tea**	
11:00	45 minutes	**session (1)** Introduction and first steps of the 5Es model: Engagement: • How to elicit students' prior knowledge? • How to engage it to new knowledge? (Presented by the researcher)	- Presentation - Video
11:45	45 minutes	**Activities (1)** Group-work: Analyzing the topic and preparing appropriate activities and questions to elicit students' prior experience about the topic and their link to the new knowledge. (Groups of subjects)	**Topics** - Group (a) Diffusion - Group (b) Osmosis - Group (c) Surface area volume ratio - Group (d) Active transport
12:30	30 minutes	Discussing /debating and summarizing participants' outcomes and writing them on the mainboard (All the members)	
1:00	**30 minutes**	**Lunch**	
1:30	60 minutes	Questions and discussion to motivate and prepare teachers for the next session: - Which activities are you using to present a new concept? - Is there any local material we could use in conducting these activities?	Questions to Ponder
2:30	**End**	**End**	**End**

In the following section, I present and describe the main activities that constituted the INST programme workshop.

- A demonstration unit of Osmosis and Diffusion that was conducted by the researcher on the basis of the textbooks. The objective of this activity was to help biology teachers in gaining a new understanding of the osmosis and diffusion subject knowledge. The demonstration lesson also aimed at presenting teachers with new ways of teaching osmosis and diffusion using the activity-based approach. It should be noted that the demonstration unit during this programme was planned to explore one step each day of the 5Es strategy.
- Group-work that was based on groups of participants. This activity aimed at giving participants an opportunity to share ideas on the ways of teaching successfully using the activity-based approach, considering the conditions prevailing in their schools such as large classes, lack of appropriate teaching aids, etc.. It also aimed at providing teachers with collaboration experience. Each group had to co-plan a 20-minute micro-lesson.
- Group Discussion was held to provide participants with adequate opportunity to discuss and argue in detail other possible and remaining lessons contained in the materials. This activity was conducted following the belief that learners learn best when they are actively engaged in the process. In the same perspective, Tobin (1993) claims that elucidating something to an equal usually helps one to perceive things in another way and more clearly and spot irregularities in one's own comprehension. The participants were gathered in small groups of 4 to 5 subjects (teacher participants). They were expected to argue the concepts of (1) Osmosis in an animal cell and plant cell, (2) Diffusion in liquid and gas, (3) Surface area to volume ratio using potato slides as well as (4) active transport. This exercise aimed at enabling them to acquire a better understanding of the concepts to be taught. Through this exercise, they identified places were the concepts were not clear, and also the seemingly difficult ones. It was conducted in the form of an argument from which they expressed their opinions to clarify obscure areas of the unit.
- Micro-teaching that aimed at enabling the participants to exercise the teaching of Osmosis and Diffusion using the activities based on local materials in a very simplified and restricted environment. Each participant presented a lesson that was prepared in a group, which was followed by a discussion. To carry out this activity, the participants reversed their roles. They were participants – teacher, observer, and student. The observer recorded the events during the lesson and later on discussed them after the lesson. These events were used as the basis of the discussion. This

activity was intended to help them increase their experience in conducting a classroom observation.

l. Peer collaboration

Peer collaboration plays a significant role in the INST programme. In the present study, it has helped biology teachers to increase their discernment in the manner to conduct collective activities about osmosis and diffusion. It has also helped them in the manner to conduct different types of collective activities to improve their PCK. Successful collective activities proposed were the following:

- Co-planning of the lessons: it was part of group work initiated in the workshop that consisted of encouraging participants to prepare their lessons in a group so as to share ideas about how the unit can be best taught under normal circumstances.
- Observations: it was an activity that consisted of mutual observation of biology teachers. They observed each other, especially while presenting the activities of lessons. Each observation session was followed by feedback based on the presentation. This feedback consisted of helping participants improve their teaching skills and reinforce their teaching practice and provide constructive hints (Showers & Joyce, 1996; Gottesman & Jennings, 1994). In sum, the main purpose of the observation was to strengthen participants' teaching approach skills acquired during the workshop sessions to deal with the 5Es strategy. It was accompanied by a follow-up consultation between the researcher and the participants based on how to conduct activities and present them in an appropriate manner as proposed by the 5Es strategy.
- Study groups were an activity that consisted of preparing participants in the workshop to prepare a lesson to be taught in their respective schools using activity-based strategies.

The workshop expected to see each participant implementing the ideas developed during the training programme to teach Osmosis and Diffusion in real classroom situations.

m. Synthesis

In this part, I have presented the preparation and development of the INST programmes in reference to perceptions gained from the contextual analysis and literature pinpointed in this study. The improvement of the programme involved different groups but focused mainly on biology teachers. The programme aimed at helping grade 10 secondary school biology teachers to develop their PCK through content knowledge, pedagogical knowledge, and understanding learners. It focussed on the subject matter and the knowledge of the curriculum, because of teachers' need for help in this area. The Osmosis and Diffusion unit was selected to be the principal focus of the programme in order to avoid inadequate coverage of many topics. The choice of this topic was justified not only by the fact that many teachers assume these concepts are difficult to understand and teach, but also because there are many misconceptions about them that need to be addressed.

Peer cooperation was considered a significant part of the programme as teachers could help one another by employing different strategies during the programme. The materials constituted another significant element of the programme. It covered four activity-based lessons that covered the grade 10 syllabus unit of Osmosis and Diffusion. These lessons were developed on the basis of activity-based strategies to help teachers use the learner-centred method. The materials also covered procedural guidelines to help teachers teach lessons in a step-by-step, reasonable way following the 5Es strategy. The target was to ease students' involvement in classroom practices.

Teachers could improve their knowledge of the subject matter in Osmosis and Diffusion and acquire new ways of teaching from activity-based principles. The materials designed by the researcher were then presented to experts for assessment and tested on a small scale, which helped to its improvement. This process was totally different from the ways materials are usually designed in Libya. It has been observed that it is beneficial to have this type of formative evaluation so as to gather different propositions and opinions on how to improve the materials. Even though the content of the materials was much respected by the teachers and care taken to use simplified teaching techniques, a major problem was observed during the implementation of the activity-based lessons. Only a few teachers were able to use them effectively in their teaching practice, because of the difficulty of deviating from the chalk-and-talk method. The activity-based approach seemed quite new and inspiring them. This indicates that the materials by itself were not adequate. This is why the workshop was fundamental to help teachers in their endeavor to gain an understanding of ways to continue with activity-based teaching.

Despite the fact that I worked to help teachers by means of my demonstrations of the lessons and organization of collective activities such as co-planning and micro-teaching, the most important focus of the workshop was to help biology teachers acquire a new understanding of the subject matter bearing in mind the time constraints of the programme and the school year planning.

The following section presents the first tool used to examine the effectiveness of the INST programme and different activities conducted in favour of biology teachers.

3.4.2 Questionnaire

In light of the research design of this study, the first tool used for data collection was a questionnaire, which was designed for the present study to be able to gain a preliminary understanding of the phenomenon under investigation. Besides, there are some contextual reasons for the use of the questionnaire as the first phase. To illustrate the above claim it is important to mention that studies conducting surveys are common in Arabic educational search settings and Libya is not making an exception to this.

Choosing data collection methods does not depend on research questions only but on the original research situation including what works most efficiently, in that case, to provide the data needed (Maxwell, 1999). Moreover, the questionnaire helped me to get access to my participants, and more particularly to those who were willing to participate in the interview. The reason is that most Libyan females in general and teachers, in particular, are not familiar with interviews and observations especially the taking of photos and recording of videos. To avoid any misunderstanding related to the above, I took my time to provide them with adequate information to clarify their inquiries of the data collection methods. Having access to the fieldwork, I was introduced by the Libyan Teachers' Training Centre coordinators and administrators on the first day of the workshop. I also provided them with more information on the purpose of the study and the five-day workshop. The workshop gave me a chance to establish a relationship with the participants and to gain an understanding of their social world of needs in their teaching.

3.4.2.1 Questionnaire Design

The questionnaire (see Appendix A) is constructed based on research questions of the present study, namely, the influence of in-service training programme on teachers' knowledge of teaching, precisely the context of biology curriculum they are teaching and their practices. Two constructs were developed, the first section consisted of 20 items to collect the general perception of the need for teaching biology in Libya and the second section was divided into four phases, namely, context variable, input variable, process variable, product variable.

The questionnaire began with an attached cover letter, to inform the participants about the context and purpose of the investigation. Moreover, it assured them of confidentiality and anonymity (Punch, 2009), that their participation was completely voluntary, and they had the choice of access to the questionnaire's results (BERA, 2004).

The first section of the questionnaire consisted of 20 items, in the first part items 1-6 required the participants to provide background information, such as the workplace, gender, school type (government and/private school), academic/professional qualifications, area of specialization and teaching experience. The second part from items 7-16 were intended to quest about the teaching preparation of the biology curriculum, the suggested the topic, the scheme integration, the arrangements of the course contents, the suggested activities, the teaching strategies, the time allocated for teaching, the problem teaching topics, the instructional materials, the equipment, and the teaching facilities required for effective teaching of biology, the biology laboratory materials, the infrastructures that are needed to perform some of the activities suggested in the Biology core Curriculum.

The third part of the first section from items 17-20 were open-ended questions that were raised to explore the influence of the training workshops, the social and the cultural context of teachers' knowledge, and the practice of teaching biology. As mentioned by Patton (2002), "the reason behind gathering reaction to open-ended questions was to allow the researcher to understand and capture the points of view of teachers without predetermining those points of view through the prior selection of questionnaire categories" (p. 21). These questions were questing whether the participants had ever received any training or attended any seminar/workshop on the teaching of biology, experience challenges affecting educational development in Libya, and also their opinion to solve these problems.

In section two, a Likert scale was applied, which is a commonly used technique. It provides a range of replies to a given statement (Cohen et al., 2007). Questions were asked to teachers to select one of the categories, which best reflects the degree of their consensus, in the following order Strongly Agree=SA, Agree=A, No Opinion=NO, Disagree=D, Strongly Disagree=SD. The reason for using the Likert scale is to have more in-depth answers than a simple yes/no format to allow participants more opportunity to express their opinion. As an interpretive researcher, this allowed me to find a greater variety of participants' responses. At the end of the questionnaire, the participants were asked regarding their willingness to participate in an interview and observation after the completion of the in-service training programme and to provide their contact details.

The questionnaire was developed based on several sources. Firstly, I read the literature extensively based on two main areas: teachers' pedagogical content knowledge (PCK) and professional development (PD) in the science context, especially in biology. Secondly, I researched questionnaires related to studies similar to the current study. Also, the development of the questionnaire stemmed from my teaching experiences as a biology teacher, a teacher trainer in Libya as well as a lecturer at the Faculty of Education at the University.

3.4.2.2 Validity and reliability of the questionnaire

The validity of the questionnaire is the extent to which the questionnaire items measure what they are designed to measure (Cohen et al., 2007). Validity consists of two types, namely, content and constructs validity. Construct validity is established on the basis that the constructs of the research consider the literature review substance. According to Cohen et al. (2007), "to establish construct validity the researcher would need to be assured that his or her construction of a particular issue agreed with other constructions of the same underlying issue this can be achieved by rooting the researcher’s construction in a wide literature search which teases out the meaning of a particular construct and its constituent elements" (p.138).

The construction of the questionnaire is thus based on the extensive literature about teachers' knowledge of pedagogical content for the biology context they are teaching. As stated in Chapter Two, I addressed the elements and variables of teaching as well as rating scales and criteria. Thus, I selected items that I considered the best to represent the crucial variables of teachers' knowledge of the biology curriculum in the context of Libya. This process assisted me to address the construct validity.

Content validity addresses a content review that needs to be offered by experts who can determine whether the scale items express the notions of the questionnaire that are expected to be measured. Based on this, I had several consultations with the three experts who had experience regarding the construction of questionnaires in the field of teachers' professional development domain. Two of them were experts in the biology context and one in social sciences. The content of the questionnaire had changed several times in response to some of their suggestions. Thus I made many modifications to some of the items including the structure, wording, and terms applied. Whereas no selection of items can be assumed to present a full picture, since we all have various views of what is necessary, it was my view that the final form probably provided a reasonably valid instrument to explore in-depth participants' views.

After having discussed, the first tool I have used for data collection in the following section I present the second one: the semi-structured interview.

3.4.3 Semi-structured interview

The most powerful source of data collection is the interview that has many advantages. For instance, it provides one-to-one interaction between the researcher and the participants (Tashakkori & Teddlie, 1998). Using it in the current study assisted me to explore the research problem from the teachers' perspectives. Also, it has an advantage over other data collection tools in that it allows for further interpretation if the question is not clear or if the answer is ambiguous, which is not the case for the questionnaire (Tashakkori & Teddlie, 1998).

Moreover, the semi-structured interview provided me with an opportunity to discuss and clarify topics with the participants in more detail. For example, it helped me to encourage the participants to elaborate on the original responses (Hancock, 1998). Furthermore, there is flexibility in presenting the questions, and they may not precisely follow the sequence in the list of questions. Besides that, the researcher can ask questions, which are not on the interview schedule, thus giving the participants a great deal of freedom on how to respond.

Furthermore, an interview elicits the actual beliefs of the participants (Shore, 1986) as it is an efficient way to understand the teachers' knowledge of teaching, transforming knowledge and understanding what they do and why they do it from their perspectives. In terms of words, because no one cannot observe everything he/she may want to know, interviews can afford access to the context of teachers' action and thought (Seidman, 2013), and therefore this tool provided me a way to explain the meaning of teachers' action. In this regard, I conducted interviews with each teacher as well as made classroom observations. I thus employed semi-structured interviews in which the interviewees were ready to tell their stories in their own words, (Smith, 1995). As a consequence, during the interviews, I probed interest in raising concerns and further modified the interview questions to a particular context. This approach enabled me to move beyond my personal experiences and ideas to comprehend the teachers' points of view. However, I was concerned that the respondents might have been giving positive responses based on my expectations. To remedy this, I asked additional general questions

Interview Questions development

The interview questions were adopted and modified from earlier studies particularly form Park's (2005) interview schedule to investigate the influence of the in-service training programme on biology teachers' PCK. The interview schedule consisted of five sections (see Appendix B). The first was about their background in teaching biology. The second was about planning for a class or a unit. The third was about the retrospective interview on teaching a class. The fourth was about changes that occurred after the training programme and lastly, the fifth was about the teachers' understanding of students' thinking about the content they are learning.

In total, the interview consisted of forty-four main questions. Also, I did not include issues related to their knowledge of curriculum context and school infrastructure, which I had addressed in the questionnaire. As discussed above, a semi-structured interview is characterized by its flexibility. This unique feature helped me to be an interpretive researcher to obtain a thorough understanding of the phenomenon under investigation.

After having discussed, the second tool I have used for data collection I will now present the third one namely, the observation.

3.4.4 Observation

Observation can lead to an in-depth understanding of more than interviews alone (Patton, 1990). Furthermore, it provides insight into teachers' knowledge of the context and subject matter they are teaching in reality and helps me to explore things that they are not themselves aware of, or they are not willing to talk about (Hoepfl, 1997). The reason for using participant observation is that while interviews provide detailed information about teachers' knowledge, the observations provide direct evidence or data of their action. This can be a good example of a triangulation of data (Guion, Diehl, & Mcdonald, 2002).

While the semi-structured interview was conducted to achieve an understanding of teachers' PCK and understanding of learners by the discussion of teachers' interpretations and beliefs in teaching biology, the observation helped me to explore the range of which such experience is reflected in teachers' practice in the classroom. It helped me to investigate the relationship between what teachers said in the interview and what occurred in their classrooms (Loughran, 2004). Also, research on teachers' PCK needs to be carried out in the classroom circumstances so as to understand the teachers' in-depth living experience.

Besides that, observation assisted me in exploring further social and cultural factors, which have the possible potential to influence teachers' knowledge and practice in the Libyan context. Participant observation is seen as a suitable instrument to collect data for this investigation. The selection of the observation strategy was dependent on the assumption that it is used as a reference point to gain more understanding of teachers' practices of transfer of biology concepts to their students in a natural environment and the manner in which their knowledge of pedagogical content is represented in their teaching practices.

During observations in this research, I mostly used a video camera and observation schedule to collect data. The videotape assisted me to explore how deep teachers' knowledge of content and students' thinking about the content was embodied and represented in their teaching practices in the classroom. It was also an essential part of recall interviews. In addition, it has the advantage to revisit the recorded events and reflect on them during the data analysis process (Pirie, 1996). Documented notes were a necessary part of the observation process that thus helped me to record essential events about the teachers' actions in the classroom.

3.4.4.1 Design of observation schedule

In the current study, the observation schedule (see Appendix D) was designed to follow the teacher's action during the classroom practice. Its introductory section was prepared to record and capture the data about the date, class, teacher, observer, and number of students, length of observation, lesson topic, and lesson objectives.

The observation segments were stored on a recording. The observation categories were: to elicit students' preconceptions, to determine how clear the lesson goals were, to follow the teaching instruction and activities, to observe the teacher's behaviour at the presentation of the information, her interaction with students, the students' evaluation approaches and the conclusion, as well as the class discussions and how they were implemented. The researcher had addressed three notes for each category which are: NO=Not Observed, ONPW= Observed but not performed well, OPW= Observed, and performed well.

I was aware that I am using specific categories in the observation schedule that might influence my decision to focus on particular issues only, which are pre-identified categories. Accordingly, to the nature of the current study, I attempted not to be limited to the observation categories and followed Mason's (2006) view, which aims to have a sense of adequate attitude and selectivity. I was thus mainly interested in what was happening in the classroom. Indeed, my experience and preconceptions from a work of literature served as a filter for understanding what I had observed and recorded.

As discussed above, field notes were obtained during the observation process. Brodsky (2008) has mentioned that field notes are useful in any qualitative study to help the researcher to "record in-depth descriptive details of people (including themselves), places, things, and events, as well as reflections on data, and the process of the research" (p, 342). This allowed me to include any other matters that seemed to be relevant during the observation time.

3.4.4.2 Video and audio recording

Throughout the in-service training programme sessions, a video camera was used to generate information and capture the teachers' reactions during the activities. They sat in four groups while each group worked on one of the unit domains, which were Osmosis, Diffusion, the cell's Surface area to volume ratio, and Active transport in cells. In the second phase, the observation and interview videotaped were used. The audio-tape was essentially used for teacher interviews.

The information gathered from the video and audio recordings formed one phase of data collection for this investigation. Bottorf (2003) mentioned that "video cameras are used to capture the behaviour of interests...video recording provides a rich data source for studying interaction patterns" (p. 753). In addition to the processes that generated textual data, photographic evidence was used to capture the features of natural environments and activities during the research. However, it is remarkable to indicate its limitation. For instance, Erickson (1986) remarks that the video camera cannot catch nonverbal feelings of teachers or participants in the classrooms. Also, Babbie and Mouton (2001) indicate that "Even tape recorders and cameras cannot capture all the relevant aspects of social processes. Consequently, in both direct observation and interview, it is vital to make full and accurate notes of what goes on" (p. 295). Given the previous, audio and video recording were further enhanced by field notes.

3.4.5 The Osmosis and Diffusion Diagnostic Test (ODDT)

It was conducted to determine teachers' understanding of the biological system and concepts and how the knowledge is effectively transferred during classroom practice. This was to check whether Osmosis and Diffusion concepts were understood in-depth and the importance of biological systems explored and contextualized. Therefore, more efficient teaching strategies could be developed. As mentioned in the literature, the content is the main component of PCK. In this regard, the current study intends to investigate the influence of the in-service training programme on biology teachers' PCK.

Data collection Procedures of the (ODDT)

The Osmosis and Diffusion Diagnostic Test (ODDT) adopted and modified from (Odom, 1995) was essentially developed to detect teachers' misconceptions and deep understanding of osmosis and diffusion and cell's surface area to volume ratio in biology. The diagnostic test was developed in relation to events that have been used in many studies. The instrument was built on the two levels of knowledge, multiple-choice format. The first tier of this test involved a content question with multiple choices and the second tier involved possible reasons to justify the first part's answer: three alternative reasons and one required reason. The alternative reasons depend on misconceptions and deep knowledge of the unit the teacher has.

The content of the instrument was defined and extracted from the Libyan biology textbook of secondary school grade 10, Unit two, which is Osmosis and Diffusion. The consideration of the textbook was to determine whether the face validity and the test questions matched all of the validated content specified by the propositional knowledge in the textbook. The statements and questions were on the level of the biology teachers. This means that the whole textbook was covered by the Osmosis and Diffusion diagnostic test (ODDT).

Combining interviews, observations, and the test can increase the confidence in the research findings to provide a clear understanding of the problem under investigation, even though it can be time-consuming (Guion et al., 2002).

3.5 Data analysis plan

I analyzed the quantitative data through the use of the Statistical Package for the Social Sciences (SPSS). I analysed qualitative data by generating themes and sub-themes. To come up with sub-themes and themes linked to my research questions, I considered the tools and techniques of qualitative data collection (semi-structured interviews and observation), as well as the collected data itself. I analysed the data in six different steps related to six phases of thematic analysis (Braun & Clarke, 2006). These steps support that thematic analysis seeks to understand the experiences of participants through six phases of analysis. One of the advantages of using thematic analysis is to ensure reliability through consistency in the analysis phases. Analysing teachers' perceptions swaying their PCK through thematic analysis helps to reflect various themes emerging on different perceptions of Libyan biology teachers. Thematic analysis enabled me to meet my study's objectives. Researchers, such as Braun and Clark (2013) and many others, have also used and proposed thematic analysis as an appropriate method to analyse qualitative data (Tuckett, 2005; Joffe & Yardley 2004; Attride-Stirling, 2001).

Here are the six phases I followed and used in the thematic analysis of data:

Phase 1: Familiarising self with data

It helped me to familiarize with my data. To do so, I listened to the audio recorded interviews and watched the videos many times before starting the transcription. The transcription of the interview was made thanks to Microsoft word and it was complete and verbatim taking into account the flow and every word mentioned during the interview. According to Braun and Clarke (2006) the listening and the transcription of the data helped me to familiarise with the collected data and to have full understanding of the study content as well as to lay the foundation for the subsequent analysis.

Phase 2: Generating initial codes

This phase consists of preliminary themes identification. Thematic codes were generated and aimed to provide a guide of the interview as well as the observation. First, following the interview protocol I went through all the transcripts to highlight the codes. I made sure that the codes represented the key information from the participants' transcribed scripts (King, 2004).

Phase 3: Searching for themes

The codes generated during the second phase were grouped into categories according to their similarities. Then, similar codes were clustered together to form the umbrella codes which became themes in the study.

Phase 4: Reviewing the themes

Closely related themes were reviewed and regrouped again. Then, I re-examined them to identify clear distinctions between them. This phase includes verification of the themes, spotting similarities and merging parallel themes.

Phase 5: Defining and naming the themes

From the main themes I established the potential sub-themes. The main themes were then given definitions to clarify the essence of each of them. The themes that were developed in the previous phase of review were then defined and named.

Phase 6: Producing the report

The final phase of thematic analysis is the writing of the research report or the research analysis. In this study, this it was based on the interview findings and the themes that emerged from the developed themes. In brief, throughout the thematic analysis I made a research journey. First, I became familiar with the information that participants shared, next I made the process easier by coding the key points of information, and then, I redefined the codes and showed five main themes of the results, with sub-themes that emerged under those main themes. Both the tests' mark and themes were combined to explain the research questions (Guion et al., 2002).

3.6 Validity and Reliability

Bogdan & Biklen (2007) describe reliability as a "fit between what [researchers] record as data and what occurs in the setting under study, rather than the literal consistency across different observations" (p. 40). However, the aim of any research is to generate knowledge that is valid and reliable in an ethical manner. In this study, all instruments had been edited by experts in the field to check for errors and omissions or inadequacies. I also recorded and documented all the tools, tests, interviews, and observations and trial-tested them in a pilot study with teachers who were not participating in the study. Furthermore, validity was ensured by triangulation (Holloway & Todres, 2003). Triangulation is the term used for the utilization of multiple methods of data production strategies and data sources. To ensure reliability and minimize inaccurate data production, triangulation was employed in this study.

3.7 Ethical considerations

When conducting research, a researcher has a moral and professional obligation to be ethical, even when the research subjects are unaware of, or unconcerned about ethics (Creswell, 1994). Therefore, this research followed strict ethical codes. Permission to undertake the study was obtained from the Ministry of Education and schools' teachers in Libya.

Participation in the study was completely voluntary and participants were informed about the aim and purpose of the study, the nature of the study, and the commitments involved in the study so that they could make their decision whether or not to participate in it. They were also allowed to withdraw from the research at any stage without any negative consequences. They were further guaranteed anonymity and confidentiality this means that in any case their identity and schools were not divulged. Participants were assured that they would be informed about the likely publication of the research findings (Neuman, 2013; Christians, 2005; Bogdan & Biklen, 2007).

3.8 Summary of the chapter

The study aimed to at determining the nature of the influence of the INST Programme on biology teachers' PCK and its relationship with practice. In pursuance of this aim, a number of certain questions were raised. Further, the study adopted a mixed-methods case study design where the unit of analysis was teachers' change. The participants in this study were 22 biology teachers in the first phase of data collection and 5 biology teachers in the second phase. These participants were volunteers selected from the target population based on the following criteria: teaching area (biology) and grade level of teaching (Grade 10). The study took place in the context of grade 10 secondary school with biology teachers following the teaching of Osmosis and Diffusion unit by means of 5Es strategies. Data collection included a questionnaire, an ODD test, semi-structured interviews, and observations. All data sources were analyzed for evidence of the influence of the INST Programme on biology teachers' PCK. The following chapter presents the findings of this study from the two phases of data collected during and after the workshop.

Chapter 4: Data collection, analysis and findings

4.0 Introduction

This chapter is concerned with the analysis of the data collected from the participants during the first and second phases of the study. As mentioned in the previous chapter the study has adopted a mixed-methods approach involving a combination of qualitative and quantitative methods. As indicated in Chapter One, the study aimed to determine the influence of an in-service training programme on the teachers' subject matter and pedagogical content knowledge as well as on their knowledge of their students. In pursuance of that aim answers were sought to the following questions:

1. What is the nature of Libyan biology teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK)?
2. How effective is an in-service programme in enhancing the teachers' SMK and PCK?
3. To what extent has the in-service programme enhanced their instructional practice and the way their learners learn biology?

For ease of reference, the data collected will be categorized and analyzed accordingly

Table 4-1: Data sets analysed in the study

	Instrument	Purpose of the instrument	The Contributions to answer research questions
The first phase of data collection	Questionnaire	- Provide demographic information on participants - Identify and describe teachers' perception of the biology curriculum and context	Whether or not any change has occurred in biology teachers' subject matter knowledge and context perception after attending the INSTP
	Osmosis and Diffusion Diagnostic Test (ODDT)	- Identify any change in teachers' understanding of Osmosis and Diffusion concepts. - Describe if there were any teachers' misunderstanding of Osmosis and Diffusion concepts.	- Is there any change in teachers' understanding of Osmosis and Diffusion concepts after attending the INSTP? - What were the misconceptions teachers had and whether they were corrected or not?
	The INSTP video record	- Describing teachers' reactions to the activities and workshop sessions and peer collaboration.	- How biology teachers interact with one another during INSTP activities. - Identify teachers' needs for future INSTP.
The second phase of data collection	Focus group, observations checklist, and video record	- Determining and describing teachers' practice with their students and using activities to administer the concepts of Osmosis and Diffusion in the classroom. - Recording variable and teachers' physical interaction in the classroom. - Checking the item on the list. - Helping to identify more questions for the interview.	- Teachers' understanding of students' prior knowledge, ability, thinking about the content. - Teachers' presentation of the concepts. - Teachers' behaviours in the classroom.
	Focus group interviews	- Gathering information about the influence of the INSTP on teachers' change and beliefs.	- Backgrounds to biology teaching - Planning for Osmosis. - Retrospective Interview on classroom teaching activities. - Changes that might have occurred after the training programme -Teachers' understanding of students' conceptions of the content

At this junction, I would like to mention that even though the study generated data necessary to answer the main research question of my present study with the help of the proposed instruments that I described in my methodology chapter, the workshop discussions and teachers' reflections were considered as insights that have brought in a good understanding of other data sets.

4.1 Data analysis

The data were immediately analysed after the collection phases. The quantitative and qualitative data were analysed separately, before merging them for the subsequent analysis, involving comparing and contrasting the results (statistical and qualitative comparisons of results) to answer the research question. In light of what precedes, it should be noted that in this study I tried my best to avoid bias that could impact the results in one or another way. On one hand different factors such as choice of the participants, the data collection methods, the data types as well as the time chosen to collect the data played a significant role in my endeavour to avoid bias. On the other hand, the objectivity in data collection determined by my personal beliefs, the Cronbach alpha coefficient of the tools used for this data collection and the analysis stages I followed have helped me to avoid the bias. Equally important, I followed the aims, the research design and the research questions.

4.1.1 Quantitative data analysis

Data from the questionnaire and test constituted the quantitative data of the investigation. For each teacher participants, there are two data entries. These entries represent two different sets of data. One entry is intended to capture data collected before and after attending the workshop sessions. In this regard, I used descriptive, parametric and non-parametric statistics in form of mean (M), standard deviation (SD), t-test, and Wilcoxon signed-rank test (W) to analyze and interpret the data collected.

The quantitative data were subjected to the SPSS and Excel spreadsheet to calculate percentages/frequencies, p-value, and mean scores of the major themes and the sub-themes. In addition, I also calculated measures of the reliability of the results using Cronbach's alpha for section "B". The percentages provide the descriptive summaries of their responses to the questionnaire section "A".

For the data analysis generated from the Osmosis and Diffusion Diagnostic Test (ODDT), I have used and compared the mean scores of the t-test to determine whether or not there was a significant change in biology teachers' scores in their understanding of the concepts. Furthermore, I conducted a deep analysis to clarify in which specific area misconception was corrected. Lastly, I linked the analyses to the research questions to gain a deeper understanding of the effects of the in-service programme.

4.1.2 Qualitative data analyses

According to DiCicco-Bloom and Crabtree (2006), when an interviewer elicits the perceptions – he/she explores meanings and opinions in order to gain a deeper understanding of an issue at stake in an investigation. He/she shares his/her experiences and opinions on the phenomenon under investigation. He/she does the analysis and interpretation in the light of guiding aims, objectives, theories, and questions. This can be achieved optimally through qualitative research (Krauss, 2005). In this study, the subjects' unique meanings and interpretations of their experiences about the influences of the INST programme on their PCK could be better understood by triangulating them with the qualitative component of this research. It is through qualitative data analysis that the researcher is able to "generate new levels and form of meaning, which can, in turn, transform perspective and actions" (Krauss, 2005, p. 764). In this phase of the research, I was guided by the epistemological considerations, which guide qualitative data analysis, based on the fact that:

1. Face-to-face interaction is the biggest condition of participating in the mind of another human being, understanding not only their words but the meanings of those words as understood and used by the individual, and;
2. One must participate in the mind of another human being in order to acquire social knowledge (Krauss, 2005, p. 764).

In addition, I thought that the epistemological considerations above could give me the opportunity to gain a deeper insight into how and why the subjects in my investigation developed or drew meanings/interpretations from their experiences or their social settings.

The provisional themes that were developed to guide the analysis of the survey data were also employed in the process of analysing the qualitative data (Brown et al, 1999). The audio records from the interviews, first of all, were manually transcribed; verbatim (Thomas & Beauchamp, 2011; Srnka & Koeszegi, 2007) to ensure that the transcripts were the true reflections of the subjects' views for each question (DiCicco-Bloom & Crabtree, 2006). The interview transcripts were manually analysed, using the constant comparative method to generate conceptual themes from the subjects' responses (Thomas & Beauchamp, 2011; Wilkins & Woodgate, 2008; Kerrigan, 2014).

Thus, the observation of both classroom and practical activities makes up a set of qualitative data collected. As far as classroom observation is concerned, remarks were made and noted down about how subjects performed as well as in conducting practical activities associated with Osmosis and Diffusion lessons.

The qualitative information recorded, focused on their ability to explain the Osmosis and Diffusion concepts in different ways, their ability to simplify classroom activities and their talent to include students in the achievement of classroom activities. The results were categorized 'sufficient,' 'satisfactory' or 'more support needed.' The teacher who succeeded in performing the stated activities without many problems was categorized as having a sufficient understanding of the biology subject matter. The teacher, who could perform and explain Osmosis and Diffusion with some degree of difficulty and a significant amount of student participation, was categorized satisfactory. The teacher, who had problems explaining the concepts and had very little students' participation, was categorized as being in need of more support.

In this method, I read the transcripts carefully and took notes on significant impressions from the responses in terms of regularities and patterns (Rowley, 2014; Frykholm, 1999). This enabled me to effectively label phrases, sentences, and words that were relevant, thus coding/indexing their opinions about what they were asked (Rowley, 2014; Jang et al., 2008). The coding focused on ideas that were repeatedly emphasised in the responses or explicitly stated opinions relating to a particular question (Rowley, 2014). Additionally, I coded phrases, sentences, and words that were related to literature sources and related theories or concepts. Also, I created the major themes representing subjects' views about the influence of the INST programme on their PCK from the sub-categories of such opinions obtained during coding (Rowley, 2014; Frykholm, 1999; Kaiser & Vollstedt, 2007). I also looked for connections between the themes for a deeper understanding of the expressed opinions (Rowley, 2014). This rigorous data analysis approach helped to maximise the potential for generating meanings and interpretations of subjects' perceptions about the influences of the INST programme on their PCK.

The descriptions were based on the connections and differences in opinion as expressed by the subjects. In all the above data analysis phases, I was able to maximise the reliability and validity of the results by controlling my personal views and any preconceived knowledge from being imposed on their interpretations of their experiences. Figure 4.1 presents a summary of this process, which is supported by Krauss' (2005) opinion that qualitative researchers need to describe the processes of their data analysis approaches so as to guide their understanding of how conclusions are drawn in the study because there are no standard templates for qualitative data analysis.

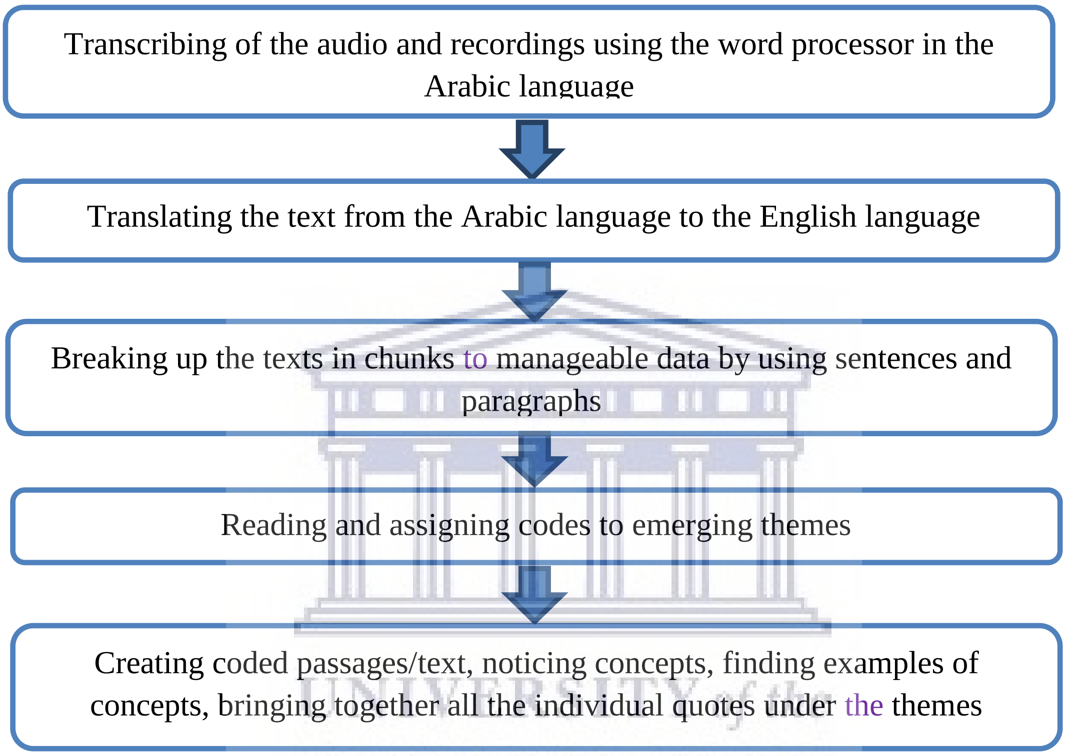


Figure 4.1: A manual step-by-step approach in qualitative data analysis

4.2 Data presentation

4.2.1 Data presentation from the first phase

The data are presented in the same order in which the collection took place. As mentioned earlier, this investigation is participatory action research. The first phase of data collection occurred before, during, and after the workshop sessions. The data collection tools that were used were the questionnaire (pre and post), the ODDT (pre and post), and the video-recording of the subjects' reaction in the workshop sessions.

4.2.1.1 Data Presentation from Questionnaire

As mentioned in Chapter Three, the questionnaire consisted of two sections. Section A aimed at gathering basic information about the participants and their context. Therefore, I implemented it once before the workshop sessions took place. Section B aimed at comparing subjects' knowledge and perception of the content and subject matter they taught before and after the workshop.

4.2.1.1.1 Questionnaire section "A"

This section is categorized into four sub-categories: (1) teaching strategies most adopted in the classroom, (2) problems faced by subjects in teaching the content, (3) problems identified with the arrangement of the content in the current curriculum of biology in Libya and finally (4) probable training courses attended.

Data from each of these sub-categories are summarised and presented in the following tables.

Table 4.2: Problems identified with the arrangement of the content in the Biology curriculum.

Items	Number of subjects	**Percentage**
1- Some of the suggested topics treated in middle school would have been suitable for students in their last year of secondary school level.	7	**31.8%**
2- The learning of topics such as Osmosis and Diffusion poses greater problems and as such should be treated at another level.	2	**9.1%**
3- Most of the chapters do not present biology as integrated and sequentially arranged for effective teaching and learning.	16	**72.7%**
4- The arrangement of the course content does not provide a sound basis for laying adequate foundations for subsequent specialist study in science in tertiary institutions.	3	**13.6%**
5- Some of the suggested activities did not emphasize the use of locally available materials and reflect what is available in the student's immediate environment.	16	**72.7%**

The data presented in Table 4.2 shows that the two problems identified by about 73% of the subjects regarding the arrangement of the content of the biology curriculum are: (1) the chapters do not present science as an integrated subject and the content is not sequentially arranged for effective teaching and learning; (2) the activities not emphasizing the use of locally available materials or reflecting on what is available in the student's immediate environment. Also nearly, a third i.e. about 32% of subjects thought that topics treated in the middle school would have been suitable for students in their last year of secondary school level.

In light of the above findings, I would like to state that the arrangement of activities and examples in the adopted biology curriculum were not modified to address the activities using local material of the Libyan environment, and student's learning needs, aspiration, and targets. Furthermore, most experiences were not designed taking into account the availability of materials to be used in the Libyan context for instance the curriculum requires the teachers to expose their students to Osmosis and Diffusion practical activities based on microorganisms such as bacteria. These activities require well-equipped microbiology labs which are hardly found in secondary schools. Thus, because of the lack of well-equipped microbiology labs in schools, I have instead opted for the use of eggs and dyes that were likely reproducing the same Osmosis and Diffusion principles as the microorganisms and easy to use. By so doing, teachers were encouraged and comforted to design and conduct practical activities related to good teaching practice of Osmosis and Diffusion concepts.

Table 4.3: Teaching strategies teachers adopt in teaching biology lessons in the classroom

	Subjects out of 22	Percentage
Student-based approach	1	4.5%
Lecture Method	6	27.3%
Discussion Method	14	63.6
Field trip	0	0%
Demonstration	8	36.4%
Questioning Method	3	13.6%

The data presented in Table 4.3 above showed that the majority of the participants (63.6%) used discussion strategies in teaching while 36.4% used the demonstration method, 27.3% use direct presentation through lectures to present their lessons and (13.6%) used the questioning method, while only one teacher representing 4.5% used the student-based approach. However, it has been revealed that field trips as a teaching strategy are not used by teachers.

In keeping with the data presented in Table 4.3 above, it appears that teacher-centre strategies are the most frequently used approach for classroom presentation; good examples of this being the 'Lecture Method' and 'Demonstrations'. These strategies do not stimulate or guarantee students' participation in the classroom. They do not succeed to shift a lesson from being teacher-centred to student-centred (Kim et al., 2013; Chan & Elliott, 2004) as recommended by the Libyan biology curriculum. It is a monotonous, boring, one-way teaching where the teacher considers himself/herself as the tank and source of knowledge that has to fill the empty containers who are students. Taking into consideration active teaching principles, this strategy is not recommended as it excludes students from their own education process.

Therefore, the preferable strategy seems to be discussion strategies. They value students and allow their participation in their education process. These strategies take into account students' background knowledge by building new knowledge on what students already know. This way of teaching is motivating because it engages students. It creates an interaction in the classroom between the students themselves and between students and the teacher. Discussion strategies are the most interactive teaching procedures. They help students to reconstruct knowledge from different perspectives. It is the most recommended strategy in the Libyan science curriculum. It arises students' curiosity.

At this junction, it is important to mention that by principles the questioning method, which resembles an interaction between teacher and students, is not only part of the discussion strategies but it is also used when it comes to lecturing method, to demonstration methods and to recapitulate what has been taught. While using any of the above-stated strategies the teacher uses the question method to make sure students are listening, attentive, or have an opinion or an observation. However, using the questioning method does not guarantee success in the teaching process.

In keeping with the above, it has been also observed that even though, the majority of the subjects used the discussion strategies, a good number of them also use the demonstration strategies, which consist of teachers presenting new concepts or notions to their students. According to Bartos, Lederman, and Lederman (2014), a lack of knowledge of topic-specific teaching strategies may be the reason for ineffective lessons, as well as the source of difficulties in providing adequate explanations to students' questions.

However, the subjects, who were not comfortable or they have not enough skills to guide either discussion or demonstration strategies, tended to use the Lecture Method. It should be noted that the strategy is not good for biology classroom presentation in view of the large number of terms that tend to occur in rapid succession within a small text space. The data also revealed that student-based approach is not used by teachers due to their lack of knowledge to design and conduct practical activities based on student-centred approaches (Kim et al., 2013). Thus the finding of this study in line with Northedge (2003); Prosser Rickinson, Bence, Hanbury, and Kulej, (2006) and Butcher (2012) reveal that teachers' practice did not reflect teachers' thinking. It is widely documented in the literature that student-centred emerged as a substantial shift from teachers-centred approaches. This is consistent with the finding of this study which shows that the programmes are rated most positively.

Table 4.4: Problems faced by teachers in teaching the content

Item		Yes	Percentage	No	Percentage
1- Is the time allocated for teaching in your school adequate to cover the course content for the year?		8	36.4%	14	63.6%
2- Do you have a problem teaching any topic in your subject area if your answer is "Yes" please indicate the topic?	Plant science	5	22.7%	14	63.6%
	Heredity/Genetics	2	9.1%		
	Human Biology	1	4.5%		

The data presented in table 4.4 about problems teachers face in their teaching of biology revealed that 63.6% of subjects indicated that the time allocated for teaching a lesson in their school was not enough to cover the course content for a year. 36.4% mentioned having problems with teaching topics in the subject area, 22.7% of them having teaching difficulties in teaching plant science, 9.1% having problems with heredity and genetics, and 4.5% having difficulties with human biology.

In light of the findings above, it can be said that there is an imbalance between the course content planned to be taught for a year and the time allocated for its delivery. Such discrepancy engenders problems that could affect the normal teaching practice resulting in the selection and use of inappropriate teaching approaches as revealed by the teaching strategies presented above (Creasy et al., 2012).

On the other hand, even if the majority of subjects had reported not having problems with teaching. To the best of my knowledge, I do not share this point of view as far as it does not corroborate with the results of the pre-test conducted to check the level of teachers' PCK. Therefore, to handle the situation, I have considered the fact that a good number had admitted experiencing problems in teaching botany, and based on the obtained results at the pre-test I have chosen Osmosis and Diffusion as part of this investigation.

Table 4-5: Training courses attended by the subjects

Items	Yes	Percentage	No	Percentage
1- Have you ever attended any seminar/workshop on the teaching of biology?	4	18.2%	18	81.8%
2- If you were given the opportunity, are you willing to attend a workshop/seminar at your expenses?	12	54.5%	10	45.5%

The data presented in Table 4.5 about probable training courses attended revealed that 81.8% of the participants have not attended any workshop or a seminar on teaching biology, whereas 45.5% indicated that if they had the opportunity they would participate in any workshop or seminar at their own expense.

In keeping with the spirit of the above findings, one might see that after their pre-service or initial training as teachers, the majority of these Libyan subjects involved in this study have not undergone any professional development, no seminar, and no workshop to update their PCK. However, the findings indicate that for their professional success these teachers are willing to attend workshops and/or seminar even if it requests them to pay from their own pockets. This attitude highlights a great desire and eagerness they had for both their professional upgrade and PCK development. Many scholars supporters of professional development think that attending workshops or seminars is key to self-development and professional success (Day, 1999).

4.2.1.1.2 Questionnaire Section "B"

Intended to answer the research question of the present study, this section of the questionnaire had been used twice, before the workshop sessions and after it. The reason was to measure the variation in the teachers' perception of context and biology teaching variables as shown in Table 4.6 below. At this juncture, it is important to mention that taking into consideration the nature of the data to be collected, I have employed five evaluative criteria based on a Likert scale as follow: Strongly Disagree (SD), Disagree (D), Not Sure (NS), Agree (A) and Strongly Agree (SA).

Table 4.6: Teaching variables relative

Variables	Number of items	Analysis technique
1. Teaching context variable	4	Percentage and Wilcoxon signed-rank test
2. Teaching input variable	5	Percentage and Wilcoxon signed-rank test
3. Teaching procedural variable	4	Percentage and Wilcoxon signed-rank test
4. Teaching product variable	5	Percentage and Wilcoxon signed-rank test

The data contained in Table 4.6 above indicate that to evaluate teachers' perceptions about biology teaching, the survey looked at variables such as teaching context, teaching input, teaching procedural, and teaching product. To get insights about these teaching variables, the data were statistically analysed to generate percentages of occurrence of each item via the Wilcoxon signed-rank test.

Apart from the teaching variables used above, the study resorted to statistical and descriptive analysis to determine the reliability and the internal consistency of the tool used to collect data.

Table 4.7: Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.737	.745	36

The data presented in Table 4.7 above indicated that the tool used to collect data (section B of the questionnaire) had a very high internal consistency justifying its validity and reliability on measuring what it was designed for. Its Cronbach alpha coefficient value was .737. In keeping with the above, it should be noted that an alpha coefficient of above 0.5 is to be an acceptable threshold for small samples (Nunnally, 1978) as in the case of this study.

Therefore, taking into account the above-mentioned criteria I have used through my quantitative data presentation: namely: Strongly Disagree (SD), Disagree (D), Not Sure (NS), Strongly Agree (SA) and Agree (A), and also based on Cronbach alpha coefficient, when I look at the data my exploration showed that the first two evaluative criteria SD and D likewise the last two criteria SA and A appeared to be more or less the same. Therefore, I thought it would be efficient and also it would be effective to combine the first two and the last two into a set each except for the evaluative criteria "Not Sure (NS)" which stands alone.

Table 4.8: Teachers' knowledge of the biology context before and after in-service

Item		Likert scale (percentage)					Wilcoxon signed-rank test (W)	
		SD	D	NS	A	SA	p-value	Z
(1) The objectives of biology as spelled out in the Core Curriculum are clearly stated and achievable.	pre	4.5	4.5	0	86.5	4.5	.001	3.300
	post	0	4.5	0	36.4	59.1		
(2) The ways by which topics are broken down in the biology curriculum facilitate the efficient teaching of the course.	pre	0	13.6	4.5	81.8	0	.024	2.252
	post	36.4	13.6	0	36.4	13.6		
(3) The prescribed content for each year of study is adequate because it is arranged in the order of complexity such that it becomes more detailed as the years' progress.	pre	4.5	31.8	9.1	45.5	9.1	.027	2.209
	Post	0	9.1	9.1	50	31.8		
(4) The selected content takes the age of the students into consideration for effective implementation.	pre	0	0	0	68.2	31.8	.556	.577
	post	0	0	0	59.1	40.9		

(SD = Strongly Disagree, D = Disagree, NS = Not Sure, A = Agree, SA = Strongly Agree).

The data presented in Table 4.8 above about the teachers' knowledge of the biology context reveal that out of the four items only item number 4 is not statistically significant at p = 0.05 level i.e. items 1-3 are statically significant at p ≤= 0.05. As far as the item (1) is concerned the Wilcoxon signed-rank test (W) value (Z= 3.300, p= .001) indicates that the INSTP probably elicited a statistically significant change in teachers' perception about the objectives of the biology as spelled out in the Core Curriculum. Regarding item (2), the (W) value (Z=2.252, p= .024) shows that the INSTP brought about a statistically significant change in teachers' perception, of the ways by which topics are broken down in the biology curriculum facilitate the efficient teaching of the course. Concerning item (3) the (W) value (Z=2.209, p=.027) indicates that the INSTP caused a statistically significant change in teachers' perception of curriculum construction. As for item (4), the (W) value (Z=.570, p=0.556) shows that the INSTP did not elicit statistically significant change in teachers' perception of the selecting content considers the age of the students for effective implementation.

Table 4-9: Input variable of teaching biology

Item		Likert scale (percentage)					Wilcoxon signed-rank test	
		SD	D	NS	A	SA	P-value	Z
1. Depending on the teaching resources available, most of the time I select topics for teaching without strictly following the order suggested in the Core Curriculum.	pre	4.5	22.7	31.8	27.3	13.6	.023	.981
	post	0	36.4	9.1	54.5	0		
2. I feel that the government should make more effort to supply more teaching and laboratory materials to schools for effective biology teaching.	pre	0	0	0	9.1	90.9	.034	2.121
	post	4.5	0	0	27.3	68.2		
3. The inclusion of certain science allowance for teachers by government is a way of encouraging more people to specialize in science-related courses.	pre	0	0	18.2	31.8	50	.007	2.697
	Post	0	27.3	9.1	31.8	31.8		
4. More teachers should be sent for in-service training to encourage them to perform well in their work.	pre	0	0	0	40.9	59.1	.782	.277
	post	0	0	4.5	27.3	68.2		
5. I enjoy attending seminars or workshops for self-improvement.	Pre	0	0	4.5	36.4	59.1	.083	1.732
	post	0	0	0	18.2	81.8		

(SD = Strongly Disagree, D = Disagree, NS = Not Sure, A = Agree, SA = Strongly Agree).

The data presented in Table 4.9 above about the input variable of teaching biology exhibits that out of the five items only items 4 and 5 are not statistically significant at p = 0.05 level i.e. items 1-3 are statically significant at $p \leq 0.05$. In other words, there is no statistically significant difference between the teachers' stances at the pre- and post-test, regarding sending teachers for in-service training to encourage them to perform well in their work (item 4) and teachers' enjoyment of attending seminars or workshops for self- improvement (item 5).

Concerning the item (1), the p-value (.023) shows a significant difference between the pre- and post-input variable values. This suggests that the teachers seemed to have adopted the idea of selecting the topic according to their students' prior knowledge instead of following the order of the core curriculum. In other words, the teachers had become more cognizant of their students' abilities and prior knowledge than was the case before their workshop experience.

As far as the item (2) is concerned, looking at the data and the p-value (.034), it should be noted that even though the difference between the pre- and post-input variable values is not big, however, the truth is that the teachers have learned a little more about using activities to deliver their lessons than was previously the case. Therefore, they unanimously pleaded for the government to make more effort to supply more teaching and laboratory materials to schools for effective biology teaching.

Regarding item (3), considering the pre- and post-test variable values as well as the p-value (.007), it should be noted that a statistically significant change has been observed in teachers' perceptions about the incentive issue. This implies that though the teachers agreed on the issue yet they differ in their perceptions. In other words, they do not necessarily reject the item but differ in their way of perceiving this incentive.

Concerning item (4) the (W) value (Z=.277, P=782) points out that there is no statistically significant change in teachers' perception after the INST programme. As for item (5), the (W) value (Z=1.732, P=.083) indicates that there is no statistically significant change in teachers' perception after the INST programme.

In general, it can be noted that in most cases the Post variable values revealed that subjects have manifested a positive attitude about seminars, workshops, and any other means that can contribute to the improvement of biology teaching. This can be considered as a positive attitude and a key factor in professional and academic success (Wischow et al., 2013).

The data presented in Table 4.10 below reveals that: out of the four items only item number 4 is not statistically significant at p = 0.05 level i.e. items 1, 2 and 3 are statically significant at p = 0.05 as far as Item (1) is concerned the (W) value (Z=2.310, p=.021) shows that there is a statistically significant change in teachers' perception. About Item (2) the (W) value (Z=3.638, P=.000) indicates that there is a statistically significant change in teachers' perception. As for Item (3), the (W) value (Z=1.859, P=.058) indicates that there is a statistically significant change in teachers' perception. Concerning Item (4) the (W) value

(Z=.611, P=.541) shows that there is no statistically significant change in teachers' stance before and after attending the INSTP.

Table 4.10: Teaching biology procedural variable

Item		Likert scale (Percentage)					Wilcoxon signed-rank test	
		SD	D	N	A	SA	P-value	Z
1. Teaching science by the discovery approach is adequately reflected in the biology course.	pre	0	0	18.2	36.4	45.5	.021	2.310
	post	0	0	0	31.8	68.2		
2. The science teacher(s) must make his/their students see the course as an investigation of nature within the environment.	pre	0	0	4.5	81.8	13.6	.000	3.638
	post	0	0	0	22.7	77.3		
3. In Libya, teachers handling the sciences are expected to use local examples to foster learning and enable the students to know about their environment through improvisation.	pre	0	4.5	13.6	40.9	40.9	.058	1.859
	Post	0	0	0	36.4	63.6		
4. Teaching approaches such as the lecture method and field trips motivate students to learn more than the activity-oriented and the student-based approaches	pre	0	0	4.5	31.8	63.6	.541	.611
	post	0	9.1	9.1	13.6	68.2		

(SD = Strongly Disagree, D = Disagree, NS = Not Sure, A = Agree, SA = Strongly Agree).

Considering the above-presented data unveiling subjects' perceptions about teaching procedures, the findings revealed that in one way or another change has occurred after they have attended the INSTP in line with the socio-cultural theoretical construct underpinning the study. According to Giannakakos, Vladescu, Kisamore and Reeve (2016) the teaching procedures are among the key factors to teaching practice success when followed and implemented adequately. In this respect, Park and Oliver (2008) have contended that most teaching failures are attributable to the bad or erroneous application of teaching strategies.

Table 4.11: Teachers' knowledge of product variable

Item		Likert scale (percentage)					Wilcoxon signed-rank test		
		SD	D	N	A	SA	Mean	p-value	Z
1. One of the goals of biology is to enable students to gain the concepts of the fundamental unity of biology from their daily life routine.	pre	0	0	4.5	95.5	0	3.95	.034	2.121
	post	0	0	4.5	68.2	27.3	4.23		
2. In Libya, students who study biology as a subject are expected to develop certain skills such as observing, investigating and synthesizing.	pre	0	4.5	18.2	54.5	22.7	3.95	.007	2.675
	post	0	0	4.5	18.2	77.3	4.73		
3. The kinds of activities suggested for use in the Core Curriculum permits students to use scientific techniques later in life in the fulfillment of the national philosophy of self-reliance.	pre	0	0	31.8	68.2	0	3.68	.008	2.673
	Post	0	0	4.5	77.3	18.2	4.14		
4. The course objectives provide for satisfactory achievement on national needs and aspirations.	pre	0	4.5	18.2	50	27.3	3.95	.323	.988
	post	0	0	22.7	77.3	0	3.77		
5. Through the biology course, students have an adequate foundation for subsequent specialist study at university.	Pre	0	0	0	0	100	4.00	.002	3.162
	post	0	0	0	54.5	45.5	4.45		

(SD = Strongly Disagree, D = Disagree, NS = Not Sure, A = Agree, SA = Strongly Agree).

The data presented in Table 4.11 above about teachers' knowledge of product variables indicated that concerning Item (1) the (W) value (Z=2.121, P=0.034) indicates that there is a statistically significant change in teachers' perception regarding of the biology goals. On Item (2), the W value (Z=2.675, P=0.007) shows that there is a statistically significant change in teachers' perception of students who study biology and are expected to develop certain skills such as observing, investigating and synthesizing. As far as Item (3) is concerned about the activities suggested for use in the Core Curriculum; the W value (Z=2.673, P=0.008) indicates that there is a statistically significant change in the teachers' perception. In regard to Item (4), the W value (Z=0.988, P=0.323) shows that there is no statistically significant change in teachers' perception of the objectives on national needs. As for Item (5), the W value (Z=3.162, P=0.002) indicates that there is a statistically significant change in the teachers' perceptions about the adequacy of the foundation of the biology course.

In general, the data presented above show that in general the teachers were generally disposed to in-service training (INSTP). This finding exemplifies the importance and the necessity of this training programme in the field of science education. It should be noted that the training programme does not come to change the order that is in the field but to reinforce and align theoretical knowledge and practice to generate practical understanding in the field. This corroborates Ibrahim's (2015) findings of the impact of INSTP he used in his study. He found the programme to have empowered the teachers in their instructional practice.

4.2.1.2 Data Presentation from Osmosis and Diffusion Diagnostic Test (ODDT)

As far as the aim of conducting this kind of investigation is concerned the first step was the preparation of ODDT to be analyzed. I checked whether the test items and all demographic information were completed. The data were collected on the basis of 12 questions. Each question contained two tiers, the content choice, and the reason. In keeping with the above, the item score was given only to the teacher who correctly answered both tiers (the content choice and the reason). The correct combination of the content and the reason is shown in Table 4.13 below.

The data generated from the ODDT have been analyzed based on teachers' scores to the test investigating the following two assumptions:

1. The absence of the INSTP influence on teachers' understanding of Osmosis and Diffusion concepts.
2. The presence of the INSTP influences on teachers' understanding of Osmosis and Diffusion concepts.

The SPSS software finds a suitable statistics technique (t-test) to provide an answer to the above-mentioned assumptions as presented in Table 4.13 below.

Table 4.12: Result of paired samples t-test for teachers' scores on ODDT.

	Pair 1	Mean	N	Std. Deviation	T	df	Sig. (2-tailed)
Test 1	Score on the test before training	7.5000	22	1.81921	**4.715**	**21**	**.000**
Test 2	Score on the test after training	9.5455	22	1.47122			

The data presented in Table 4.12 above shows that there was a significant improvement in teachers' understanding of the osmosis and diffusion concepts after they attended the INSTP.

The second phase analysis of data was to determine misconceptions teachers have about Osmosis and Diffusion. It was based on two-tier multiple-choice items (see appendix E). As an illustration, the data related to the item (6) is presented in Table 4.13 below (see Appendix F for the rest of the results tables).

Here is the content of Item 6:

Suppose you add a drop of blue dye to a container of clear water and after several hours the entire container turns light blue. At this time, the molecules of dye:

a) *Have stopped moving?*
b) *Continue to move around randomly?*

The reason for my answer is:

a) *The entire container is the same colour; if the dye molecules were still moving, the container would be different shades of blue.*
b) *If the dye molecules stopped, they would settle to the bottom of the container.*
c) *Molecules are always moving.*
d) *This is a liquid; if it were solid, the molecules would stop moving.*

Table 4.13: Combined ODDT pre and post results based on item 6.

Answer Reason		Have stopped moving	Continue to move around randomly
The entire container is the same color; if the dye molecules were still moving, the container would be different shades of blue.	Pre	4.5%	4.5%
	Post	4.5%	4.5%
If the dye molecules stopped, they would settle on the bottom of the container.	Pre	18.2%	9%
	Post	0%	0%
Molecules are always moving.	Pre	4.5%	59%*
	Post	0%	91%*
This is a liquid; if it were solid, the molecules would stop moving.	Pre	0%	0%
	Post	0%	0%

* The correct answer

In a typical multiple-choice test with four possible answers, there is a 25% chance of guessing the correct answer. For two-tier items with two selections on the first tier and four selections on the second tier, there is a 12.5% chance of guessing the correct answer combination.

Table 4.14: Percentages of teachers' selection of the desired content choice and combination of content choice, and reason.

Item	Pre		Post	
	Content choice	Combination of the question and reason	Content choice	Combination of the question and reason
1	95.5%	86.4%	100%	91%
2	100%	18.2%	100%	59%
3	95.5%	54.5%	100%	82%
4	100%	91%	100%	95.5%
5	45.5%	41%	63.6%	54.5%
6	72.7%	59%	95.5%	91%
7	100%	95.5%	100%	100%
8	68%	45.5%	82%	63.6%
9	54.5%	36.6	95.5%	63.6%
10	95.5%	91%	100%	100%
11	63.6%	45.5%	77%	72.7%
12	95.5%	72.7%	100%	91%

Table 4.14 above shows that the range of correct answers based on content choice (on the first tier) of the pre-test went from 45.5 - 100%, whereas in the second tier of pre-test the combination of the correct answers and their justifications reduced the range of correct answers from 18.2% - 95.5%. However, in comparison, the correct answer for the first tier of the post-test ranged from 63.6% - 100%, and the combination of the two tiers (post-test) ranged from 54.5% - 100%. The pre-ODDT results indicate that teachers did not have a satisfactory understanding of items (2, 3, 5, 6, 8, 9, 11, and 12) as highlighted in yellow while the post-ODDT results indicate significant change, which is highlighted in red in the table above.

In keeping with the above data, it should be noted that some subjects had some misconceptions about the two similar but different notions they had to teach, Diffusion and Osmosis. This misconception has also been confirmed by the data collected from the interviews. It should be noted that the subjects' misconception and misunderstanding of Osmosis and Diffusion are due to the fact that the teaching materials they are using to teach these concepts are not adequately prepared. On the other hand, the examples provided are not based on the students' daily life experiences. However, the data indicate that the above teachers' issues were slightly corrected by the new approach introduced to them during the professional development workshop. In other words, their understanding of the concepts after the workshop was better than it was before. This corroborates with Ipek, Kala, Yaman and Ayas (2010) as well as Kaltakci-Gurel, Eryilmaz and McDermott (2016) who claimed that teachers' misconceptions will greatly decrease if science education programmes in higher institutions take into consideration different areas of identified misconceptions while designing their pre-service programmes.

Considering that some of the teachers were experiencing problems with these two notions, the majority of misconceptions that were found were improved, corrected and addressed in six of the seven conceptual areas covered by the test: the particulate and random nature of matter, concentration and tonicity, the influences of life forces on Diffusion and Osmosis, the process of Diffusion, and the process of Osmosis as shown in Table 4.15 below.

Table 4.15: Items of propositional knowledge statements and topic areas improved by the INSTP.

Topic area	Teachers percentages		Propositional knowledge statements
	Pre	Post	
1. The particulate and random nature of matter.	43.9%	77.3%	2,3,6
2. Concentration and tonicity.	36.6%	63.6%	9
3. Influence of life forces on Diffusion and Osmosis.	45.5%	73%	11
4. Membranes.	72.7%	91%	12
5. Process of Diffusion.	41%	54.5%	5
6. Process of Osmosis.	45.5%	36.6%	8
7. Kinetic energy of matter.	91%	100%	1,4,7,10

The data presented in Table 4.15 above addresses the most propositional knowledge, and the topic area improved after teachers attended the INSTP. Their improvement in the pre-test ranged from 36.6% - 91% whereas in post-test it ranged from 54.5% - 100%.

The findings above reveal that even though in general Libyan biology teachers were not poor, an improvement has been observed in their understanding of the concepts after they have attended the INSTP. This justifies the importance and necessity of conducting INSTP to attend to some issues of misconception biology teachers might be experiencing. Rozenszajn and Yarden (2013) believe that if teachers' misconceptions are not attended to and corrected before, they will pass from teachers to learners and affect learners' comprehension.

4.2.1.3 Data presentation from biology subjects' reaction to the in-service training programme

The training programme concerned in this study took a week and was intended for subjects. It aimed at enhancing their PCK on the selected unit (Osmosis, Diffusion) so as to help them understand the use of the 5E's model and to enable them to teach, Osmosis and Diffusion unit. It took place in the teacher training centre in Tripoli the capital city of Libya. This training programme was designed to meet the requirements of the biology objective as stated in the Libyan curriculum and to make teaching biology as effective as possible. It included the 5Es instruction steps, which are: Engage, Explore, Explain, Elaborate, and Evaluate. The course was held through an active and deep discussion about each step. All the activities conducted during this training programme were to help subjects in planning, implementing, and delivering efficient biology courses to their students.

The data I am presenting in this section are classified into three different categories: (a) environment (b) process and (c) content. As far as the environment is concerned the data revealed that the majority of the subjects described the setting where the workshop was organized as suitable. As mentioned in the previous chapter, the professional development occurred at the Teachers' Training Centre, which has all the necessary facilities, such as data projector, whiteboard, WIFI, and stationery for each participant. They also mentioned that the venue was comfortable and quiet. Besides, they appreciated the catering service during the workshop. The following extracts from the interview with teachers during the workshop can serve as evidence to the above claims:

- *It is suitable because it has Wi-Fi and it also has enough tables and chairs for all of us.*
- *The place is a suitable and comfortable, very quiet place far from the sound that can distract us.*
- *The space of the venue is suitable.*
- *It is enjoyable because there are enough water and a good lunch.*

Concerning the process (delivery and organisation of the workshops) it had 5 sessions each day. Each session addressed one of the 5Es strategies. The first day presented the Engagement phase which is the first step of the 5Es. The second day presented the Exploration phase which is the second step of the 5Es. The third day presented the Explanation phase which is the third step of the 5Es. The fourth day presented the Elaboration phase which is the fourth step of the 5Es. Finally, the fifth day presented the Evaluation phase which is the fifth step of the 5Es. The participants appreciated the nature of the presentations, information shared, the period the workshop was organised (before the beginning of the school year), time management as well as the expertise of the workshop facilitators. They described the workshop as effective, well-presented, and well-organized as the extracts below indicate:

- *The workshop was well-organized.*
- *I found the procedures helpful.*
- *It was useful because it took place before the school year started.*
- *I wish to have similar workshops about the rest of the curriculum units.*

In addition to the above comments, it is important to mention that the director of the Training Centre, where the workshop programme was held, asked me to provide him with the in-service training package so that it could be included in their training plan in the future.

In regard to the content, the workshop sessions were designed to enhance Libyan grade 10 biology teachers' PCK. This programme was based on how to address aspects related to Osmosis and Diffusion using the 5Es strategy so as to help them teach these notions taking into consideration learners' understanding and thinking on the basis of their prior knowledge and their ability. Teachers were seated into four groups with each group consisting of five to six teachers as follows:

- Group "A" working on Diffusion.
- Group "B" working on Osmosis.
- Group "C" working on Surface area volume ratio.
- Group "D" working on Active transport.

The reason for this is to cover all the units in the textbook and to know the relationship between the concepts when each group presents their work.

On the first day, after having explained the procedures, handed the questionnaire and ODDT as well as introduced the first stage of the 5Es model “the Engagement stage” the group worked in their respective groups to analyse the topic and prepare appropriate activities and questions to elicit students’ prior experience about the topic and link it to the new knowledge. After an hour discussion all the groups agreed on the following questions and activities to identify students’ previous knowledge and stimulate their thinking:

1. *How does water reach the top of a tree?*
2. *How do unicellular organisms feed themselves?*
3. *How do the organisms live in saltwater?*
4. *Phenomenon analysis for a reason.*
    - *Smell the perfume from a distance?*
    - *Putting a drop of dye into a glass of water?*
5. *Video show.*

After watching videos about how to prepare laboratory activities using local materials and discussing sample materials that can be used to design activities for Osmosis and Diffusion the subjects agreed that there is local material to use in the laboratory during practical activities to deliver Osmosis and Diffusion concepts.

In this way, teachers task accesses the learners’ prior knowledge and helped them become engaged in a new concept through the use of questions or short activities that promote curiosity and elicit prior knowledge (Bybee et al., 2006). The activities make connections between what they already know and present learning experiences which are Osmosis and Diffusion concepts, expose prior conceptions, and organize students’ thinking toward the learning outcomes of current activities.

On the second day after having presented the second stage of the 5Es model, “the Exploration” the subjects worked in their respective groups on specific activities. They came up with appropriate ideas to use for the teaching of Osmosis and Diffusion concepts. They also came up with ideas about how to link Osmosis and Diffusion concepts. They also discussed how to plan and organize appropriate activities as well as how the teachers can make visible their students’ comprehension and thinking about the content.

<u>Group "A"</u> worked on Diffusion and focused on the following two activities: Gassed diffusion and Liquid diffusion. For the first activity they agreed on using perfume and for the second they agreed on using water and dye. The following extracts can serve as evidence:

> *I will spray some perfume at the back of the classroom and then will ask students, when they small it, how it has arrived where they are and why the students at the back of the classroom have smelt it first.*
> *This activity aims to present liquid diffusion. As materials we need two cups of water, the first cup will contain warm water and a second cup of cold water. Then, students will add drops of dye in the cups.*

What students should observe is that:

- *There is a difference between Solvent and Dissolved.*
- *The solvent moves from high concentration to low concentration.*
- *Dye spread faster in warm water than in cold water.*
- *Diffusion occurs diagonally until it covers the whole cup.*

Based on the above excerpts stating that teachers have agreed about conducting the experiment and what students should observe, it is important to make students understand that the movement of dye molecules will not stop even if one cannot see how they move/spread into the water. Thus, students conclude that particles in liquids and gasses can move around each other. Consequently, Diffusion in liquids is slower than Diffusion in gasses because gas molecules have more kinetic energy and are smaller than liquid molecules.

<u>Group "B"</u> worked on Osmosis activities. They agreed on using plant stalks, carrot, salt or sugar, knife, or scalpel as they are locally available. After having agreed on materials to use, they also agreed on procedures to be followed:

Firstly: The teacher has to fill one cup with salted water and another with pure water.
Secondly: The teacher has to divide longitudinally the plant stalk in two pieces and put each piece in cups that were filled before one with pure water and the other with salted water;
Thirdly: After a given period of time to invite students to observe.

Besides, they listed what they had observed:

- ***<u>Observation one:</u>*** *<u>The half piece of plant stalk in salted water had bent toward the sectioned side.</u>*

- ***Cause:*** *Students understood that the sectioned side of the stalk had bent toward the sectioned side because it had lost the water due to the high concentration of the water in the cup. Therefore, the cells had contracted and the plant stalk had turned to that side.*
- ***Observation two:*** *The half piece of plant stalk, which was in pure water bent toward the opposite sectioned side.*
- ***Cause:*** *Students understood that the sectioned side of the stalk had bent toward the opposite sectioned side because its cells have absorbed water and increased due to the fact that they were less concentrated than water concentration in the cup.*
- ***Note:*** *The plant stalk bent from the side that was not cut because it was covered by a coat that stops water to come in or out.*

Taking into consideration what has been chosen as material and what happened as a reaction, the finding is that if the salt concentration in water is higher it causes the cell plasma membrane to shrink away from the cell wall or that it will cause plasmolysis. On the other hand, what happened to the plant placed in pure water is explained as turgid or bloated in reference to the hypertonic state in the cells compared to the surrounding hypotonic state.

Group "C" worked on the surface area to volume ratio activities. They agreed on using three cups as containers, potato to be cut in pieces, a ruler, or sensitive scales as locally available materials. After having agreed on materials to use and practiced the surface area to volume ratio they also agreed on procedures to follow:

Group presentation*: the material we need: three cups of water, pieces of potato in three different sizes of one centimetre, three centimetres and six centimetres, a ruler, or sensitive scales.*

The procedure is that: measuring the three pieces of potato, either by ruler or scale, and write down the sizes. Put a one-centimeter piece of potato into cup number one, then the three-centimeter piece of potato in cup number two and the six-centimeter piece of potato into cup number three. After a period of time, measure them again and find the variation.

<u>Group "D"</u> work on Active transport

This group struggled to create a hands-on activity for active transport due to the nature of the concept. However, they could formulate some stimulating questions such as: "How does the cell release particles when the concentration outside is higher than inside? Or "How does the cell get rid of the waste?" Such questions are based and related to the understanding of concepts such as Osmosis and Diffusion. Therefore, a discussion with videos could clarify and elucidate the active transport concept.

The procedure is:

- *<u>Teachers raising questions to their students before the lesson to stimulate their thinking and making it visible.</u>*
- *<u>How the cell survives when the substances outside are less than inside the cell.</u>*
- *<u>Watching videos.</u>*
- *<u>Giving examples.</u>*

From the above findings, I conclude that the subjects' readiness to design practical activities using local material can help their students understand 'Osmosis and Diffusion' better. This improvement is probably a result of the opportunity that the teachers had to argue and discuss during the INST programme. In keeping with the above, I would like to mention that researchers have therefore revealed that teachers have a powerful, long-lasting influence on their students. This implies that they directly affect how students learn, what they learn, how much they learn, and the ways in which they interact with one another and the world around them (Stronge, 2018).

On the third day after having presented the third step of the 5Es model "the Explanation stage" and discussed how to provide a variety of examples and how to correct students' misunderstanding of the concepts, the participants prepared the questions and activities to encourage the students to explain Osmosis and Diffusion in their own words. In this session, they also scanned the textbook to find out typical examples from the local environment from which students can observe the targeted phenomena in their daily life. They also scanned and reviewed the textbook to find out any concepts likely leading to confusion used in the curriculum. They all agreed that:

- *In some specific points, the textbook is not clear, for instance, Water effort is used in the textbook as Osmosis, which led to the teachers' misunderstanding of the Osmosis concept.*
- *Some activities in the textbook required materials, which are not easy to find in the local environment so that they ignore such activities.*
- *Examples in the textbook are not easy to see in the student's daily life.*
- *The link provided for a website in the classroom textbook does not work, because it belongs to the local network in Singapore.*

Based on the discussion about whether they should provide students with pre-designed data collection forms or allow them to make their own and also about the advantages and disadvantages of each strategy, participants agreed that:

> *Students' data collection forms depend on time availability. "If students have enough time, it is better for them to design their own data collection forms rather than us designing for them." Teachers mentioned that the good reason is that students develop their ability in writing reports about the activities and outcomes of the experiments when they design their own report forms. Whereas it should be noted that when teachers provide students with pre-designed data collection forms the advantage is saving time and another very important factor is that students may not include all the variables which are supposed to be added.*

Based on the discussion about whether it is better for each student to collect his/her own data, or collect in groups, participants agreed that:

> *Since students are working in groups, they should write their reports in a group so that they enhance themselves and transfer their ideas to one another through discussion. However, they mentioned that this can make some group members passive and dependent on active and clever students.*

Based on the discussion about the reasons for students to report their data to the whole class, participants stated that:

> *Students' presentation of their report to the whole classroom assists other groups in seeing the experiments in a different way from what they have seen*

before or made themselves. Therefore, it helps them to clarify and elaborate their information on those specific experiments.

From the above findings, one can assert that the teachers have come to appreciate the value and the importance of students' interactions in the classroom. This consideration has motivated them to enhance and value student-centered approaches instead of teachers-centered ones. This finding is in harmony with Bybee et al. (2006) who think that students' interactions in the classroom encourage them to interact positively with one another which results in critical thinking skills when students are required to explain and teach each other.

On the fourth day, after having presented the fourth step of the 5Es model "the Elaboration stage" and discussed how to conduct additional activities and experimental inquiry, teachers worked in their respective groups to prepare tasks to encourage students to apply or extend the concepts and skills in new situations.

After the discussion, participants agreed that:

- *Teachers should attempt to provoke challenges on students' conceptual understanding and skills. In this phase, the students can participate in an extension or a different activity that either re-teaches an objective or teaches more details about the concept being taught.*
- *The students should develop a deeper and broader understanding of more information, and adequate skills.*
- *Use of exercise books to conduct in-depth and more activities.*
- *Students should apply their understanding of the concept by conducting additional activities.*
- *Teachers should use students' differences to elaborate and extend or enrich their lessons in order to address different categories of students, the ones below, and the others above the required level. This means repeating the same explorative activity with more input from the teacher to guide students with a low level and correct their misunderstandings.*

The above findings based on discussion and illustration revealed that after the INST programme the subjects have gained insights on the importance of using practical activities designed on the basis of local materials. This is consistent with Hoskins (2013) who supports that students benefit from practice because they are able to apply knowledge through interaction. In this context, it should be noted that students connect with the material when they work with texts and concepts beyond a one-time exposure. Therefore, the teachers will use this awareness to enlighten students and prevent them from misunderstanding the concepts.

On the fifth day, after having presented the fifth step of the 5Es model "the Evaluation" and discussed in groups on how to develop a scoring tool, how to conduct the objective evaluation and how to write a report, the participants agreed that:

- *The students' initial assessment depended on how the lesson was presented following activities or any other method.*

The assessment phase encouraged the participants to assess their students' understanding and abilities and provided them with opportunities to evaluate their students' progress towards achieving the educational objectives.

From the above agreement, they decided:

- *To determine: what students had effectively learned. What they had not understood and what would have been done to help them.*
- *To make a reflection, a project, a book report, or a model. For instance, about diffusion concept activities it was made sure that students could distinguish between Solvent and Dissolved. They could notice that Diffusion occurred faster at high temperatures. This could easily help to grade or make a note of what was learned and what needed to be retaught.*

From this finding, I could conclude that teachers' knowledge and beliefs of teaching biology with an activities-based approach became much useful than lecturing methods. They reflect on their students' progress than the teaching procedures. This helps them not only to develop their knowledge and opinions of teaching-practice efficacy but also to provide information about the knowledge and skills students have acquired as well as to make available richer data about the effects of the curriculum or teaching methods (Jauhiainen, 2013).

4.2.2 Data presentation from the second phase

4.2.2.1 Background information of the participants in the second phase

The second phase of data collection involved 5 grade 10 teacher participants. All of them were female. This cannot be astonishing, because in Libya most males are not willing to work as teachers. However, there is a low percentage of males working at schools not only as teachers, but the majority of them also work as managers or they occupy other positions of responsibility and management.

Four out of the five subjects had a Bachelor's degree in Science, and one had a Bachelor's degree in Science and Medical Technology (See Table 4.16 below). They all had a maximum of nine lessons per week. In keeping with the above, it is apposite to mention that the Libyan Minister of Education (1997) had changed the Faculty of Education to the Faculty of Science and Art.

In the past, teachers used to have between 16 -24 lessons weekly, but in 2017 the Minister of Education issued a new regulation, which determined the number of lessons at a maximum of nine lessons per week. However, it has been observed that the reduction of lessons per week has generated an imbalance between the content to be taught and the time allocated for teaching. This means that teachers have many notions to teach in a limited time. Even though the consequences are addressed later in this thesis, at this juncture I hasten to mention that teachers are skipping some notions to teach the ones that are considered and checked at the national test. This is in harmony with the Report of the Independent Teacher Workload Review Group which suggests that "School leaders must have the confidence to reject decisions that increase burdens for their staff. Teachers themselves must be more active in using evidence to determine what works in the classroom" (2016, p. 4). Table 4.16 below also shows that teachers' teaching experience was quite high ranging from 10-26 years. These subjects helped me to collect qualitative data of this study from observation and interviews.

Table 4.16: Background information of the participants in the second phase of data collection

	Gender	Qualification	Number of the lessons in the week	Teaching experience
Teacher 1	F	BSC	9 lessons	13 years
Teacher 2	F	BSC/medical technology	9 lessons	16 years
Teacher 3	F	BSC	9 lessons	10 years
Teacher 4	F	BSC	9 lessons	20 years
Teacher 5	F	BSC	9 lessons	26 years

Taking into account the data presented in the table above each subject was sufficiently experienced to provide this study with adequate data. It has been observed that low knowledge of the field may influence the participants' understanding of the questions in the data collection tool and consequently impacting the data collection process (Bonevski, Randell, Paul, Chapman, Twyman, Bryant & Hughes, 2014).

4.2.2.2 Data from Observation

Having positive reactions to the programme is an important indicator of its impact. However, in this study, the teachers' adequate use of the programme by means of practical works was considered the most important indicator. This section presents data related to the teachers' use of the programme through practice. The focus is on the extent to which they conduct or use practical activities and supplementary materials in their actual teaching of Osmosis and Diffusion lessons that were part of their training programme during the workshop.

4.2.2.2.1 Observed use in practice

Five different observations were conducted in grade 10 secondary school classes where Osmosis and Diffusion were taught. During these observations, it has been noted that all the teachers used the programme extensively. Different parts of a lesson were followed and respected. The activities and materials were prepared with the intention to cover the content of the osmosis and diffusion topic as outlined in the syllabus.

4.2.2.2.2 What did the lessons look like?

As mentioned-above the observation focused on observing teachers' basic teaching skills, their subject matter knowledge as well as their use of activity-based teaching approach. The overall observations revealed that the impact of the programme was generally regarded as satisfactory. The majority of teachers followed the basic idea of the INST programme for each of the three aspects of the lessons. However, it has been observed that in general most of the teachers performed slightly better in the subject matter knowledge than in other areas.

In terms of teaching skills, they did slightly better in activity-based teaching than in basic teaching skills. This performance might be attributed to their tendency to skip some basic teaching skills such as introducing the purpose of the lessons, ensuring full participation of all students, encouraging students to ask questions, and giving full attention to areas that reflect activity-based teaching. In terms of relative performance, one teacher out of five performed better than others in all the aspects. It was also observed that one of the teachers had performed poorly in activity-based teaching.

The reason for this performance can be understood in EckBeats' (2015) five reasons why teachers fail. He suggests that:

1- Teachers fail because their heart is not in the job.
2- Teachers fail because they are teaching the wrong thing.
3- Teachers fail because they are not prepared.
4- Teachers fail because they are overwhelmed.
5- Teachers fail because they are too scared to ask for help.

Despite the fact that they had planned and allocated a specific time to each stage of the lesson, it was observed that they had difficulties following these time frames. There were several reasons to explain this. First, the first lesson period started late and affected the whole plan. Consequently, they were forced to skip some of the basic teaching skills. Second, activity-based teaching, which was new to students, created difficulties for the teachers estimating the appropriate time for each stage of the lessons. In most cases, the earlier stages took more time than the latter ones. Yet, it is known that good time management is vital for students to shine (Gettinger & Seibert, 2002; McLeod, Fisher & Hoover, 2003). It helps students prioritize tasks and accurately judge the amount of time needed to complete them. It also allows teachers to accomplish more in a shorter period of time, which leads them to take advantage of learning opportunities.

After having discussed the time-framework of the lessons observed, the next three sections present teachers' performance in each of these sections: the introduction, the body, and the conclusion as outlined in the observation checklist (See Table 4.18).

As far as the introduction of the lesson is concerned it has been observed that during this stage, teachers appeared to be adequately prepared except one whose lesson introduction was affected by a late start. In most cases, they introduced their respective lessons by a short recall session, asking students questions related to the previous lessons or by a question and answers session about their background knowledge on Osmosis and Diffusion. Yet, on some occasions, some of them started their lessons with practical activities related to the Osmosis and Diffusion concepts. In general, these findings are in harmony with Holme, (1994) who suggests that a good introduction provides interest and motivation to the students. It focuses students' attention on the lesson and its purposes. It also convinces students that they will benefit from the lesson.

A good example of lessons introduced by the use of practical activity is the one which started with an observation of two pieces of carrots that were immersed, one in freshwater and the other in salty water, followed by questions to state the differences which introduced better the topic of the new lesson.

However, it was observed that two teachers did not succeed to involve students in their recall sessions. This was in contradiction to the principle of prior knowledge according to which the teachers should recall the knowledge the learner already has already acquired before they transmit new information. The good way of introducing a lesson is to go back and forth between asking questions, eliciting students' ideas based on their experiences (Brown et al., 2013). In their classes, it appeared that most students were not confident about their answers to questions, and their questions were confusing and not easy to understand. Equally important, some activities took longer than anticipated, hence affecting the time-frame for the other stages of the lesson.

In general, it was observed that some even though teachers, during the introduction stage of their lessons, were implicitly preparing their students for activities to be conducted. The above data have revealed that each class was not an easy task. Some teachers have experienced serious problems than others. Most of these problems were related to time constraints and an appropriate teaching methodology. Consequently, lessons were either badly taught or not finished. In this context, I realised that there is a necessity to address the issues that made teaching a difficult task by preparing teachers to practical ways they have to deals with such situations without disrupting the normal teaching-learning process (Gay, 2018). In regard to the body of the lesson, generally, it has been observed that it involved different classroom activities where the students explored and explained the concept for the first time. It has also been observed that most of the activities were conducted in groups of five or six students. In other cases, teachers explained and presented the results to students.

On an individual basis, it has been observed that:

- **Teacher (1)** had all the adequate and necessary teaching materials. She used them properly and ensured the participation of all her students. However, due to time constraints, she did not do all the activities. This is not consistent with good time management as suggested by McLeod, Fisher, and Hoover (2003) as well as Gettinger and Seibert (2002). This resulted in skipping some basic teaching skills such as encouraging the students to ask questions. However, she could effectively handle the issue and tried to maintain a positive learning environment during her presentation.

She had written the objectives of the activity on the board of the lab, and also a brief demonstration of how to conduct the activity. The demonstration was visible and clear to all the students. This finding is in harmony with Panasuk, Stone and Todd's (2002) view that successful teaching and learning relate to good lesson planning. It is important to mention that even though the teachers did not have enough time to support students by advising and encouraging them to ask questions or to answer all their questions, and allow them to answer her questions, her knowledge of the subject matter was satisfactory because she clarified the new terms and concepts appropriately and correctly. This is in agreement with the views of Ball and McDiarmid (1989), as well as Gettinger and Seibert (2002) according to which the mastery of the subject matter and PCK are essential to successful teaching and learning.

- **Teacher (2)** had some of the teaching materials for osmosis and diffusion and did the experimental work in front of the students as suggested by Panasuk, Stone, and Todd (2002) in regard to good ways of presenting a lesson. Although she effectively handled timing difficulties, she did not encourage her students either to ask questions or to assure them to participate in the learning exercise. But she mentioned the objectives of the lesson and demonstrated how to conduct the activity and interacted equally with students. She answered their questions correctly and clarified the new terms and concepts appropriately. Based on the above, her subject matter knowledge was satisfactory as the result of her good PCK (Ball & McDiarmid, 1989).
- **Teacher (3)** did not have the necessary and adequate teaching materials. She used the talk-and-chalk method and a little demonstration. She was not satisfactory because she did not clarify the concepts. This finding was in contradiction with principles according to which good teaching practice also relates to the use of teaching aids and reality in the classroom (Jenkins & Eliason, 2008). However, she maintained a positive learning environment during the lesson and effectively handled timing issues in harmony with time management as indicated by Gettinger and Seibert (2002). Her demonstration was visible and clear to all the learners. She encouraged them to ask questions but did not manage to get sufficient time to answer all their questions. Even though she had answered some of their questions correctly and clarified the concept

appropriately she did not relate the questions to their daily life in contradiction with the contextualization of teaching practice advocated by Jiménez-Aleixandre and Reigosa, (2006).

- **Teacher (4)** had all the adequate and necessary teaching materials in the lab. She moved around the class to ensure the participation of all the students and divided them into groups. She also maintained a positive learning environment during the activity. However, she skipped the presentation of the activities' objectives in order to save time. Her demonstration of how to conduct activities was clear and visible for all the students and she supported the groups by asking them questions.

  Despite her encouragement for them to ask questions, she seemed to be different from the other teachers. She devoted sufficient time to get feedback from students. Her knowledge of the subject matter was adequate since she had clarified the new terms and concepts appropriately and related the activities to students' daily life experiences.

  In light of the above findings, teacher 5 represents all the characteristics of a good teacher in regard to her time management skills (Gettinger & Seibert, 2002; McLeod, Fisher & Hoover, 2003), PCK, and subject matter mastery (Ball & McDiarmid, 1989).
- **Teacher "5"** had most of the teaching materials and ensured the participation of all the students. Moreover, she organised and divided the class into groups and moved around the class. She also maintained a positive learning environment during the activity. However, she did not encourage them to ask questions and she did not present the objective of the activity or supported the students by advising them. Even though she could answer their questions correctly and clarify new terms and concepts appropriately, she failed to associate the activities to their daily life.

In light of the above findings, I support the notion that teacher 5 tends to follow a reasonably good approach. However, the same data reveals that to some extent, this teacher, like others also experiences some difficulty with time management, PCK, and subject matter mastery. This is in total or partial contradiction with Gettinger and Seibert (2002); McLeod, Fisher, and Hoover (2003) as well as Ball and McDiarmid (1989), who think that good teachers are those who have good time management skills, and have both adequate PCK and good mastery of the content they teach.

The above-presented data indicate probably that most Libyan biology teachers even those with long teaching experience have different levels of teaching difficulties besides the problem of time constraint. The findings related to their way of handling the body of the lesson revealed that various issues of teaching-practice need to be addressed. According to Bybee (2014), a good presentation of the body of the lesson is the source of students' success. In this situation based on problems observed a workshop can be held to prepare teachers on how these issues can be addressed. The following table 4.18 summarises the observation about the conclusion of different lessons.

Table 4.17*: Summary of observation of the conclusion stage of the lesson*

Item	T1	T2	T3	T4	T5
Basic teaching skills					
1. Teacher summarises the lesson	-	-	-	-	√
2. Teacher asks groups to present their results	√	√	-	-	-
3. Teacher summarises the findings of activity	-	-	-	-	√
4. Teacher spends the time to discuss the activity thereafter	√	-	-	-	-
5. Teacher asks learners questions and waits for responses	-	-	-	-	-
6. Teacher encourages learners to ask questions	*	-	*	-	-
7. Teacher gives homework (assignment)	-	-	-	-	-
8. Teacher explains the significance of the homework	-	-	-	-	-
9. Teacher clarifies how the homework will be done	-	-	-	-	-
Activity-based teaching					
1. The teacher asks the group to report their results to the class	√	√	-	-	√
2. Teacher draws a conclusion from the activity(ies)	√	*	√	*	√
3. Teacher, together with learners, draw conclusions from the activities	*	-	-	-	√
4. The teacher guides the learners to know the differences in their results	√	*	-	-	*
Subject matter knowledge					
1. Teacher correctly clarifies the results of the activity	√	√	√	√	√
2. Teachers relates the activity to the theory behind it	-	-	-	-	-
3. Teacher provides theoretical conclusion from activity	-	-	-	-	-
4. Teacher appropriately summarises the lesson	*	*	√	*	√

Note: (√) = Observed and performed well (*) Observed but not performed well (-) = Not Observed

This stage involved a variety of activities depending on what was done or conducted during the development stage (the body stage) of the lesson. In most cases, it consisted of controlled practices, involving asking the students questions about what they have learned. However, it has been observed that in most classes the presentation stage was conducted in a rush due to time constraints (see Table 4.18).

The observation revealed that the majority of teachers ended their lessons with a summary without reaching a concrete conclusion about what the students had learned. It was either done in a rush, because the body of the lesson was longer or because the lesson itself started late. Generally speaking, the majority of basic teaching skills for this stage were skipped because of the lack of time. This finding agrees with those of Gettinger and Seibert (2002) as well as McLeod, Fisher, and Hoover (2003) who believe that bad time management is the cause of most botched lessons.

This stage was also devoted to give homework and assignments to students or to correct other classroom exercises. The correction of classroom exercises was sometimes postponed, or students were asked to finish writing their reports. In the last circumstance, they were collecting their exercise books to mark and provide feedback. It was also intended to give a summary of the lesson and to inform students about what they would learn in the coming session.

In conclusion, classroom observation had revealed that teachers were enthusiastic about the activities and materials they have extensively used, along with some other materials while teaching Osmosis and Diffusion lessons. The additions were made not because the materials were deficient, but rather to enrich the lessons. This has helped to cover a subtopic that was not included in the syllabus but felt by the teachers as important and that can by any chance be assessed at the national exam. It was also observed that they did slightly better in activity-based teaching than in basic teaching skills even though, because of time constraints, they were forced to skip some activities involving basic teaching skills such as encouraging students to ask questions or explaining the purpose of a lesson.

4.2.2.2.3 Interaction between Beliefs, PCK, and Practice

This study subscribes to Clark and Peterson's (1986) reciprocal theory of the relationship between the domains of teacher thought and action. These researchers propose that teachers' actions are in large part caused by teachers' thought processes, including beliefs and knowledge, which are in turn affected by teachers' actions. Therefore, the teachers' beliefs and PCK were not the only factors that influenced their practice in this study. They did not solely rely on their beliefs and PCK as they made instructional decisions. Additional factors and key factors that influenced their practice consisted of basic teaching skills; activity-based teaching; subject matter knowledge; teacher-centred; learner-centred and also of the level of teachers' understanding of their learners' conceptual development.

As a matter of fact, the study indicates that as far as basic teaching skills are concerned most of the teachers were influenced by their concerns for covering the required curriculum. In doing so, they considered the state and district standards as the reference point that dictated their choice of topics to cover in class. This concern was driven by the district expectation that students pass the national standardized test. For example, teachers made instructional decisions based on their personal goal for teaching, namely preparing successful citizens who are able to make decisions based on evidence, as well as their concerns for covering the content required for the National Test. However, the teachers were also concerned about maintaining control of their classrooms. On the other hand, their didactic practice reflected that concern as well. This view is consistent with Lestari, Suprapto, Deta, and Yantidewi, (2018) who think that basic teaching skills determine the success of learners based on the teaching objectives of that subject.

About *activity-based teaching* the data revealed that most subjects after the INST tried to practice activity–based teaching with their students. However, the data revealed that not all of them were successful in using pedagogical techniques consistent with that goal. Considering what has been observed one can say that the teachers' automatism and routine are still missing as they were not using these techniques before. This is in harmony with Shulman (1986) who supports that practice is the mother of sciences.

Regarding *subject matter knowledge* the data showed that the majority of subjects improved their subject matter knowledge. According to the findings, the teachers seemed to gain some level of maturity in teaching by explaining and discussing concepts and their principles adequately. The finding is consistent with Nixon, Campbell, and Luft, (2016) who believe that subject matter knowledge can improve with classroom teaching experience.

Concerning *teacher-centred teaching methods* as proposed by Abdella (2015), the data revealed that the subjects believed their students were incapable of problem-solving and refused to think because of the existence of competing priorities. They believed their students lacked the necessary background to engage in this new way of thinking and were incapable of such forms of independent learning. For that reason, the teachers believed they had to completely structure the learning environment and transmit discrete facts of knowledge to students who were not able to construct knowledge on their own. This finding is in contradiction with that of Eckel (2019) who supported that the best way of succeeding in teaching is to put learners in the center of all teaching activity. In the same way, teaching is successful if students can make use of or understand what they have learned in their everyday life as part of their life.

The teachers' practice was also mediated by contextual factors that inhibited or promoted the translation of their beliefs and PCK into practice and their use of 5Es as an instructional strategy. These contextual factors included administrative support, availability of resources, and teacher autonomy (Clark & Peterson, 1986).

Relating to *learner-centred methods* as indicated by Eckel (2019) and Mavhunga & Rollnick (2016) the data revealed that even though the subjects believed their students were capable of learning and to undertake problem-solving as well as learn in a different way, e.g. through active learning, they mainly resorted to teacher-centred teaching methods because of the reasons mentioned in the above paragraph. This finding supports Obeidi (2013) who argues that the Libyan education system is led by cultural beliefs and practice.

Finally, in regard to the *level of understanding of learners' conceptual development,* the data indicate that students persevere in their choice of instructional strategy whenever they faced difficulties. They were adjusting themselves in the learning environment where the teachers were mainly concerned about finishing the list of content to be taught without caring about the way it should be taught successfully. This is consistent with Dani's (2004) view that students always try to understand the concepts they are taught. However, they do not care about the importance or efficacy of the notions they have learned in their everyday life.

In brief, the interaction between teachers' beliefs, PCK, and practice were mediated by their previously held beliefs about their students. However, Richardson (2003b) affirms that the question remains unanswered as to whether beliefs guide actions, actions guide beliefs, or that they interact such that beliefs or actions may be dominant and affect the other depending on other factors. These other factors may include the physical setting or external influences (e.g. school, principal, community, and curriculum), degree of autonomy (flexibility in planning), teacher empowerment, and task demands. In the next section, I shall present the data from interviews.

4.2.2.3 Data from interviews

The present study aimed at investigating the manner in which an in-service professional development programme can engage teachers based on educational activities and how it can help and bring effective changes in teaching practices.

Specifically, the present study targeted grade 10 secondary school biology teachers. It was intended to determine these teachers' PCK and opinions about teaching biology. Besides, it examined the impact of the INST programme on these teachers by exploring their updated PCK and opinions about teaching practice. Their PCK was defined as their comprehension and perception of their knowledge of the curriculum, their understandings of learners' comprehension, their knowledge of biology notions, and finally, their understanding of educational techniques.

Results from the present study revealed that the INST Programme conducted, resulted in changes based on their teaching practice. The degree of change that occurred differed from one teacher to another based on different reasons related to each one's comprehension. However, the reasons that intervened or obstructed change were their prior knowledge structures, worries to follow the syllabus for national examinations, and the number of lessons to teach and some other local contextual aspects.

The teachers manifested change in both their knowledge of educational strategies and their perceptions of learners' understanding of biology. For example, it has been observed that most teachers have started using constructivist teaching strategies to determine the role of their learners' background knowledge in the comprehension or the miscomprehension and/or the obstruction of the acquisition process. In this perspective, each teacher used a determination process and strategies of her/his own. Therefore, the findings they got were not similar but they provided adequate and informed answers to their different queries.

This difference resides in the extent to which their PCK steered their practice and also on how their background knowledge and the changes that followed as a result of the INST Programme was related in most cases to their educational practices. Unsurprisingly, the teachers' opinion structures diverged noticeably. To illustrate, Teacher 1 and Teacher 5 adopted opinions consistent with constructivist theories of teaching and learning biology. For example, they used language and teaching methodologies consistent with the requirements of constructivist practices. These approaches consist of practices such as the role of prior knowledge and alternative conceptions in promoting or inhibiting students' learning. On the other hand, Teacher 2, Teacher 3, and Teacher 4 adopted opinions aligned with the positivist/old-style and procedure theories of biology teaching and learning practices. For example, they were found to hold positivist views, believing that the substantive content of science is fixed and unchangeable rather than tentative (Abd-El- Khalick & BouJaoude, 1997). Teachers, who carry positivist views of their discipline, teach their discipline as a body of knowledge. They also emphasize not only on presenting vocabulary as a balanced presentation of human and rule-based knowledge generation but also as cautious evaluation of knowledge claims. These views support limited laboratory work and the presentation of science as a method of understanding the world (Gess-Newson, 1999). However, they differed in their process and knowledge of how to deal with the requirements for learning and the areas of students' difficulty.

The most striking characteristics of their opinions that functioned the most in their achievement of PCK and their teaching practice of subject matter, involved their opinions about biology, the aim of teaching and the views of their role as teachers, and their opinions on how students study. Some of these opinions were impacted by the INST programme. As an illustration, all the teachers changed their opinions on their role as teachers from an old-style perspective to a constructivist perspective that highlights facilitation. However, Teacher 3 and Teacher 4 preparation did not reveal this new role. In other words, their preparation revealed a constructivist opinion on their role as teachers.

Other reasons that facilitated the transformation of teachers' PCK to concrete exercises depended on circumstantial reasons. Such reasons involved resources, availability of administrative support, and the level of independence each teacher had. As an illustration, Teacher 1, Teacher 2, and Teacher 5 had appreciated total independence in their classrooms. They freely adapted curricular materials in alignment with practical exercises after they had been involved in the INST programme. However, Teacher 3 and Teacher 4 had to follow the curriculum as instructed by the local teaching authorities so as to respect the timetable and evolve at the same pace with other teachers and students in the area.

After having introduced the salient findings of this study, the following sections present five case studies and pay particular attention to the participants' background, the teaching context and opinions about biology, the theories about teaching, learning and PCK in terms of their conceptions of the biology concept and finally to the curriculum and instructions. The case studies allow the investigation of the interaction between the various aspects of teachers' teaching related to their context, background, opinions, and knowledge.

4.2.2.3.1 Teaching background of participants

This element of the participants refers to their intellectual and professional biography, namely their previous experiences in biology and the reasons responsible for their choice of a teaching career in biological sciences. Together, these aspects have the potential to provide insight into their practice and knowledge base for teaching. The data have indicated that Teacher 1, Teacher 2 and Teacher 4 did not want to be teachers when they graduated from the Faculty of Science, but unfortunately, they did not find the careers they had hoped for. They did not either want to face many of the cultural challenges or to stay at home. They considered the fact that in Libyan society the best career for women is to be teachers. They reflected on their years of schooling and came to the realization that their favourite subject was biology.

However, these teachers loved biology, due to the fact that they constantly excelled in it and it helped them to satisfy their natural curiosity. This sense of satisfaction with biology was fuelled by their apprenticeship in the discipline of teaching. The following excerpt from subjects can serve as evidence:

> **Teacher 4:** *I loved biology through my teacher, and then I studied in the Faculty of Science, specializing in animal science.*

> **Teacher 1:** *I really enjoy teaching Biology and I love activities more than theoretical teaching.*

As far as the context of the study is concerned; all subjects were grade 10 secondary school biology teachers in the Hia Alandalus district in Tripoli the capital city of Libya. They had three different books to cover during the school year, namely: the textbook, the activities book, and the homework book. This means that they had the opportunity to teach Osmosis and Diffusion unit. The school year in Libya starts from September to July and is divided into two semesters. The first semester is from 1 September to 15 January. The present investigation took place during the first semester of 2017. A typical school day starts at 7:30 AM and ends at 1:45 PM.

Teacher 1, Teacher 3, and Teacher 5 used the lab to teach Osmosis and Diffusion whereas Teacher 2 and Teacher 4 used the lab as a normal classroom. It has been observed that Teacher 1 and Teacher 3 had fully equipped labs in their school and that the other teachers' school labs lacked some equipment.

4.2.2.3.2 Beliefs about teaching biology

Concerning their comprehension of the reasons for teaching biology, they related it to a constructivist stance that had been clearly noticed in their practice. They believed that biology involves the knowledge of the world and the way of knowing what explains it and its interactions. This was in alignment with the constructivist view that recognizes biology as one way of explaining life. To the question about why they opted to teach biology, they referred to the study of living and non-living organisms and their connections. The following excerpt from a participant can serve as evidence:

> **Teacher 1:** *It is very important to learn biology because it concerns all life phenomena around us. We need to teach biology to young people to give them insights, which can help them develop their knowledge of the environment surrounding them and also develop their perception of living organisms.*

Most of the subjects agreed that biology plays an important role in the comprehension of all aspects of life. Many of the discipline's topics deal with phenomena people experience every day. Theories about teaching biology, which is considered as determinant elements of teachers' PCK, relates to teachers' understanding and beliefs about the objectives and goals for teaching biology at a given grade and the consequential orientations or views in the direction of biology teaching practice. In the next section, I present data related to teachers' goals and objectives for teaching biology and their subsequent opinions about teaching and learning.

As far as the teachers' goals for teaching biology are concerned, each teaching goal had a number of specific objectives for teaching biology. Most of these objectives relate to the teachers' overall teaching and learning purposes, one of which was to prepare their students to become prosperous and responsible citizens. Many of the teachers believed that it was essential for their students to be skilled to use knowledge acquired in the classroom to have an appropriate and healthy lifestyle in society and to make decisions based on evidence and knowledge. The following excerpts from the participants can serve as evidence:

> **Teacher 1:** *My aim of teaching biology is to help students achieve knowledge of the vital processes that occur in the environment around them and its effect on their bodies.*

> **Teacher 2:** *I think that teaching biology is teaching life itself. For example, there is a unit on food such as fat, carbohydrates, proteins, and their relationship with a healthy life, which is supposed to be taught before secondary school to warn students about their diet behaviour and the related consequences.*

> **Teacher 4:** *My primary goal in teaching biology is to help students develop their thinking and know their organism and know the world of organisms in the environment surrounding them.*

> **Teacher 5:** *As most secondary school students are adolescents and maturing, teaching them Biology helps them to understand the nature of the phenomena around them and what happens in their bodies.*

Thus, linked to their desire of preparing useful members of society, their notions of the necessity to teach biology at secondary school centred on giving their students the required foundations and skills for their life and future careers. In keeping with the above, they believed that teaching biology at secondary school should focus on scientific content and processes that prepare a foundation for future learning.

Besides, the teachers included personal objectives for teaching biology. Their personal objectives stemmed from their general purpose of teaching. They aimed to prepare useful members of a society who would be able to make decisions based on evidence. For that reason, the majority of them estimated that their students would be able to use evidence to support their work at all times. In that way, the emphasis on evidence would be apparent in their practice as it is discussed in the section related to instructional strategies. Teachers also believed in instilling the big picture of biology into students' lives to help them realize the success of knowledge acquired in the classroom and hopefully engender excitement and interest in the discipline. Finally, they underscored the role of social cooperation in the generation of knowledge, in their endeavour to prepare students for their roles in society. The following excerpt from a participant can serve as evidence:

> **Teacher 1:** *A lot of students' experience with biology is that they don't like it since it's boring or dumb or they don't understand the need why they should use it. I have faith that at some point when they leave my classroom, they will at least have some enthusiasm for some aspect of biology.*

Regarding the teachers' perceptions of teaching biology, they mentioned that it relied on their objectives and aims for teaching biology that was not only consistent but also driven by the INST programme orientations towards better teaching of biology. They expected their students to create a community of learners whose members share responsibility for understanding biology concepts. They also intended to instil in their students an understanding of the processes of biology, based on process skills such as making observations and evidence-based inferences. They also believed that biology teaching was happening only when students were involved and learning. They further explained their role as people who engage students in learning activities and practices by guiding them through leading questions.

In short, their considerations for teaching biology mainly focused on increasing students' understanding of notions and processes (Prawat, 1992) that align with the constructivists' view of learning. In Elliott, Kratochwill, Littlefield, Cook, and Travers (2000) words, according to this view, "people actively construct or make their knowledge […] determined by the experiences of the learner" (p. 256).

Most of the teachers believed that students' commitment and prior knowledge played a significant role in their learning of biology. In this regard, they aimed at accomplishing two purposes namely, active involvement in the learning process and connecting what they learn in class with their life worlds outside the school. They explained prior knowledge as their comprehension of scientific concepts that result from life involvements or previous formal education. Furthermore, they believed that prior knowledge played a significant role in setting the context for acquiring new concepts, for relating new notions to what they already knew or to their daily experiences. For that reason, many of them started each lesson with a short recall session aimed at checking and activating students' prior knowledge. However, as grade 10 secondary school students come from different middle schools their prior knowledge was also different and thus they were not on the same cognitive level. The following excerpts from subjects can serve as evidence:

> **Teacher 1:** *The basic concepts of osmosis and diffusion are taught in the preparatory (middle) stage, but when students have not well assimilated these basic concepts it becomes difficult at this level to deepen these notions as I have to build new knowledge on previously learned concepts. Sometimes, I need to give a full lesson on those notions to raise students to the required level for the unit or lesson scheduled at the secondary school stage. For this reason, sometimes, I require the student to do quick activities in groups.*
>
> **Teacher 2:** *I check students' prior knowledge and then adapt my teaching to their level of comprehension. I try to make the information as simple as possible for them.*

The teachers' practice revealed their focus on students' prior knowledge to stimulate engagement and relevance when they strive to link concepts learned to situations they might face in their everyday experiences. They stress the interconnectedness and relevance of learning experiences as being reliable with their objectives of teaching biology, theories about the unified nature of conception, and perceptions of how they learn best. For that matter, the objectives of teaching biology comprised promoting the understanding that concepts can explain their lives. The following excerpts from participants can serve as evidence:

> **Teacher 1:** *The basic concepts of osmosis and diffusion are taught in the preparatory stage, but when students have not well assimilated these basic concepts, it becomes difficult at this level to deepen these notions as I have to build new knowledge on previously learned concepts. Sometimes, I need to give a full lesson on those notions to raise students at the required level for the lesson scheduled at the secondary school stage.*

Teacher 2: *The goals are to develop students' knowledge of their bodies and also develop critical thinking about life and the world surrounding them.*

In light of the data presented above I would like to mention that as far as the requirements for learning are concerned, teachers should put emphasis on the importance of their students' prior knowledge. According to them, good teaching-learning can occur when students have good background knowledge on which to elaborate new knowledge and develop their understanding. The priory knowledge also helps to link abstract notions to reality. According to Willingham (2006, p. 42) "the more you know, the easier it will be for you to learn new things."

Unfortunately, the above-stated two excerpts indicate that it is likely possible to find some learners in some classes without adequate background knowledge on which to build new knowledge. This becomes an issue not only for learners but also for teachers who face a stumbling block where learners cannot assimilate new notions that are the continuation of what could have been learned in previous classes. It creates a delay in the teaching-learning process. To address this issue, it is necessary to know the cause and to find an adequate solution. Otherwise, this will always result in loss of important time that could be used to learn other notions.

4.2.2.3.3 Teachers' knowledge of areas of students' learning obstacles

The data I collected to explore teachers' knowledge of their students' learning obstacles revealed that abstraction, altered conceptions (misconception), and students' ability as the main causes.

As far as abstraction is concerned, teachers found areas of student learning obstacles related to students' growing and prior knowledge. They stated that abstract notions or concepts that lack connections to their experiences, unfamiliar terms, and misunderstandings are sources of learning obstacles. Developmentally, they agreed that most of their students went through obstacles in learning abstract concepts. They considered their role "students' assistant" to be that of building on their students' abstract concepts the evidence-based representations relating to natural or lived experiences, rather than simply talking in the abstract. In this way, they recognized how providing students with tangible experiences with adequate or adapted materials made understanding and absorbing abstract concepts more accessible. The following excerpts from the participants can serve as evidence:

> **Teacher** 5: *Active transport is not easily understood by students due to its abstraction. They always ask to understand how water moves from a low to high concentration and active transport is a movement of some substances into and out of the cell against concentration.*
>
> **Teacher** 3: *I think what makes biology easy to teach is the use of practical work and experiments. When a lesson is taught, with active methods, through experiments it is easier for learners to understand and see what happens. For example, the lesson on classification is difficult for students, because it is presented without practical activities. As a result, their learning is always poor. However, a lesson on osmosis and diffusion based on practice makes acquisition and understanding easier for them, because it is not based only on abstract concepts but on practice and experiments as well.*
>
> **Teacher** 2: *I think that training in the enzymes unit will be welcome because this unit is more ambiguous and abstract than other units in the program. It is difficult to clarify the concepts within the content and although I have tried to explain it as much as I can, students still have problems understanding it.*
>
> **Teacher** 4: *There are some difficult concepts such as the genetics' concepts and others, which make it difficult not only teaching but comprehension as well. I try to explain the concepts of inheritance through the adjective characteristics before introducing the concept of genetics, but when modern on the nuclear and the transfer of qualities between generations is difficult for students to understand then also plant taxonomy is quite difficult for them.*

In regard to altered conceptions (misconception), the data revealed that the teachers mentioned that students' misconception is a foundation of misunderstandings and learning obstacles. However, even though they have identified and spoken about their misunderstandings in the classroom, they were not precise in their arguments about this issue during interviews that were intended to discuss this matter. Two teachers have indicated the case of misunderstandings in their interviews. The following excerpts from the participants can serve as evidence:

Teacher 2: *Students are always confused about the Water effort and Osmosis. It is difficult for them to distinguish between the high Water effort and the concentration of the solvent. In order to help them understand, I used to write it as an equation on the blackboard to clarify the ambiguity between the concepts. According to me, as a biology teacher, Osmosis becomes complicated because of Water effort.*

Teacher 1: *I know that the Water effort is the number of water molecules in the solution. Therefore, when there are a 15% solution and a 10% solution it means that the Water effort in the solution is 10% higher than the Water effort in the 15% solution, because of the high number of water molecules.*

Teachers are attentive about students' misunderstandings. Their use of mental techniques to resolve them was reliable with their understanding. Two different lessons based on Osmosis and Diffusion during the INST programme presented techniques to unveil their own misunderstanding (to recognize and define them and ways to get rid of). One of the conceptions addressed in the INST programme was teachers' own misunderstanding in their interpretations. The following excerpt from a participant can serve as evidence:

Teacher 4: *I correct the students' wrong concept by discussing with them and by asking them parallel questions to their alternative misconception. From one or both of these processes, they realize that the answer they have given needs to be corrected. Or sometimes I do the corrections by linking related concepts such as linking what happened in the Osmosis and Diffusion and the Water effort. I discuss with each group to see if they have achieved the goals and to check whether there is a misunderstanding of the concepts or no.*

As for *students' ability* the teachers revealed their aims for teaching biology, and their willingness to use constructivist theories of teaching and learning. However, if misunderstandings emerged as barriers to *students' ability*, teachers used techniques reliable with pedagogic theories of change to remove them. Regardless of their opinions according to which students were confronted with problem-solving techniques, teachers' determination and self-reliance in their abilities caused their confidence in learning. The following excerpts from the participants can serve as evidence:

> **Teacher** 4: *For example, I had some shy students in the first year. They used to cry every time they were not able to answer questions correctly. At first, it was difficult for me to understand or explain it and it is only later I understood that I have to help them overcome their shyness and not to be afraid of failing or making mistakes by giving them the opportunity to participate several times in discussions with other students. I also tried to put them in groups to help them socialize and integrate into team and group work.*

> **Teacher** 5: *Some students have the ability to discuss in a scientific way, and some are not able to. I think that this variation comes from home or from their previous grade at middle school. Nevertheless, some of them changed in the second year of secondary school and they improved. I do not know why, for example, one of them, when she was in the first year she was not active at all and when she passed in the second year, she became more active and changed completely. As mentioned before, the teenage stage plays a role.*

Taking into account the above-presented data, I hasten to mention that Libyan biology teachers involved in the study seemed to be aware of areas of their students' learning obstacles. This apprehension is the vital spirit that can help improve on the one hand their instructional practice and on the other hand the learning process. In this regard when teachers are able to identify their students' learning problems, they can adapt and improve their teaching practice to match their expectations (Timperley, Wilson, Barrar, and Fung, 2008).

4.2.2.3.4 Mastery of Evaluation and assessment in biology

The data I collected in relation to teachers' mastery and understanding of evaluation in biology revealed that the teachers' knowledge was reliable with their capacity to use examinations as a formative evaluation technique. This knowledge results in both their success and failure in employing evaluation approaches in the teaching and practice of biology. The data indicated that the teachers' understanding of evaluation and assessment scheme or technique points to their understanding of necessary approaches to the aspects of the objectives and learning of biology. The data also revealed that approaches of evaluation and assessment are based on specific tools, activities, techniques or processes used through specific units, and also the benefits and handicaps connected with the use of a given kind of evaluation/assessment scheme or technique.

In keeping with the above, the subjects assumed that it was essential to evaluate aspects of biology learning connected to elucidations and presentation of notions (theoretical understanding) based on concrete biology notions and practices concentrated on students' thinking. These aspects of biology learning were reliable with a constructivist understanding of learning and corresponding to aspects of scientific literacy. In the same vein, the subjects compared studying or knowing a concept to the capacity to enlighten and practice it. They supported that knowing a concept infers the capacity to use that concept in other circumstances and relies on links among other subjects to overcome new obstacles. The following excerpts from the participants can serve as evidence:

Teacher 2: *I have changed the students' assessment plan because the evaluation depends on the lesson presentation. For instance, when it was an oral presentation the evaluation was oral, but now that the presentation is conducted through practical activities the evaluation is also conducted through the activities they have accomplished. Some reach satisfactory results and others were not.*

Teacher 2: *I try to know my students during the discussions and activities I conduct in the classroom. For example, when students ask me why water moves and substances do not move during osmosis, I understand that they have not realized that the semi-permeable membrane allows only water to pass through it.*

This helps me understand their way of thinking and their comprehension of the concepts.

Teacher 3: *The evidence that shows my students have reached the objectives of the lesson is the way they report their activities, their reaction in classroom activities, and their performance in tests and exams.*

Teacher 4: *Assessment is dependent on what I have taught them either through theoretical explanations or practical activities. For instance, in osmosis and diffusion the findings of experiments and the reports they have prepared in their group, apart from the tests and the exams.*

In the same vein, the data revealed that the teachers' mastery of evaluation and assessment in Biology refers to their knowledge of evaluation techniques. This means that teachers' selection of evaluation and assessment techniques contained real evaluations in the kind of tasks and old-style evaluations (kind of written quizzes and formative evaluations such as questioning at checkpoints).

According to the curriculum, at the end of each unit teachers are required to evaluate their students' accomplishments. In the context of this study, these strategies were planned to combine all notions developed in the Osmosis and Diffusion unit so as to determine students' comprehension of these strategies by means of using them or combining various other components of the booklet. The data revealed that the teachers' selection of evaluation and assessment techniques was not good. When it came to evaluating the aspects of biology learning, the majority of techniques were judged as not being relevant. Teachers generally based their evaluation on written examinations. However, they recognized that this was not a good way of assessing students in circumstances where the main focus was real learning. Their deficiency of familiarity and required talents in evaluating their learning by means of questions that can be transformed in numerical value remains a problem. The best way they could imagine to properly evaluate students' learning by means of questions involved the use of comprehensive question/answer essays. The following excerpt from a participant can serve as evidence:

Teacher 1: *I evaluate my students either individually or collectively in small groups. Evaluation tasks are either theoretical or practical or they combine both aspects. Students design their* *reports on their own or through my guidance and according to the availability of time of practice so that they take advantage of their time in the experiments rather than spend time on the design... For example, in the case of osmosis and diffusion, when students are able to justify the changes in the sizes of carrots and when they want to check with the microscope what happened to the cells?*

In spite of what preceded, a number of teachers persist with the old-style, teacher-constructed kinds of evaluation that rely on using multiple-choice, close-ended questions and fill in the blank question as well as on laboratory reports assessments to check students' notions. The following excerpt from a participant can serve as evidence:

> **Teacher 5**: *I check my goals from students' discussions on the lessons, their reports on the activities, their answers to exams and tests*

One of the participants admitted that her current capacity in using formative questions comes from the INST programme during which she had been initiated to use this type of evaluative tool. She declared that before she used to consume more time supervising group activities by means of debates and questions based on barriers encountered by students. However, she recognized that the INST programme has empowered her to correctly evaluate specific notions her students have learned so as to determine their development. The following excerpt from her can serve as evidence:

> **Teacher 1**: *During the activities, I am spending additional time moving around and chatting to them throughout the class as they go for it. I notice that it has been a great idea. Via checking how students are doing the activities at different steps, what they have written, and making them halt and asking them about it. I feel I have gotten the results pretty significant, everybody has the same idea rather than having entirely different ideas and they have to repeat everything.*

To sum up, the teachers' constructivist understandings of learning were manifested in their selection of learned aspects to be reliably evaluated in regard to scientific literacy. These aspects were based on the elucidation and presentation of notions (theoretical understanding) through different biology lessons and the aptitude to facilitate studying with concrete facts based on students' thinking. However, a good number of participants admitted that the difference existing between their opinions and practices is due to the insufficiency of information about ways to evaluate learning that was poorly developed during the INST programme. After having presented aspects of teachers' knowledge of evaluation and assessment in biology the next section presents data related to knowledge of biology curriculum.

4.2.2.3.5 Knowledge of biology Curriculum

The data I collected related in reference to teachers' understanding and use of the biology programme revealed that teachers were anxious to satisfy the demands of the Libyan Ministry of Education. Besides, they comprised elements likely unveiling teachers' understanding of detailed curricular packages in terms of overall knowledge of objectives and knowledge of specific curricular programmes.

As far as the overall knowledge of objectives is concerned the data revealed that in making educational judgments, teachers based themselves on national and local objectives and aims, as well as national assessments. In addition, they indicated that the national and local criteria lead the instruction and the curriculum. In this context, they were generally anxious about the aims of coverage and were ensuring that their students were sufficiently prepared to succeed at the test even though the number of lessons per week had diminished. The following excerpt from one of the subjects can serve as evidence:

> **Teacher 5**: *The government did not think that changing the timetable of lessons without modifying the curriculum is a disaster for teachers and students, because now the number of lessons is insufficient. Before the government changed the course load, Biology had 9 lessons weekly among them two consecutive lessons intended for experiments, but now we have only 3 lessons per week, this is not enough to teach and conduct experiments, because students need time to acquire skills.*

The data also indicate that because of the time constraint indicated above (from 9 hours to 3 hours) with the same curriculum programme, teachers were selecting subjects to teach so as to comply with the district assessment criteria. They were doing this in order to prepare their students for the test, yet targeting the global understanding. The following excerpt from one of the subjects can serve as evidence:

> **Teacher 3***: I know that all the lessons are important, but considering time constraints I think that I can skip the unit on enzymes, but this is not a good decision, because it is connected to the digestive system. Therefore, I look at units with the possibility of many lessons and condense other lessons. For example, the unit on osmosis needs more than ten lessons according to the textbook, but I have condensed and reduced them to three. I have attempted to focus on the basic concepts of the unit. However, this decision is not without consequence. It has not helped me to teach actively, using practical work and experiments.*

As mentioned earlier in table 4.4 the teaching time reduction is a very serious issue in the teaching of biology in Libya. However, it should be mentioned that most of the teachers have made a concerted effort to accommodate the change and adapt their teaching practice accordingly. Considering that, it was the end of the first semester of the school year when the data was collected, I asked teachers how they proceeded to decide on selecting relevant subjects and the order of importance they followed to teach the selected subjects, one of them stated:

> **Teacher 4**: *Actually, I am suffering from it, because the school has started very late and the final exams are due in a week and I do not have enough time to teach all the remaining lessons. During this week, I am trying to develop a simplified plan based on definitions and examples to teach osmosis and diffusion concisely as well as active transport, instead of conducting full and structured experiments like the ones we conducted during the workshop sessions.*

Concerning the knowledge of specific curricular programmes the data revealed that the biology curriculum used in grade 10 in the Hai Alandalus district is the one authorised by the government. However, the teachers' understanding of the curriculum as directed by their willingness to cover national criteria related to the preparation of students to the national test.

The data indicated that to reach the goal of preparing students for the national test, the programme should be taught completely, but this generates a serious problem as the number of lessons per week had been decreased by the authorities without adapting the content to be taught in the available time. As a result, the teaching practice has become mainly theoretical. The following excerpts from the participants can serve as evidence:

> **Teacher 1**: *In this way, some activities mentioned in the curriculum are simply merged with others or compressed in a very short time. (The curriculum consists of three books, the textbook, the activity book, and the booklet of practical exercises). For example, I use exercises as a test, because of this time constraint.*

> **Teacher 5**: *The government did not think that changing the timetable of lessons without modifying the curriculum is a disaster for both teachers and students because the number of lessons is insufficient. Before the government changed the course load, biology had 9 lessons weekly among them two consecutive lessons intended for experiments, but now we have only 3 lessons a week, this is not enough to teach and conduct experiments.*

> **Teacher 4**: *As I mentioned earlier, I have a problem with managing the remaining teaching time and the number of lessons to teach. A lesson has a limited time of maximum 40 minutes, even with this limited time it was feasible in the past to teach all the lessons in the curriculum because we had a sufficient number of lessons a week of 9, then they were reduced to 7, then to 5 and lastly we have only 3 lessons left a week and the curriculum has not been revised. It is difficult to expand or deepen lessons or consider all students' questions. According to the curriculum, I have 4 lessons for each unit, I try to cover general concepts of the unit and conduct one fast experiment because the students are required to do the practical test. They must conduct experiments, get results,*

and interpret them. Another strategy is to use the time allocated to other subjects when those teachers are absent.

Teacher 2*: I teach nine lessons per week that means three lessons for each class. The reality is that the number of lessons per week is not enough for all the lessons as planned in the curriculum. Taking this into account, I try to cover the curriculum, but without going in-depth and teaching a concept extensively. For example, in food preservation, I do not ask students to go through all the activities.*

According to the above evidence, one of the most important factors that impede the teachers' implementation of the new curriculum is time allocated to deliver the content. I think this is the logical consequence of the erratic decisions or planning policy made by the authorities in charge of education in Libya.

Therefore, this study finds it necessary to adopt the new curriculum not only to achieve the content during the allocated time but more importantly to provide teachers with necessary techniques, strategies, and adequate teaching materials that can make their teaching practice easier.

4.2.2.3.6 Knowledge of instructional strategies

The data I collected in relation to teachers' knowledge of instructional strategies indicated that the teachers' choice of specific techniques to use in their teaching was determined by their aims and the purposes of teaching that were fully described by the INST programme. Some teachers established their judgments on their understanding of students' abilities.

The understanding of educational strategies and aspects of their PCK involves their understanding of specific questions and specific strategies. Specific questions and strategies are generally relevant to educational techniques specific to the teaching of a specific subject, contrary to the teaching of other subjects. Particular topic techniques have a restricted scope, they relate to teaching practice of certain topics, and can be in the form of demonstrations or practical activities.

The data also indicated that some teachers were experienced regarding their ability to use a number of educational techniques such as hands-on activities and guided inquiry in their performance as well as many other instructive techniques like recovering information from writings or pictures. Besides the above techniques, they were capable to use the 5Es' strategy as a result of the INST programme course. The strategy used a combination of practical activities and educational techniques. The following excerpt from a participant can serve as evidence:

> **Teacher 2:** *At the beginning of the lesson I started by asking questions to evaluate students' prior knowledge so that I can adapt the teaching to their level. This way of proceeding motivates students for the new lesson. When I applied the 5Es for the first time, their reaction was strange, they were asking why I was asking them questions on lessons they have not yet been taught, but they had recognized the benefit of the strategy only when I introduced the new lesson to them. They understood that all the concepts are linked in one way or the other and that it is not possible to go forward without looking at what has been covered previously.*

The data indicated that the teachers agreed that despite their constant use of practical activities before attending the INST programme, they realized that after they have attended the INST programme their teaching practices changed considerably. They admitted that as prospective teachers, they introduced to conducting activities on the basis of instructions on how to conduct an activity and by stating the expected students' results. After attending the INST programme, they said that discussions with the students started from the beginning of the activities so as to motivate their curiosity, their prior knowledge and focus on the use of evidence to support the practice as it was progressing. They emphasized both the use of evidence and the reliable use of leading questions to orient students during the processes. This secured the opinion that their techniques allowed questions even during the students' practical or other kinds of exercises. Some of the teachers felt that their interactions with students revealed their search for knowledge. The following excerpt from a participant can serve as evidence:

> **Teacher** 1: *Considering the time constraints, they need an assistant to achieve the right results. I did not give them the results*

directly, but we discussed the process to use and this leads them to find the right direction towards the expected results.

The data collected in this section aimed at inspecting the manner in which a professional development exercise engaged teachers in knowing more about biology content, standard assessments, teaching practices, and curriculum adjustments based on their judgments and practice. More explicitly, the data meant to determine the effect of the INST programme on the understanding of grade 10 biology teachers, their action, their pedagogical knowledge, their understanding of students' comprehension, and their understanding of the programme they were teaching.

4.2.2.4 The INST programme achievements

Taking into consideration the data presented in sections above and the findings ensuing therefrom, I hasten to mention that change has occurred in the teachers' knowledge. The INST programme has affected in one way or another, the teachers' opinions, their PCK as well as their actions.

4.2.2.4.1 Opinions shift

Many of them showed changes in their familiarity with educational techniques, learners' understanding of biology, evaluation, and opinions about biology teaching practice. As a consequence of their participation in the INST programme, their opinions about teaching biology practice gained some changes. It should be mentioned that before the teachers participated in this study they held old ideas about teaching and what or how to teach. This lack of adequate information was not good for the educational system considering that their role as teachers was not only to supervise activities conducted by their students but also to share information with them as well as to show and explain to them how to conduct activities in the laboratory. This implies that some teachers were not aware of what they were supposed to teach in a constructivist way, i.e. their teaching was not adapted to the classroom context. Instead of being co-participants of learning, they depended solely on the transmission of content. However, after the INST programme, their opinions aligned more with the constructivist perception of teaching than was previously the case. They indicated that their role as teachers resided in smoothening student learning, supervising them by means of questions, and preparing the atmosphere for good learning. These opinions agree with the practices shaped during the INST programme. However, it is important to mention that while some teachers have started thinking that instruction means helping students to socially build their understanding of the subject, others have not yet adapted their thinking to this new opinion as they still believe that instruction is to pass knowledge to students.

The above point of view is congruent with studies conducted by Cronin-Jones (1991) as well as Mitchener and Anderson (1989) whose subjects adopted new instructional strategies as a result of participating in a training workshop. The findings revealed that, in many cases, the teachers modified or refused to implement the programme they were knowledgeable about because it did not coincide with their style of teaching and their goal of teaching.

One of the teachers' objectives in teaching biology involved making biology a pertinent subject. Later, their objectives were extended. They understood the meaning of concrete representation in biology and included the necessity for their students to count on tangible evidence when concluding a concept. This new objective connected with their previous one that the teacher extended their teaching practice in biology as they understood the significance of learning by doing. Their students had not only to learn but to follow the processes as a device to solve problems of life as well. They also recognized the value of collective collaboration for biology learning as an outcome of the input from the INST programme.

In keeping with the above, Bandura's (2001) notion of socio-cognitive theory believes that learning occurs in a social context with a dynamic and reciprocal interaction of the person, environment, and behaviour. Therefore, teachers' actions give rise to self-reactive influence through performance and comparison with personal goals and standards. Further, they seemed objectivist, rooted in a valued system, and a sense of personal identity. Finally, they invest activities with meaning and purpose. The goals are to create motivation by enlisting self-evaluative engagement in activities. By making self-evaluation conditional on matching personal standards, the teachers appeared to give direction to their pursuits and to create self-incentives to sustain their efforts for goal attainment. Moreover, they did things that seemed to give them self-satisfaction as well as a sense of pride and self-worth, and to refrain from behaving in ways that could give rise to self-dissatisfaction, self-devaluation, and self-censure. In other words, they appeared to have gained a reasonable level of self-reliance while at the same time they were well aware of the influence of a much broader network of proxy and collective agencies (Bandura, 2001). In light of this, it can be said that most of the subjects involved in the study have imbibed the benefits of group work stressed in the in-service programme to which they were exposed. In the same vein, many of them opted for inquiry methods rather than adhere to the familiar traditional instruction method.

4.2.2.4.2 Pedagogical Content Knowledge shift

The teachers' constructivist opinions, their understanding of the curriculum, and the evaluation comprised old-style elements. On the one hand, their PCK was a combination of old-style and social constructivist understandings of evaluation, educational tactics, programme and student comprehension in biology. Besides, they showed that to enable student comprehension, it is necessary to present new concepts in appropriate contexts. Another aspect of students' learning and the presentation of concepts are essential aspects of student learning to evaluate. They have also pointed out that theoretical understanding was also well-informed about using other reliable approaches of evaluation like the student report. Additionally, they mentioned practices and exercises of the biology programme, which depended on the government principles and national test to be guiding their teaching practice. In light of the above-stated claims, I believe that the Libyan teachers involved in this study recognized that the biology programme was bogged down by an examination-driven instructional practice and that it was necessary to work on how to make it more adapted and efficient for the Libyan educational system.

In the same perspective, the data revealed that as an outcome of the teachers' input from the INST programme, they have changed and adapted themselves to the context. This means that the teachers' knowledge of their students, their skills in using the 5Es model of instruction as well as their evaluation skills and teaching practice have undergone to some extent some modification in order to adapt to the requirements of the environment. However, in other circumstances, their familiarity with the students' understanding of biology was adjusted to promote their social constructivist understandings. Their familiarity comprised the role of revising previously acquired information and misunderstandings to either encourage or prevent their learning, even though all the teachers are the same and do not act in the same way when it comes to studies or aspects of their learning obstacles.

The teachers became familiar with the constructivist concept and precise educational tactics and mentioned the 5Es as educational techniques in teaching biology. Their opinions about the significance and the role of research about teaching biology were improved. The 5Es went beyond the simple fact of engaging students in practical exercises. It included both practices and processes of argumentation and dialogue which in turn impacted their professional practice as mentioned by wuanyanwu & Ogunniyi (2020).

4.2.2.4.3 Teachers' Action shift

The teachers described their teaching practice as clarifying new concepts, giving directions for activities, observe and managing students' behavior, and collecting classwork. The nature of their instruction was consistent with improving and activity driven orientations to biology teaching. After participating in the INST programme, their practice was enhanced and changed, to different degrees. Also, the nature of their instruction became more consistent with the INST programme's orientations to biology teaching.

Concomitant changes in practice did not always accompany the changes captured in the teachers' PCK and beliefs. However, these PCK and beliefs were guided and translated into their practice in most cases. Despite this, the changes in their practice were reflected on their changes in PCK and beliefs. Most of their cases, beliefs, and PCK were coherent and reflected constructivist views that translated into practice.

For example, they relied on instructional strategies where students collaboratively engaged and linked in the construction of activities. Most of them also actively engaged the students' prior knowledge and addressed their alternative conceptions (misconception) through the conceptual change technique. Finally, they consistently used questioning and discussion to facilitate student learning and underlined their reliance on evidence and indication to support conclusions.

Equally, some of their PCK and beliefs lacked coherence, displaying a combination of constructivist views. Their traditional PCK translated into their practice. For example, about their knowledge of strategies, teachers practice was characterized in using hands-on activities where students were exposed to knowledge in groups independent of their teachers. Also, even though they believed their role as a teacher involved facilitating student learning, they consistently transmitted knowledge they held to students by emphasizing explanations, real-life examples, which were not familiar to the students' daily classroom and dictations of the correct answers to the textbook questions.

However, despite subjects' preference for a constructivist view of biology teaching, this does not always translate to their instructional practice. By assuming the role of being the primary source of knowledge and that their major task was to re-arrange the environment to help their students remove epistemological obstacles to learning, they tended to fall into the trap of being information-driven rather than adopting problem-solving instructional approaches. In the process, they did not give their students sufficient opportunities to take their own initiatives in the performance of the classroom tasks assigned to them. Despite this, the teachers made some attempts to create a better learning environment for their learners than was the case before participating in the project. For instance, they made a concerted effort to arrange the classroom in such a way as to facilitate more discourse than was previously the case.

Thus, these practices reflected a merely constructivist view of biology teaching rather than their expressed constructivist beliefs. Finally, teachers' goals and purposes of teaching biology guided and translated into their practice partly, rather, their practices reflected a constant concern of maintaining control of students and covering the material related to the textbook. On a regular basis, they spent class time monitoring students' behavior whenever they were working in groups. Their concerns for covering the textbook stemmed from the district requirements that all grade 10 biology teachers follow the same curriculum and complete the textbook.

Interestingly, the teachers expressed constructivist views about their students' learning that were not applicable to their use of assessment. They emphasized that the central role of prior knowledge and misconception in students' learning was interaction with students and active learning. However, the teachers used more traditional procedures of assessment to assess students learning, a practice they related to time, and insufficient emphasis on inquiry assessment in the INST programme. Finally, even though they believed that the biology curriculum needed modification to deliver, their views were undergoing some change as evidence in their decision not to accept the biology textbook and instead develop their own curricular materials. They developed and used an investigation based on the textbook, and relied on their experiences in the INST programme to do so.

In light of the above-stated findings, I am inclined to believe that, teachers' PCK improvement has provided them with new insights. This awareness is likely to help teachers on how to adequately handle the new curriculum taking into consideration the time allocated for science teaching. On the one hand, it can be noted that these new insights seemed in line with Shulman's (1986) notion of pedagogical content knowledge (PCK). According to this notion, the instructional programme appeared to imbue teachers with insights on how to present the content of this new curriculum in an adequate and acceptable manner. On the other hand, these new insights imply a way to present the new curriculum that not only satisfies the students' needs but also helps them to achieve the aim of learning the biology curriculum in the Libyan context. Furthermore, the study has helped to 'classify different domains and categories of teachers' knowledge, and it also has helped and informed on how to form and represent that knowledge.

In keeping with the notions of PCK and the new insights on how to present the content of the curriculum, three forms of teachers' knowledge emerge the propositional knowledge, the case knowledge, and the strategic knowledge (Shulman, 1986, p. 10). As a way of explaining the three types of knowledge, the investigation reveals that much of what is taught to teachers is in the form of propositions; it is the teacher's duty to attribute specific knowledge for a determined notion by means of appropriate strategies for practical teaching and learning.

4.3 Data categorization and findings

The data analysed in this chapter addressed the issue under investigation and has provided informed answers to the main research question of the present study.

❖ In relation to the impact of the INST programme the following list is worthy of closer consideration:

1. The value of teachers' knowledge of biology curriculum structure
2. The implementation of obstacles to the arrangement of the content in the Biology curriculum.
3. Teachers' comprehension of the Input variables in teaching biology.
4. The abilities shift of teachers' mastery of procedural variables in teaching biology.
5. Teachers' knowledge of product variable of teaching biology
6. The shift in Biology teaching goals and objectives
7. The value of knowledge of specific curricular programmes
8. Teachers' perception and beliefs about teaching biology
9. The importance of teachers' in-depth understanding of the biology concepts

❖ In relation to how the INSET programme impacted teachers' knowledge of instructional strategy the data provided four findings in terms of :

1. Teachers' selection of right instructional strategy
2. Relationship between Beliefs/Knowledge and Practice
3. Change in practice
4. Teacher education and induction

❖ In relation to the influence of the INSET programme on the teachers' knowledge of learners the data provided three findings that revealed the following:

1. The importance of teachers' knowledge of learners' prior knowledge (what they knew)

2. The usefulness of the teachers' knowledge of learners' ability (what they could do)

3. Teachers' knowledge of students' understanding and thinking about the content.

4.4 Major findings

In this chapter, I have presented and analysed the data that sought to address the three sub research questions of this study. In light of this analysis and presentation, it was found that:

(a) In general most of the teachers performed slightly better in the subject matter knowledge than in other areas.
(b) In terms of teaching skills, most teachers performed slightly better in activity-based teaching than in basic teaching skills.
(c) Most teachers and their teaching practice were influenced by their concerns for covering the required curriculum.
(d) The INST programme has influenced biology teachers' subject matter knowledge,
(e) The INST programme has influenced biology teachers' knowledge of instructional strategy.
(f) The INST programme has influenced biology teachers' understanding of their learners.
(g) The majority of the Libyan biology teachers after the INST tried to practice activity–based teaching with their students.
(h) After participating in the INST programme, biology teachers' practice was enhanced and changed positively to different degrees.

(i) The teachers manifested change in both their knowledge of educational strategies and their perceptions of learners' understanding of biology.

(j) Most teachers have realized that their students' understanding or misunderstanding of certain notions was related to their background knowledge, to the teachers' knowledge of their students' ability, and the ways they perceive the new notions.

The above-stated findings are extensively discussed in chapter five.

Chapter 5: Discussion

5.0 Introduction

Chapter Four has presented the data analysis in relation to the research objectives and in light of teachers' development. The present chapter provides the supporting analysis and the underlying reasons for the findings and discusses the results of the influence of the INST programme on the teacher participants' understanding of the subject matter they are teaching, their knowledge of how to transfer the content, and the understanding their learners. It also draws some conclusions and makes a number of recommendations. Briefly, it recapitulates the research problem through the three research questions and identifies and discusses specific themes from the data as it relates to the reviewed literature. Furthermore, it offers a summary of the overall findings focused on the biology teachers' PCK improvement. The chapter is organised according to the main aims and arguments of the study.

The aim of this study has been to (1) seek teachers' in-depth understanding of the subject matter they are teaching; (2) their abilities to access the curriculum materials for effective teaching; (3) develop effective teaching strategies; and (4) seek their skills to integrate their understanding of the subject matter with their understanding of teaching strategies.

In pursuance of the above aim the study answers were sought to the following questions:

1. What is the influence of the in-service training programme on biology teachers' PCK in Libya?
2. What is the influence of the in-service training programme on the biology teachers' understanding of the subject matter they are teaching?
3. What is the influence of the in-service training programme on the teachers' knowledge of instructional strategy?
4. What is the influence of the in-service training programme on teachers' understanding of their learners?

5.1 Recapitulation of the research problem and approach

A key concept of this research is the pedagogical content knowledge (PCK) of biology teachers. This combination of subject matter knowledge, pedagogy forms, and understanding of learners constitute a unique part of the knowledge base of the teaching profession that could help biology teachers implement the curriculum effectively. In the INST programme several choices had been made to exemplify PCK. First, Osmosis and Diffusion were chosen as topics that biology teachers in Libya indicated to be among the most challenging concepts to teach or learn. Second, from the perspective of pedagogy, an activity-based approach was preferred, because student-centred learning is promoted in the Libya biology curriculum. Thus, activity-based teaching of the Osmosis and Diffusion unit is a challenge for teachers from both the content and instructional perspective. The results of this study indicate that the biology teachers could implement active learning strategies in teaching the Osmosis and Diffusion unit, but that this combination put a rather heavy cognitive load on them. As a consequence, teachers' basic teaching strategies should show their real level of proficiency.

From hindsight, it might have been a good idea to choose a less difficult topic as a starting point to learn and practice activity-based lessons. Had that been the case, teachers could have focused their full attention on integrating their understanding of the content and teaching strategy in their normal routines, without having to spend too much energy and time on the subject matter. Despite the fact that they appreciated the importance of activity-based teaching for ensuring student participation, some of them had reservations about it. For them, the activity-based approach was more time consuming than other methods. Their concern relates to large class sizes, lack of appropriate teaching material, and pressure to finish the syllabus in limited time.

5.2 The influence of the INST programme on biology teachers' subject matter knowledge (SMK)

One of the aims of the present study was to determine the extent to which Libyan biology teachers' understanding and use of biology programme orientations satisfy Libyan education policy demands based on balanced assessments and checks. In regard to this aim the following research question "What is the influence of the INST programme on biology teachers' subject matter knowledge?" has generated enough insights to be considered to explain how the in-service training programme can influence teachers' subject matter knowledge. The findings revealed that teachers' knowledge relates to their understanding of the subject matter and can be judged on their capacity to attain and achieve the objectives and goals of teaching biology. Besides, their knowledge also comprises their understanding of detailed curricular packages, their overall knowledge objectives as well as accomplishments and the elements used in each of them. These findings reinforce Shulman's (1987) point of view when he thinks that:

From being able to comprehend subject matter for themselves, to become able to elucidate subject matter in new ways, reorganize and partition it, clothe it in activities and emotions, in metaphors and exercises, and examples and demonstrations, so that it can be grasped by students. (Shulman, 1987, p. 13)

Based on his point of view, I maintain that biology teachers' subject matter knowledge is grounded on their knowledge of biology curriculum structure as well as their in-depth understanding of the biology concepts.

5.2.1 Teachers' knowledge of biology curriculum structure

Teaching biology includes the communication of knowledge skills and opinions to individuals, which makes it very essential for teachers to comprehend the subject matter prior to teaching it. The comprehension of the subject matter of a branch of knowledge empowers teachers to design their lessons and also to assess their students' performance. Designing a teaching plan necessitates them to make their teaching methods easier in order to pass on the essence of the content to the students in a well-organized way. Assessments of students' assignments of a specific lesson are based on particular standards, which are fundamental to that lesson. For a teacher to be competent to assess an assignment based on a certain lesson, he/she must have a good understanding of that lesson.

Understanding requires being capable to use logical notions and skills as instruments to increase control over real-world issues. In this context, students either cooperated with others or worked alone to comprehend biology, to explain and think rationally through an issue and interpret or recount it based on their comprehension and prior knowledge. A theoretical mastery of a discipline and the ability to be critical of the information itself can permit students to be real actors of their learning. In addition, the teachers' subject matter knowledge impacts their ability to help students acquire the subject matter content. The information they have about a discipline influences their ability to teach that discipline, to plan for activities lessons based on local situations, to prepare and to answer questions related to the discipline as well as to give tasks to students based on it.

Teachers' knowledge about a subject matter should exceed the limits of the curriculum they teach. When they possess such knowledge the likelihood to see them explaining this curriculum according to the students' understanding is high. This kind of understanding encompasses an understanding of the intellectual fabric and essence of the subject matter itself.

For example, while the maths teacher needs to know how to solve calculus problems he must also be able to understand the importance of calculus in industries. Similarly, biology teachers need to know how to investigate and interpret the liquid transfer between the cells as their understanding of the substance of biology as well as its nature. In this context, epistemology can shape what teachers are trying to make their students learn. In other words, a deep understanding of the concept can effectively be transferred to the students as suggested by Bybee (2014), Lankford (2010), Walter (2013).

This requires that teachers draw simultaneously on their substantive understanding of the biology concept, their knowledge about the discourse, the activities, and epistemology of biology and their knowledge about a particular subject matter that enables them to teach by using different teaching methodologies. When they fully understand the subject matter they teach, they will know which pedagogy is best suited for them to help students learn the subject matter (Shulman, 1986; Borko, Bellamy, & Sanders, 1992). Sometimes, dedicated students challenge teachers to simplify the subject matter for them. The extent to which teachers can do this depends on their understanding of the subject matter. This view is consistent with Ozden (2008) and Shulman (1986) who believe that teachers' mastery of biology curriculum structure plays an important role to give varied and alternative answers to students' questions about a subject matter as well as the problems identified with the arrangement of the content in the Biology curriculum.

Based on the data analysis presented in Chapter Four, the questionnaire section "A" related to problems identified with the arrangement of the content in the biology curriculum, the data analysed and presented in Table 4.2, has revealed that the biology curriculum does not emphasize on the use of locally made materials or reflect on what is available in the student's immediate environment. The reason for this is that the biology curriculum in Libya was adopted from the Singaporean curriculum. Teaching and learning materials for biology lessons can be improvised using materials such as wood, waste paper, stones, soils, plants, and metals found in the immediate environment. The meaning of improvisation in this context is the art to make something using materials from the immediate environment (Kalande, 2006). Consequently, the activities and examples of the concepts in the content do not consider the Libyan student's environment. According to this finding, it becomes clear that the biology curriculum in use has been adopted but not adapted to the environment in which it was intended to be taught. Therefore, after the participants had attended the INST programme, which was designed to teach Libyan students and use activities adapted to their environment, it has been observed that the teachers were more comfortable with activities and examples of the concepts they had to teach (See chapter four, section 4.2.1.3, the fourth day of presentation).

5.2.1.1 Teachers' knowledge of input variable in teaching biology

In light of the findings shown in Table 4.9, this investigation indicates that as far as teachers have developed their knowledge of the curriculum they were teaching, they had also modified the content of this curriculum according to the students' environment. This can be illustrated by their perception of:

- Selecting topics for teaching without strictly following the order suggested in the Core Curriculum.
- Government making more effort to supply more teaching and laboratory materials to schools for effective biology teaching.
- The inclusion of certain science allowance for teachers.

The above-mentioned perceptions act as a governmental and a pedagogical way of encouraging more people to specialize in biology-related courses. These findings agree with Hawedi (2015) who believes that the context-specific nature of teaching contributes to the empowerment of teachers to enhance the status of instruction taken up as a profession. They also stand as the achievement of the objectives of teaching biology as stated in the Library of Congress – Federal Research Division (2005).

5.2.1.2 Teachers' knowledge of procedural variable in teaching biology

Taking into account the data analysed in Chapter Four, the biology teachers, in their teaching practices, experienced problems with content activities and examples. Based on the initiation of teaching biology by the discovery approach, they seemed to be conscious about teaching biology adequately. This approach, as a pedagogical device aims at making students see the course as an interface from where to investigate the nature within the environment, has clearly increased, and shifted biology teaching from the teacher-centred approach to the student-centred approach. The above-stated point of view is consistent with Schwarz et al.,

(2008) who encourage teachers to base and tailor their teaching on students' prior knowledge. Biology teachers are expected to use local examples to foster learning and to enable their students to know about their environment through improvisation as stated by Beyer and Davis (2009).

5.2.1.3 Teachers' knowledge of product variable of teaching biology

In light of the findings based on the data presented in Chapter Four, Table 4.11, it has been found that according to the teachers' knowledge and belief, students only gain knowledge mainly from teachers. However, after the teachers had been exposed to the INST programme, it was expected that they try to enable their students not only to understand the concepts of fundamental units of biology from their daily life routine but also to try to get more information related to the same phenomena in different and various ways as indicated in Shulman's (1987) categories of the knowledge base for teaching.

In keeping with the above-stated finding, students who study biology subjects are expected to develop certain skills such as observation, investigating, and synthesizing as indicated and advised by Borko et al., (1992). Naturally, this can be made possible by teachers' understanding of activities suggested for use in the Core Curriculum. It can permit students to use scientific techniques later in life in the fulfilment of the national philosophy of self-reliance even though, it has been observed that teachers are facing obstacles to modify and adapt these activities in accordance with the local environment. However, based on the finding that teachers' knowledge of curriculum construction had slightly improved as a result of the INST, I believe that in general biology teachers' knowledge can be empowered by helping them to develop their teaching practice as supported by Pugach and Johnson (1995), Loucks-Horsley et al., (2010).

Knowledge of countrywide and learning objectives

In making educational judgments, teachers based themselves on national and local objectives and aims, as well as national check-ups such as course objectives provided for satisfactory achievement of national needs and aspirations. Despite this, they assumed that national and local criteria directed the instruction and the curriculum. In keeping with the above, they were generally anxious about the aims of coverage and were ensuring that their students were sufficiently prepared to succeed at the test. The questions which arise from this finding and the related practices is to know: (1) how Libyan biology teachers escape from the bias of

“Test-based teaching”; and (2) how they manage to adequately teach the required content in a limited time without leaving aside important notions (Grissom, Loeb & Mitani, 2015).

In short, it can be noted that whatever the case might be biology teachers' use of the curriculum was directed and affected by the aims of coverage and their own aims for teaching. Consequently, because of their disappointment with the existing curriculum programmes and their plan, they ended up selecting subjects to teach based on the district criteria. They were doing this in order to prepare their students for the test, yet targeting global understanding. The findings have also revealed that when selecting subjects to teach they followed the order of importance. This way of doing is contrary to effective teaching practices as suggested by Guskey (2002). However, this practice can be improved if teachers work as a group as suggested by Little and Lieberman (1990); Durksen, Klassen and Daniels (2017). An effective way to have teachers to work together seems to be their exposition to some workshops and INST.

5.2.1.4 Biology teaching goals

The order of importance is defined by the aims and objectives of teaching. The teachers had a number of objectives for teaching biology most of them related to their overall purpose for teaching and learning biology. Their purpose for teaching is involved in preparing prosperous responsible citizens. Many of them believed it was essential for their students to be skilled to use the knowledge acquired in the classroom on the basis of 5Es model (Midigo, Mwanda, Odundo & Midigo, 2017) to appropriately function in society, decide matters based on evidence and live by standards such as righteousness and the desire for substantive knowledge as suggested by Ogunniyi (2006).

Thus, linked to their desire of preparing useful members of society, the teachers’ notions of the necessity to teach biology at secondary school centred on giving students the required foundations and skills for their life and future careers. In keeping with the above, they believed that teaching biology at secondary school should focus on scientific content and processes that prepare the foundation for future learning (Biology textbook, 2016; Biology Book of activities, 2016).

Teachers also detailed personal objectives for teaching biology that stemmed from their general purpose of teaching. They aimed to prepare useful members of society who would be able to make decisions based on evidence. For that reason, the majority of teachers estimated that their students would be able to use evidence to support their work at all times as suggested by Pugach and Johnson (1995) as well as Nieveen (1997) when they refer to practical teaching. In that way, the emphasis on evidence would be apparent in teachers' practice discussed in the section related to teachers' knowledge of instructional strategies, as a result of their experience in the INST programme. They also refer to themselves on how to successfully install the big picture of biology into the students' lives to help them realize the success of knowledge acquired in the classroom and hopefully engender excitement and interest in the discipline. This point of view is in agreement with Bybee (2014) when he defines teachers' role. Finally, teachers underscored the role of social cooperation in the generation of knowledge in their endeavour to prepare students for their roles in society.

In brief, concerning biology teaching goals, the findings are in harmony with Hyland, Kennedy, and Ryan's (2006), point of view according to which goals are divided into aims, objectives, and outcomes.

5.2.1.5 Knowledge of specific curricular programmes

The findings based on the data analysed in Chapter Four, (Tables 4.8;4.9;4.10 and 4.11) have revealed that the curriculum programme biology teachers use in grade 10 secondary school in the district is the one authorised by the government. However, these teachers' understanding of the curriculum as directed by their willingness to cover national criteria related to preparing students for the national examination. To reach that aim, the curriculum should be covered completely, but this creates a serious problem as the number of lessons per week had been decreased by the authorities without adapting the content to the available time. As a result, the teaching practice has become mainly theoretical. This teaching practice does not agree with Magnusson, Krajcik, and Borko's (1999) view of coherence of orientations toward biology teaching and the focus of the curricular materials.

Teachers' perception and beliefs about teaching biology

Concerning teachers' comprehension of the reasons for teaching biology, the findings based on the data analysed in Chapter Four have revealed that teachers related it to a constructivist stance, which had been clearly noticed in their practice. They believed that biology involved the knowledge of the world and the way of knowing what explains it and its interactions. This was in line with the constructivist view that recognizes biology as one way of explaining life. When asked about reasons motivating them to teach biology, teachers referred to the study of living and non-living organisms and their connections. They believed biology plays an important role in the comprehension of all aspects of life. Many of its topics deal with notions people experience every day. Theories about teaching biology, one of the elements of their PCK, relates to their understanding and beliefs about the objectives and goals for teaching biology at a given grade and the consequential orientations or views in the direction of biology teaching practice. They held a recommendation for teaching biology that was motivated by their aim for teaching and also as an outcome of their previous experiences with biology science.

The findings have also revealed that their objectives for teaching biology were consistent and driven by the INST programme orientations towards better teaching of biology. They expected their students to create a community of learners whose members share responsibility for understanding biology concepts. They also intended to instil in their students an understanding of the processes of biology, containing process skills such as making observations and evidence-based inferences based on principles of practical teaching processes as mentioned in Magnusson, Krajcik and Borko (1999). They believed that biology teaching was happening only when supplemented by students' learning. They further explained teachers' role as people who engage students in learning activities and practices by asking them leading questions and giving them cues to practical works.

In short, teachers' considerations of teaching biology were in line with constructivist views of teaching biology that demand teachers to use new and adapted teaching techniques (Loucks-Horsley et al., 2009; Putnam & Borko, 2000). The above claim summarises teachers' knowledge of biology curriculum structure but cannot be a solution to increase students' understanding of concepts and processes if teachers' in-depth understanding of the biology concepts is not considered.

5.2.2 Teachers in-depth understanding of the biology concepts

Taking into account McConnell, Parker, and Eberhardt (2013), the findings based on the data analysed in Chapter Four from the ODD test have provided evidence that Libyan biology teachers have misconceptions about Osmosis and Diffusion. This identification is of direct relevance to biology teachers because it is consistent with Ozden (2008) who thinks that this knowledge can be used to develop instructional approaches to hopefully correct these misconceptions.

The finding based on the T-test has provided an answer for the assumptions that there is an influence of the INST programme on teachers' in-depth understanding of Osmosis and Diffusion concepts. The results of the T-test imply that there was a significant improvement in their understanding of the Osmosis and Diffusion concepts after attending the INST programme than before doing so. Therefore, I am inclined to believe that this finding harmonises with Loucks-Horsley et al (2009) who support that a well-implemented professional development experience can continuously ensure a positive influence on teachers' chances of succeeding in enhancing students' learning, leadership, and the school community.

These findings are similar to the ones by Zuckerman (1993) in that both studies have found that high school science students improved their conceptions of Osmosis and misconceptions related to categories of knowledge such as the particulate and random nature of matter, concentration and tonicity, the influence of life forces on Diffusion and Osmosis, membranes, the process of Diffusion, the process of Osmosis and kinetic energy of matter. This implies that after the INST programme, the biology teachers were more comfortable in their classrooms than they were previously before their exposure to the training programme.

According to the findings, the teachers removed their misconceptions through the in-service training programme. For example, some specific points in the grade 10 biology textbook, which are not clear and often led to teachers' misunderstanding as in the case of Water effort and Osmosis, have been cleared. The practice of Osmosis has helped the majority of teacher participants understand the concept, however, their argumentation about Water effort and Osmosis helped the majority of them to clarify their understanding of the concept. In light of this, one can assume that the present study has confirmed some of the principles stated by Loucks-Horsley et al (2009). In the same vein, one could say that the in-service training programme has to some extent influenced Libyan biology teachers' subject matter knowledge. Based on the similarity of findings with wuanyanwu & Ogunniyi (2020) and Zuckerman (1993) the following three domains, teachers' in-depth understanding of the concept (metacognition), knowledge of design, and conduct activities and knowledge of tangible examples from the local environment, have been concerned by change. This change process can be summarised as shown in figure 5.1 below:

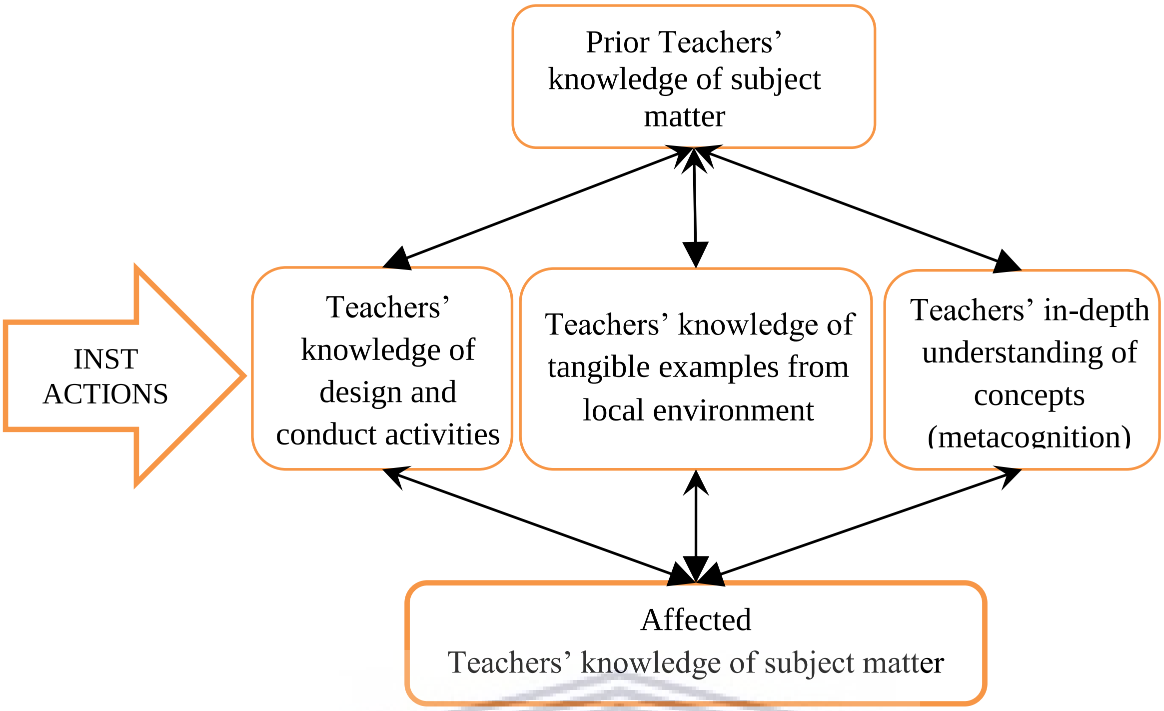


Figure 5.1: Affected teachers' knowledge of the subject matter

In brief, the findings indicated that the influence of the INST programme on biology teachers' subject matter knowledge (SMK) was manifested in their understanding of the subject matter. This was visible on the way they were teaching after they attended the INST. For example, teachers who did not have enough knowledge about Osmosis had a deep understanding of the concept and were able to provide good examples for it from the local environment and something that could be observed in the students' daily lives. Conversely, they were able to teach the students all the main points of the lesson. They could prepare and create student-centred activities and supervise them to obtain the concept alone. Their knowledge of subject matter affects their teaching and consequently affects students' understanding.

In keeping with the above point of view, the ability to clarify misconceptions of knowledge depends to some extent on teachers' understanding of the subject matter. When they clarify their own misconception of the concept, they make a positive impact on students' learning; otherwise, they contribute to the students' misconceptions, which, in turn, will impact negatively on their learning. In view of the above, I would like to conclude that the subject matter knowledge of a teacher can either impact positively or negatively on the teaching and learning process in the classroom.

5.3 The influence of the in-service training programme on teachers' knowledge of instructional strategy

5.3.1 Teachers’ knowledge of instructional strategy

In the light of the data presented and analysed in Chapter Four, the findings have revealed that Libyan biology teachers’ knowledge of instructional strategy is a kind of duplication of a study by Magnusson et al. (1999), which distinguishes between subject-specific strategies (dealing with more general techniques for teaching science) and topic-specific strategies (dealing with both demonstrations and activities to assist students to understand specific notions and concepts). In the present study, the professional development programme was mainly focused on the above-mentioned aspects of PCK in order to help Libyan biology teachers develop strategies for teaching Osmosis and Diffusion that were explicit and reflective. As an approach, I focused on subject-specific strategies namely the 5Es strategy.

The findings illustrate that the teachers were not only able to implement these strategies as modeled for them, but also to improvise and develop their own unique strategies for embedding the concepts into their teaching. This improvisation is in harmony with Beyer and Davis (2009), Cochran et al. (1991), Magnusson et al. (1999) as well as Nelson and Grossman (1990). It mainly consists of teachers identifying aspects of Osmosis and Diffusion that were inherent in the lesson, and asking students to narrate or explain these aspects on the basis of their background knowledge. The identification of these opportunities hinged on teachers’ own understanding of the concepts, as well as their ability to design learning experiences that engage students in ways that reflect Osmosis and Diffusion concepts. This implies that their SMK mediated their choice and implementation of instructional strategies.

For example, teachers drawing on their general PCK related to using students’ literature were able to emphasize the lesson. By introducing more common situations in which different observers reached different conclusions based on their personal experience and understanding. Teacher participants used the 5Es technique; regarded as strategies for engaging students in the biology classroom in the same way scientists work in laboratories (Bybee et al, 2006; Sickel & Friedrichsen, 2015). They aimed at helping students recognize in which way their prior or background knowledge influences their ideas. They address the subject matter in this way to make ideas about scientific concepts more accessible to their learners. I consider that the teachers’ use of the 5Es model can serve as evidence of the INST contribution to teachers' development. The teacher's knowledge of instructional strategy results in the adjustment of their management of practical related teaching practice.

5.3.2 Change in Practice

Considering the change in teachers' action and practice, the data presented and analysed in Chapter Four under the observation section, has revealed that, to understand the role of beliefs, practical knowledge, and the perceptions of context on teachers' implementation of the 5Es model, I have to consider whether each factor supported or constrained teachers when teaching Osmosis and Diffusion. To make such distinction, I need to make sure that most teachers' beliefs, knowledge, and/or perceptions were either aligned with the purpose and descriptions of different lesson phase or they were simply positive reactions to a given lesson phase or they had nothing at all with the lesson. In keeping with the above, most teachers' reactions observed were supporting teachers' improvement in teaching practice. They were not only evaluating students' abilities in comprehending scientific concepts but also engaging them to explore and explain the related scientific phenomena (Bybee, 1997).

After determining initial supports and constraints, I used the model derived from the literature on reform-based biology teaching with a focus on a particular 5Es model to help with understanding changes in teachers' practice. With the Engage, Explore, Explain, Elaborate and Evaluate phases, they learned that students enjoyed thinking about the Osmosis and Diffusion concepts (supportive practical knowledge) and this was filtered through beliefs that the Osmosis and Diffusion helped them track their understandings. Therefore, with the Explore phase, as indicated by Bybee (2014) teachers learned that students had considerable difficulty with discovering the concept of Osmosis on their own (practical knowledge).

Also, teachers were sequencing their instruction in a way that the natural water movement was used as a verification activity (checkpoint) after providing notes (context). I consider these two factors to be initial constraints to their teaching of the explore phase in accordance with the 5Es model. However, instead of discontinuing this phase or changing their sequence of instruction, they continued exploring before explaining and added a second activity to place more emphasis on the Explore phase. This was because of their strong view that students learn best by discovering concepts through thinking about "tangible," real-world phenomena (supportive beliefs) as suggested by Ibrahim (2015). The environmental constraints were filtered through a core belief about learning biology and, therefore, they continued the exploration and explanation sequence and adapted to students' difficulties with gathering information by modifying hand-outs and supporting their abilities to construct data tables.

Regarding Explain and Elaborate phases, I observed that teachers' core beliefs about biology teaching and learning did not support their use of the Explain phase or Elaborate phase in accordance with the 5Es model. Their belief did not include a strong role to manage students' ideas or link the exploration phase to the explanation phase and did not focus on the role of applying concepts to multiple phenomena for an in-depth understanding of the concept. Thus, in the face of their perceived constraints, students had difficulty constructing explanations and applying their understanding to different scenarios, so they spent less time on the Explain phase, disconnecting the Explain phase from the Explore phase, and removing the Elaborate phase. The conclusion is that teachers did not consider that students were lake in using scientific official language, instead, they encouraged them to use their own words as mentioned by Mwanda et al (2017), "During the explanation, teachers should encourage students to explain concepts in their own words, ask for evidence and clarification of their explanation, and listen critically to one another's explanation and those of the teacher" (p.4).

5.3.3 Teacher Education and Induction

Considering teacher education and induction, the data presented and analysed in Chapter Four, has in light of the findings, from the standpoint of educators and their knowledge of scientific instruction revealed that the 5Es model is a useful way to sequence biology concepts (Brown et al., 2013). In conjunction with how the 5Es model was understood in the INST programme, teachers appeared to view it as revealing their practical knowledge from the perspective of helping students engage in inquiry, having more control over the procedures of a scientific investigation, and developing ways to represent information. According to Wilson et al., (2010) viewing the 5Es model as a format for teaching biology through inquiry is very important. However, in the absence of a constructivist orientation, emphasizing the need to confront students' misunderstandings and help them apply concepts to new contexts may be because teachers understood the 5Es model without proper attention given to conceptual learning. Similarly to Volkmann et al., (2009) this study brings attention to the need to emphasize both scientific inquiry and constructivism when training teachers about the 5Es model in the in-service preparation programmes, as both are important aims for biology education.

This case study further supports the need for more biology induction programmes in Libya. Teachers' discovery-oriented beliefs were strongly held throughout their training. They needed opportunities to reflect on their knowledge and discovery-oriented beliefs, as well as their emerging practical knowledge, perceptions of context, and understanding subject matter. It would be helpful for biology induction programmes to not only help biology teachers develop and implement the 5Es model but also become advocates of reform-based strategies and promote them in a way that fosters collaboration and gives value to other colleagues' ideas. The above-stated view is in agreement with different research such as Anderson (1996), Ball and Cohen (1996), Frykholm (1999), Shulman (1987) as well as Schwarz et al., (2008).

In short, knowledge of instructional strategy involved their knowledge of the planning of activities, knowledge of presenting and guiding the activities and knowledge of assessing their students as presented in Figure 5.2 below.

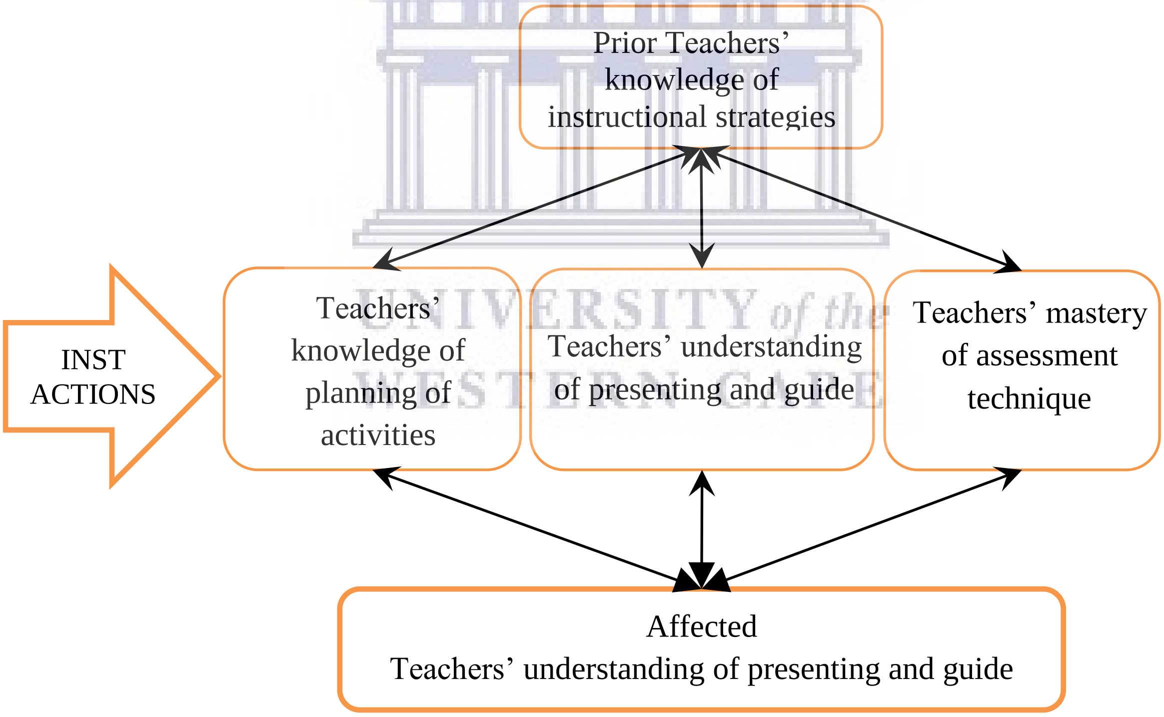


Figure 5.2: Knowledge affected teachers' knowledge of the subject matter

5.4 The influence of the in-service training programme on teachers' understanding of learners

Knowledge of learners involves their knowledge about learners' prior knowledge of the concept, ability to conduct activities and prerequisite knowledge such as making students thinking visible by hands-on activities, discussion, questions, explanations, and any reaction from students to provide feedback on their thinking and abilities and what learners already know. In this respect and considering the findings related to this investigation, I am inclined to agree with Bybee et al (2006) who also believe that teachers need to know how to "expose prior conceptions and organize students' thinking toward the learning outcomes of current activities."

5.4.1 Teachers' knowledge of learners' prior knowledge (what they know)

The findings revealed that there was a clear shift in what the biology teachers understood prior knowledge to be and, not unexpectedly, this caused them to act differently in the classroom. The teachers in this study held superficial conceptions of knowledge and prior knowledge. They discussed knowledge as if it was a static object, and learning was an accumulation of more bits of information. Therefore, when they discussed prior knowledge it was perceived through this limited lens, leading to teaching actions that tried to uncover, which bits of knowledge their students had previously learned, which gaps need filling, then adding on more information. These findings confirm Magnusson et al. (1999) who indicate that teachers' knowledge should include learners' need for learning particular content, their understanding of variations in students' thinking, learning manners and developmental levels within specific subject domains and concepts that students find difficult to absorb due to the degree of abstraction, alternative conceptions, or big challenges with the investigation of the problem. In light of the above-stated findings, the teachers reinforced their conceptions of prior knowledge and its importance to determine their students' prior knowledge through the engagement phase of the 5Es model. This fits well and also confirms Kelly's (1955) point of view according to which if activities uncover factual information rather than explanation, they limit their own opportunities to learn about how prior knowledge can be theorized and structured to build on new knowledge.

The findings refer to how teachers run into situations when their ideas about what their students should know and what they knew did not match. This conflict between expectation and reality could lead them to shift their ideas about what prior knowledge is, as their own experience base is expanded. Learning to teach is complex and as part of this learning, where attention can be focused, needs to be prioritized. Their attention was focused on the content they needed to teach and what information was needed to transfer the content. At this juncture, the findings evoke Daw, Shabash, El-Bouzedi and Dau's (2016) notion of the modern world and advanced technologies influence on the standard of teaching as well as Abbar's (2016) idea of providing students with relevant information related to the topics they are learning.

Considering the findings, teachers' attention, in addition to being focused on content, was organized around instruction and what they needed to do to get through the teaching day although the time element plays a critical role. A few teachers were limited in their focus because their own knowledge was poorly organized. They interpreted the events in their classrooms in a limited fashion. In other words, they did not consider prior knowledge as a starting point to develop their students' thinking as stated by Berliner (1994). However, I assume that teachers, who had the benefit of knowing the content (in-depth understanding of the subject matter) and knowing how to teach, were able to focus on their students. Thus, their thinking about prior knowledge was more complex, including a wider range of meanings, and their ability to work with their students' ideas became flexible allowing them to shift between science content and life experiences. The findings are in line with Cobb's (1994); Kieren and Steffe's (1994) theories that emphasize the power of students' prior knowledge on students' learning. Therefore, completing Bloom (1956); Gagné (1967) I consider the differences in thinking and action as part of the development of teachers' expertise.

According to Smith (2000) teachers' knowledge of their students helps them predict the types of learning problems that will arise and plan to address these problems. The findings revealed that the teachers acted intentionally when they were assessing their students' prior knowledge. Teachers' actions were intentional, not intuitive. These examples help to address the question raised by Peterson and Comeaux (1987), "how does teaching intuition work?" Intuitiveness for the expert teacher is a planned event. However, in order to do this one needs to be able to describe the differences not only in what expert teachers do in classrooms but in how they determine which actions to take when faced with students. This implies that in teacher education a good teacher must unpack what it means to be an intuitive teacher. An expert teacher's actions should be intentional, not intuitive (Smith, 2000). Expert teachers act intentionally when they assess their students' prior knowledge. This helps them predict the types of learning problems that would arise and how to plan to address those problems.

5.4.2 Teachers' knowledge of learners' ability

Teachers' knowledge of students' cognitive and skills abilities is affected by their knowledge of students' prior knowledge. They focused on students' capacity, which revealed their aims for teaching biology and constructivist theories of teaching and learning. However, the students' misunderstandings emerge as barriers to their capacity. Some of the teachers used reliable techniques with pedagogic theories of change to remove them. Regardless of their opinions that students were challenged with problem-solving techniques, their determination and self-reliance in their students' capacities caused their confidence in learning.

Teachers develop an awareness of the factors that influence a learner's abilities and capabilities in biology, such as their skills, prior knowledge, their abilities with hands-on activities, and their cultural and social backgrounds. However, as mentioned in the context of the study (Chapter One) Libyan social culture in the classroom is affected by community culture. From both observations and interviews, the teachers adopting the cultural role to manage the classroom seemed to limit their students' interactions with their teachers or other students. All this knowledge and variables forced teachers to skip many elements of the introduction of a lesson and directed them to the modified 5Es strategies. This also helped them to form a background that informed the practical implementation of strategies and activities in the classroom (Riffel, 2020; Erickson, 1987).

5.4.3 Teachers' knowledge of students' thinking on the content

For teachers to develop students' thinking, they need to know the starting point of their prior knowledge. There may, however, be a big possibility that their prior knowledge or preconceptions are in fact misconceptions. In this investigation, teachers paid attention to this domain of knowledge and they thus needed to determine the way of students thinking about the concept.

Scanning and triangulating the findings of this investigation led to teachers attempting to make their students' thinking visible through externalizing their thoughts through speaking, writing, drawing, and related activities. They could then direct and improve those thoughts, also emphasizing documenting their thinking for later reflection as suggested by Perkins (2008). They tried that during the explanation stage of the 5Es strategies. For example, one of the teachers engaged with a group of students to discuss whether water molecules move randomly or not. However, as soon as she realised the lesson time was running out, she ended the discussion without clarifying the students' thinking on the concept. Thus, it is obvious that making student thinking visible influenced teachers' knowledge of students' misconceptions.

The sociocultural character of the classrooms and schools did not seem to show clearly how thoughtful learning and teachers address or deal with sociocultural factors considered as obstacles to learning development. However, even though the above-stated issue remained unclear, the findings indicated that three domains of the in-service training programme have influenced the teachers' knowledge of learners as shown in the following Figure 5.3.

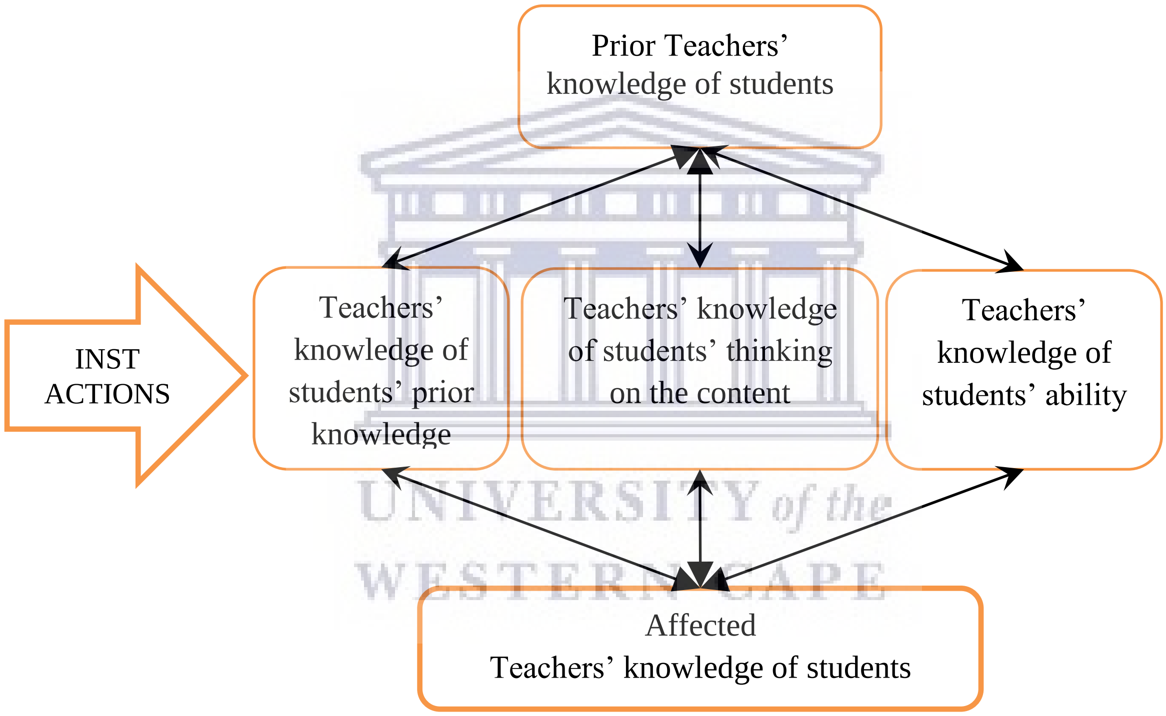


Figure 5.3: Knowledge related to teachers' understanding of learners

5.5 Biology teachers' pedagogical content knowledge

The results of this investigation suggest that biology teachers' pedagogical content knowledge and beliefs concerning the use of experiments in teaching biology regarding the implementation and integration of knowledge in practice were slightly changed by the intensive in-service training programme. The findings have indicated that the INST programme has influenced biology teachers' subject matter knowledge, their knowledge of instructional strategy as well as their understanding of learners. This influence justifies the observed changes. The findings are in accordance with research conducted by Haney et al. (1996), which study concerned the stability of teachers' beliefs. According to the above-mentioned study, students' conceptual change is a slow and gradual process. For teachers, changing beliefs and adopting new ideas also seem to be a slow and gradual process. The findings are also in harmony with the model of practical conceptual change (Anwar, Rustaman, Widodo 2014 , Feldman, 2000), which state that in order to change a practical belief the teacher should first acknowledge the deficiencies in the existing beliefs. In this study, the INST programme provided opportunities for teachers to express their beliefs in the conducting of activities teaching Osmosis and Diffusion using the 5Es strategies as well as sharing opinions with peers in small groups when they were planning experiments during the workshop sessions. It appears that their initial beliefs were not explicitly elicited. Furthermore, they could implement the practical work they were trained about during the workshop sessions (Jauhiainen, 2013).

In order to change their beliefs, teachers need to become aware of their beliefs. Considering the data collected through interviews, most teachers revealed that they often had difficulties in expressing their beliefs or giving reasons for their educational decisions. However, Shulman (1986) thinks that professional teachers can reason their decisions and justify their actions. This implies that teacher training should encourage teachers' free reflection (thinking about their thinking) and help them make their beliefs explicit and becoming conscious of their PCK. Practical ways of fulfilling the above view are to encourage conversation with peers as proposed by Nicolini (2016). It provides forums in which teachers can express their conceptions, share ideas about teaching, and develop them further (Loucks-Horsley, Love, Stiles and Mundry (2010).

Although the teachers' training centre provides some courses to enhance their teaching skills, some biology teachers seem uncertain about teaching practice. This implies that the centre has not succeeded in enhancing their metacognitive development. In keeping with this failure Troop-Gordon and Ladd (2015), Yildirim and Tezci (2016) aa well as Hoy and Murphy (2001) suggest a more profound analysis of beliefs and knowledge. Nevertheless, despite the centre's attempts to provide teachers with in-service training opportunities to help them express their beliefs, improve their ways of teaching, and use appropriate activities remain a challenge affecting their PCK and beliefs.

An expert teacher takes students' conceptions into account and creates opportunities and engaging activities that help them identify their conceptions, guide them toward constructing new meanings for concepts, and promote their conceptual understanding. It is not effective for the teacher to present information about scientific concepts and assume that the students will immediately understand and adopt it unless they consider students' prior knowledge, ability, and their thinking about the content. Equally important, it should not be assumed by the teacher trainer that by merely presenting information about teaching methods the teachers will automatically understand what is to be done or uniformly make these ideas their own and adopt them as part of their PCK. This is in agreement with Hodson (1996), Loughran et al. (2012) who support the notion that an expert teacher trainer acknowledges their previous beliefs and practices and builds on them to develop PCK.

Activities, discussions, scientific argumentation, and other opportunities could guide teachers in developing their PCK and enhance their understanding of biology teaching. Another reason for the course principles being valued least might be that it introduced the practical principles of the perception approach and dealt with the ontological and epistemological nature of teaching biology. Furthermore, all the activities in the laboratory course, which were closely linked to the teachers' daily work, were considered advantageous to achieve biology goals in Libya. These outcomes are consistent with research findings on teachers' conceptions of teacher knowledge (Ghebru & Ogunniyi 2017 Asikainen & Hirvonen, 2010).

The findings of the study are consistent with Shulman's (1986) idea of the wisdom of practice according to which teachers begin to value the knowledge that is directly related to their practice and theoretical or abstract aspects of knowledge. However, researchers have noted the importance of theoretical knowledge in teachers' knowledge base. According to McConnell, Parker, and Eberhardt (2013) as well as Ball et al. (2008), theoretical knowledge is the cue to teachers' understanding and misunderstanding of concepts, presenting, or misrepresenting of knowledge. A good teacher training programme to develop teachers' PCK should be grounded on values of the knowledge base for teaching as suggested by Shulman (1987). Therefore, attention should be paid to help teachers to accomplish this for example by recognizing the usefulness of training and practice in developing their PCK.

One possible way of doing this is to introduce an in-service and pre-service teachers' training to the concept of PCK focusing on knowledge related to teaching bases instead of general knowledge of education, hoping that it will support learning about teaching and thinking about teaching biology as a specialized and professional practice requiring much more than different teaching methods. Hence, teachers could be encouraged to become acquainted with the theoretical and practical underpinnings of the different teaching approaches and achieve an even higher level of PCK. For instance, in this study, most of the teachers understand Osmosis and Diffusion concepts theoretically whereas when they were implementing them in the classroom with activities the situation became quite difficult.

According to the present study theoretical knowledge of teachers aimed at developing their deep understanding of scientific concepts as proposed by McConnell, Parker, and Eberhardt (2013) as well as Bybee (2014). This understanding results in teachers' ability to identify, explain, and apply concepts. As one can see theoretical knowledge in itself does not cater to PCK. It needs to be completed by practical knowledge. Equally important, is the practical knowledge of the teachers aimed at guiding their movements in a highly contextualized environment to conduct practical activities and experiments (Shulman, 1987). Therefore, the findings related to both domains of theoretical and practical knowledge of Libyan biology teachers reflect teachers' knowledge of topic-specific strategies and knowledge of subject-specific strategies (Magnusson, Krajcik & Borko, 1999).

The biology teachers' PCK provided a framework for the study to investigate the influence of the in-service training programme and also served as a framework for the aims of the INST programme. In short, to improve their education an empirical model of the competence of PCK and its relation and integration with practicing in the classroom are shown in Figure 5.4 below.

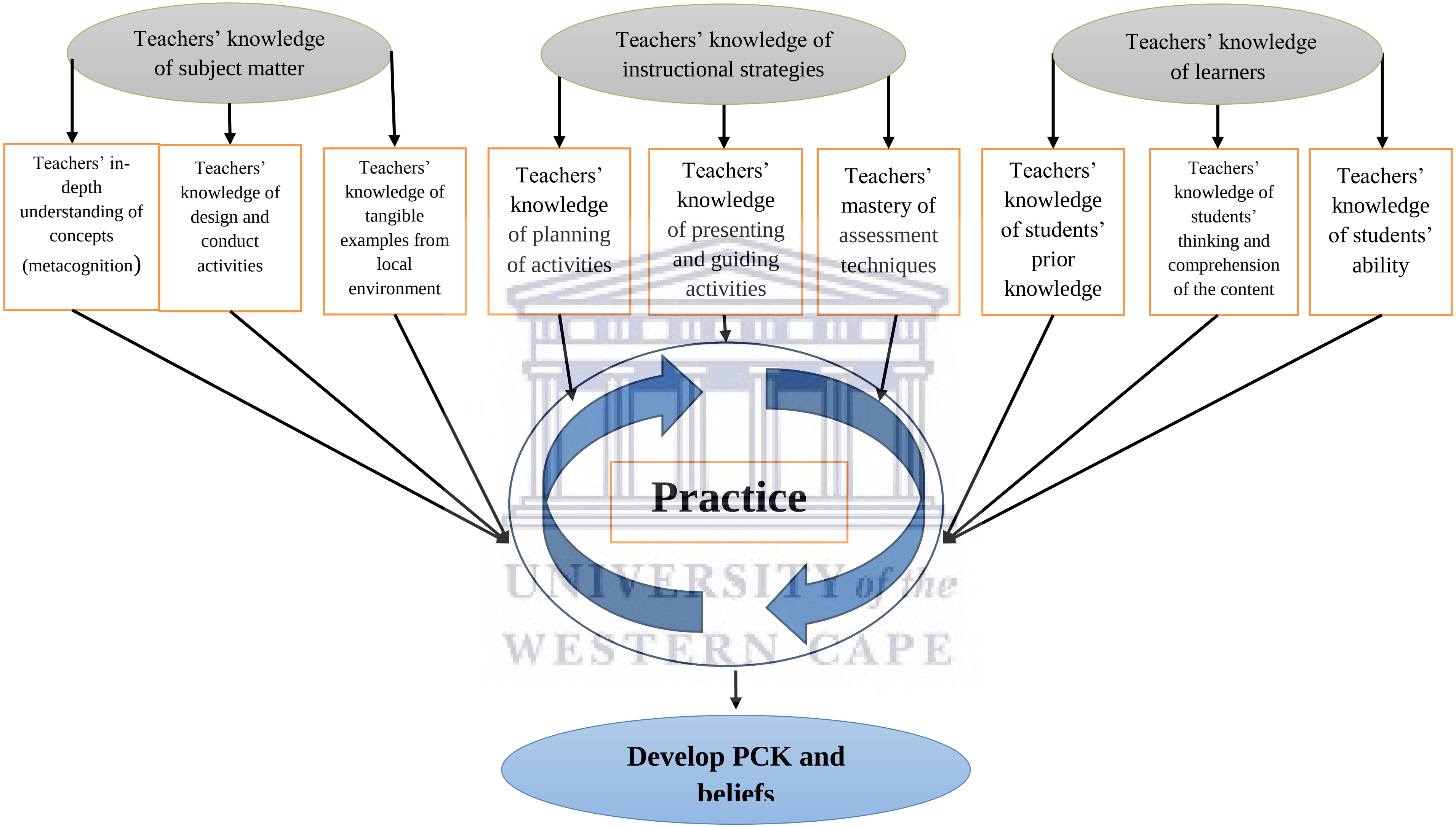


Figure 5.4: Empirical model of biology teachers' PCK

The components of the above empirical model of the competence of PCK implies that this research investigated whether teachers understood what they had to teach, whether they knew how to proceed to teach it and also whether they were able to illustrate the notions they had to teach with adequate examples extracted from the learners' everyday life experience to define the extent of teachers' knowledge of the subject matter. This refers to investigating teachers' in-depth understanding of concepts or the metacognition, investigating their knowledge of design and of how to conduct activities as well as their knowledge of tangible examples from the local environment to determine their knowledge of the subject matter.

Besides, the model also evaluated whether teachers knew how to plan their teaching activities, whether they were skilled enough to present and guide learning activities, and whether they had good assessment techniques to determine teachers' knowledge of instructional strategies. This refers to evaluating teachers' knowledge of the planning of activities, their knowledge of how to present and guide activities as well as their mastery of assessment techniques so as to determine their knowledge of instructional strategies.

Equally important, the model assessed whether teachers' built the new notions they had to teach on their students' prior knowledge, whether they took into account their students' thoughts about the new notions they were introduced to, and whether the new notions were adapted to the students' ability to determine teachers' knowledge of their learners. This refers to assessing teachers' knowledge of their students' prior knowledge, their interest in their students' thinking and comprehension of the content as well as their knowledge of their students' ability so as to determine the teachers' knowledge of their learners Mavhunga (2019).

In brief, the practice of all these three components is decisive for the development of PCK and its related beliefs.

Chapter 6: Conclusion and suggestions for Future Research

6.0 Context-responsive design choices

This study has underlined the need for responsiveness to particular educational development characteristics at various system levels when trying to apply general principles (de Feiter, Vonk & van den Akker, 1995). For example, because of the combination of generic and site-specific development components in Libya, it is feasible to realise development approaches that are completely tailor-made to the local needs of all schools and teachers. Comparable problems with biology education are apparent throughout the entire country. It makes sense in such a context to modify curriculum activities and in-service programmes at a national level. Of course, such a general strategy cannot adequately address local, specific needs of teachers as they work to implement activities in their classroom practice. As at the time of this study, I was not aware of any specific site for teachers' professional development approach in Libya.

6.1 Teacher and learning

The findings of the present study indicate that subject matter knowledge, learner knowledge and instruction knowledge within practice deserve even more attention than initially expected. Based on the above-mentioned results of the present investigation, the INST programme had to be bolstered in this area. The learning task was very complicated and challenging for the teachers. At the same time, the instructional protocol and the implementation of a new pedagogical approach and activities seemed to be a difficult achievement for most of the participants. Likewise, the instructional strategies adopted in the study seemed to result in some form of cognitive overload for the teachers, hence, some of them began to skip some sessions.

Nevertheless, I can conclude that the INST programme seemed to contribute to an improvement in teachers' PCK. Regarding future directions, in terms of both instruction strategies as well as research activities, it seems worthwhile to further explore and evaluate efforts to scale up the professional development approach with multiple components as applied in the INST programme. This study seems to show promising signs of producing building blocks and valuable professional experiences based on topic-specific levels.

A major challenge seems to be how to develop an approach that combines the strengths of interventions at both generic and site-specific levels, which is at the same time feasible when implemented on a large scale. Based on the study's theoretical framework, which means the change examined in PCK, lies within the normative reductive perspective that represents a voluntary and naturalistic approach to change as well as an enhanced deep reflection on beliefs and practices (Chin & Benne, 1969; Loughran, 2013). Within this perspective, the first-order or second-order change could occur (Cuban, 1988). The first-order change consists of minor changes in the organization of the classroom, the curriculum, and other factors. Second-order change entails different ways of thinking, teaching, and learning. The difference in the type of change that occurred in the teachers can also be explained through the normative re-educative perspective emphasis on their cognition, and factors (such as beliefs and practice) that influence the outcomes of the change process (Richardson, 1996**).** These factors consist of individual and/or contextual factors (Cronin-Jones, 1991; Hogan & Berkowitz, 2000; Gess-Newsome & Lederman, 1993; Smith & Neale, 1989) or cultural, political, and technical dilemmas (Anderson, 1996). However, a fuller discussion of these issues is beyond the scope of this study.

6.2 Implication of the study

Based on the findings of this investigation, the following are some implications for policy considerations of biology curriculum developers in Libya:

- The present study like others sought to determine the contribution of workshops to the development of Libyan biology teachers' pedagogical content knowledge. However, the Libyan Ministry of National Education can expand it in manifold ways such as: increasing the regularity of the workshops for the biology teachers; intensifying their supervision; using classroom observation not as an inspection to find fault with the teachers but as a way to determine their needs in order to plan future workshops.
- Higher institutions preparing teachers for biology teaching should be conversant with the classroom context in Libya as well as spearhead the running of seminars and workshops not only for pre-service teachers but also in-service teachers as well as subject advisers and curriculum planners in the Ministry of Education. Such seminars and workshops are likely to provide unique opportunities to expose prospective and in-service teachers to research-based innovative instructional strategies such as the 5Es strategies discussed earlier, discursive and dialogical instructional strategies, and so on.

- Since Libyan biology teachers have little opportunities for their professional development, the seminars and the workshops organized in this study are likely to help them get the opportunity to participate in professional development programmes, practice what they have learned as well as cascade such new experiences with their counterparts who may not have such opportunities.
- This study has revealed how the inadequacy of instructional resources has adverse effects on the teachers' instructional practices in terms of their lack of motivation to prepare teaching aids and using or improvising local materials in teaching biology. In light of this, it seems reasonable to find more effective ways and means to mitigate their lack of motivation and to come up with useful insights that can enhance their instructional practices.
- As far as practical activities are concerned, opportunities should be created during the professional development workshops for the teachers to develop exemplary instructional materials that they can in turn use in their classrooms. In addition, curriculum developers should try to modify the activities included in the biology books taking into account the Libyan environment and the availability of materials. I am sure this will help to boost teachers' instructional practices than has been the case so far.
- Whatever the case, it is evident from the findings of this study that the success of a professional programme to a large extent is dependent on the collaborative and follow-up efforts of other stakeholders in terms of administrative support at various levels: school; schools of the district; Ministry of Education and so on.
- Furthermore, a study focused on both teaching practices in the classroom and practical works can be undertaken in order to determine the real mastery of teaching methodologies and directives by Libyan biology teachers and the comprehension level of their students. Such a study while being concerned with both theory and practice can yield an array of beneficial insights into the how and why of the INSET programme.

In conclusion, the study has provided some useful insights into possible ways of enhancing biology teachers' instructional practices in Libya. It has also revealed how the attendance of well-organized seminars and workshops could assist them in their work more efficaciously than otherwise has been the case. Furthermore, the findings do suggest that the professional development of biology teachers and perhaps other teachers require the joint effort of several stakeholders involved in the education process such as the teacher training institutions, curriculum planners, subject advisers, school administrators, and others. However, whatever the merit of this relatively small qualitative study the findings are not meant to be generalized beyond the educational districts of the participating teachers. Nevertheless, it is hoped that the findings would prove to be useful and informative for researchers working in the area. Also, with the experiences gained in the study, I intend in future studies to use a larger and more representative sample of teachers from the different districts in Libya so as to enable me to generalize the findings to the whole country.

6.3 Further research

In order to develop more understanding of the complex change process that teachers experience as a result of reform-oriented education in Libya, additional researches are needed.

- ❖ An area that requires further research is the potential of professional development programmes that incorporate action research components and basic learning in practice on the change in teachers' thoughts and actions.
- ❖ Investigations of the different types of teacher support that mediate change in their thoughts and actions. For example, the teacher-teacher collaborations lead to improve using and developing hands-on activities in practice and meaningful action research components that promote lasting change in their beliefs, knowledge, and practice? What aspects of administrative support are most conducive to lasting change?
- ❖ The influence of INST programmes on the culture of teaching in classrooms.
- ❖ Studies to investigate the influence of the in-service training programmes on teachers' understanding of subjects such as chemistry, physics, mathematics, and the nature of the change processes that can occur in these settings. These studies might explicate the meaning of constructivist practices in general and particularly in teaching biology. The studies should further consider and explore their knowledge and practice as they relate to the change process.

However, I would like to mention that if there is something I would like to do differently if I am going to do this study again I would like to build one teaching model for all science lessons of the biology family.

6.4 Summary

This case study relied on exploratory action research mixed methods to investigate the influence of a professional development programme effort that immersed teachers in learning biology content through modelling sound pedagogical practices and their effect on their thoughts and actions. Participants in this study consisted of 22 female biology teachers in the first phase and five in the second phase. Data sources included a test, semi-structured interviews, a questionnaire, open-ended classroom observations, and teachers' reactions in workshop sessions. The resulting data were examined with the intent of discerning some influences and changes in the teachers' knowledge and practice towards constructivist based practices. Data were also examined to determine where the changes took place and the factors that mediated change in teachers' thoughts and actions.

The findings indicate that, as a result of their participation in the INST programme, first and second-order changes seemed to have occurred within the thoughts and practices of the participants even though such changes were not all that significant. Furthermore, several cultural and political dilemmas mediated the change process such as beliefs about students' abilities, prior knowledge, their understanding of the concept, teachers' designing of activities and linking them to their students' daily life concerns for coverage and control, depth of content knowledge, administrative support, availability of resources and teachers' autonomy. These factors facilitated or inhibited to some degree the development of teachers' PCK and its adoption in practice.

These findings were compared with the existing literature on teachers' PCK, beliefs, and change in an effort to more firmly establish a conceptual framework regarding the factors that could have influenced the change process. Implications of these findings suggest that to promote change, professional development programmes should:

(a) Explore teachers' beliefs,

(b) Be situated in practice,

(c) Immerse teachers in learning content knowledge through discovery approaches.

(d) Emphasize and model the different aspects of activities-based instruction,

(e) Acknowledge prior or background knowledge in order to consider individual and contextual factors that mediate change by developing collaborations for support.

(f) Take place over an extended period of time as the change in belief and practice does not occur easily.

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Appendices

Appendix 1 Questionnaire for Biology Teachers

Dear teacher,

In this questionnaire, you are requested to express your candid opinion on the effect of In-service professional training for the implementation of Biology curriculum concerning teaching strategy, integration of subject content as well as availability and utilization of instructional materials in your school. I assure you that your responses will be used strictly for research purposes and the information given will be treated confidentially.

The questionnaire is divided into two sections, please be sincere in your reply and respond to all questions as the study is not intended at knowing about each school or an individual, but rather to find out ways of solving the identified problems.

Section A: Please supply the information below:

1. Name of School: ……………………………………………………………..
2. Sex: male ☐ female ☐
3. School Type: who sponsors the School? (Tick off one) private ☐ or the public ☐
4. Your Academic/Professional Qualifications:
   ……………………………………………………..
5. Tick off your area of Specialization Biology ☐ Chemistry ☐ Physics ☐ Others (specify) ……………………………………………..
6. Teaching Experience (tick one) 0-2 years ☐ 3-5 years ☐ over six years ☐.
7. Do you prepare your scheme of work directly in the order it is listed in the Biology Core Curriculum? Yes ☐ No ☐
8. From the following indicate problems that can be identified with the arrangement of the contents in the Biology Curriculum you are using currently (Please tick two).

- Some of the suggested topics treated at the middle school would have been suitable for students in their last year of secondary school. ☐
- The learning of topics such as diffusion and osmosis poses serious problems and as such should be treated at another level. ☐
- Most of the chapters do not present Science as integrated and not sequentially arranged for effective teaching and learning. ☐

- The arrangement of the course content does not provide a sound basis for laying the adequate foundation for subsequent special study in Science at tertiary level ☐
- Some of the suggested activities should have emphasized on using locally made materials and reflect what is available in the student's immediate environment. ☐

9. Which of the following teaching strategies do you adopt for teaching during your lessons in the classroom? (tick off one) (a) Student-Based approach ☐ (b). Lecture Method ☐ (c). Discussion Method ☐ (d). Field trip ☐ (e) Demonstration ☐ (f) Questioning ☐ Method
10. Is the time allocated for teaching in your school adequate to cover the course content for the year? Yes ☐ No ☐ .
11. Do you have a problem teaching any topic in your subject area? Yes ☐ No ☐.
12. If your answer to question 11 is "Yes" please indicate the topic.
    Topic: plant science ☐ Heredity/Genetics ☐ Human Biology ☐
    specify…………………………………………………………………………………
13. Do you confirm that your School has necessary if not all instructional materials, equipment, and teaching facilities required for effective teaching of Biology Yes ☐ No ☐ ?
14. How often do you use instructional materials available in your school? (tick one)
    (a) Frequently ☐ (b) sometimes ☐ (c) Not at all ☐.
15. Have you ever attended any Seminar/Workshop about teaching Biology? Yes ☐ No ☐ (tick one). If yes, what are the activities that have been carried out during the workshop you have found they make your lesson more interesting to the students in your School?
    ....……………………………………………
16. If given the opportunity, are you willing to attend a workshop/Seminar at your expenses? (tick one) Yes ☐ No ☐ Kindly state the reason why?
    ………………………………………………………………………………………..…
17. When compared to other schools, my school has (a) Most ☐ (b) Some ☐ (c) Few ☐ instructional materials and infrastructures for effective teaching and learning of biology (tick one).

Section B: To know your opinion, please indicate your level of agreement or disagreement by ticking off (√) in the appropriate column.

	CONTEXT VARIABLE	SA	A	N	D	SD
1.	The objectives of the Biology as spelled out in the Core Curriculum are clearly stated and achievable.					
2.	The order in which topics are put in the Biology Curriculum facilitates the efficient teaching of this course.					
3.	The prescribed content for each year of study is adequate because it is arranged according to complexity. It becomes more detailed as the year progress.					
4.	The selected content takes the age of the students into consideration for effective implementation.					

	INPUT VARIABLE	SA	A	N	D	SD
1.	Depending on the teaching resources available, most of the time I select topics for teaching without strictly following the order suggested in the Core Curriculum.					
2.	I feel that the Government should make more efforts to supply more teaching and laboratory materials to schools for effective Biology teaching.					
3.	The inclusion of science allowance for teachers by the Government is a way of encouraging more people to specialize in science-related courses.					
4.	More Teachers should be sent for In-service training to encourage them to perform better in their work.					
5.	I enjoy attending seminars/workshops for self-improvement.					
	PROCESS VARIABLE	**SA**	**A**	**N**	**D**	**SD**
1.	Teaching science by discovery approach is adequately reflected in the Biology course.					
2.	Science teachers must make their students see the course as an investigation of nature within the environment.					
3.	In Libya, teachers of Sciences are expected to use local examples to foster learning and enable the students to know about their environment through improvisation.					
4.	Teaching approaches such as Lecture Method and Field Trip motivate students to learn more than Activity Oriented and the student-based approach recommended for the course.					
	PRODUCT VARIABLE	**SA**	**A**	**N**	**D**	**SD**
1.	One of the goals of biology is to enable students to gain the					

	concepts of the fundamental unity of science from their daily life routine.					
2.	In Libya, students who study Biology are expected to develop certain skills such as observation, investigation. synthesizing etc.					
3.	The kinds of activities suggested for use in the core curriculum permit students to use scientific techniques later in life for the fulfillment of the National philosophy of self-reliance.					
4.	The course objectives provide for satisfactory achievement on national needs and aspirations.					
5.	Through Biology courses, students have an adequate foundation for subsequent special study at University.					

Appendix 2 Interview Questions Adopted and modified from (Park 2005)

Backgrounds to biology Teaching

1. Can you tell me about your background in biology and science teaching?
2. What do you see as your strong points in the teaching practice of Biology?
3. In which areas do you feel relatively weak in your teaching practice?
4. What is biology teaching in your mind?
5. Can you describe what your biology classes look like?
6. What are the characteristics of your biology teaching?
7. Can you tell me what you think are the reasons for learning Biology at secondary school?
8. What are your goals for your students?
9. What do you think makes Biology difficult for students?
10. How would you help to solve the difficulties students have in learning biology?
11. What can make the study of biology easier for students?
12. Can you tell me about the classes you are teaching?
13. How do you decide what to teach and what not to teach?
14. How do you decide when to move from one concept to another?
15. What is your opinion on students' interaction in biology's lab?

Planning for a Class (or a Unit)

1. Have you taught this unit before?
2. How comfortable are you with the subject matter developed in this unit you are teaching?
3. What are your goals for this unit?
4. What subject matter or concepts do you think students might have difficulties with? Why do you think so?
5. What kinds of students' misconceptions associated with this unit have you noticed?
6. How would you help them correct their misconceptions?
7. What kinds of things do you take into consideration in planning this unit?
8. How do you create individual goals or objectives for each topic or class compared to creating for units?
9. How do you plan to assess student learning in this unit?

10. What evidence are you looking for to make sure that students have managed to address the goals for the lessons?

Retrospective Interview on Teaching a Class (or a Unit)

1. Do you use the lab for teaching biology? If yes how often do you use the lab?
2. Have you ever used the 5Es technique to teach biology before? If no, which technique do you use?
3. What changes will you bring to this unit next time you are going to teach? Why?
4. What do you think was the most effective teaching moment in teaching this unit?
5. What showed you that students were effectively learning?
6. Based on specific examples of representations, strategies, activities, etc. used by the teacher during teaching the unit:

   - Why did you decide to use this?

   - Did you prepare this activity before your students practice it in a biology lab? If yes, do you think this change as a result of participating in a training programme?

   - What evidence did you have that this worked?

   - What counts as a high level of accomplishment for this activity?

   - How did you know whether it was effective?

Changes Occurred after the training programme

1. Have you recently made any change in ways of representing Biology subject matter?
   - If yes, why?
   - How has the training programme influenced these changes?
2. Have you recently made any changes in ways of interacting with students?
   - If yes, why?
   - How has the training programme influenced these changes?
3. Have you recently made any change in teaching planning, classroom activities, or classroom management skills?
   - If yes, why?
   - How has the training programme influenced these changes?
4. Have you recently made any change in your ways of assessing students' learning?
   - If yes, why?

- How has the training programme influenced these changes?

5. Have you recently experienced your subject matter knowledge is deepen or broaden?
   - If yes, why?
   - How has the training programme influenced these changes?
6. Have you noticed any changes in student performance after your involvement with the training programme?
7. Are there things at the local/school/state level that influence the way you teach? If yes, give some examples.

Teachers understanding of Students' thinking of the content

1. From your experiences, how do1 you describe student's characteristics in the biology classrooms? (Cognitive, affective, and social aspects).
2. How do you know when your students understand a concept?
3. What are the instructional challenges you encountered that were caused by your students' temper? How did you handle those challenges?
4. How do you take look at students' temper in your teaching?
5. How do you think your students come to believe in their minds that they understand something?
6. Are there any other comments that you would like to add?

Appendix 3 Teacher selected interviews- (example teacher 1)

What is your background in teaching science?

At secondary school, I studied basic sciences. At high school, I did not study science education but I loved Biology thanks to my teacher. Then, I studied at the Faculty of Science to specialize in animal science and I graduated in 2000. After graduating I enrolled in a training course in one of the hospitals. When I finished training I was employed in the laundry center of the kidney and I worked there for two years before working in a laboratory for special medical analysis. Then after, I got a job as a teacher because in Libyan society teaching is acknowledged as the most appropriate for women. Therefore, since 2004 or for almost 13 years I have been teaching general biology and other related subjects such as environmental microbiology …. etc. at the secondary school level. At the time the government has forbidden non-qualified teachers to teach I worked in a private school for four years and then I have been called back again to work in public schools.

What do you think are the positive aspects of your teaching of biology?

Teaching in the laboratory is one of the most interesting aspects for both my students and me. In the lab, I noticed that even the weak students were active and capable of performing well in the way I did not expect them to. Meanwhile, teaching outside of the lab, in a normal class, some students are bored and not interested in learning this was a mixed school with both boys and girls students, many times boys want to do things in their own way mostly when they work with girls, but in the lab, boys do the experiments much better and professionally higher than girls.

What do you think is your weakness in your teaching?

English I think my proficiency level in terms of the pronunciation of the biology concepts is not good. Sometimes, I need help from some other people for better pronunciation of the terms.

How many classes are you teaching?

This year, I am teaching three classes, each class has three lessons a week. This means that I have nine lessons a week because many students have left the school some afraid of the high teaching standard and others just following the movement. They have preferred to go to schools where the teaching standards are less challenging. This is why my teaching hours are not too high.

How do you maintain disciple in your class?

Very often, I divide my classes into groups. Each group contains weak, intelligent, shy, and aggressive students in order to reach some of their preachings.

What do you think are the reason for teaching biology?

It is very important to learn biology because it concerns all life phenomena around us. We need to teach biology to young people to give them insights that can help them develop their knowledge of the environment surrounding them and also develop their perception of living organisms.

What is your aim in teaching biology?

My aim is to help students reach the knowledge of the vital processes that occur in the environment around them and its effect on their bodies.

According to you what makes teaching biology relatively difficult?

When I consider the biology curriculum in middle and high school, I may say that; the teaching competencies of teachers make the teaching of biology difficult for students. For example, the basic concepts of osmosis and diffusion are taught in the preparatory stage, but when students have not well assimilated these basic concepts it becomes difficult at this level to deepen these notions as I have to build new knowledge on previously learned concepts. Sometimes, I need to give a full lesson on those notions to raise students at the required level for the lesson scheduled at the secondary school stage. For this reason, sometimes, I require students to do quick activities in groups.

How do you decide on which concepts to give priority and teach when it is almost the end of the semester?

When I do not have enough time, I consider and teach only the basic concepts of the unit or the main idea of the subject matter and expand it according to the availability of the time. For example, for Osmosis and Diffusion, the basic idea is the movement of the water molecules and substances through the semipermeable membrane and I have to make sure that my students have understood it.

When do you decide to move from one concept to another within the unit?

Before introducing a new lesson, I briefly present a summary of the previous lesson. Through this review and discussion, I note how well students have comprehended the concept. If I receive satisfactory answers from most students, then, I decide to go to the next concept.

How do you describe your students' participation in-class activities?

Before they start working on the experiment, they were confused and had problems with the normal procedure to follow. Consequently, they were not sure about their own final result and they did not get the right one, although I allow those who have the doubt to run the experiment at another time, they are afraid that the result will not appear in the exam.

Have you ever taught Osmosis and Diffusion before?

Yes, I have taught it several times, and I have checked what I have been teaching in this workshop we have attended. I am satisfied with my concept of knowledge of the subject within the limits of the school curriculum. Always I have been telling my students to comprehend what osmosis and diffusion are rather than memorize them and that they can reach the result by understanding the phenomenon and interpreting it.

What is the main objective of the osmosis and diffusion unit?

The main goal is to help students know the behavior of the cell. For example, to know how single-cellular and multicellular cells live in saltwater and freshwater, such as food, saline, or sugary, and to know how they are preserved and what happens to them. The position of algae and fungi does not grow or does spoil the food.

The concept such as "water stress" makes students' comprehension difficult. What are other concepts also making it difficult for students to comprehend easily the lessons?

The water effort is not a problem for me although I have met some teachers who have a misunderstanding of the concept. For example, I know that Water effort is the number of water molecules in the solution. Therefore, when there is a 15% solution and a 10 % solution it means that water effort in the solution10% is higher than the water effort in the solution 15% because of the high number of water molecules.

How do you correct students' misconceptions of a given concept?

Through discussions and question-answer techniques, they identify their mistakes and correct them.

What are the factors you take into consideration when you are planning to teach a unit?

Very often, I consider the time and look at the number of components to exploit from the content. Sometimes I need more lessons for one unit, in the past, we used to prioritise our colleagues who needed more time to finish their lessons, but this year we all need time. In the allocation of hours for each course, the ministry of education has allocated 3 hours per week to biology in grade 10 at secondary school. With only 3 hours per week, it becomes impossible to teach extensively the curriculum. In this way, some activities mentioned in the curriculum are simply merged with others or compressed in a very short time. (The curriculum consists of three books, the class book, the book of activity, and the booklet of practical exercises.) For example, I use exercises as a test because of this time constraint.

How do you evaluate your students?

I evaluate my students either individually or collectively in small groups. Evaluation tasks are either theoretical or practical or they combine both aspects. Students design their reports on their own or through my guidance and according to time availability, they practice. so that the students take advantage of their time in the experiments rather than the time spent on design.

Did you know the 5Es learning strategy of the Biology course before?

No, I did not know it before. When students were experiencing carrots I did not do anything because I wanted them to discover what will happen. They prepare the carrots and salted water and tried the experimentation. First, they weight the carrots and they also used the thread before the experiment, and then they left in the slot and freshwater, and the second day I made the experience examined by the rest of the students to describe what happened with carrots. One of the carrots had increase in size and the other had decreased. Students were very excited about the experience.

Which evidence indicates that students actually learn?

Their enthusiasm and interest in practical work are the evidence. For example, in the case of osmosis and diffusion when students are able to justify the changes in sizes of carrots and when they want to check with the microscope what happened to the cells.

Why were you helping and guiding your students to reach the expected results?

This year, students do not have the required level. Therefore, considering the time constraint they need an assistant to reach the results in time. I did not give them the results directly but we discussed the process to use and this leads them in the right direction towards the expected results. Otherwise, they would not get it.

After having followed the workshop, do you feel that you have acquired something new which has changed your teaching practice?

Yes, there is a big change in my teaching practice especially at the teaching activities level, and at the assessment of the understanding of students. Thanks to the experiments we have done, I have learned and discovered things I did not know before, such as potatoes, carrots and egg, … and when doing the tests I was not allowing students to answer each other questions, but with this workshop, I have understood that each student's answer is a piece of evidence that will helps me to determine the level of students understanding. In addition, I have benefited from the discussions and dialogues sessions with other teachers present at the workshop. From the sessions, I have determined the advantages and disadvantages of the activities that I was conducting. The workshop was really important for me because it has helped me to evaluate myself in regard of methodological requirements and try to change the method of teaching as much as I can by adopting many of the new ideas I did not know before.

Have you changed your way of interacting with students after the workshop?

My interaction with students is quite rigorous. Some of the students are even afraid to attend my class, but, after having attended it they find that it is different and interesting. I do not like losing time because the time allocated to each lesson is not enough for all activities. Therefore, I've preferred to assess the students rather than losing lesson time. osmosis and diffusion were supposed to be taught in the previous week, but due to the midterm examinations which were drawing near and the short time we had for preparation, I placed the samples before the lesson so that the students did not have to wait for the results, I had been helped by the lab assistant to practice the osmosis and diffusion's activities that we had done in the course of the sessions.

Is there any change in students' performance after you participate in the workshop?

Yes, there is a change. Students reacted positively when they saw the change in the experiment. They were also excited and much involved in the experiments, they were asking questions to understand what has happened and why this happened like that. I think this will stimulate them to study biology for scientific purposes.

How do you describe your students?

My class is a normal class where there are motivated students with the desire to learn and share knowledge with others and shy and non-motivated ones who do not want to learn at all. I am trying to help this category of students by involving them in group work with other students to motivate and push them to learn from them and work with them as a team. Another is the category of perfectionist students always fearing to make mistakes but I motivate them not to be scared of making mistakes because we sometimes learn from our mistakes in this case even if they give wrong answers I encourage them and help them to get the right one. Teaching grade 10 at secondary school is difficult because students are freshly coming from middle school and also they are teenagers.

What proves that students have learned what they were supposed to learn?

For example, in the case of osmosis and diffusion lesson, I use a sample of one group experiment to evaluated another group. I ask them to say which sample was placed in freshwater and which one was placed in the salted solution and they have to give the correct answer. If they are able to give the correct answer just by observation this proves that they have assimilated.

Are there any comments you want to add?

I wanted to reduce some of the topics in the curriculum of living organisms because the students studied them in many places.

Appendix 4 Observation schedule adopted and modified from (Kitta, 2004)

Observation	Notec		
	NO	ONPW	OPW
Introduction to the lesson **Basic teaching skills**			
1. Preparedness of the teacher for the lesson			
2. Teacher recall on the previous lessons and waits students' answer			
3. Teacher makes clear statement on the purpose of the lesson			
4. Teacher makes references to textbooks (where necessary)			
5.Teacher discusses and review previous homework (when necessary)			
Activity-based teaching			
1. Teacher introduces the lesson by an activity			
2. Teacher asks learners about their ideas about the activity			
3. Teacher clarifies how the activity will be conducted			
4. Teacher explains the relationship of the activity with the previous lesson			
5. Teacher establishes relevance of the activity to the learners' daily lives			
Subject matter knowledge			
1. Teacher gives appropriate information about the lesson			
2. Teachers gives accurate information to learners about the activity			
3. Teacher relates the information to the previous topics/lessons			
Body of the lesson **Basic teaching skills**			
1. Teacher has all the necessary teaching materials			
2. Teacher ensures all the students participate			
3. Teacher encourages students to ask questions			
4. Teacher organises students in groups			
5. Teacher supervises group presentations			
6. Teacher effectively handles timing difficulties			
7. Teacher moves round the class			
8. Teacher's preparedness contributes to a smooth lesson			
9. Teacher maintains positive learning environment during activity			
Activity-based teaching			
1. Teacher introduces the activity			
2. Teacher gives the objective of the activity			
3. Teacher divides class in groups for the activity			
4. Teacher demonstrates how to do the activity			
5. The demonstration is visibly clear to all the learners			
6. Teacher supports groups of students by asking questions			
7. Teacher supports groups of students by giving advice			
8. Teacher gives clear instructions on how to perform the activity			
9. Teacher closely supervises the groups by moving around the class			
10. Teacher interacts equally with all groups			
11. Teacher encourages learners to ask questions			
12. Teacher allows sufficient time to answer questions			
13. Teacher interacts with students during activities			
Subject matter knowledge			

1. Teacher relates appropriately one activity to another			
2. Teacher answers students' questions correctly			
3. Teacher clarifies the new terms and concepts appropriately			
Conclusion of the lesson			
Basic teaching skills			
1. Teacher summarises the lesson			
2. Teacher asks groups to present their results			
3. Teacher summarises the findings of activity			
4. Teacher spends time to discuss the activity thereafter			
5. Teacher asks learners questions and waits for responses			
6. Teacher encourages learners to ask questions			
7. Teacher gives homework			
8. Teacher explains the significance of the homework			
9. Teacher clarifies how the homework will be done			
Activity-based teaching			
1. Teacher asks the group to report their results to the class			
2. Teacher draws conclusion from the activity(ies)			
3. Teacher, together with learners, draw conclusions from the activities			
4. Teacher guides the learners to know the differences in their results			
Subject matter knowledge			
1. Teacher correctly clarifies the results of the activity			
2. Teacher relates the activity with the theory behind it			
3. Teacher provides theoretical conclusion from activity			
4. Teacher appropriately summarises the lesson			
General impression **Basic teaching skills**			
1. Teacher asks thought inciting questions			
2. Teacher listens to students' answers			
3. Teacher encourages students to ask questions			
4. Teacher is well prepared for the lesson			
5. Teacher uses the time rationally			
6. Teacher uses classroom aids properly			
7. Teacher improvises the teaching aids			
8. Teachers uses teaching aids to make the lesson more clear			
Activity-based teaching			
1. Teacher organises students in groups for classroom activities			
2. Teacher clarifies the activities			
3. Teacher guides students in doing activities			
4. Teacher gives students opportunity to reflect on the results			
Subject matter knowledge			
1. Learners meet overall lesson objectives			
2. Teacher appears confident in lesson content			
3. Teacher seem to have firmed the understanding of the subject area			

- NO=Not Observed, ONPW= Observed but not performed well, OPW=Observed and performed well

Appendix 5 the Osmosis and Diffusion Diagnostic Test (ODDT)

ADOPTED AND MODIFIED FROM (Odom, 1995)

1a - Suppose there is a large beaker full of clear water and a drop of blue dye is added to the beaker of water. Eventually, the water will turn a light blue color. The process responsible for blue dye becoming evenly distributed throughout the water is:

a. Osmosis

b. Diffusion

c. A reaction between water and dye

1b. The reason for my answer is:

a. The lack of a membrane means that osmosis and diffusion cannot occur.

b. There is a movement of particles between regions of different concentrations.

c. The dye separates into small particles and mixes with water.

d. The water moves from one region to another.

2a- During the process of diffusion, particles will generally move from:

a. High to low concentrations

b. Low to high concentrations

2b. The reason for my answer is:

a. There are too many particles crowded into one area, therefore they move to an area with more space.

b. Particles in areas of greater concentration are more likely to bounce toward other areas.

c. The particles tend to move until the two areas are isotonic and then the particles stop moving.

d. There is a greater chance of the particles repelling each other.

3a. as the difference in concentration between two areas increases, the rate of diffusion:

a. Decreases

b. Increases

3b. The reason for my answer is:

a. There is less room for the particles to move.

b. If the concentration is high enough, the particles will spread less and the rate will be slowed.

c. The molecules want to spread out.

d. The greater likelihood of random motion into other regions.

4a. A glucose solution can be made more concentrated by:

a. Adding more water

b. Adding more glucose

4b. The reason for my answer is:

a. The more water there is the more glucose it will take to saturate the solution.

b. Concentration means the dissolving of something.

c. It increases the number of dissolved particles.

d. For a solution to be more concentrated, one must add more liquid.

5a. If a small amount of sugar is added to a container of water and allowed to sit for a very long period of time without stirring, the sugar molecules will:

a. Be more concentrated on the bottom of the container.

b. Be evenly distributed throughout the container

5b. The reason for my answer is:

a. There is a movement of particles from a high to low concentration.

b. The sugar is heavier than water and will sink.

c. Sugar dissolves poorly or not at all in water.

d. There will be more time for settling.

6a. Suppose you add a drop of blue dye to a container of clear water and after several hours the entire container turns light blue. At this time, the molecules of dye:

a. Have stopped moving

b. Continue to move around randomly

6b. The reason for my answer is:

a. The entire container is the same colour; if the dye molecules were still moving, the container would be different shades of blue.

b. If the dye molecules stopped, they would settle to the bottom of the container.

c. Molecules are always moving.

d. This is a liquid; if it were solid the molecules would stop moving.

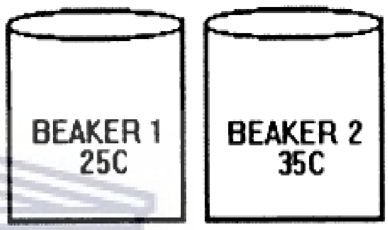

Figure 1

7a. Suppose there are two large beakers with equal amounts of clear water at two different temperatures. Next, a drop of green dye is added to each beaker of water. Eventually, the water turns light green (see Figure 1). Which beaker became light green first?

a. Beaker 1

b. Beaker 2

7b. The reason for my answer is:

a. The lower temperature breaks down the dye.

b. The dye molecules move faster at higher temperatures.

c. The cold temperature speeds up the molecules.

d. It helps the molecules to expand.

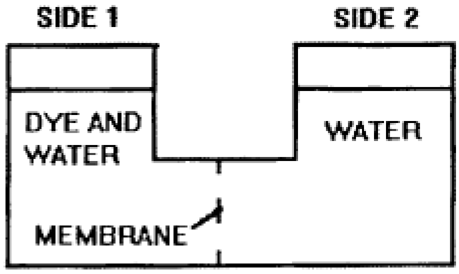

Figure 2

8a- In Figure 2, two columns of water are separated by a membrane through which only water can pass. Side 1 contains dye and water; Side 2 contains pure water. After two hours, the water level in Side 1 will be:

a. Higher

b. Lower

c. The same height

8b. The reason for my answer is:

a. Water will move from the hypertonic to the hypotonic solution.

b. The concentration of water molecules is less on Side 1.

c. Water will become isotonic.

d. Water moves from low to a high concentration.

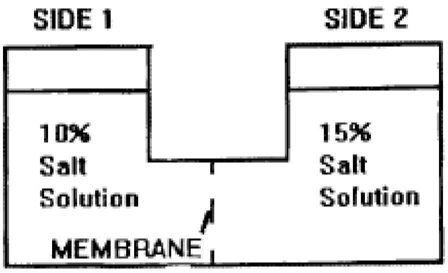

Figure 3

9a- In Figure 3, Side 1 is ____________________ to Side 2.

a. Hypotonic

b. Hypertonic

c. Isotonic

9b. The reason for my answer is:

a. Water is hypertonic to most things.

b. Isotonic means "the same".

c. Water moves from a high to a low.

d. There are fewer dissolved articles on Side1.

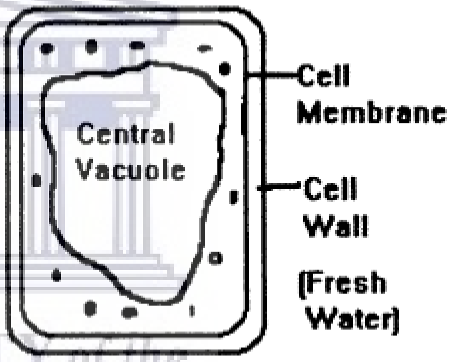

Figure 4

10a. Figure 4 is a picture of a plant cell that lives in freshwater. If this cell was placed in a beaker of 25% saltwater solution, the central vacuole would:

a. Increase in size

b. Decrease in size

c. Remain the same size.

10b. The reason for my answer is:

a. Salt absorbs the water from the central vacuole.

b. Water will move from the vacuole to the saltwater solution.

c. The salt will enter the vacuole.

d. Salt solution outside the cell cannot effect the vacuole inside the cell.

11a. Suppose you killed the plant cell in Figure 4 with poison and placed the dead cell in a 25% saltwater solution. Osmosis and diffusion would:

a. Not occur

b. Continue

c. The only diffusion would continue

d. Only osmosis would continue

11b. The reason for my answer is:

a. The cell would stop functioning.

b. The cell does not have to be alive.

c. Osmosis is not random, while diffusion is a random process.

d. Osmosis and diffusion require cell energy.

12a. All cell membranes are:

a. Semipermeable

b. Permeable

12b. The reason for my answer is:

a. They allow some substances to pass.

b. They allow some substances to enter, but they prevent any substance from leaving.

c. The membrane requires nutrients to live.

d. They allow ALL nutrients to pass.

Appendix 6 Crosstab for each Question in the ODD Test

Question-1- Suppose there is a large beaker full of clear water and a drop of blue dye is added to the beaker of water. Eventually, the water will turn a light blue color. The process responsible for blue dye becoming evenly distributed throughout the water is:

reason \ Answer		Osmosis	Diffusion	A reaction between water and dye
The lack of a membrane means that osmosis and diffusion cannot occur.	Pre	0	1	0
	Post	0	0	0
There is a movement of particles between regions of different concentrations.	Pre	0	19*	0
	Post	0	20*	0
The dye separates into small particles and mixes with water.	Pre	0	1	1
	Post	0	2	0
The water moves from one region to another.	Pre	0	0	0
	post	0	0	0

*** The correct answer**

Question-2- During the process of diffusion, particles will generally move from:

reason \ Answer		High to low concentrations	Low to high concentrations
There are too many particles crowded into one area, therefore they move to an area with more space.	Pre	4*	0
	Post	13*	0
Particles in areas of greater concentration are more likely to bounce toward other areas.	Pre	1	0
	Post	4	0
The particles tend to move until the two areas are isotonic and then the particles stop moving	Pre	17	0
	Post	4	0
There is a greater chance of the particles repelling each other.	Pre	0	0
	post	1	0

* The correct answer

Question_3_ As the difference in concentration between two areas increases, the rate of diffusion:

reason \ Answer		Decreases	Increases
There is less room for the particles to move.	Pre	1	2
	Post	0	0
If the concentration is high enough, the particles will spread less and the rate will be slowed.	Pre	0	2
	Post	0	0
The molecules want to spread out.	Pre	0	5
	Post	0	4
The greater likelihood of random motion into other regions.	Pre	0	12*
	post	0	18*

*** The correct answer**

Question_4_ A glucose solution can be made more concentrated by:

reason \ Answer		Adding more water	Adding more glucose
The more water there is, the more glucose it will take to saturate the solution.	Pre	0	0
	Post	0	0
Concentration means the dissolving of something.	Pre	0	2
	Post	0	1
It increases the number of dissolved particles.	Pre	0	20*
	Post	0	21*
For a solution to be more concentrated, one must add more liquid.	Pre	0	0
	post	0	0

*** The correct answer**

Question_5_ If a small amount of sugar is added to a container of water and allowed to sit for a very long period of time without stirring, the sugar molecules will:

reason \ Answer		Be more concentrated on the bottom of the container	Be evenly distributed throughout the container
There is a movement of particles from a high to low concentration.	Pre	4	9*
	Post	4	12*
The sugar is heavier than water and will sink.	Pre	4	1
	Post	1	0
Sugar dissolves poorly or not at all in water.	Pre	2	0
	Post	0	0
There will be more time for settling.	Pre	2	0
	post	3	2

* The correct answer

Question-6- Suppose you add a drop of blue dye to a container of clear water and after several hours the entire container turns light blue. At this time, the molecules of dye:

reason \ Answer		Have stopped moving	Continue to move around randomly
The entire container is the same colour; if the dye molecules were still moving, the container would be different shades of blue.	Pre	1	1
	Post	1	1
If the dye molecules stopped, they would settle to the bottom of the container.	Pre	4	2
	Post	0	0
Molecules are always moving.	Pre	1	13*
	Post	0	20*
This is a liquid; if it were solid the molecules would stop moving.	Pre	0	0
	post	0	0

* The correct answer

Question-7- Suppose there are two large beakers with equal amounts of clear water at two different temperatures. Next, a drop of green dye is added to each beaker of water. Eventually, the water turns light green. Which beaker became light green first?

reason / Answer		Beaker 1	Beaker 2
The lower temperature Breaks down the dye.	Pre	0	0
	Post	0	0
The dye molecules move faster at higher temperatures.	Pre	0	21*
	Post	0	22*
The cold temperature speeds up the molecules.	Pre	0	1
	Post	0	0
It helps the molecules to expand.	Pre	0	0
	post	0	

* The correct answer

Question-8- In Figure 2, two columns of water are separated by a membrane through which only water can pass. Side 1 contains dye and water; Side 2 contains pure water. After two hours, the water level in Side 1 will be:

reason / Answer		Higher	Lower	The same height
Water will move from the hypertonic to the hypotonic solution.	Pre	10*	1	1
	Post	14*	0	0
The concentration of water molecules is less on Side 1.	Pre	4	5	0
	Post	3	0	0
Water will become isotonic.	Pre	0	0	0
	Post	0	0	0
Water moves from low to a high concentration.	Pre	1	0	0
	post	1	4	0

* The correct answer

Question-9- In Figure 3, Side 1 is _____ to Side 2.

reason / Answer		Hypotonic	Hypertonic	Isotonic
Water is hypertonic to most things.	Pre	1	0	0
	Post	0	0	0
Isotonic means "the same".	Pre	0	0	0
	Post	0	0	0
Water moves from a high to a low.	Pre	3	2	0
	Post	1	7	0
There are fewer dissolved articles on Side1.	Pre	8	8*	0
	post	3	14*	0

* The correct answer

Question-10- Figure 4 is a picture of a plant cell that lives in freshwater. If this cell was placed in a beaker of 25% saltwater solution, the central vacuole would:

reason / Answer		Increase in size	Decrease in size	Remain the same size
Salt absorbs the water from the central vacuole.	Pre	0	1	0
	Post	0	0	0
Water will move from the vacuole to the saltwater solution.	Pre	0	20*	0
	Post	0	22*	0
The salt will enter the vacuole.	Pre	1	0	0
	Post	0	0	0
Salt solution outside the cell cannot effect the vacuole inside the cell.	Pre	0	0	0
	post	0	0	0

* The correct answer

Question-11- Suppose you killed the plant cell in Figure 4 with poison and placed the dead cell in a 25% saltwater solution. Osmosis and diffusion would:

reason / Answer		Not occur	Continue	Only diffusion	Only osmosis
The cell would stop functioning.	Pre	10*	0	0	0
	Post	16*	0	0	0
The cell does not have to be alive.	Pre	0	1	2	2
	Post	0	1	1	0
Osmosis is not random, while diffusion is a random process.	Pre	1	1	2	0
	Post	1	0	2	1
Osmosis and diffusion require cell energy.	Pre	3	0	0	0
	post	0	0	0	0

* The correct answer

Question-12- All cell membranes are:

reason / Answer		Semipermeable	Permeable
They allow some substances to pass.	Pre	5	0
	Post	2	0
They allow some substances to enter, but they prevent any substance from leaving.	Pre	16*	0
	Post	20*	0
The membrane requires nutrients to live.	Pre	0	0
	Post	0	0
They allow all nutrients to pass.	Pre	0	1
	post	0	0

* The correct answer