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RESEARCH PAPER

# Secondary School Science Teachers' Practices for the Development of Critical Thinking Skills: An Observational Study

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**ABSTRACT**

In the national curriculum policy documents, to produce rationale and independent critical thinkers, different pedagogical practices have been recommended like cooperative learning, questioning, discussion, etc. This qualitative case study aimed at analyzing secondary school science teachers' practices for the development of critical thinking skills in secondary school students. There were twelve classrooms (four from each subject of Physics, Chemistry, and Biology) selected as cases. Video recording was used for the observations for six lessons in each classroom. In this way, a total of 72 observations were conducted, each lasting for approximately 35 minutes. Qualitative content analysis was used for data analysis through *Nvivo* 12. The findings of the observations revealed that all the teachers used the lecture method most of the time. They used this to cover the content at a given specific time. There was not much focus on the development of critical thinking. In a few classrooms, the students were engaged and active during learning different specific topics. Whiteboards were used as a visual aid by most of the teachers. Furthermore, to some extent, discussion, questioning, and daily life examples were used in different classrooms. It is recommended that teachers' professional development should be conducted to focus on the development of critical thinking skills through pedagogical practices, which have been recommended by the national education policy documents.

## Introduction

Science education has shifted towards a broader perspective of twenty-first-century skills especially, critical thinking (hereafter CT) development. It seems that the main purpose of science education has become CT skills development among students so that they can effectively deal with every sphere of life. Moreover, it is often asserted in international theoretical literature that education should be aimed to produce rational thinkers (Scherer, 2001)—considering it among twenty-first-century skills (Cahit, 2019; Wagner, 2014). To become a critical thinker is important in every sphere of life like economics, information, and politics (Bailey & Mentz, 2015) because of the knowledge explosion in the twenty-first century and because of the need for critical evaluation of the information (Zhang & Kim, 2018).

In the national context, the educational policy documents, that is, National Education Policy (NEP, 2009) and National Curriculum for Physics, Chemistry and Biology, Grade IX-X (2006), all focus on rational thinking, independent thinking, reasoning, critical thinking, and creativity which are significant to produce intellectual skills among learners. CT in science education has been emphasized due to building up domestic behavior for personal, ethical, political, and cultural perspectives (Yacoubian, 2015). Furthermore, CT is fruitful for the academic and everyday life of the learners in the teaching-learning process (Dwyer, Hogan, & Stewart, 2011).

CT has been given much importance due to its twenty-first-century skill. CT should be involved in the teaching-learning process since it is useful in the general and academic life of an individual (Dwyer et al., 2011). It may serve as the guidance of learners to find the solution to their social problems. Therefore, it is necessary to acquire the required information for their solutions. According to Paul and Elder (2006), it is not limited to any specific subject but serves for rationale and logical thoughts. Within an information society, learners should get not only knowledge but also the ability to compare and evaluate the knowledge critically with their understanding.

CT plays an important role in science education. There is a positive correlation between CT and science education, especially when it is taught with experimentation and observation. In different contexts, several authors have described its role. In the view of Yacoubian (2015), CT is the foundation pillar in science education for fostering scientific knowledge and future citizens. In science education, the ability to question formulation and critical questioning are the significant aspects of science education (Demir, 2015; Osborne, 2014). Critical thinking in science education is linked with the practice of debate, discussion, and argumentation (Osborne, 2014); problem-solving (Demir, 2015); rigorous testing, evaluation (Osborne, 2014); evaluation, assessment, and rejection of arguments (Brown, Pishghadam, & Sadafian, 2014).

However, rote memorization is believed to be a big hindrance in the production of knowledgeable, well-rounded, and critically thinking science students. According to the progressive educationists in Pakistan, students perform low in the questions requiring CT skills since there are traditional classrooms where rote-learning and memorization are promoted to get good grades. This is the age of logical reasoning; therefore, the students should be developed with CT skills.

In the international literature, different techniques have been suggested for the development of CT skills like questioning (Inamullah, Bibi, & Irshadullah, 2016; Rashid & Qaisar, 2016; Santoso, Yuanita, & Erman, 2018); inquiry-based learning (Agustini & Suyatna, 2018; Bevan, 2017); cooperative learning (Huang et al., 2017; Nezami, Asgari, & Dinarvand, 2013); and debates (Othman, Sahamid, Zulkefli, Hashim, & Mohamad, 2015).

The education policy documents emphasize on development of CT skills for learners of the twenty-first century. These documents aim to develop CT skills to face the challenges of the world, problem-solving, and decision making. These policy documents recommend different pedagogical practices to develop CT skills such as cooperative learning, discussion, problem-solving, learning by doing, and active involvement. Therefore, the current study was carried out to explore the science teachers' enacted practices for CT skills development in science students.

## Literature Review

CT has been defined in different ways within the theoretical literature. For example, it is defined as goal-oriented and logical thinking (Halx & Reybold, 2006); "the art of analyzing and evaluating thinking" (Paul & Elder, 2006, p. 88), inference, explanation, self-regulation, interpretation, and evaluation (Facione, 2007); analysis, evaluation with decision-making skills (Mendelman, 2007); having judgment and selection through cognition (Cottrell, 2011); and decision of facts and opinions with logical reasoning (Fahim & Pezeshki, 2012). In the current study, the definition used for CT was as a "reflective, reasonable thinking focus on deciding what to believe or do" (Ennis, 1993, p. 179).

CT has become a significant phenomenon for the development of information, political, economic, and technological forces (Bialik & Fadel, 2015) and to get success in academia and career (Shaw et al., 2019). For dynamic citizens and to contribute to the world, educationists have emphasized its acquisition (Erstad & Voogt, 2018). It has been given importance for students' positive outcomes (Spatariu, Winsor, Simpson, & Hosman, 2016). In the view of Hatcher (2006), CT has been given a significant position due to its importance in the workplace, in mental and spiritual questioning, to evaluate people and policies to offer solutions to their social problems.

Evaluation with questioning is considered the basic level of CT skills. Further characteristics are analysis of information, context, situation, comprehension of abstract ideas, open-mindedness, and communication with others. According to Bailin (2002), the characteristics of the problem and context where thinking occurs is not a procedure for thinking as it needs to be heuristics and helpful in problem-solving as CT critical knowledge is seen in the process (Bailin, 2002). Furthermore, he argues that for context, CT should be focused on tasks and problem-solving. It also involves the concentration of specific criteria for the comprehension and solution of the problems.

The vital role of CT in science education has been described by different researchers in several contexts (Jamil, Azmat, & Muhammad, 2021; Jamil, Muhammad, & Qureshi, 2021; Naseer, Muhammad, & Masood, 2020). CT is promoted as the foundation pillar in science education because of its importance for inculcating scientific knowledge in future citizens. In science education, the formulation of critical questioning is an important aspect (Demir, 2015; Osborne, 2014). In addition, CT and science education have linked with discussion, debates, and argumentation practices (Osborne, 2014), evaluation of rigorous testing (Osborne, 2014), and problem-solving (Demir, 2015). Practical skills have also been discussed in the literature, having linkage with critical thinking and science like problem-solving (Demir, 2015) and decision making (Vieira, Tenreiro-Vieira, & Martins, 2011). Generally, the process of CT is related to research and scientific methods like exploration and observation (Demir, 2015) and the construction of reliable knowledge (Osborne, 2014). Science as an active process with argumentation has a significant role in knowledge production as well as CT skills development. Consequently, CT has an important role in the practice and application of the scientific process in the following aspects (Jamil & Muhammad, 2019; Jamil, Muhammad, Masood, & Habib, 2020).

Theoretical literature suggests different strategies for the development of CT skills in science education (Santos, 2017). These are debate, discussion, problem-solving and argumentation with the defense of ideas, inquiry-based learning, and evaluation of arguments (Duran & Dökme, 2016); questioning, engaging students, discussion, group activities, collaboration, role-playing, self-evaluation, simulation, presentations, and technology (Demir, 2015; Savich, 2009; Tok, 2012); engaged pedagogy, explicit instruction (Hooks, 2010); project-based methods, problem-solving (Hooks, 2010; Orlich, Harder, Callahan, Trevisan, & Brown, 2012; Osborne, 2014); conversation, cooperative/collaborative learning, observation, interaction and evaluation (Fung, 2014; Osborne, 2014).

In Pakistan, it is allegedly reported that teachers usually aim to get good grades instead of developing CT skills. This is done by emphasizing rote learning. In the traditional lecture method, questioning is discouraged. Similarly, assessment is also done without focusing on CT skills development. The courses are teacher-centered instead of student-centered (Khan, 2017). In today's scenario, cramming and rote learning has become the main hurdles in the development of CT. This practice leads to poor learning, which prevails in Asian countries (Shaheen, 2012). It is a hindrance to the building of a democratic society, having serious personal, political, ethical, and cultural implications (Yacoubian, 2015).

In addition, the above-discussed literature suggests different pedagogical practices for the development of CT skills in different international contexts. Therefore, it was of great significance to conduct a study of teachers' practices about pedagogy for the development of CT skills. Consequently, the aim of the study was: To explore enacted practices of secondary level teachers regarding pedagogy for the development of CT skills.

## Material and Methods

The qualitative case study research design underpinned by the interpretivism paradigm (Merriam, 2009; Stake, 2013) was used in the current study since the assumption was that reality is socially constructed. The researchers aimed to explore the science teachers' enacted practices about pedagogy for the development of CT skills.

Four public schools were selected as research sites from the district of Faisalabad, Punjab. All four public schools were from the same geographical area. The schools were selected from the Punjab School Education website. The selection of these schools was made due to easy access to them (Hancock & Algozzine, 2016). For the selection of the sample, the purposive sampling technique was used since this type of sampling is used to get more insight from the "information-rich participants" (Patton, 2015).

Twelve science teachers were selected from four selected public schools. From each of the schools, Physics, Chemistry, and Biology teachers were purposely selected as participants. Since "gathering and processing observation data are labor-intensive activities" (Simpson & Tuson, 2003, p. 26), the sample size was deliberately kept small. The current study conducted seventy-two classroom observations (six from each of the participants) while teaching these science teachers in natural settings. These classroom observations were video recorded. Furthermore, field notes were prepared for data analysis. The main focus of these classroom observations was to explore teachers' enacted practices about pedagogy for developing CT skills.

"Transcripts of classroom discourses" (Wragg, 2013, p. 74) were created by repeatedly watching video recordings of the observations—and noting down all the conversations. For the data analysis, transcripts and field notes were imported into N*vivo* 12. Coding of data was done, and nodes were created for the relevant data (Edhlund & McDougall, 2019; Woolf & Silver, 2017). Keeping in view the filed notes, four nodes were created, that is, classroom atmosphere, teachers' interaction in the classroom, the focus of the study, and pedagogical practices used in the classroom.

## Results and Discussion

Findings of the current study are described under the following four themes:

### Classroom Atmosphere

Most of the teachers observed during the fieldwork were using the lecture method as their main method of teaching in their classrooms. They were focused on completing their lectures in provided 35 minutes. In all the classrooms, the whiteboard was used as a visual aid on which teachers wrote topics and sub-topics of the relevant lectures. Few of the teachers asked questions about the topic of that specific day and then wrote it on the whiteboard. Some teachers explained the topic with previous knowledge after writing it on the board. For example, the following field note illustrates this situation in the classrooms:

> The teacher announced the topic "Newton 2nd Law of Motion." He wrote the topic on the whiteboard. Then he described some relevant terms like Velocity and asked the student to describe this term. One of the students raised his hand and defined the term. The teacher praised him and said, 'Good.' Then he linked it with the topic and further explained with examples. (Field note Physics 2.1)

Some of the teachers asked the students some relevant questions about the previous topics and related to the current topics for brainstorming. The students raised their hands and replied to their answers one by one. Teachers praised them in answering the right answer and further explained in case of any ambiguity or wrong answer. Then the teachers explained each concept in detail in simple words and announced the topic. The following field note illustrates this aspect:

> The teacher entered the class, after greetings, he narrated the last day discussed lesson which was about, what is Chemistry? The teacher asked, who would tell me the answer? Few of the students raised their hands. The teacher took the description of different students one by one. Then he revised and explained himself. Then he announced the topic of that day. (Field note Chemistry 3.1)

In most of the classrooms, a noisy environment was observed. It was due to less interaction of the teachers with the students. In this way, students' participation was very low. Only the front sitting students seemed to be active and attentive. The following field note explains this as under:

> The teacher explained the concept with an example. In the meanwhile, some of the students from the backside were making some noise. Students in the front row were active participants. Backbenchers just had a chit-chat. (Field note Physics 3.3)

There were few classrooms with a good learning environment too. In such classrooms, the teachers were observed to be active. As a result, students participated actively through discussions with the teachers. In such lectures, students were engaged during the explanation of any topic due to asking relevant questions and explanations through examples. The following field note describes this:

> The teacher described the term "Wave." It was asked by the students with the relevant question then explained by the teacher with examples. The process of its production was discussed by the teacher. Students were very much attentive and participative in the discussion and listened to the explained examples carefully, which was explained with its two types. (Field note Physics 2.3)

**Teachers' Interaction in the Classroom**

Analysis of all classroom observations revealed that most classrooms were less interactive regarding teachers and students. As described above, mostly lecture method was used in all classrooms. Lectures were started by announcing the topics and writing them on the whiteboard, which was used as a visual aid in all classrooms. In such conditions, teachers seemed busy on the whiteboard. Few of the students sitting in front were engaged with teachers since the main focus of the science teachers was to cover the lecture content in a given 35 minutes. Therefore, most of the students seemed passive. In the view of the following field note, it can be illustrated as under:

> The teacher wrote the topic on the whiteboard. He asked relevant questions about the concept. Some of the students defined it. Rest was explained by the teacher. The students sitting in front of the teacher were engaged with the teacher while sitting at the back were whispering and talking to each other. (Field note Chemistry 2.3)

In a few of the classrooms, teachers used some pedagogical practices recommended for CT skills development. These techniques were questioning, discussion, and using relevant examples. It was observed that in such classrooms, students were active and participative.

In a few lessons, the questioning technique was used. To do this, some relevant questions were asked by the students before starting any topic or sub-topic. On getting correct answers to the questions, teachers praised and provided the right answer in case of wrong. The questioning technique was used on different stages of the lectures, in the beginning, at mid, and at the end of the lecture for revision. Few of the teachers used the questioning technique for brainstorming of the students. Such type of questions was asked before the start of the lesson. These were from different aspects regarding the relevant lesson. Sometimes, these were asked at the start or whenever they needed. The following field note describes this aspect:

> Then the teacher asked, 'First of all, tell me about the chemical bond.' Then some of the students raised their hands to answer the question. The teacher asked them to describe the definition. The students described the definition one by one. The teacher praised on right answers. Then he asked if there was anyone else for the response, but no one replied. (Field note Chemistry 4.3)

The questioning technique was also used at the end of the lecture for the revision of the lesson. The questions were asked from the students one by one to check their understanding regarding the particular concepts. These were further explained by the teachers in case of any ambiguity. This technique was observed to make the students active since they were attentive to asking questions from them. The following field note describes this aspect:

> The teacher asked, what is science? Few of the students raised their hands. Then the teacher asked them one by one as they replied, and the concept was further explained with relation to the current topic. (Field note Physics 3.2)

In the same way, through answering questions, students participated in the discussion too. According to the following field note:

> The teacher asked about Physics, as what was it? Students were invited to describe it. After taking feedback from some of the students, the teacher further explained with examples. (Field note Physics 3.1)

Few teachers kept their classes interactive while solving different formula questions. For example, in one classroom, 'salt' was asked to be explained. When students were unable to answer the question, the teacher explained it through different examples and its process of preparation. Regarding the engagement of the students, some of the students were participative with the teachers during the teaching of different topics and subtopics. To engage the students, a few teachers explained their content by providing relevant examples. In doing this, students were observed as active and engaged in discussing different concepts through examples. For example, one of the participants was asked to explain "liquid and gas." After defining both concepts, these were explained with relevant examples and formulas. Moreover, their processes of formulation were also discussed. Similarly, one of the science teachers explained the "Characteristics of Water" through its freezing and boiling point. The following field note describes the explanation through examples by a participant:

> The teacher defined the term with complete details. After explaining the production and positivity, and negativity of ions, he gave some examples related to Sodium Chloride. Students were actively participating and taking an interest in the lesson. (Field note Chemistry 4.3)

Similarly, Newton's 3$^{rd}$ law of motion was also explained by a teacher through examples with action and reaction, hitting a ball, traveling of the rocket in space, etc. Similarly, the teacher provided some more relevant examples during the explanation in the following way:

The teacher explained the ultrasound waves, then described their usage with different examples. The first example was given to break the clot of blood. Next was given as in bakery items like milk through ultrasonic waves, and it is made safe and drinkable for a long period. In planes and heavy machinery, these are used to diagnose any crack which is unable to see with the human eye. In the same way, sea depth is also measured with these waves. (Field note Physics 2.4)

**The Focus of the Lesson**

In almost all the lessons, the focus was on the teaching of the topics of that day. Almost all the teachers used the lecture method. Overall, teachers remained busy with the whiteboard since it was used as the main visual aid. The participants wrote topics and sub-topics on the whiteboard for further explanation. Doing so, students sitting in front seemed to be engaged while discussing and asking some relevant questions. The remaining backbencher students were passive with no focus on the lecture. In a few of the classrooms, different methods were used as the use of the whiteboard, questioning, discussion, description through examples, and diagrams. But the aim of these strategies was not to develop CT skills. The further explanation is as under.

As discussed earlier, the whiteboard was used as a visual aid in all the classrooms. Teachers announced the topics and wrote on whiteboards for further explanation. The focus of the study was to make the students understand the specific concepts while asking questions from the previous knowledge. This technique was also used for the brainstorming of the students. Some of the students raised their hands. Teachers praised them for answering the right answer and further explained in case of any wrong answer. Through this technique, the students were observed as following field note illustrates this in these words:

> The teacher wrote the formula on the whiteboard. He further explained how it was formulated with division and multiply process. Students were engaged and having silence, were sitting attentively to listen to the teacher-specific topic. (Field note Physics 2.1)

Whiteboard was also used for the solution of numerical questions. In a few of the classrooms, the focus of the study was observed through the use of questioning during different times in the lectures, as in the beginning, center, and sometimes at the end, to conclude the overall lesson. The use of this technique seemed to make the students active and engaged. According to a field note, it is described as under:

> The teacher announced the topic "Ultrasound Waves." It was written on the whiteboard. Students were asked about what waves were. The teacher asked different questions related to the topic. Students were engaged and asked to reply to the questions. After having a response from the students, the teacher further explained the topics. (Field note Physics 2.3)

The students' understanding was made a clear, thorough explanation of relevant examples. These living examples from surroundings were fruitful for the students in understanding the topics and sub-topics. This technique caused the students to be active. In a few of the classrooms, topics were revised for the understanding of the students. After teaching each topic, it was revised by asking relevant questions from the lesson. In this way, students remained active. The revision was made by asking questions from the different students. The students explained according to their understanding. The following field note illustrates this aspect:

> After completing, the whole lecture, the teacher revised it. All topics were asked by the students to describe them one by one. Students raised their hands, and after pointing towards them, all the concepts were revised. (Field note Chemistry 3.2)

Similarly, revision of the whole topic was done by another teacher since it was used for a clear understanding of the topics and subtopics. The following field note describes this:

> The teacher also revised the different taught aspects of the topic at the end. To accomplish this, the teacher asked questions about different taught concepts. They were asked to describe their perception of the topics they had taught in the lecture. Students recalled the memory and described the concepts one by one. Some of the students were asked to come on the whiteboard and explain the concepts. If anyone hesitated during the description, these were further explained. (Field note Biology 3.4)

In a few of the classrooms, the teacher called the students to come on the whiteboard for the description and solution of any question. This method made the students attentive and confident. The following field note describes this aspect in these words:

> One of the students was ordered to write on the whiteboard according to the instructions of the teacher. The student came and wrote the description of the term on the whiteboard. Then the teacher explained the further concept with an example. (Field note Chemistry 1.3)

Few of the teachers used diagrams to develop an understanding for the students. The topics were explained on the whiteboard after making a diagram. One of the Biology teachers used the whiteboard to make a diagram of a Cell and then explained its different aspects. The following field note illustrates this aspect:

> The teacher made a diagram on the whiteboard to describe "DNA." He pointed out towards the whiteboard for its further explanation with examples. (Field note Bio 2.6)

**Pedagogical Practices used in the Classroom**

The current study aimed to explore science teachers' enacted practices of pedagogy for the development of CT skills at the secondary level. This was the main aspect of the study since classroom observations were conducted to explore teachers' enacted practices in the natural setting. According to the observations and field notes, all the classrooms were taught with the lecture method. There were a few techniques that were used by some of the teachers during classroom teaching. These were the use of questioning, discussion, examples, and making diagrams. These techniques were not being used for the development of CT skills among students instead, rather than for just a clear understanding of the students. Further explanation of these techniques as under.

In all the classrooms, the whiteboard was used as a visual aid. Teachers wrote their topics and subtopics with some descriptions on them. They explained them by pointing out towards the whiteboard for the understanding of the students. In such classrooms, there was not the proper engagement of the students with the teacher since teachers remained busy on the whiteboard in their maximum time. Teachers used it for writing their topics, sub-topics, and further explanation. The following field note illustrates this aspect:

> After the announcement of the topic, the teacher wrote it on the whiteboard. For the attention of the students, he explained the concept in detail for the student's understanding and participation. (Field note Physics 1.6)

During another observation of a Physics teacher, formulas were explained on the whiteboard. On the other hand, a Chemistry teacher wrote the topic on the whiteboard and asked the students to describe it. Few of the students narrated it. Then the teacher further clarified and explained in detail. According to a field note, it was described as under:

> After the announcement of the topic, the teacher wrote it on the whiteboard. For the attention of the students, he explained the concept in detail for the student's understanding and participation. (Field note Physics 4.1)

In some of the classrooms, teachers used the questioning technique. It was used at different levels, that is, in the start, in the middle, and at the end of the lecture to revise the topic. It was used at the beginning of the lecture in some of the classrooms for brainstorming. The students were asked questions related to the topic. They replied one by one according to their understanding. The teachers praised on answering the right while they were given the right answer having any misconception. It can be seen in the following field note:

> Before starting the lesson, the teacher told the students that they were taught about Chemistry the previous day. Then he asked some questions related to the previous day's topic. Students raised their hands, and the teacher pointed them out to describe them one by one. The teacher admired them for the correct description and explanation. After the description of a few students, he started to further explain it and then started the topic of that day. (Field note Chemistry 3.1)

In observation of a Biology teacher, he explained "Transportation" with "Blood Circulation." Further, he inquired about some relevant questions about blood groups and their diseases. Moreover, these were explained for more understanding. The following field note describes this example:

> The teacher announced the topic "Ionic Compound Formula." After the announcement, he asked the students about the "Ionic Compound." One of the students raised his hand and replied about the question. Then the teacher further explained it on writing the whiteboard with complete detail. Also provided different examples of Sodium Chloride and Potassium Chloride, etc. (Field note Chemistry 2.1)

The questioning technique was also used for the revision of the previous knowledge. Few of the teachers used it frequently while teaching any topic and sub-topics. The following field note illustrates this aspect:

> The teacher asked about the "Capacitor." One of the students replied. Then the teacher asked if there was any other student to describe, but no one was ready to explain. The teacher himself elaborated the term with detail and presented different examples for a complete understanding of the students. (Field note Phy 3.5)

The questioning was used at the end of the lecture, too, in a few classrooms. The students were asked relevant questions about the taught topic to check their understanding of the taught topic. On answering the right, students were praised, while they were explained with correct answer if there were unaware of the right answer. Since this was a revision of the topic, therefore, students took an interest and engaged in the classroom. The following field note illustrates this:

> The teacher asked, what is science? Few of the students raised their hands. Then the teacher asked them one by one as they replied, and the concept was further explained with relation to the current topic. (Field note Physics 3.2)

In some classrooms, the use of examples with the questioning technique was observed. The teachers asked some questions about any topic. After answering from the students, they were explained through different examples. In this way, students were observed engaged in their lectures. The following field note describes this aspect:

> After explaining the concept, the teacher asked the students how to make normal salt? Few of the students described according to their perceptions. Then the teacher explained it with examples, asked the student to make normal salt. (Field note Chemistry 1.5)

Similarly, during another classroom observation, the teacher explained about the human body skeleton. The science teacher provided relevant examples for complete understanding. Similarly, one of the teachers defined "Heart Attack" and its reasons with different examples. In the same way, to understand "Ultrasound Waves," one of the science teachers explained it with examples. The following field note describes one more example about this aspect:

> Then the teacher described "Branches of Physics." One by one, all the branches were discussed after writing these on the whiteboard. Furthermore, relevant examples were provided as to where these branches might be used? (Field note Physics 3.3)

In a few of the lectures, examples were provided at the beginning of the lecture. After writing the topic on the whiteboard, it was explained in detail through relevant examples. This way was proved to be effective for students' understanding of their engagement in the classroom. One of the Chemistry teachers explained solid, matter, and gas with examples from daily life. He also further explained its characteristics and usage too. Similarly, one of the teachers described Compound and Formula with the provision of relevant examples. In the view of the following field note, it can be observed:

> The teacher wrote the Compounds with Formulas on the whiteboard with different examples. He also explained the formulation of these formulas by giving examples from daily life. The students were attentive and engaged in their classrooms. (Field note Chemistry 1.4)

Similarly, while observing a Biology teacher, cleanliness was explained with the slogan of "Clean and Green Pakistan" given by the government. In the same way, "Zigzag" technology example and use of fertilizers were also given in this respect. The following example illustrates this aspect:

> The teacher started the next sub-topic, "Power of Plants." He defined it earlier, then explained it with the process of transparency. A student further provided details explaining the process of moving from one place to another on the whiteboard with examples. (Field note Biology 4.1)

In a few lessons, teachers used discussion and diagrams during their lectures. Through these techniques, students seemed to be engaged in the classrooms since these were used for complete understanding. The students responded to all the questions asked by the teachers. The diagrams were also used to make a clear understanding of the students. The following field note has narrated this situation:

> The teacher explained the concept with examples of Sodium. Students were engaged. Furthermore, the teacher drew a diagram on the whiteboard. He also drew its aspects and explained them with examples. (Field note Chemistry 4.3)

One of the teachers used a chart for the teaching of different aspects with the help of examples. The following field note describes this aspect:

> The teacher announced the topic "Types of Chemistry," wrote on the whiteboard, and then described its types. Furthermore, he explained it from the chart to point out different types and their usage in practical life. Students were listening very attentively and engaged with the teacher. (Field note Chem 3.1)

**Conclusion**

The current study aimed to explore science teachers' practices about pedagogy for developing CT skills. The participants of the study were observed six times during their teaching of science subjects (Physics, Chemistry, and Biology) in their 35 minutes class period. Overall, all classrooms were airy with proper light. All the science teachers were mostly using the lecture method during their teaching. Whiteboard was used as video aids in almost all the classrooms. Teachers wrote their relevant topics and sub-topics on the whiteboard and then explained them with different examples and discussions. Most of the classrooms were observed as noisy due to a lack of students' engagement and interaction with the teacher. In such classrooms, the teachers remained busy on the whiteboard most of their time. Doing so, the students sitting in front of the teachers were active and participated in the lecture while backbenchers were observed passively.

The study was conducted to observe science teachers enact pedagogical practices for CT skills development since it is among twenty-first-century skills as well as important due to growth in different aspects like information, economics, and technology (Bialik & Fadel, 2015). Few observed classrooms had a good learning environment where the teachers used different pedagogical practices like discussion, questioning, giving examples, and diagrams. There are previous studies with some relevant pedagogical practices to develop CT skills. This study found questioning techniques often used by the participants. This technique has been used for the development of CT skills in previous literature (Inamullah et al., 2016; Rashid & Qaisar, 2016; Santoso et al., 2018). In the same way, the discussion technique is used in previous studies for the development of CT skills (Bevan, 2017; Khan, 2017). However, in the current study, we found very little use of the discussion method. Furthermore, some pedagogical practices are recommended for CT skills development by previous researchers, but these were not used by the observed participants. These techniques are guided inquiry method (Azizmalayeri, MirshahJafari, Sharif, Asgari, & Omidi, 2012); discussion, questioning, practical work (Alosaimi, 2013); debates (Othman et al., 2015); problem-based learning (Chen, 2015); inquiry-based learning (Duran & Dökme, 2016); cooperative learning (Huang et al., 2017; Nezami et al., 2013) and active learning (Zhang & Kim, 2018). Some pedagogical practices were used by the observed science teachers but without focusing on CT skills development. Rather, they covered their planned lessons in a given time.

The education department should focus on implementing the pedagogy for the CT due to its focus on all secondary-level science policy documents of Physics, Chemistry, and Biology. There should also be the professional development of teachers related to pedagogy for CT skills development so that focus may be given on CT skills development as recommended by the international literature and national education policy documents.

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