Sir Syed Journal of Education & Social Research
Vol. 4, Issue 2, 2021 (April – June)
ISSN 2706-6525 (online), ISSN 2706-8285 (Print)
ISSN 2706-9362 (CD-ROM), ISSN 2706-6525 (ISSN-L)
DOI: https://doi.org/10.36902/sjesr-vol4-iss2-2021(21-30)

SJESR
Sir Syed Journal of Education & Social Research

Critical Thinking Skills Development: Secondary School Science Teachers' Perceptions and Practices

* Muhammad Jamil, PhD Scholar
** Dr. Yaar Muhammad, Assistant Professor (Corresponding Author)
*** Dr. Naima Qureshi, Assistant Professor

Abstract

This multiple case study aimed to develop an understanding of science teachers' interpretations and enacted practices about policy documents' recommendations for developing critical thinking skills among secondary students in public schools. Four public secondary schools were selected through the purposive sampling technique. Data were collected in three different phases. First, four education policy documents, including National Education Policy (2009) and National Curriculum for Physics, Chemistry, and Biology Grades IX-X (2006), were analyzed. In the second phase, 12 science teachers from four public schools (3 from each school teaching Physics, Chemistry, and Biology) were interviewed. Besides, these 12 science teachers were observed (every six times) while teaching in a real-life context through video-recorded classroom observations and reflective field notes. With the facilitation of NVivo 11, qualitative content analysis was used to analyze the data obtained from all sources. The findings revealed that critical thinking was emphasized in all policy documents, and different pedagogical practices for developing critical thinking were suggested to be used in science classrooms. Analysis of interview data revealed that teachers had some awareness about critical thinking. Furthermore, the classroom observations revealed that they were mainly using the lecture method with some other pedagogies without focusing on critical thinking. A top-down change is also recommended for the implementation of the policies. The assessment system might also be revised, focusing on critical thinking skills development.

Keywords: Critical Thinking, Education Policy Documents, Pedagogy, Science Teachers

Introduction

In the global context, science education has shifted towards the attainment of twenty-first-century skills, especially critical thinking (hereafter CT). It has been defined as logical thinking, independent thinking, reflective thinking, and self-directed thinking. In science education, the main purpose of science education is to develop scientific knowledge among contemporary learners to deal with society effectively. Besides, science education focuses on developing different aspects like personal, political, ethical, and cultural (Yacoubian, 2015). In this way, CT in the teaching-learning process is necessary for positive academic outcomes and everyday life (Dwyer, Hogan, & Stewart, 2011). Furthermore, international literature also focuses on producing rational thinkers (Scherer, 2001)—due to twenty-first-century skills (Wagner, 2014; Cahit, 2019). Becoming a critical thinker (Higgins, 2015) is significant in every walk of life (Bailey & Mentz, 2015) since, in the twenty-first century, it is needed to evaluate information in a critical way (Zhang & Kim, 2018).

CT has been considered among twenty-first-century skills, and it has an important role in science education. It correlates with science education through observation and experimentation. Several authors have described the role of CT in science education in different contexts. Yacoubian (2015) is of view that CT is the main pillar of science education which promotes scientific knowledge among future learners. The science teaching-learning process is focused on individual progress concerning academic life (Dwyer et al., 2011). It guides the learners to solve their social problems. In this contemporary era, the students should not only get the required knowledge but also need an ability to think critically and rationally to form a judgment with their understanding.

* University of Management and Technology, Lahore Email: jameelphd@gmail.com
** University of Management and Technology, Lahore Email: yaar.muhammad@umt.edu.pk
*** University of Education, Lahore Email: naima.qureshi@ue.edu.pk

Rote memorization is considered a significant hindrance in developing CT among science students. The progressivist educationists in Pakistan believe that students perform low due to less questioning since, in traditional classrooms, rote-learning promotes good marks. Being in the logical and rational era, contemporary students should be developed with logical and rational thinking.

The international literature suggests different pedagogical practices for the development of CT skills like argumentation, evaluation, students' engagement and inquiry-based learning (Duran & Dökme, 2016b), collaborative learning, discussion, group activities, role-playing, presentations, and technology (Savich, 2009; Tok, 2012; Osborne, 2014), engaged pedagogy, questioning, inquiry, and project-based methods (Hooks, 2010; Orlich, Harder, Callahan, Trevisan, & Brown, 2012), cooperative/collaborative learning, conversation, interaction, debates and problem-solving (Fung, 2014; Osborne, 2014).

In educational policy documents, including the National Education Policy (NEP, 2009) and the National Curriculum (NC, 2006) for Physics, Chemistry, and Biology, emphasize CT skills development among science students. These documents focus on CT to produce productive citizens to face global challenges. Different pedagogical practices are suggested, such as inquiry-based teaching, student-centered pedagogies, teamwork and problem-solving (NEP, 2009), problem-solving, questioning, discussion, debates, cooperative learning, and students' involvement (NCP, 2006), activity-based, participative, interactive, practical, laboratory work, inquiry-based, group-work, flowcharts, diagrams, graphs and fieldwork approaches (NCC, 2006), team-setting, group work, formulation of questions, diagrams, audio-video presentation, flowcharts, graphs, demonstration, debates, investigation and drawing (NCB, 2006).

The above discussed national and international literature focuses on CT regarding science education. Therefore, it was of great significance to develop an understanding of how science teachers interpret and enact education policy document recommendations regarding CT skills in public secondary schools.

Research Questions

The following research questions guide this study:

1. What are the recommendations of education policy documents for the development of CT skills among secondary school students?
2. What are the science teachers' interpretations of education policy documents' recommendations for CT skills development?
3. What are the science teachers' enacted practices of education policy document recommendations for CT skills development?

Literature Review

In the theoretical literature, CT has been defined in different ways. It is defined as logical and goal-oriented thinking (Halx & Reybold, 2006); self-regulation, inference, explanation, interpretation, and evaluation (Facione, 2007); decision-making skills with inference, analysis, and evaluation (Mendelman, 2007); a cognitive activity having judgment and selection (Cottrell, 2011); logical reasoning and deciding the facts after taking opinions and examining them before acceptance (Fahim & Pezeshki, 2012) and "the art of analyzing and evaluating thinking" (Paul & Elder, 2006, p. 88). The current study used the most used definition for CT in literature, which stipulates it as a "reflective, reasonable thinking focus on deciding what to believe or do" (Ennis, 1993, p. 179). In this regard, the ability to analyze, synthesize and evaluate was considered useful.

CT is considered important to develop information, economic, technology, and political forces (Bialik & Fadel, 2015) and for academic and career success (Shaw et al., 2019). Educationists focus on its acquisition due to make them dynamic citizens to contribute to the global economy through their contribution (Erstad & Voogt, 2018). It has been given importance to students' positive outcomes (Spatariu, Winsor, Simpson, & Hosman, 2016). According to Hatcher (2006), CT has been focused due to its significance at the workplace, in spiritual and mental questioning, and in evaluating people and policies with the solution of their social problems.

In science education, CT plays a significant role. According to Yacoubian (2015), it is the foundation of science education to produce scientific knowledge in students. Critical questioning is the most significant aspect of science education (Osborne, 2014; Demir, 2015). Furthermore, theories, hypotheses, and experiments are the basis of science education.

In the national context, most education policy documents focus on developing CT skills. The NEP (2009) narrates the aim of education, curriculum, and SLOs to develop CT skills for twenty-first-century learners. The educational objectives have been described as "To develop a self-reliant individual, capable of analytical and original thinking, a responsible member of society and a global citizen" (NEP, 2009, p. 19). In the same way, the Physics curriculum aims at developing problem-solving skills to be developed in secondary school students. In the curriculum document, the aim is narrated as "To develop the ability to describe and explain concepts, principles, systems, processes and applications related to physics and develop the thinking process, imagination, ability to solve problems, data management, investigating and communication skills" (NCP, 2006, p. 5). The curriculum of Chemistry also focuses on producing independent thinkers to solve real-life problems. It is discussed as "An ability to apply the understanding of Chemistry to relevant problems (including those from everyday real-life) and to approach those problems in rational ways" (NCC, 2006, p. 2). The curriculum of Biology also emphasizes CT skills development since it is described as, "To enable all students to develop their capacities as successful learners, confident individuals, responsible citizens and effective contributors to society" (NCB, 2006, p. 1). In all the above educational policy documents, the focus is on conceptual and reasoning-based studies to solve real-life problems.

Student-centered interactive approaches are recommended like questioning, engagement, problem-solving, discussion, debates, cooperative learning, group work, and practical work for developing CT skills. It is also focused that the assessment system should also emphasize analysis, synthesis, evaluation, problem-solving and analytical thinking. The main focus should be on the assessment of higher-order abilities. Furthermore, a practical examination is recommended to explore the daily life experience, problem-solving, and investigation skills of the students. Different techniques are discussed for formative assessment like lab completion, worksheets, quizzes, review questions, observations, oral presentations, and classroom discussions. Paper setters should focus on curriculum rather than a textbook with questioning for the development of CT and problem-solving.

In the international literature, CT is also emphasized in science education. In the view of Bailin (2002), CT should be an integral aspect of science education. Yacoubian (2015) concludes that CT contributes to the formation of a democratic society with benefits for personal, ethical, cultural, and political contexts and understanding of scientific knowledge. Its significance is increasing gradually in all societies (Demir, 2015). Questioning and evaluation are the basic levels of CT skills. More attributes are analysis of information, situation, context, open-mindedness, comprehension of abstract ideas, and communication with others. The formulation of critical questioning is an important aspect of science education (Osborne, 2014; Demir, 2015). Furthermore, CT in science education has a connection with discussion, debate, and argumentation practices (Osborne, 2014), problem-solving (Demir, 2015), and evaluation of rigorous testing (Osborne, 2014). In literature, practical skills have also been discussed, which may be linked with critical thinking and science like decision making (Vieira, Tenreiro-Vieira, & Martins, 2011) and problem-solving (Demir, 2015). In short, CT has a vital role in the application and practice of the scientific process.

In science education, different pedagogical practices have been suggested to develop CT skills (Santos, 2017). These strategies are problem-solving and argumentation, discussion, debate, with the defense of ideas, evaluation of arguments; inquiry-based learning (Duran & Dökme, 2016a); questioning, engaging students, discussion, collaboration, group activities, self-evaluation, simulation, role-playing, presentations and technology (Savich, 2009; Tok, 2012; Demir, 2015); explicit instruction, engaged pedagogy (Hooks, 2010); project-based methods and problem-solving (Hooks, 2010; Orlich et al., 2012; Osborne, 2014); cooperative/collaborative learning, interaction, conversation; observation and evaluation (Fung, 2014; Osborne, 2014).

In the Pakistani context, it is reported that teachers aim to get good grades rather than to develop CT skills. The main practice is rote learning. Traditionally, the lecture method is being used with the discouragement of questioning. Teacher-centered approaches are being used instead of student-centered (Khan, 2017). In today's context, cramming has become the main hurdle in CT skills development. In the same way, assessment techniques also do not emphasize CT skills development. This practice prevails in Asian countries, which leads to poor learning (Shaheen, 2012). This is hindering the building of a democratic society that has serious ethical, personal, political, and cultural implications (Yacoubian, 2015).

Also, the above-discussed literature suggests different pedagogical practices for the development of CT skills in international contexts. Therefore, it was of great significance to conduct a study of teachers' interpretations and enacted practices concerning educational policy documents' recommendations for CT skills development. Consequently, the aim of the study was: To develop an understanding of how science teachers interpret and enact education policy documents' recommendations regarding the development of CT skills among science students of the secondary level.

Methods

The current study used a qualitative research approach. The multiple case study research design was applied underpinned by the interpretivism paradigm (Merriam, 2009). This research paradigm "Constitutes the abstract beliefs and principles that shape how a researcher sees the world, and how s/he interprets and acts within that world" (Kivunja & Kuyini, 2017, p. 1). The multiple case study design was considered the most relevant for the current research since this design offers more robust and compelling evidence than a single case study design as there is not just a single case (Yin, 2018). This methodology was used to develop an understanding of the participants' multiple viewpoints and their practices for the development of CT skills among secondary school students.

Four public schools from district Faisalabad, Punjab we as research sites. All the schools were selected from the same geographical area and due to relatively easy access (Hancock & Algozzine, 2016). The purposive sampling technique was used to get to select the study sample for "information-rich participants" (Patton, 2015). From four public secondary schools, twelve science teachers were selected who were teaching Physics, Chemistry, and Biology. Seventy-two classroom observations (six from each of the participants) were conducted while teaching in a real-life context in a natural setting. Video recording and reflective field notes were prepared for further data analysis.

Different data collection methods were used keeping in the view objectives of the study. Document analysis was used to analyze education policy documents. Besides, study science teachers' interpretations and enacted practices were explored through semi-structured interviews and reflective field notes in classroom observations. This methodology was used to get an in-depth exploration. Science teachers' interpretations were explored through a self-developed semi-structured interview guide. Classroom observations were conducted regarding pedagogical practices for the development of CT skills to explore teachers' enacted practices.

Data were analyzed through the qualitative content analysis technique (Schreier, 2012) since it was the most suitable technique for "describing material that requires some degree of interpretation" (Schreier, 2012, p. 2). Moreover, this analysis is useful for interpreting a large amount of text data (Mayring, 2014). NVivo 11 was used to facilitate qualitative content analysis. Transcripts and field notes were imported into NVivo for data analysis. Nodes and child nodes were created to code the relevant data (Woolf & Silver, 2017; Edhlund & McDougall, 2019).

Findings

The findings of the study were based on the four research questions. They are described as follows:

Policy documents' recommendations for the development of CT skills

Four education policy documents (National Education Policy (2009) and National Curriculum for Physics, Chemistry and Biology (2006) for Grades IX-X) were analyzed to develop an understanding of the policy recommendations for developing CT skills in secondary schools.

According to the analysis, the aim of education is described to promote higher-order thinking to make the students independent and responsible. In NEP (2009), the aim of education is narrated as to make the students self-reliant and independent. The Physics curriculum also emphasizes problem-solving. In the same way, Chemistry and Biology also focus on developing CT skills since it is described as "To produce students who will be capable of doing independent thinking, asking questions and looking for answers on their own" (NCC, 2006, p. 1). All the policy documents focus on CT skills development.

Teachers are expected to make their classrooms activity-based with questioning. In the same way, students should also have the ability to identify, analysis and problem-solving. Teachers' training is also suggested to enhance pedagogical content knowledge, content, assessment, and monitoring system. They should include problem-solving, conceptual understanding, and practical work in their classrooms. The assessment system is discussed in the NEP (2009) for quality education. The suggested pedagogical practices in National Education Policy (2009) are inquiry-based learning, questioning, problem-solving, discussion, cooperative learning, active involvement, and learning-by-doing.

In the same way, the curriculum documents also recommend learner-centered pedagogical practices like group work, inquiry-based learning, workshops, flowcharts, diagrams, graphs, and activity-based approaches like fieldwork, laboratory work, and demonstration. These have been described in the Physics curriculum as "Questioning, problem-solving, discussion, cooperative learning, debates, and students' involvement (NCP, 2006, p. 59). In the Biology curriculum, it is described that there should "Be student-centered, assisting students in deriving their concepts from evidence and providing practical opportunities to develop individual reasoning abilities and motor skills" (NCB, 2006, p. 90). Chemistry (2006) narrates it as "Teachers are encouraged to design their lessons in such a way that suitable questions and activities are incorporated to develop various types and levels of thinking in students, including analysis, evaluation, critical thinking, and creative thinking" (NCC, 2006, p. 28).

An assessment system for CT is also focused. In the question paper, it is suggested to give maximum place for analysis, synthesis, and evaluation. It has been narrated as "Need for inculcating critical and analytical thinking skills for producing life-long independent learners have to be emphasized. Assessment mechanism should be such that analytical thinking and critical reflections are tapped and encouraged" (NEP, 2009, p. 48). In the Chemistry curriculum, it has been described as "Assessment should measure the capacity of students for critical judgment" (NCC, 2006, p. 48). The curriculum of Biology describes this as "Questions involving unfamiliar contexts or daily-life experiences may be set to assess candidates' problem-solving and higher-order processing skills." (NCB, 2006, p.8). In the Chemistry curriculum, it is recommended that the assessment questions should be based on different stages of Bloom's Taxonomy. In assessment questions, 40% weightage should be given to higher abilities.

Teachers' interpretations of Pedagogy for CT skills development

Teachers' interpretations were explored through science teachers' semi-structured interviews. Findings were divided into six sub-themes that is, perception about the concept of CT, the importance of CT, the focus of the department on training/ professional development of the teachers, pedagogical practices used by teachers in the classroom, assessment system regarding CT, and barriers in developing CT skills.

All participants had an awareness of critical thinking. They defined it in different ways like conceptual study, the ability of students for understanding, knowledge with deep thinking, the reasoning behind knowledge, and avoiding rote learning. For example, one of the participants stated,

> Critical thinking is about the development of deep thoughts. It is very necessary for students, especially in science students. Students should know how the mind works? We need to prepare the teachers and students for answering how and why type questions in which there is a need for logic and rationale. So, it is about deep thinking about any concept. (Chemistry Teacher-4)

All participants admitted its significance in science education at the secondary level with different perspectives like the purpose of education, need in science education, for decision making, and facing the challenges of the world. One of the Chemistry teachers narrated that CT skills development in science subjects is necessary to fulfill the purpose of education. Logic and reasoning were needed regarding this. Moreover, it was described that critical thinkers should be produced. According to one of the participants, it was illustrated in the following way:

> 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 in teaching-learning. Therefore, there is a great need to focus on this concept, and students of science subjects should be trained to answer the questions with reasoning and logic. (Chemistry Teacher-4)

All the participants were of the view that the education department had no interest in developing CT skills. There were no professional training or refresher courses in this regard. Some participants explained that the Directorate of Staff Development provided training at the start of the job without focusing on this phenomenon. One of the participants was stated,

> I have not seen any educational or monitoring officers who demanded such type of creativity and skills. Usually, visitors are educational officers who focus on

> enrolment, attendance, and cleanliness of the school. In the same way, schools are visited by Monitoring and Evaluation Assistants (MEAs) with different indicators; both of these have no such focus on developing CT skills. But in my experience, matric class results are observed. If the result is below their expectations, then heads' explanation is called (Chemistry Teacher-4)

Most participants reported that they used different pedagogical practices like questioning, discussion, group work, activity-based, experimental, practical-based learning by doing, whiteboard, models, and charts. However, the focus of these classroom techniques was not developing CT skills among secondary-level science students. Few participants used group work instead of cooperative learning. One of the Physics teachers explained pedagogy in such a way:

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

Teachers reported the use of a discussion technique while teaching science. The following field note describes the discussion technique used by one of the participants:

> Discussion is an important technique but seldom used in my classroom. If some topics need to be explained, they are required to be discussed. In this way, students have positive and negative aspects of the concept. So, they may understand it. (Physics Teacher-3)

Few teachers used practical-based work. Teachers described that through learning by doing and practical work, students can get conceptual understanding. Few of the teachers used whiteboards, models, and charts. One of the participants was of the view that he showed charts and models relevant to the topics as an introduction.

Moreover, the participants were not satisfied with the assessment system since it was not developing CT among science students. It was promoting just rote learning to get good grades and marks. It was suggested that question papers should be focused on higher-order thinking questions. One of the participants demanded change from top-down. They suggested that educational officers should focus on and implement the policy for the development of CT skills. It was also suggested that education policy should be revisited for the promotion of CT skills. Question papers were suggested to be designed, keeping in view CT skills questions that assess secondary level science students of such skills.

Teachers' enacted practices regarding the development of CT Skills

The science teachers were observed through classroom observations while teaching their respective science subjects, that is, Physics, Chemistry, or Biology, for 6 lessons. Classroom observations were aimed at the identification of science teachers' pedagogical practices for developing CT skills in secondary school students. It was observed that almost all classrooms had natural light with proper ventilation. Most of the teachers used the lecture method in classrooms, and they used whiteboards as a visual aid for writing topics and subtopics. The main focus of the participants was only to complete the content in provided 35 minutes. There was found less interaction in most of the classrooms while teachers remained busy writing on the whiteboard. Few of the students were attentive, sitting in front. The following fieldnote illustrates this aspect:

> The students sitting in front of the class were attentive. There was some whispering from the backbenchers. Most of the students were making noise since the teacher was busy writing on the whiteboard. (Field note Phy 1.4)

Few of the classrooms were found to be interactive. The teachers used student-centered techniques like discussion, questioning, explanation through examples, diagrams, models, and the use of charts. In a few of the classrooms, the participants used the questioning technique. This technique was used in different stages at the start, middle and end. It can be illustrated through the following field note:

> Then the teacher asked, 'First of all, tell me about the Chemical Bond.' Then some 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. (Fieldnote Chem 4.3)

Similarly, few teachers used examples for further explanation in their classrooms. The following field note illustrates this:

> The teacher explained ‘Ultrasound Wave,’ then described its usage with various examples. The first example was given: It is used to break a clot of blood. Next, through the ultrasonic wave milk is made safe and drinkable for an extended period. In planes and heavy machinery, these are used to diagnose any cracks which are unidentifiable with the human eye. In the same way, sea depth is also measured with these waves. (Field note Phy 2.4)

Discussion & Conclusion

The current study aimed to develop an understanding of how science teachers interpret and enact education policy documents’ recommendations for the development of CT skills. Education policy documents were analyzed through qualitative content analysis. Teachers’ perceptions about CT skills development were explored through semi-structured interviews, and finally, the teachers were observed in their classrooms with video recordings and reflective field notes to explore teachers’ practices for the development of CT skills.

In all the education policy documents, the aim of education is described to promote higher-order thinking to make the students independent and responsible. All the policy documents focus on CT skills development. Teachers are asked to make their classrooms activity-based with questioning. Teachers' training is also suggested for the development of teachers' pedagogical content knowledge. They should include problem-solving, conceptual understanding, and practical work in their classrooms. The suggested pedagogical practices are inquiry-based learning, questioning, problem-solving, discussion, cooperative learning, active involvement, learning-by-doing, group-work, workshops, flowcharts, diagrams, graphs, and activity-based approaches like fieldwork, laboratory work, and demonstration. CT is also focused on the assessment system. In the question paper, it is suggested to give maximum place for analysis, synthesis, and evaluation to get higher abilities. Arif's (2011) study of the Mathematics curriculum in the Pakistani context analyzed four objectives: enhancing the ability of the reasoning among students, analytical and critical examination of the students, and spirit of discovery and exploration. The findings revealed that no objective was achieved. In the same way, a study conducted concerning the Chemistry curriculum found that the curriculum did not fulfill the needs of the modern age (Rehman, 2004).

The science teachers were observed six times during teaching science subjects (Physics, Chemistry, and Biology). The classrooms were ventilated with proper light. In most of the classrooms, the lecture method was used. The teachers mostly used a whiteboard as a visual aid for writing topics and subtopics of the lesson. There was found less engagement of the students in a few classes since teachers in such classes remained busy at the whiteboard. The students sitting in front were active, while students sitting at the back did not take interest. In a few of the classrooms, there was a good learning environment. The teachers used different student-centered techniques like discussion, questioning, providing examples and diagrams. In previous literature, there are studies in which some relevant pedagogical practices are used for the development of CT skills. The likewise questioning technique has been used for CT skills development by researchers (Inamullah, Bibi, & Irshadullah, 2016; Rashid & Qaisar, 2016; Santoso, Yuanita, & Erman, 2018). Similarly, the discussion is used for CT skills development (Bevan, 2017; Khan, 2017). Still, there were some studies with recommended pedagogical practices for CT skills development, but these were not used by the observed participants. For example, inquiry-based learning (Duran & Dökme, 2016a); guided inquiry method (Azizmalayeri, MirshahJafari, Sharif, Asgari, & Omidi, 2012); cooperative learning (Nezami, Asgari, & Dinarvand, 2013; Huang et al., 2017); active learning (Zhang & Kim, 2018); debates (Othman, Sahamid, Zulkefli, Hashim, & Mohamad, 2015); discussion, questioning, practical work (Alosaimi, 2013); and problem-based learning (Chen, 2015). According to the findings of the current study, the science teachers used some of the pedagogical practices, but their main focus was not the development of CT skills. Instead, it seemed that they were more inclined towards covering the planned lessons in a given time.

The above findings identify gaps between education policy document analysis, science teachers’ interpretations, and enacted practices for the development of CT skills among secondary school science students.

Different pedagogical practices have been suggested in education policy documents. Teachers have an awareness of CT and its importance. They also used different student-centered pedagogical practices in their classrooms but without focusing on CT skills development. Their primary focus is only to get good grades and marks in their annual examination by the Board of Intermediate and Secondary Education (BISE). There is a difference between education policy recommendations and enacted practices of the science teachers. There is no focus of monitoring and educational officers on CT skills development rather than just on enrolment, attendance, cleanliness, and good results. Their main focus is only to get their students passed in the examination. There is needed a top-down change. Department and monitoring officers might focus on this. There should be motivation and appreciation from the department. As a teacher described the inspection of the school and its focus in the following words:

The educational officers mainly focus on cleanliness, enrolment, Learning and Numeracy Drive (LND) tests of 3rd grade, and presence of staff in school, but not on the quality of education. There is no focus or special interest in developing CT skills among students. The monitoring system is just about different activities instead of developing CT skills. The education department and higher authorities should focus on the implementation of the pedagogy for the CT since it has been focused on NEP (2009) and National Curriculum for Physics, Chemistry, and Biology (2006). Teachers should be provided with refresher and professional development courses regarding pedagogy for CT skills development.

There should also be a focus on training and refresher courses for enhancing teachers' knowledge and skills related to the students' development of CT skills. The master trainers should deliver further training, keeping in view the importance of CT. All science teachers used group work, discussion, questioning, activity-based, practical-based, experimental, learning by doing, and the use of audio-visual aids techniques in the classroom, but the focus of these classroom techniques was not developing CT skills among secondary level science students. The focus should be only on the development of CT skills, and relevant pedagogical practices should be used according to the topic. This is possible with only top-down change and priority of the department.

The assessment also plays a significant role in the development of CT skills. The change is required according to the suggested curriculum documents since it is not promoting CT skills development among secondary-level science students. The revision of the curriculum is necessary to focus on the development of CT skills. The current assessment system focuses on getting good marks through rote learning, and the students can achieve more than 95% marks in science subjects because deep thinking questions are missing. Paper setters should design the question papers in line with the guidelines of education policy documents. The question papers should be based on a conceptual and reasoning basis consistent with the allotted criteria of higher-order thinking in policy documents. How and why type of questions should be used based on curriculum, not on textbooks, so that students may demonstrate their ability to understand the original concept. From the above discussion, it is clear that top-down change is needed for implementation and revising the assessment system focusing on CT skills development.

References

Alosaimi, K. H. (2013). *The development of critical thinking skills in the sciences.* (Unpublished doctoral dissertation), University of Dundee, Dundee.

Arif, M. (2011). *Analysis of mathematics curriculum at secondary school level in Pakistan.* (Unpublished doctoral dissertation), Foundation University, Islamabad,

Azizmalayeri, K., MirshahJafari, E., Sharif, M., Asgari, M., & Omidi, M. (2012). The impact of guided inquiry methods of teaching on the critical thinking of high school students. *Journal of Education and Practice, 3*(10), 42-48.

Bailey, R., & Mentz, E. (2015). IT teachers' experience of teaching–learning strategies to promote critical thinking. *Issues in Informing Science and Information Technology, 12*(1), 141-152. doi:10.28945/2257

Bailin, S. (2002). Critical thinking and science education. *Science & Education, 11*(4), 361-375.

Bevan, S. R. (2017). *Thinking culturally about critical thinking in Cambodia.* (Unpublished doctoral dissertation), London South Bank University, London.

Bialik, M., & Fadel, C. (2015). *Skills for the 21st century: What should students learn?* Boston: Center for Curriculum Redesign

Cahit, E. (2019). A review on the relationship between critical thinking skills and learning domains of the Turkish language. *Educational Research and Reviews, 14*(3), 67-77.

Chen, D.-L. (2015). *Developing critical thinking through problem-based learning: action research for a class of media literacy.* (Unpublished doctoral dissertation), Durham University, Durham.

Cottrell, S. (2011). *Critical thinking skills: Developing effective analysis and argument*. New York: Palgrave Macmillan.

Demir, S. (2015). Perspectives of science teacher candidates regarding scientific creativity and critical thinking. *Journal of Education and Practice, 6*(17), 157-159.

Duran, M., & Dökme, İ. (2016a). The effect of the inquiry-based learning approach on student's critical-thinking skills. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(12), 2887-2908. doi:10.12973/Eurasia.2016.02311a

Duran, M., & Dökme, İ. (2016b). The effect of the inquiry-based learning approach on student's critical thinking skills. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(12), 2887-2908.

Dwyer, C., Hogan, M. J., & Stewart, I. (2011). The promotion of critical thinking skills through argument mapping. In C. P, Horvath, & J. M. Forte (Eds.), *Critical Thinking* (pp. 1-26). New York: Nova Science Publishers.

Edhlund, B., & McDougall, A. (2019). *NVivo 12 Essentials*. Stallarholmen: Form & Kunskap AB.

Ennis, R. (1993). Critical thinking assessment. *Theory into Practice, 32*(3), 179-186. doi:10.1080/00405849309543594

Erstad, O., & Voogt, J. (2018). The twenty-first-century curriculum: issues and challenges. In J. Voogt, G. Knezek, R. Christensen, & K. Lai (Eds.), *Second Handbook of Information Technology in Primary and Secondary Education* (pp. 19-36). Cham: Springer.

Facione, P. (2007). Talking critical thinking. *Change: The Magazine of Higher Learning, 39*(2), 38-45. doi:10.3200/CHNG.39.2.38-45

Fahim, M., & Pezeshki, M. (2012). Manipulating critical thinking skills in test-taking. *International Journal of Education, 4*(1), 153-160. doi:10.5296/ije.v4i1.1169

Fung, D. (2014). Promoting critical thinking through effective group work: A teaching intervention for Hong Kong primary school students. *International Journal of Educational Research, 66*(3), 45-62. doi:10.1016/j.ijer.2014.02.002

Halx, M. D., & Reybold, L. E. (2006). A pedagogy of force: Faculty perspectives of critical thinking capacity in undergraduate students. *The Journal of General Education, 54*(4), 293-315. doi:10.1353/jge.2006.0009

Hancock, D. R., & Algozzine, B. (2016). *Doing case study research: A practical guide for beginning researchers*. New York: Teachers College Press.

Hatcher, D. L. (2006). Stand-alone versus integrated critical thinking courses. *The Journal of General Education, 55*(3), 247-272. doi:10.1353/jge.2007.0002

Higgins, S. (2015). A recent history of teaching thinking. In R. Wegerif, L. Li, & J. C. Kaufman (Eds.), *The Routledge International Handbook of Research on Teaching Thinking* (pp. 19-28). London: Routledge.

Hooks, B. (2010). *Teaching critical thinking: Practical wisdom*: Routledge New York.

Huang, M.-Y., Tu, H.-Y., Wang, W.-Y., Chen, J.-F., Yu, Y.-T., & Chou, C.-C. (2017). Effects of cooperative learning and concept mapping intervention on critical thinking and basketball skills in elementary school. *Thinking skills and creativity, 23*(1), 207-216.

Inamullah, H. M., Bibi, W., & Irshadullah, H. (2016). An analytical study of questioning leading to critical thinking in secondary level classrooms. *Journal of Social Sciences & Humanities, 24*(1), 105-126.

Khan, S. I. (2017). *An investigation of the concept of critical thinking in the context of a functional English course in a BEd Degree in Pakistan.* (Unpublished doctoral dissertation), University of Glasgow, Glasgow.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education, 6*(5), 26-41.

Mayring, P. (2014). *Qualitative content analysis: theoretical foundation, basic procedures, and software solution*. Klagenfurt: SSOAR.

Mendelman, L. (2007). Critical thinking and reading. *Journal of Adolescent & Adult Literacy, 51*(4), 300-302.

Merriam, S. B. (2009). *Qualitative research and case study applications in education. Revised and expanded from "Case study research in education"*. San Francisco: Jossey-Bass.

NC. (2006). *The national curriculum for grades IX-X*. Islamabad: Ministry of Education, Government of Pakistan

NCB. (2006). *The national curriculum for Biology grades IX – X*. Islamabad: Ministry of Education, Government of Pakistan

NCC. (2006). *The national curriculum for Chemistry grades IX – X*. Islamabad: Ministry of Education, Government of Pakistan

NCP. (2006). *The national curriculum for Physics grades IX – X*. Islamabad: Ministry of Education, Government of Pakistan

NEP. (2009). *The National Education Policy (NEP)*. Islamabad: Ministry of Education, Government of Pakistan

Nezami, N. R., Asgari, M., & Dinarvand, H. (2013). The effect of cooperative learning on the critical thinking of high school students. *Technical Journal of Engineering and Applied Sciences, 3*(19), 2508-2514.

Orlich, D. C., Harder, R. J., Callahan, R. C., Trevisan, M. S., & Brown, A. H. (2012). *Teaching strategies: A guide to effective instruction*. Boston: Wadsworth.

Osborne, J. (2014). Teaching critical thinking? New directions in science education. *School Science Review, 95*(352), 53-62.

Othman, M., Sahamid, H., Zulkefli, M. H., Hashim, R., & Mohamad, F. (2015). The effects of debate competition on critical thinking among Malaysian second language learners. *Middle-East Journal of Scientific Research, 23*(4), 656-664.

Patton, M. Q. (2015). *Qualitative research & research methods (4th ed.)*. Thousand Oaks: Sage Publications, Inc.

Paul, R., & Elder, L. (2006). *The thinker's guide to scientific thinking*. Tomales: Foundation for CritiRowman & Littlefield Publishers.

Rashid, S., & Qaisar, S. (2016). Developing Critical Thinking through Questioning Strategy among Fourth Grade Students. *Bulletin of Education and Research, 38*(2), 153- 168.

Rehman, F. (2004). *Analysis of national science curriculum (chemistry) at secondary level in Pakistan.* (Unpublished doctoral dissertation), University of Arid Agriculture, Rawalpindi.

Santos, L. F. (2017). The role of critical thinking in science education. *Journal of Education and Practice, 8*(20), 159-173.

Santoso, T., Yuanita, L., & Erman, E. (2018). *The role of student's critical asking questions in developing student's critical thinking skills.* Paper presented at the Journal of Physics: Conference Series.

Savich, C. (2009). Improving critical thinking skills in history. *Networks: An Online Journal for Teacher Research, 11*(2), 1-13. doi:10.4148/2470-6353.1106

Scherer, M. (2001). How and why standards can improve student achievement: A conversation with Robert J. Marzano. *Educational leadership, 59*(1), 14-18.

Schreier, M. (2012). *Qualitative content analysis in practice*. London: Sage Publications.

Shaheen, N. (2012). *International students at UK universities: Critical thinking-related challenges to academic writing.* (Unpublished doctoral dissertation), University of Huddersfield, West Yorkshire.

Shaw, A., Liu, O. L., Gu, L., Kardonova, E., Chirikov, I., Li, G., . . . Guo, F. (2019). Thinking critically about critical thinking: validating the Russian HEIghten® critical thinking assessment. *Studies in Higher Education, 1*(1), 1-16.

Spatariu, A., Winsor, D. L., Simpson, C., & Hosman, E. (2016). Further classification and methodological considerations of evaluations for online discussion in instructional settings. *Turkish Online Journal of Educational Technology-TOJET, 15*(1), 43-52.

Tok, E. (2012). The opinions of preschool teacher candidates about creative thinking. *Procedia-Social and Behavioral Sciences, 47*(1), 1523-1528. doi:10.1016/j.sbspro.2012.06.854

Vieira, R. M., Tenreiro-Vieira, C., & Martins, I. P. (2011). Critical thinking: Conceptual clarification and its importance in science education. *Science Education International, 22*(1), 43-54.

Wagner, T. (2014). *The global achievement gap: Why even our best schools don't teach the new survival skills our children need and what we can do about it:* New York: Basic Books.

Woolf, N. H., & Silver, C. (2017). *Qualitative Analysis Using NVivo: The Five-Level QDA® Method*: Routledge.

Yacoubian, H. A. (2015). A framework for guiding future citizens to think critically about the nature of science and socioscientific issues. *Canadian Journal of Science, Mathematics and Technology Education, 15*(3), 248-260. doi:10.1080/14926156.2015.1051671

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). New York: Sage publications.

Zhang, L., & Kim, S. (2018). Critical thinking cultivation in Chinese college English classes. *English Language Teaching, 11*(8), 1-6.