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Teaching Science Students to Think Critically: Understanding Secondary School Teachers' Practices

Muhammad Jamil[1], Yaar Muhammad[2]

PhD Scholar, University of Management and Technology, Lahore.
Assistant Professor, *University of Management and Technology, Lahore, Pakistan*
Corresponding Author's Email: yaar.muhammad@umt.edu.pk

ABSTRACT

Critical thinking is considered an important aspect of formal education and one of the 21st-century skills in contemporary literature. Policy documents National Education Policy 2009 and National Curriculum for Physics, Chemistry and Biology, Grades IX-X, 2006 all focus on developing students' critical thinking to become independent, logical, rationale and decision-makers. The purpose of the current qualitative study was to explore teachers' perspectives regarding pedagogical practices for the development of critical thinking skills of secondary school science students. Using basic qualitative research design, twelve secondary school teachers of Physics, Chemistry and Biology were purposively selected as participants from a district in Punjab through criterion sampling technique. In-depth semi-structured interviews in which questioning and probing often continued for as long as an hour were conducted for data collection. Qualitative content analysis was used to analyze interview data through *NVivo 12* software. According to the findings of the study, the teachers used different pedagogical practices that are, questioning, group work, activity-based teaching, discussion, demonstration, learning by doing and audio-visual aids in their classrooms. However, their main focus was only to get good grades for students instead of developing critical thinking. It is suggested that a top-down (policy to practice) change should be implemented in order to ensure that science teachers use relevant pedagogical practices for developing critical thinking in students. Assessment system should also be revised so that these skills may be developed in science students.

Keywords: *critical thinking, pedagogy, science education, secondary level*

Introduction

The global science education discourse has shifted toward a broader concern around the twenty-first-century skills especially, the development of critical thinking (hereafter CT), which is now considered as one of the key goals of science education. This is often argued that emphasis on critical thinking in science education is necessary for scientific development as well as for the building of democratic behaviours in the personal, political, ethical and cultural sphere (Yacoubian, 2015). Moreover, it is argued that the teaching-learning process involving critical thinking is useful for the academic life of an individual but also for the everyday life of the learner (Dwyer, Hogan, & Stewart, 2011). Furthermore, it is asserted that critical thinking may serve for the guidance of learners to find the solution of their social problems as living within an information society, where learners get knowledge and ability to compare and evaluate knowledge critically with their understanding.

Likewise, in the current Pakistani educational policy context, there is much emphasis on the development of critical thinking of students. For example, National Education Policy (Government of Pakistan, 2009) and National Curriculum for Physics, Chemistry and Biology (2006) not only emphasize the need for developing CT skills of students but also suggest different pedagogical practices for developing CT skills among secondary school students.

There is a focus on developing CT skills among learners of twenty-first-century. These policy documents also underscore that the aim of education should be to develop CT skills with decision making, problem-solving so that citizens can face challenges of the twenty-first century. These documents recommend teachers to use inquiry, problem-solving, cooperative learning, discussion, active involvement, conversation, and learning by doing as necessary pedagogical practices.

Progressive educationists in Pakistan often highlight that students are performing low in questions related to CT as this is being ignored in traditional classrooms where transmission pedagogy and rote memorization are promoted only for gaining good grades in state exams and the process of analysis, synthesis and evaluation has been ignored. They also highlight that the age of secondary school students is the most suitable for critical thinking. At this stage, CT skills should be promoted among students using different teaching strategies. They also recommend different teaching strategies for the promotion of higher-order thinking skills and consider rote memorization as a big hindrance in the production of knowledgeable and well-rounded critical thinker students.

Literature Review

Critical thinking is variously defined in the theoretical literature. It has been defined as learning to think (Dewey, 2004); meaningful, logical and goal-oriented thinking (Halx & Reybold, 2006); inference, interpretation, explanation, self-regulation and evaluation (Facione, 2007); logical reasoning and deciding the facts after taking opinions and examining them (Fahim & Pezeshki, 2012); and a metacognitive process of analysis, synthesis and inferences based on domain-specific and general knowledge for logical conclusions and solution of different life problems (Garner, Pugh, & Kaplan, 2016). However, this study uses a mostly used definition in theoretical literature—which considers critical thinking as "reflective, reasonable thinking focus on deciding what to believe or do" (Ennis, 1993, p. 179).

Being a twenty-first-century skill, critical thinking is of vital importance. Educationists and experts emphasize the need and acquisition of twenty-first-century skills to become productive citizens, to fulfil the job market requirement and to become part of the global economy (Erstad & Voogt, 2018). Significance of CT skills development has been explained because of many factors and reasons (Guttami, 2005). These factors are motivation for the learning, classroom learning environment development, transformation of knowledge inactive way, correct and acceptable explanation of the students, the ability of learners to learn by themselves, performance development in all subjects, encouragement of questioning by teachers, discussion, dialogues, and broad-mindedness of the students. In the same way, Simister (2004) describes that thinking critically helps in enhancing the learning experience of students, in developing a deep understanding of their environment, sharpening their ability to be right decision-makers, respecting others and providing assistance to learners to become creative in problem-solving.

Moreover, the importance of CT skills has been described in different aspects. It has been deemed important by different researchers for positive students' and educational outcomes (Spatariu, Winsor, Simpson, & Hosman, 2016). Learning of CT skills is essential to become

effective reflective thinker (Higgins, 2015). It is required in different phases of life for academic success, employment, and professional development. In the view of Hatcher (2006), it is a necessary skill because of its importance at the workplace for questioning, evaluating people, policies and institutions as well as for solving social problems. CT skills development is productive for academic outcomes as well as reasoning and problem solving (Higgins, 2015). Indeed, it is a required skill to be successful in life.

In literature, there have been discussed different barriers affecting the development of CT skills. These have been described with both students' and teachers' perspectives (Buskist & Irons, 2008). From the students' point of view there were reported five areas, that is, teachers' authority, unwillingness due to culture and lack of experience, unacceptable intellectual demand for CT, memorization as easier and faster process and no reward of assessment. Problems described from teachers' perspective were identified as accountability from authorities, lack of time due to pressure on teaching, research and management, uncertainty as fear of the unknown, no institutional support, and unawareness of assessment of CT skills.

There have been discussed four broad areas affecting the development of CT skills in Pakistani context (Cassum, Profetto-McGrath, Gul, Dilshad, & Syeda, 2013). These aspects are teacher competence, nature of students, the type of learning environment and organizational ethos and resources. These barriers may be overcome through different factors like the teacher's role to encourage students, friendly attitude, guidance for students, giving ample time for thinking and using the questioning technique. Being a role model, teachers can impart CT skills among students. In the same way, students' academic and social background with different personal issues may be resolved for developing CT skills. Assessment criteria should be based on CT skills.

Rote memorization is, however, considered one of the biggest hurdles in developing students' CT skills. In Asian countries, there is a general practice of memorization instead of critically questioning knowledge, resulting in poor learning outcomes (Shaheen, 2012). Because of content focused examination, rote learning has been promoted. That is why students with rote learning become passive learners (Vandermensbrugghe, 2004). In the Pakistani context, the main aim is to get good grades. This aim is achieved by training of memorization and encouraging cramming in schools. The traditional lecture method is dominated in science classrooms. Assessment is done based on rote memorization. Most of the courses are text-based and are conceptualized as teacher-centred instead of learner-centred (Khan, 2017).

Theoretical literature suggests various strategies for the improvement of critical thinking in science education (Santos, 2017). For example, Following strategies for the development of CT skills are suggested: discussion, debate, problem-solving and argumentation with the defence of ideas, evaluation of arguments; inquiry-based learning (Duran & Dökme, 2016); engaging students, questioning; discussion, group activities, collaboration, self-evaluation, role-playing, simulation, presentations and technology (Demir, 2015; Savich, 2009; Tok, 2012); explicit instruction, engaged pedagogy (Hooks, 2010); problem solving, project-based methods (Hooks, 2010; Orlich, Harder,

Callahan, Trevisan, & Brown, 2012; Osborne, 2014); cooperative/collaborative learning, conversation, interaction; observation and evaluation (Fung, 2014; Osborne, 2014).

The above-discussed literature suggests different pedagogical practices for the development of CT skills in different contexts. Therefore, it was of great significance to conduct a study of teachers' perspectives regarding pedagogical practices for developing CT skills in science subjects (Physics, Chemistry and Biology) at the secondary level in the Pakistani context. Consequently, the aim of the study was: To explore the perceptions and practices of secondary level teachers regarding pedagogy for the development of CT skills.

Methodology

The current study used the basic qualitative research approach (Merriam, 2009) underpinned by interpretivist paradigm, which assumes that reality is socially constructed, complex and ever-changing. Here the researchers aimed to develop an understanding of the meanings the participants of the study had about the phenomenon of CT skills (Creswell, 2009). Moreover, this research approach was used to understand the teachers' perceptions and practices for developing CT skills in secondary school students.

Four public schools were selected as research sites from Faisalabad district in Punjab. The schools were run by Punjab Education department through district provincial government as these all schools were a typical example of "non-elitist system of education, fully dependent upon the state, functions for the most part in Urdu" (Rahman, 2005, p. 28). These public secondary schools were from the same geographical area. Selection of these schools was made from the official website of Punjab Education department. These schools were selected because of relatively easy access to them (Hancock & Algozzine, 2016). Sample for the study was selected through purposive sampling technique. This technique is used to get more insight from the "information-rich participants" (Patton, 2015). Three secondary school teachers (Physics, Chemistry and Biology) from each of the school were purposely selected as participants. The criteria for the selection of participants were: teachers' teaching in the selected geographical area, teaching Physics, Chemistry and Biology subjects and having a minimum of 6 months teaching experience. The selected participants of the study had different teaching experiences, from 1 to 30 years. Twelve teachers were recruited from four public schools. A total of three participants per school were included. Semi-structured interviews were used to explore teachers' perceptions about pedagogical practices for developing CT skills among secondary level students. After reviewing relevant literature, a semi-structured interview protocol was constructed as a data collection tool for this study. It was ensured that the interview questions in most part remained flexible and open-ended, thus, allowing the participants to express their perceptions and views about the CT skills and report their practices freely. The interview guide comprised of questions regarding teachers' perception about CT, its importance, pedagogical practices for developing CT skills, assessment system and hurdles in CT skills development. The interviews continued for as long as an hour with probing questions. Proper permission was taken from the heads of the relevant institutions. The interviews were conducted at the concerned schools with prior

communication with the participants about their availability. All audio-taped interviews were translated and transcribed for analysis. To describe the meanings of qualitative data systematically (Schreier, 2012), qualitative content analysis was used for the analysis of data obtained from semi-structured interviews. *NVivo 12* was used to facilitate the whole process of analysis.

Findings/ Results

Findings of the study are described in different themes which are as follows in detail:

Perception of the concept of 'Critical Thinking'

The interviewed teachers were asked to describe and explain their perceptions of 'critical thinking.' All the science teachers were aware of the concept of critical thinking as they defined it as the concepts-based study, learning with understanding and reasoning, deep thinking and learning with deep knowledge. All the teachers were well aware of the concept regarding CT. Most of the teachers described this concept as knowledge creation ability, deep thinking and concepts-based learning. A teacher explained it as:

> *CT means we should develop concepts-based leaning in the students instead of just cramming. They must be taught with different examples to make their concepts clear. As you know Mathematics and Physics are such subjects which cannot be understood and taught properly without completely understanding concepts. (Physics Teacher-2)*

Themes and sub-themes were created for analysis to address the objectives of the study. To establish the credibility of the study, the member checking technique was used and the findings of the science teachers' interviews were shared with the participants of the study to add or edit something.

Similarly, another teacher explained CT as a concepts-based study. According to his point of view, teaching with complete understating and clear concepts results in the promotion of critical thinking. It was also perceived as the creation of the ability of understanding in students rather than only rote learning. A participant described it in the following words:

> *In my point of view, students having complete understanding may learn better than only by rote learning. Students should have thinking capacity. If they are given any task, if they can describe it in their own words, it means it is critical thinking. (Chemistry Teacher-3)*

CT was also perceived as teaching reasoning and practical work. Participants believed that students should be taught in such a way that they know the reason behind what is being taught, their solutions and their implementation in practical life. They also believed that all this should be done with practical tasks like learning by

doing etc. They emphasized that science subjects demanded reasoning and logic with each concept and topic. Moreover, they argued that there was a need to teach students the reasoning behind the taught content and their implementation in practical life.

Importance of CT as Perceived by the Participants. All the interviewees were asked about the importance of CT, especially in science subjects at the secondary level for quality education. They acknowledged its vital importance regarding different aspects like the purpose of education, decision making, and progress in every walk of life. As it was explained by a teacher as follows:

> *These are of vital importance regarding the concepts-based study. The purpose of education cannot be fulfilled without developing CT skills in science subjects. As I explained earlier, in science subjects we need logic and rationale for the students to teach and learn. (Chemistry Teacher-4)*

In the same way, the aim of education was also mentioned as the development of CT skills. As narrated by one of the teachers, CT skill must be the aim of education, especially in science subjects this should be focused. Science teaching should be based on experiments, assumptions and their proof, which demands logic and reasoning behind every talk. Moreover, it was also explained that CT must be produced in today's learners of science because these skills are based on logical reasoning and thinking. They believed that because of deep thinking, students may succeed in every walk of life after consulting different modern techniques. Moreover, it was explained by a teacher in the following words:

> *Science is all about logic and reasoning, it all comes through thinking skills by the students. If students are trained at their secondary level, they will make it a life skill and use in their decision-making. (Physics Teacher-3)*

Most of the teachers asserted CT skills' importance for quality education. They perceived that for quality education there was "dire" need of CT skills development in secondary level science students. Furthermore, students' competency and preparation of future life, CT skills were acknowledged as important. Most of the teachers were of the view that in the twenty-first century, the purpose and objective of science education should be the development of CT skills. They argued that as science subjects required logical reasoning and experiments, the progress in the fields of education as well as practical life, CT skills are much important. Moreover, most of the participant emphasized that the aim of education was to produce critical thinkers. One of the participants was of the view:

> *Regarding science subjects, which is all activity-based and practical, students should have a complete*

> *understanding of concepts and rote learning must not be there. Especially, science teachers should focus on concepts-based study and understanding based on observation and discussion. (Physics Teacher-4)*

In the same way, few teachers described CT skills importance for science students by underscoring the importance in their practical life of the students. A teacher explained it as:

> *This is very important in their practical life. They study the laws of motion, and they cannot apply in daily life. So, no benefit of the study if they cannot apply it in daily life. The things students are taught, if they learn them practically, they will use them in their life. (Physics Teacher-1)*

The importance of CT was described in different aspects for science students at the secondary level as for decision making, with rationale and the logical reasoning, and concepts-based study. It was underscored that by developing critical thinking in students, students can take decision by themselves. They were of the view that books only have some examples but by giving examples from daily life there is a focus on creativity in students after that they can understand them easily and take decisions.

Most of the teachers considered the development of students' CT skills crucially important at the secondary school level. They believed that with the proper training of the teachers, students can do the desired task in a conceptual and good way. This level was considered the best level for concept building. One of the participants described it in the following words:

> *In basic science subjects, critical thinking is very important and without it, you cannot move forward. If you have the ability for critical thinking, you will be multi-dimensional and bring new things, especially, in science subjects like Physics, which all depends on rationale and logic. Students must be taught with such techniques which may be helpful for their future lives. (Physics Teacher-4)*

Another teacher emphasized this as:

> *Yes, definitely. We need this because these students who are studying in tenth class, they will go for medical fields or engineering. Critical thinking will help them to explore many things if they know through practical or clarification of concept at this age. (Biology Teacher-1)*

One more aspect described by the participants was the competency building in the students. As CT skills promote students' competency which is beneficial for their academic and practical life. A participant emphasized this aspect of CT skills in the following words:

> *These skills are needed in secondary school students' competency. Secondary level students must be much focused on this. They should be taught with complete understanding and with concepts-based teaching, students are able to explain each concept in their own words. So, these skills must be developed in students for higher academic competency. (Chemistry Teacher-3)*

In the same way, CT was explained as important for the preparation of future students regarding different fields of education as well as for the progress in their practical life. It was considered necessary at the secondary level for the students which may adopt medical or engineering fields. They emphasized that there is a need for complete understanding and concepts-based leaning, so students must be prepared for upcoming challenges in their study as well as real life. Furthermore, it was described important regarding innovation in science.

Most participants saw the importance of teaching CT skills within the science subject in terms of developing students' interest in science. They believed that if students see or explore things practically, they will learn with great interest and it will be beneficial for them. Through learning by doing they may seek great understanding and critical thinking. A teacher explained it in the following words:

> *Just take an example of this. Once I was teaching hydrogenation in my classroom. My students asked if they could try it in their home and I said, "Yes." The students were eager and energetic that they could start their own industry if they are able to succeed in doing so with practical work. (Chemistry Teacher-2)*

Similarly, it was perceived important because of practical work in science subjects which is necessary for the upcoming academic and practical life of the students. Participants believed that because of no practical work at science labs, the students are unable to understand the concept behind it. Therefore, CT was thought to be important because of practical work in the classroom. As science subjects demand CT skills, while teaching science, the experimental method was preferred over the theoretical method to teach the high school students. According to the perception of teachers, for logical reasoning and experiments, CT skills were necessary. Practical aspect regarding the importance of CT was described by a teacher in the following words:

> *Science cannot be proved right without implementing it in real life. I often give examples*

> *of different procedures regarding science subject like Biology. In Biology, we may explore flowers' different parts. Students can understand in the best way when they observe and explore it. In the same way, through a microscope, they may observe different unseen organs. (Biology Teacher-4)*

According to a few participants, the importance of CT skills as described in terms of the crucial level of secondary level for the science students. At this age level, CT skills development was thought to be most useful for academic and future practical life. Importance of CT was highlighted and linked with future progress in different fields and overall success in life.

Pedagogical practices used by teachers in the classroom

Most science teachers reported that they had been using pedagogical practices such as group work, discussion, questioning, activity-based teaching, demonstrations, learning by doing, and audio-visual aids in their classrooms. However, the focus of these teaching methods/techniques was not to develop CT skills.

Regarding cooperative learning methods in the classroom, most of the teachers were not fully aware of these specific methods rather they were using these techniques as group work. According to their perception, students were being taught in groups because of the large size of classes in public schools. They believed that these methods were usually good for concepts-based teaching. After making groups of the students, they were assigned tasks to complete it. In the same way, teachers were using this method to make their students understand the concepts with clarity. One of the participants explained his views as follows:

> *I make different groups of students to make them understand the specific phenomenon. There are students of different calibres. Through group work, they can learn in a better way. The weak students also may learn well from shining or intelligent students. Thus, this strategy is useful for science students. (Physics Teacher-2)*

Questioning technique was being used by most of the participants. They underscored the importance of this technique. This technique was being used to make the students curious by asking different questions about specific topics and for better understanding of the students. Questioning technique during lectures was considered very beneficial. They reported that through discussion and questioning, topics related science subject could be taught easily and a complete understanding of science subjects could be achieved. One participant provided an example regarding questioning technique in the following words:

> *In Chemistry, when I am teaching the topic "element." I ask the students whether water is*

> *an element or not. They reply with no as it is composed of two different elements. Similarly, I ask them if they ever have heard about enzymes. They give the example of pepsinogen. In this way, I use this technique and get productive results. (Chemistry Teacher-2)*

Most of the teachers were aware of the importance of the discussion method. One of the science teachers was using the discussion method within the traditional lecture method. This method was not mostly used because of the large class size. As one of the participants claimed:

> *Discussion is much important technique but seldom used in my classroom. If there are some topics which need to be explained in a good way, they are discussed. In this way, students have positive and negative aspects of both the concept. So, they may understand it for a long-run process. (Physics Teacher-3)*

Most of the participants reported that experiment-based methods were being used in their classrooms for a better understanding of scientific concepts and theories. They believed that students may learn the concepts in the best way through learning by doing. They underscored that by doing experiments, they were able to describe and understand the concepts in a better way. Some teachers claimed to perform experiments for the students but because of the shortage of experiment apparatus, all the prescribed experiments were not possible. Most of the teachers shared their experience with experiment-based methods. One of the participants explicated it as:

> *Practical based work is compulsory for understanding and concepts-based leaning. We have limited apparatuses for performing practicals as the department does not provide us with enough budget. Therefore, no such technique other than questions and answers sessions are followed in teaching. However, we demonstrate practicals and students perform them well. (Chemistry Teacher-1)*

Furthermore, it was believed that science cannot be understood or taught without experiments and activity-based methods. Therefore, these techniques were being used according to different topics and concepts which were taught. Students were asked to make charts for more effective work. One of the participants elucidated his views about performing experiments as:

> *I use this method a lot because it is my belief that students of science subjects learn more with observation and*

> *practical work rather than studying theory only. Experiments and activity-based methods are not used very often in my classroom, but, whenever there are some activities to be solved in exercises, these are given to students to be solved. (Chemistry Teacher-4)*

Regarding the usage of audio-visual aids in the classroom, most of the teachers reported that they used the whiteboard, charts, diagrams, models and video clips for making their lectures interesting and for developing students' better understanding of teaching science subjects. However, some factors hindered their effective use of audio-visual aids. One of the participants explained:

> *I usually, show charts and models related to any topic as an introduction to students in the laboratory. Due to the shortage of the practical apparatus, use of AV aids is limited. These models are expensive, and our budget is low. There are some models present in the science laboratory. They are explored by the students. (Physics Teacher-3)*

Hurdles in developing CT skills

Teachers were asked about the barriers/hurdles they face in developing CT skills among students. Most of the teachers were of the view that there was no focus of the department, teachers as well as the current assessment system on CT skills development. All participants of the study reported that there was no focus/encouragement by the Education Department regarding CT skills development in secondary level science students. Furthermore, there were no refresher or professional development courses to be conducted regarding CT skills development—and no monitoring officers ever encouraged for the development of CT skills, rather they had other queries while visiting schools. Their only concern was on students' results. Higher authorities and educational inspectors had no observation regarding CT skills development. A teacher described the inspection of the school and its focus as:

> *They (AEOs, Deputy etc.) are mostly from arts subjects. They mainly focus on cleanliness, enrolment, Learning and Numeracy Drive (LND), test results, and presence of staff in schools. No one focus on the quality of education. There is no focus or special interest in developing CT skills among students. They just emphasize usual activities. (Chemistry Teacher-1)*

A teacher who was working as a headteacher of the school described his views that he has not observed such practices during headship as well as teaching. He narrated:

> *But in my experience, Matric class results must be good. If the result is lower than 25% then heads' and teachers'*

> *explanations are called. So, there is no focus of the department and educational officers as well as of the monitoring system in Punjab government on CT skills development. (Chemistry Teacher-4)*

Most of the teachers reported that no monitoring officer visited the classes and praised their classroom work and they were never appreciated or motivated to use pedagogical practices to develop students' CT skills. The focus of monitoring or inspection was only on different aspects other than CT skills development like enrolment, cleanliness etc. In the same way, another participant narrated it as "in my teaching experience, no one has come here to check education system of this school nor any educational officer with the specific focus of developing critical thinking skills" (Biology Teacher-1). All the teachers reported that they had received no stuff/material from the education department regarding the development of CT skills. In this regard, one of the participants presented his views in the following words:

> *Department of Education has not provided such type of material you are asking about. From the department, no such guidelines are received but there is much focus on different other aspects of enrolment, dropout, attendance etc. So, this is not focused on. (Biology Teacher-2)*

Furthermore, the participants were asked about professional development training they might have received related to pedagogy for CT skills. All the participants had not received any specific training for developing CT skills from the Department of Education. Most of the participants had just received an induction training for 2 weeks at the start of their job but in that training, there was no focus on CT skills development.

Few of the participants reported that they received training but in the area of English language at DSD Lahore, in which different teaching techniques were explained to teach English subject to the students. There were few participants who were also working as master trainers for the specific subject and who were getting training in their specific subjects at Quaid-e-Azam Academy for Educational Development (QAED). They also reported that CT skills development had not been the focus of their training.

Most teachers identified that the current assessment system was not promoting CT skills. They demanded the system be revised. Furthermore, most of them were of the view that students can get maximum marks with rote learning. There is a need for questions that demand thinking skills. Most of the questions in papers were being repeated and solved with rote learning. Therefore, teachers and students were just emphasizing on getting good marks by memorizing the topics and questions. In this way, the examination system was not promoting CT skills development. The top-down change was demanded CT skills development. Question papers were demanded to be based on concepts and reasoning. One of the teachers demanded that paper setters should include questions with higher-order thinking to

promote CT skills among students. This type of questions must be started with how and why as one of the participants was of view:

> *In my perception, long questions should be lessened in the paper. When the paper has been designed, it should be checked whether it is designed according to allotted criteria. Questions regarding critical thinking must be included in the paper to assess CT skills of students. (Chemistry Teacher-2)*

One of the teachers claimed that the assessment system was not promoting concepts-based teaching. Tests were only 10-15% of concepts-based leaning. The remaining part was based on just rote learning. The focus of the assessment system was not on the development of CT skills; therefore, teachers just emphasized on getting good marks by making their students memorize the topics and questions. According to one participant, this situation can be improved if the department focuses on these aspects:

> *There is insufficient experiment apparatus. Therefore, models, funds should be provided in schools for developing CT skills. Students should be given prizes and motivation regarding developing CT skills development. Teachers must focus on these skills' development. The department should give awareness and importance to the teachers and promote its significance. The assessment system should be revisited. (Physics Teacher-2)*

Some teachers were of the view that training and refresher courses should be conducted for the teachers' professional development and CT skills development. Their implementation should be monitored continuously. Then, the assessment system should be changed according to the directions of education policies and curriculum to take positive results.

Discussion

The main focus of the current study was to explore science teachers' perceptions of pedagogy for developing CT skills in secondary school science students. The participants defined CT in different terms such as conceptual study, the ability of students for understanding, knowledge with deep thinking, the reasoning behind knowledge, and discouragement of rote learning. All the participants acknowledged its importance especially in science subjects at secondary level regarding different factors like purpose of education, need for science subjects, decision making, to face challenges, and make progress in every walk of life in science subjects at the secondary level. CT skills have been considered the twenty-first-century skill and important for demographic, informational, economic and technological growth (Bialik & Fadel, 2015). According

to all the participants, there was no focus or encouragement by the department for the development of skills in secondary level science students. No refresher courses and professional development training were conducted regarding this. PD sessions are considered an effective method for developing teachers' pedagogical skills (Bailey & Mentz, 2015). Therefore, PD sessions can be conducted for teachers to develop their skills. Most of the participants were of the view that they used different pedagogical practices but the focus of these classroom techniques was not developing CT skills among secondary level science students. Some of the participants used group work instead of co-operative learning. This method has been used by different previous researchers (Huang et al., 2017; Nezami, Asgari, & Dinarvand, 2013) for CT skills development. Questioning technique was also used by a few participants. This technique has also been used for CT skills development by previous different studies (Inamullah, Bibi, & Irshadullah, 2016; Rashid & Qaisar, 2016; Santoso, Yuanita, & Erman, 2018). One of the participants mentioned the use of the discussion method in his lessons since it has been used with questioning in previous studies (Bevan, 2017; Khan, 2017). Practical based work was also used by some of the teachers as one teacher believed it to be compulsory for the understanding and conceptual study. This practice has been used in a previous study by Alosaimi (2013) with discussion and questioning for developing CT skills. The Education Department and monitoring officers should focus on the implementation of this for the development of CT skills. It can be done through conducting professional development of teachers with the focus of CT skills development. Furthermore, participants were not satisfied with the current assessment system since they perceived that the current assessment system was not promoting CT skills in secondary level science students. It was suggested that conceptual and skilled based questions should be included in the assessment of CT skills among students. Overall assessment system should be revised and revisited for the development of CT skills.

Conclusions

The current qualitative study aimed to explore science teachers' perceptions about pedagogy for developing CT skills in secondary school students. All the science teachers acknowledged the importance of CT for science subjects. It was a shared perception among teachers that there was no focus of the Education Department and assessment system for the promotion of CT skills. Teachers were using different pedagogical practices like group work, discussion, questioning, activity-based, practical based, experimental, learning by doing, and audio-visual aids in their classrooms but the main focus was not to develop CT skills rather get good grades. There should be a top-down change from policy to practices with the revision of the assessment system in order to develop CT skills among secondary school science students.

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