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RESEARCH PAPER

Development of Critical Thinking Skills of Secondary School Students through Science Curriculum: Teachers' Perceptions

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ABSTRACT

The present study was conducted to investigate the development of critical thinking skills in students through secondary school science curriculum from teachers' perspective. New science curriculum has been implemented and teachers being the stake holders are involved in practical implementation of the curriculum. A five point likert type scale having reliability value 0.84 was used in order to find the teachers' perceptions, whereas its response rate was 89%. Mean, standard deviation and t-test were utilized as statistical tools for analysis of data. Teachers' perceptions regarding development of critical thinking skills in science students were positive. No significant difference was found in the views of male and female as well as in different subject teachers. It is recommended that science teachers should encourage the students to ask questions as it creates a habit of inquiry and arrange group discussion among students in order to further develop critical thinking skills in students.

KEYWORDS Critical Thinking Skills, Perceptions, Science Curriculum, Secondary School Level

Introduction

Pakistan can outperform in international commerce by development in the field of science and technology and by improving science curriculum especially at secondary school level because science plays a very significant role in the progress of a country (Asad, Rind, Khand, Rind & Mughal, 2020). A curriculum is the blue print of all activities related to an academic program. Aderonmu, Alagbe, Opoko, Oluwatayo, & Alagbe (2014) consider curriculum as the part of school academic program specifically designed to provide planned and guided teaching experiences.

Keeping in view the importance of science, the subjects of Physics, Chemistry, Mathematics, and Biology are taught at secondary and higher secondary levels (Rind & Mughal, 2020). The ever-changing scientific scenario demands transmission of modern trends to the learners through the effective curriculum of these subjects. National Science Curriculum (2009) states that teaching of science subjects should create critical thinking ability among learners. This is one of the most important 21st century skills. Socrates defined it as objective analysis of facts to draw judgments, "examining both the positive and negative aspects of something"; therefore it is considered as an inquiry method all over the world (Paul & Elder 2004). Keeping in view Bloom's taxonomy of educational objectives it was considered that critical thinking requires higher level of intellectual abilities like analysis, synthesis, and evaluation. On the other hand knowledge, comprehension, and application are lower levels of cognitive abilities requiring only remembering relating and applying information respectively. Duran & Dökme (2016) stated that critical thinkers are capable of analyzing and evaluating information. Further they can ask proper questions and point out problems, formulate the problems or questions clearly, collect relevant information, assess it, and try to solve problems using abstract ideas, think open-mindedly, and communicate effectively with others. Thus developing critical thinking being a 21st century skill is an important aspect of modern science curriculum.

The practicality of curriculum exclusively depends upon its proper implementation (Alshammari, 2013). It was proclaimed by National Education Policy that, "no educational system can rise above the quality of its teachers". The quality and the worth of a curriculum cannot be judged from its planning, rather from the capability of the teachers who are responsible for executing it (NEP, 2009). Thus teachers are the main stake-holders responsible for curriculum implementation therefore their perceptions about science curriculum are worth-while. Further, no research study was carried out before, in the province of Khyber-Pakhtunkhwa where science curriculum was evaluated from the perspective of developing critical thinking skills in the students, indicating a research gap. It is therefore considered necessary to take Secondary School teachers' perceptions about science curricula in the KPK province of Pakistan.

Literature Review

The word critical thinking came from Ancient Greek word "kritikós" meaning "of or for judging, able to discern". In Latin it was called "criticus," (Kaya, 1997). Literature survey indicates that Critical thinking is defined in many ways. Sternberg (1999) defined it as an intellectual approach for problem solving. Schreglmann (2011) defined it as a thinking process enabling the one to collect relevant data, organize it, then interpret, and evaluate it, based on criterion instead of taking the knowledge, skills and attitudes for granted. From these definitions it is clear that critical thinking is a well-organized rational thinking process or activity. Educationists believe that instead of defining only, components and characteristics critical thinking should be explained. From researches it is found that critical thinking is a multifaceted process demanding higher level thinking ability in order to process the information including identification and evaluation of assumptions; inquiring about the problem under investigation, interpretation and analysis of information, reasoning and judgment; with the consideration of context. Hence Hotaman (2008) stressed that critical thinking is a decision making rational thinking activity or a cognitive skill essential for students that helps in learning, and problem solving through proper reasoning.

According to Wen (1990) the aspects of critical thinking are;

- Probing
- Thinking exclusively
- Thinking freely
- Streamlining the information.

Johnson (2000) describes organization, analysis and evaluation as three stages of critical thinking. Critical thinkers are good observers and have effective communication skills. Beyer (1991) expressed that critical thinkers have clarity of speech and thoughts. They can define the problem clearly, ask others to speak openly and clearly, their actions are based on exclusive thinking, check their own progress, Can develop an idea, find the facts and evidence confirming regarding that idea and in the end make a judgment based on results and prior knowledge rather than dogmas and nostalgic convictions (Cervetti, Pardeles & Damico, 2001; Eryaman, 2007; Kutlu & Schreglmann, 2011). Söylemez (2015) describes that critical thinkers take unbiased decisions. They inquire about the problem or issue under consideration, then decide based on valid information with an open mind. Hence Critical thinking (CT) is a vital thinking procedure for learning using evidence. It enables a person to be a good problem solver and helps him in taking the right decision according to the situation whether it is a social setup, political issue, a problem involving ethics, or administrative matter, etc. The development of critical thinking ability is affected by several factors, like the classroom environment and the teacher's proficiency and teaching methodology, and most important, educationists must be aware of the worth of Critical

thinking and be equipped for promoting it. In order to equip the learners with higher-order cognitive thinking the educators, have to use higher-order thinking in their teaching strategies (Simpson & Courtney, 2002). Facione & Facione (2007) stressed that critical thinking skills must be demonstrated, and the demonstration requires continuous thinking and planning about what to do and why? Thus, for promoting critical thinking the teacher becomes a role model and a mentor. Contradictory to the necessary teaching methodologies, commonly used teaching methods and rote learning are widespread in majority of teaching and educational institutions in Pakistan (Khalid & Khan, 2006). Many studies have stressed the significance of critical thinking.

Bissell and Lemons (2006) worked for the promotion of higher-order thinking in college students through biology courses, keeping in view Bloom's taxonomy of educational objectives. The researcher first prepared a question using his critical thinking and the subject matter, then with the help of grading instructions evaluated the content and critical-thinking aspects of an answer. Through this method, student misconceptions about course content were removed and their critical thinking ability was also enhanced. The development of learners' Critical thinking skills is considered the main outcome of education even in any higher education discipline (Gul, Cassum, Ahmad, Khan, Saeed & Parpio, Y, 2010). Fitriani, Zubaidah, Susilo and Al Muhdhar, (2020) developed and implemented a problem-based learning-predict observe explain (PBLPOE) learning model, and compared the Indonesian students' achievement in Biology and their critical thinking skills. The results revealed a significant correlation between learners' critical thinking skills and their educational accomplishment in biology.

Critical Thinking skill is not only needed for better academic results in the teaching-learning process but is essential for a person's daily life success (Dwyer et al, 2011). Here the worth mentioning thing is that the literature survey reflects the production of rational thinkers (Scherer, 2001) being twenty-first-century skill (Wagner, 2014; Epaan, (2019). Therefore, keeping in view, the international environment, science education is now concentrating on the accomplishment of twenty-first-century skills among the students, particularly the critical thinking skill. Now the most important objective of science education is not only to provide modern scientific knowledge to the students but also to empower them to deal with their society successfully. Besides science education also helps in developing different aspects of a person's life like personality development, ethical and cultural development, providing political awareness to a person, etc. (Yacoubian, 2015).

Pakistan being a developed country needs greater number of experts in the field of science and technology, therefore development of positive science attitude and critical thinking skills are the areas of much more concern for the nation as already mentioned in national curriculum (2009) documents. Especially in the province of Khyber Pakhtunkhwa no such study is conducted earlier to take teachers' perceptions for evaluating national science curriculum regarding students' critical thinking skills.

Hypotheses

H_{01}: Teachers' perceptions about development of critical thinking skills among secondary school science students through science curriculum are not positive.

H_{02}: There is no significant difference in the perceptions of male and female teachers regarding development of critical thinking skills in science students at secondary school level in the province of Khyber Pakhtunkhwa.

H_{03}: Perceptions of Teachers' of different cadres would significantly differ regarding development of critical thinking skills in science students at secondary level.

Material and Methods

Design

It was a descriptive study where survey was conducted using questionnaire as a research tool in order to find the status of teachers' perceptions about development of critical thinking skill in students through secondary school science curriculum. Questionnaire is the most appropriate tool for collecting quantitative data in little time.

Population

The science teachers of secondary classes belonging to Khyber Pakhtunkhwa, former North West Frontier Province of Pakistan form the population of the study. According to Education Management Information System (EMIS, 2017-18) report, there were 2227secondary schools in the province of Khyber Pakhtunkhwa out of these 1422 were boys' and 805were girls' schools. While the total number of science teachers working in these schools was 4456 (3134 male and1322 females). A sample 223 science teachers was taken out of 4456, by applying the "rule of thumb" as cited by Curry, R. A., et al. (2013). The description of sample is as under.

Table 1
Population and Sample of Study

Status	Population	Sample (5%)	Male	Female
Secondary Schools	2227	112	68	44
Science Teachers	4456	223	134	89

Research Instrument

For the purpose of data collection a Likert type questionnaire was developed regarding teachers' perceptions about development of critical thinking skills in secondary school students through science curriculum. Secondary school science teachers gave their precious responses about the status of their students' critical thinking skills.

Tool was validated through the index of item objective congruence (IOC) and pilot study. In order to check the content validity, research tool having three options (Accept, Reject, Accept with some changes) was developed. Some items were reshaped in the light of valuable opinions taken from 20 experts questionnaire was now put for the purpose of reliability. Reliability of the said instrument was found 0.84 through SPSS.

Results and Discussion

One sample t-test and independent sample t-test were used for data analysis. One sample t-test gave results about teachers' perceptions regarding development of critical thinking skills in students, while the independent sample t-test found the differences in perceptions of teachers belonging to different groups. Response rate from teachers was 89%.

Table 2
Gender wise Distribution of Secondary School Teachers

Gender	Frequency	Percentage
Male	125	62.8
Female	74	37.2
Total	199	100

Table 2 shows that out of 199 respondents there were 125 male and 74 were female secondary school teachers. Of these, 63 percent were male while 37 percent were female.

Table 3
Age-wise Distribution of Secondary School Teachers

Age group	Frequency	Percentage
24-35	46	23
36-45	58	29
46-59	95	48
Total	199	100

Table 3 indicates the age of respondents. 46 out of 199 respondents were in the age range of 24 to 35 years, they form 23 percent of the total respondents. 58 respondents were having the age range of 36 to 45 years forming 29 percent of the respondents whereas 47 percent respondents had an age range 46 to 59 years.

Table 4
Academic Qualification of Secondary School Teachers

Age group	Frequency	Percentage (%)
Bachelor	49	24
Masters	145	73
MPhil	05	3
Total	199	100

Table 4 indicates the academic qualification of respondents. It shows that 24% (49) respondents had bachelor's degrees, 73% (145) were master's degree holders while only 3% (5) had an M.Phil. degree in the concerned field.

Table 5
Experience Wise Distribution of Secondary School Teachers

Experience (Years)	Frequency	Percentage (%)
1-11	39	20
12-22	88	44
23-33	72	36
Total	199	100

Table 5, is about the experience of respondents, indicating 20% (39) respondents with teaching experience of 1-11 years, while 44% (88) respondents had experience range 12-22 years and 36% (72) with experience range of 23 -33 years.

Table 6
Teachers' perceptions regarding critical thinking skill of students

Statements	Mean	SD
Students can understand science concepts easily.	3.71	0.49
Students can apply their science knowledge in their daily life.	3.80	0.42
Students can give daily life examples about the topics taught in the textbook.	3.92	0.27
Students can synthesize something new based on their learned knowledge.	3.05	0.78
Students can interpret what they have learned.	3.71	0.45
Students can infer results from their experiments.	3.40	0.65
Students have to rot memorize the lessons.	3.92	0.33
Students can help their fellows in understanding the topic.	3.79	0.41

Students actively take part in a discussion about science topics with their teachers.	3.58	0.57
Students actively take part in a discussion about science topics with their peers	3.83	0.40
Students get good marks on the test.	3.68	0.47
Students understand the topics yet they cannot get good marks on the tests.	2.17	0.39
Total	**3.54**	**0.10**

Table 6 indicates views of teachers regarding development of critical thinking skills in science students of KPK at secondary level. Teachers respond to12 statements. Mean values of all the statements (range 3.05 to 3.92) indicate teachers' positive views about development of critical thinking skills in the students. The only statement "students understand the topics yet they cannot get good marks in the tests" had Mean = 2.17, indicating teachers' negative response about the statement thus the statement is not right about the students as perceived by their teachers. The maximum mean (Mean = 3.92) is for the statement "students can give daily life examples about the topics taught in the textbook". The overall mean is 3.54 which indicate positive perceptions of teachers about science curriculum at secondary level in relation to the development of critical thinking skills in students. Despite all these teachers perceive that students have to rot memorize the lessons (Mean = 3.92).

Table 7
Teachers' perceptions about development of critical thinking skills in science students are not positive

Category	N	Mean	SD	t value	Sig
Critical thinking skill	199	3.47	0.12	95.43	0.000

Table 7 indicates the results of the one-sample t-test for analyzing teachers' perceptions regarding development of critical thinking skills in science students after studying science subjects. The corresponding null hypothesis (H_{01}) is "teachers' perceptions about development of critical thinking skills in science students are not positive". The table indicates that the mean of 199 teachers' perceptions was 3.47 at the 0.000 level of significance. The t = 95.43 at 0.000 < 0.05 which means that the perceptions of teachers regarding development of critical thinking skills in secondary school science students are significantly positive. So, the corresponding null hypothesis is rejected hereby.

Table 8
There is no significant difference in views of male and female teachers regarding development of critical thinking skills in science students

Category	Gender	N	M	SD	t value	Sig
Critical thinking Skills	Male	125	3.67	0.32	1.80	0.072
	Female	74	3.62	0.27		

The above table 8 indicates that the t=1.80, p= 0.072 > 0.05, which depicts that there is no significant difference in the views of male and female teachers regarding development of critical thinking skill in science students at secondary level. Views of both male and female teachers are positive. So the null hypothesis is accepted here by.

Table 9
Independent sample t-test for the difference of perceptions of Math/Physics and Chemistry/Biology groups

Group	N	Mean	SD	t-value	Sig
Math/Phy	71	3.76	0.24	1.56	0.114

Chem/Bio	128	3.72	2.26

Table 9 indicates the results of t-test in order to know if there is any difference in perceptions of teachers belonging to Math / Physics and Chemistry / Biology group. The results indicate that t=1.56, p= 0.114 > 0.05, which depicts that there is no significant difference in the views of teachers belonging to Math/Phy and Chem/Bio groups regarding development of critical thinking skill in science students at secondary level. The perceptions of teachers from both subject groups are positive. So the alternate hypothesis is hereby rejected.

Teachers' perceptions were taken to know the present status of development of critical thinking skills in the learners after the study of science courses. Roth & Barton, (2004) stated that teachers can enable their students to divulge their role in social change, especially the science teachers are the agents of change and novelty as they can raise the intellectual growth of their pupils. They develop the habit of scientific inquiry in their students and enable them to solve problems (National Science Teachers Association, 2006). The results of the present study showed that teachers' views are highly positive regarding development of critical thinking skills in secondary school science students of Khyber Pakhtunkhwa. Science teachers believed that science subjects are improving students' critical thinking abilities as they can ask questions during class and peer discussion, explain the topics learned in the science class, conclude or infer results from the experiments performed in the laboratory, relate their knowledge to their everyday daily life along with new examples. Further they can interpret their results. All these are features of critical thinking. These results are in line with many and one of Resnick's (1987) definitions that higher-order thinking involves higher level of thinking processes. It consists of abilities to describe something properly, to understand a phenomenon to assume or infer about something or to draw conclusions about a phenomenon, for building relationships or to represent something properly, or for analyzing a situation. Science teachers further respond that students can actively take part in class discussion. They can discuss the science topics with their teachers as well as peers; however they are more comfortable during discussion with their peers. Further they make the science topics understand each other. This is an indication that they can comprehend the topics and are also able to explain it properly. Despite all this teachers perceive that students have to rot memorize the science lessons to get good marks in the tests. this is obviously a matter of concern for curriculum developers and educationists indicating that a an improved version of text books should be brought forward which should be easy to understand and comprehensive so that students may not need to rot memorize the concepts rather they may read and explain the topics in their own words, resulting their much more interest in science subjects and improving the critical thinking skills required for a modern citizen of 21st century. Along with it students attitude towards will also increase resulting in a large number of youngsters involved with science and technology courses thus meeting the country's demand of greater science related personnel.

T- Test results indicate significantly positive teachers' perceptions regarding development of critical thinking skills in science students of secondary classes. Therefore the null hypothesis (H_{01}) is rejected. Significant difference is not found in the views of male and female teachers regarding development of critical thinking skill in science students at secondary level. Both male and female teachers have positive Views. So the null hypothesis (H_{02}) is accepted here by. The results indicate that significant difference is not found in the views of teachers belonging to Math/Phy and Chem/Bio groups regarding development of critical thinking skill in science students at secondary level. The perceptions of teachers from both subject groups are positive. So the alternate hypothesis is hereby rejected.

Conclusions

An overall result shows that teacher' perceptions regarding the critical thinking skills of students shows high positive perceptions indicating that studying science courses developed critical thinking skills. As different aspects of critical thinking, include understanding, interpretation, explaining, application inferring concluding, etc. From teachers' perceptions, it is concluded that students can apply science knowledge in their daily life and quote examples about the topics they learned in their textbooks. It was further concluded that there is no significant difference in the views of male and female teachers regarding development of critical thinking skill in science students at secondary school level.

Recommendations

It is found that students have to rot memorize the science lessons. Hence it is recommended that science teachers should encourage the students to ask questions during their class as it develops a habit of inquiry that will be helpful in developing critical thinking. Furthermore science teachers should arrange /encourage group discussion in students so that their science concepts more clear.

References

Aderonmu, P., Alagbe, O., Opoko, A., Oluwatayo, A., & Alagbe, T. (2014). Evaluating the gap between overt and operational curriculum in architectural education: implication for professional practice. In *EDULEARN14 Proceedings* (pp. 1619-1625). IATED.

Alshammari, A. (2013). Curriculum Implementation and Reform: Teachers' Views about Kuwait's New Science Curriculum. *Online Submission*, *3*(3), 181-186.

Asad, M. M., Rind, A. A., Khand, Z. H., Rind, I. A., & Mughal, S. H. (2020). Curriculum up-gradation practices among higher education institutions of Pakistan: Does curriculum ideologies make difference? *Journal of Applied Research in Higher Education*. 13(4), pp. 980-990.

Beyer, B. K. (1991). *Teaching thinking skills: A handbook for secondary school teachers* (Vol. 1). Prentice Hall.

Bissell, A. N., & Lemons, P. P. (2006). A new method for assessing critical thinking in the classroom. *BioScience*, *56*(1), 66-72.

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

Cervetti, G., Pardales, M. J., & Damico, J. S. (2001). A tale of differences: Comparing the traditions, perspectives, and educational goals of critical reading and critical literacy. *Reading online*, *4*(9), 80-90.

Collins, N. D. (1993). Teaching Critical Reading through Literature. ERIC Digest.

Curry, L. A., Krumholz, H. M., O'Cathain, A., Clark, V. L. P., Cherlin, E., & Bradley, E. H. (2013). Mixed methods in biomedical and health services research. *Circulation: Cardiovascular Quality and Outcomes*, *6*(1), 119-123.

Duran, M., & Dökme, I. (2016). 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. P., 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.

EMIS, (2017-18) Government of Khyber Pakhtunkhwa, Education Management Information System, Elementary & Secondary Education Deptt.

Eryaman, M. Y. (2007). Examining the Characteristics of Literacy Practices in a Technology-Rich Sixth Grade Classroom. *Turkish Online Journal of Educational Technology-TOJET*, *6*(2), 26-41.

Facione, P. A., & Facione, N. C. (2007). Talking critical thinking. *Change: The magazine of higher learning*, *39*(2), 38-45.

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). The Correlation between Critical Thinking Skills and Academic Achievement in Biology through Problem Based Learning-Predict Observe Explain (PBLPOE). *International Journal of Learning and Teaching*, *6*(3), 170-176.

Gul, R., Cassum, S., Ahmad, A., Khan, S., Saeed, T., & Parpio, Y. (2010). Enhancement of critical thinking in curriculum design and delivery: A randomized controlled trial for educators. *Procedia-Social and Behavioral Sciences*, *2*(2), 3219-3225.

Hotaman, D. (2008). *Evaluation of the basic skills that the new primary education program envisages to gain in line with the perceptions of teachers, parents and students* (Doctoral dissertation, Marmara University (Turkey)).

Johnson, A. P. (2000). Up and out: Using thinking skills to enhance learning. Boston: Allyn and Bacon.

Kaya, H. (1997). Üniversite öğrencilerinde eleştirel akıl yürütme gücü. *Yayımlanmamış Doktora tezi), İstanbul: İstanbul Üniversitesi*.

Khalid, S. M., & Khan, M. F. (2006). Pakistan: The state of education. *The Muslim World*, *96*(2), 305-322.

Wen, M. L. (1999). Critical thinking and professionalism at the university level,(Paper presented), British Educational Research Association Conference, University of Sussex, Brighton, 2–5 September.

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

National Science Teachers Association. (2006). NSTA position statement: Professional development in science education. *Arlington, VA: NSTA*.

Paul, R., & Elder, L. (2004). Critical and creative thinking. *Dillon Beach, CA: The Foundation for Critical Thinking*.

Penuel, W. R., Phillips, R. S., & Harris, C. J. (2014). Analysing teachers' curriculum implementation from integrity and actor-oriented perspectives. *Journal of Curriculum studies*, *46*(6), 751-777.

Resnick, L. B., & Science National Research Council (US). Committee on Research in Mathematics. (1987). Education and learning to think. http://www.nap.edu/catalog/1032.html

Rind, A. A., & Mughal, S. H. (2020). An Analysis of Pakistan's National Curriculum of Mathematics at Secondary level. *Electronic Journal of Education, Social Economics and Technology*, *1*(1), 39-42.

Roth, W. M., & Barton, A. C. (2004). *Rethinking scientific literacy*. Routledge.

Scherer, M. (2001). How and Why Standards Can Improve Student Achievement: A Conversation with Robert J. Marzano. *Educational Leadership*, *59*(1), 14-18.

Kutlu, om, & Schreglmann, s. (2011). The effect of subject-based critical thinking on critical thinking skills of teachers. *Journal of the cukurova university institute of social sciences* , *20 (1) pp165-176.*

Simpson, E., & Courtney, M. (2002). Critical thinking in nursing education: Literature review. *International journal of nursing practice*, *8 (April)*, 89-98.

Söylemez, Y. (2015). Developing critical basic language skills scales for secondary school students. Unpublished doctoral thesis. Ataturk University Institute of Educational Sciences, Erzurum.

Sternberg, R. J. (Ed.). (1999). *Handbook of* creativity. New York: Cambridge University Press.

Wagner, T. (2010). *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*. ReadHowYouWant. com. New York: Basic Books.

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