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ANALYZING STEM STUDENT INTERESTS IN DEVELOPING CRITICAL THINKING SKILLS IN PAKISTAN

Muhammad Ramzan[*1], Dr. Fouzia Perveen[2], Dr. Sobia Altaf[3]

[*1]Ph.D. Education Scholar Department of Education The Islamia University of Bahawalpur, Pakistan; [2]Visiting Lecturer Department of Education, Ghazi University Dera Ghazi Khan, Pakistan; [3]Lecturer Department of Educational Training, The Islamia University of Bahawalpur, Pakistan

[*1]mohammadramzan119990@gmail.com; [2]fouziarizwan99@gmail.com; [3]sobia.altaf@iub.edu.pk

Corresponding Author: *

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ABSTRACT

STEM Education and Critical Thinking Skills are important 21st-century skills. STEM Education is necessary to promote secondary school students' critical thinking skills. These skills are very important for teachers to respond to students. Pakistan is in the preliminary stages of integrating STEM Education in institutions like other developing countries in the world. Unfortunately, most of the secondary school students in Pakistan are unaware of STEM Education and teachers are not applying critical thinking skills in classrooms. The objectives of the study mainly deal with; to identify the importance of STEM Education in the teaching-learning process; to find out the factors affecting on critical thinking skills that can develop an interest in students in STEM Education and suggestions for how to improve critical thinking skills in students regarding STEM Education. This study was descriptive. The population of the study was secondary school students. Data was collected from 200 secondary school students through a questionnaire. The result of the research shows that critical thinking skills develop interests in students towards STEM Education.

Keywords: STEM Education, Teachers, Students, Critical Thinking Skills, and Teaching Learning Process.

INTRODUCTION

We are living in a rapidly globalizing world that is advancing technology, worldwide knowledge, inventions, innovations, and education. In this situation, people who can create changes are better able to accept leading positions to better coordinate with other societies on emerging improvements in the social order. Skills like these are crucial for a sustainable future and continuous learning. Therefore, similar skills must be taught in schools. It's fair to state that in the course of their education, students will encounter many challenges that they will later encounter in real life (Tortop, 2013).

Developing students' capacity for critical thinking and problem-solving is a stated goal of instruction across all disciplines (Olszewski et al., 2015). Interaction with the physical world is essential to learning, whereas the cognitive Olszewski and linguistic domains play a supporting role. This approach has the potential to foster intellectual growth. Knowing, doing, being, and thinking are all results of thought (Lai, 2011).

Hatcher and Spencer (2005) claimed that critical thinking is an important and crucial skill because it is effective in employment, it may aid cope with psychological and transcendence concerns, and it can be utilized to analyze public, processes and institutes thus evading societal difficulties. Developing students' capacity for critical thinking is essential for achieving desired outcomes in the classroom (Memon, 2007). Teachers can help students develop their critical thinking abilities by posing questions that encourage in-depth thought and by encouraging students to express themselves clearly and persuasively (Hoodbhoy, 2009).

The advancements in science and technology are growing rapidly day by day. The advancement of a country depends on the progress of its citizens. In this modern era, there is a trend of

STEM (Science, Technology, Engineering, and Mathematics) education. In the global world there is a huge reform in their education system they lag behind the general education and they follow the STEM (Science, Technology, Engineering, and Mathematics) education. The trend of STEM (Science, Technology, Engineering, and Mathematics) education in the global world is increasing rapidly.

Science, Technology, Engineering, and Mathematics (STEM) education blends the four areas through coherence and functional teaching and mastering techniques. Now we come to know that these disciplines should not be instructed in separation, they just present in solitude in the true world or the framework. Science is the study of nature, involving the rule of nature connected with physics, chemistry, and biology and the therapies or execution of logic, principles, ideas, and assembly linked with these programs. Science is a source of information that has been enhanced according to the conditions required that generate new knowledge.

Teaching and learning about critical thinking has been cited as an asset to a well-rounded education. Even in the current educational policy environment in Pakistan, the emphasis is on helping pupils learn to think critically. The National Education Policy (Government of Pakistan, 2009) and the National Curriculum for Physics, Chemistry, and Biology (2006), to name just two examples, both emphasize the need to teach students to think critically and offer a variety of strategies for doing so in secondary school. Teachers who have accumulated sufficient information and data in this area use these strategies and procedures in their lessons at an early stage. Improving the educational system is important, but so is giving students more control over their education and bettering their chances in the workforce and society (Sadavel et al., 2017).

Increasing success in STEM education is a monumental undertaking. There is a widespread lack of engineering expertise among educators (Al-Salami et al., 2017; Cavlazoglu & Stuessy, 2017). It is a long, difficult process of personal growth for educators to accept and implement an educational revolution (Fore et al., 2015). Smart project management requires the ability to synthesize information from a variety of sources (Koh et al., 2015). However, science teachers are expected to use technology to streamline the delivery of content rather than focusing on guiding students through the process of knowledge construction (Pringle et al., 2015).

Research Objectives

- To identify the importance of STEM Education in the teaching-learning process.
- To find out the factors affecting critical thinking that can develop interest in students toward STEM Education.
- Suggestions on how to improve critical thinking approach in students regarding STEM Education.

Review of Literature

National Science Standards and National Technology Standards state that critical thinking is a foundational ability that is woven into both. Educators almost universally acknowledge that pupils struggle with critical thinking and that the skill cannot be effectively taught in isolation. Although critical thinking is the glue that binds factual knowledge to the authority to act upon that knowledge, it is rarely recognized as a necessary component of the core curriculum (Walsh & Paul, 2014). One of the most crucial talents for a successful STEM profession is the ability to think critically (Baethe, 2013; Rehmat, 2015). So, children must enter formal education already having developed their critical thinking skills outside of class from elementary school until high school. Students' critical thinking skills can benefit from increased opportunities for hands-on learning, real-world problem solving, and meaningful interaction between students and teachers made possible via the incorporation of STEM disciplines into the classroom.

STEM education can be helpful in the development of students' critical thinking skills is crucial and research. The goal of STEM education is to prepare students for success in a competitive job market by providing them with a solid foundation in STEM education (Afriana et al., 2016). The goal of STEM education is to encourage students to think critically and creatively by blurring traditional academic lines in the study of STEM. Students in a STEM program are challenged to apply their analytical reasoning to the resolution of authentic and real-world issues. Students who take part in STEM programs show considerable improvement in these areas, as well as in their capacity for

independent thought and increased productivity on the job.

Critical thinking needs a widely accepted definition (Shernoff et al., 2017). However, no one seems to agree on how to define critical thinking (Bahrum et al., 2017). It is Lyutykh's (2009) contention that critical thinking represents the correct way of thinking. Bowell and Kemp (2005), critical-based teaching (CBT) is when an individual actively participates in taking on responsibility for the activities they encounter in daily life. It has been argued that cognitive abilities including the ability to assess arguments rationally are crucial in determining critical thinking (Mason, 2008). Pages (2007) stated that critical thinking with sophisticated mental processing analysis, synthesis, and evaluation.

Studying the global verification of critical thinking capabilities, Helpern (2001) finds encouraging results and non-specialists who demonstrate good critical thinking abilities. According to Lipman (1988) stated that critical thinking skills are required for effective norm-based moral decision-making. However, the value of critical thinking transcends national boundaries. Van Gelder (2005) argues that critical thinking is essentially universal; nonetheless, it might be difficult to transfer information and abilities from one setting to another. Numerous people argue that critical thinking includes both generalizable and field-specific components. Ennis (1989), the geometric consequence is more typically suited to the arts but is rigidly observed in the social sciences.

According to Silva (2008), there is no predetermined age at which a youngster is capable of understanding more complex forms of reasoning. Professional scientists rarely make illogical arguments Willingham's (2007) research shows that even young children exhibit critical thinking. Instilling in them the ability to recognize the difference between meaning and experimental statements, to use reasoning approaches like asking for examples when something is uncertain, to notice the difference between meaning and context, to value motivation and reality, to respect others through dialogue, to be open-minded, and to be ready to see things from another's perspective. Bailin et al. (1999) argue that critical thinking tenets, such as the ability to recognize alternatives, may be taught to elementary school students.

The National Science Teachers Association (NSTA) is a group of educators working to improve STEM (science, technology, engineering, and mathematics) education by bringing together specialists from different fields. To make learning more real and relevant a STEM curriculum equips students with the resources and chances they need to draw connections between their coursework and the wider world. Known as experiential learning, this method emphasizes acquiring the skills necessary for success in further education and the job through the solving of real-world issues and challenges, and it is widely used in the STEM fields. The positive effects of parental and instructional enthusiasm in science on children's learning and development in the subject have been well documented (Tai, et al., 2006).

According to the information of statistics right now there are more than a million STEM jobs seats in the industry, while on the other hand at the same time, only 16 percent of college students declared in STEM fields. Many new fields and professions are rising every day and the need for STEM jobs expanded three times more between 2000 and 2010, and growing day by day. So, it is very clear that STEM needs more members, and also STEM is the way to be successful in the future. One thing that must kept in mind is that STEM needs more IT professionals rather than just Computer Science. People who mastered science and mathematics have more chances of employment in this world of race. So, that is the reason we need to focus on all STEM fields altogether and should not undervalue any one of these fields. All the four domains of STEM are equally important.

To improve learning results in the classroom, schools and the education setup need to promote STEM schedules across productive courses, teaching pedagogies, and evaluation methods. There is a broad spectrum of curricular means accessible attempts underneath the national road map will be made to keep on the STEM subject's information and experience to solve the problems and critical thinking. From early years through high school teachers will assist the students, Teachers better understand and guide students' individual needs and demands according to the awaited expertise and progress in students' knowledge. There are numerous paths to link up with combined projects-based teaching of STEM that goals to enhance or refine students' motivation, involvement, and achievements. More suggestion is required for

schools and teachers to regulate which perspective does better for various designs and escorts.

Students' ability to understand and apply scientific and mathematical concepts is enhanced through trans-disciplinary model learning, as underlined by Frykholm and Glasson (2005). Trans-disciplinary model learning allows for the gradual enhancement of abilities and knowledge based on the difficulty of actual tasks or challenges (Becker & Park, 2011). Students can benefit from studying the interconnectedness of STEM disciplines and the meaning of individual concepts through the incorporation of many settings and content areas into a single learning experience (Moore & Smith, 2014). These connections among STEM disciplines suggest a novel approach to educating and empowering tomorrow's scientists (Roberts, 2013).

To show the outcomes of people's productivity, they must receive a technologically focused education in domains where they will be called upon to produce and invent (Kaplan et al., 2015). STEM is a term used to describe the study of different STEM disciplines. In the USA, STEM education is widely used to refer to a curriculum heavy in the fields of science, technology, engineering, and mathematics. Public and private institutions all around the country provide STEM-related courses (Sahin et al., 2014). The acronym STEM is an abbreviation for science, technology, engineering, and mathematics. Adaptability, communication, social skills, problem-solving, creativity, self-control, and scientific thinking are just a few of the many twenty-first-century abilities that may be honed through study in any of the STEM fields (NRC 2012).

Educators agree that a nation's ability to progress, especially economically, hinges on the quality of its primary and secondary school programs. Developing nations like Pakistan recognize the importance of bolstering their populations' scientific literacy through increased funding for K-12 STEM education. To raise the quality of life for all people, to increase innovation and productivity, and to stimulate the economic growth that is so vital to our modern civilization, science literacy is essential (Watkins, 2000; UNESCO, 2014). The need to educate students in STEM fields for societal and economic change has been recognized, but there are still obstacles to implementing long-term strategies for doing so. The relationship between education and how it may be made effective in bringing about necessary social and economic change is intricate.

The political situation has never permitted us to give attention to the fundamental educational needs, from the birth of Pakistan in 1947. This is considered conspicuous through the Education for All (EFA) goals and the post-2015 agenda for education in Pakistan (Education for All National Review Report: Pakistan, 2015). Pakistan is working continuously to give an equal approach to education at the school level (Aziz et al., 2014). Memon et al. (2010) stated that the standard of education in elementary or high schools is decreasing rapidly on the other hand demand for science education is increasing day by day. Memon et al. (2010) referred the factors such as low budget for education, simple or arts qualification of elementary teachers, the quality of teacher certification is not good, irrelevant content of education, and insufficient research on education.

Teacher training interacts with them to enhance their technology tips with the help of ICT or to improve their teaching capability in STEM subjects (Hooker, 2017). The inspection of workers in Pakistan and India shows that 56% of workers preferred non-perceptual thinking skills. This research exposed local or domestic distinctions. Such as big cities like Lahore and Delhi have more literate publics in contrast to other cities, and most of its citizens have powerful comprehension skills. As, compared to other cities with few literate communities, such as Bhopal and Multan need fundamental expertise as well as perceptual expertise, for example, honor, and powerful work morale (Burnett & Jayaram,2012). Even so, the need for skills in 11 dominant zones in Lahore expressed the major demand for proficiency in STEM-related subjects. Likely et al. (2018) stated that STEM Education can provide good work in such manners.

Research Methodology

Research is a planned pattern of work. This chapter explains how the researcher explains how this research was conducted and deals with research design, research methodology, and the approach adopted by the researcher. The main aim of this study was to learn about Analyzing STEM student interests in developing critical thinking skills. Researchers develop procedural perspectives upon which the dissertation is based (Oso & Onen, 2009). According to the study's goals, considerable thought had to be

given to the issue at hand. As a result, a descriptive research strategy was used for this investigation. Descriptive research is a valid method for investigating any given condition, as proposed by Cohen, Manion, and Morrison (2013).

The population of the study was all the teachers of secondary schools in Southern Punjab. The target populations of the study were taken from the Districts of Bahawalpur, Multan, and Dera Ghazi Khan. The sampling of the study was taken from the target population. Two hundred (200) students of secondary school were the population of the study. The researcher visited personally and gave instructions to the students about filling out the questionnaire. The SPSS tool was used to measure the frequency and percentage of analyzed data.

Table 3.1: Sample Size for Students

Sr. No	Name of Divisions	No. of secondary school students
1	Bahawalpur	70
2	Multan	70
3	Dera Ghazi Khan	60
Total	3 Division	200

The total population of three divisions of southern Punjab, secondary school students enrolled in SIS (School Information System) was 110847. Out of 110847, there were 62607 male students and 48240 female students in Public schools. The population of the study was public and private (male and female) students studying in 9th and 10th classes in three divisions of southern Punjab (Bahawalpur, Multan, and Dera Ghazi Khan). All public and private (male and female) teachers who were teaching 9th and 10th classes were also a population of the study. Before the collection of data, consent was taken from the respondents.

Questionnaire Data Analysis

Analyzing STEM student interests in developing critical thinking skills was presented in the following Table 2.

Table 4.1.1 Analyzing STEM student interests in developing critical thinking skills

Item No.	Statement	Opt.	SA	A	UD	DA	SDA	M	SD
1	I am eager to learn new things	F	198	145	21	13	7	4.34	.870
		%	51.6	37.8	5.5	3.4	1.8		
2	I always seek information that supports my viewpoints	F	144	183	19	27	11	4.10	.978
		%	37.5	47.7	4.9	7.0	2.9		
3	I can solve problems.	F	113	188	33	43	7	4.24	.967
		%	29.4	49.0	8.6	11.2	1.8		
4	I focus on questioning to understand things.	F	170	159	20	26	9	4.19	.960
		%	44.3	41.4	5.2	6.8	2.4		
5	I can understand the ideas of my class fellows.	F	134	157	40	44	9	4.05	2.302
		%	34.9	40.9	10.4	11.5	2.3		
6	I check its usability before decision making	F	132	176	37	29	10	4.02	.989
		%	34.4	45.8	9.6	7.6	2.6		
7	Problem-solving approach enhances critical thinking.	F	88	178	52	47	19	3.70	1.101
		%	22.9	46.4	13.5	12.2	4.9		
8	I always find new ideas to solve difficult problems.	F	148	167	31	25	13	4.07	1.014
		%	38.5	43.5	8.1	6.5	3.4		
9	Critical thinking improves problem-solving skills by practicing it.	F	98	188	43	37	18	3.81	1.068
		%	25.5	49.0	11.2	9.6	4.7		
10	STEM Education is project-based learning.	F	89	195	51	36	13	3.81	1.005

		%	23.2	50.8	13.3	9.4	3.4		
11	STEM Concepts help me in explaining my thoughts.	F	104	164	63	43	10	3.91	2.299
		%	27.1	42.7	16.4	11.2	2.6		
12	STEM Approach involves the active participation of students.	F	81	187	76	27	13	3.77	.972
		%	21.1	48.7	19.8	7.0	3.4		
13	STEM Educating helps to complete a task innovatively.	F	131	176	43	20	14	4.02	.996
		%	34.1	45.8	11.2	5.2	3.6		
14	STEM Education is against rote learning.	F	120	129	50	63	22	3.69	1.226
		%	31.3	33.6	13.0	16.4	5.8		
15	STEM Education practices give better solutions.	F	168	167	28	16	5	4.24	.859
		%	43.8	43.5	7.3	4.2	1.3		
16	STEM Education is based on real-life approaches.	F	88	186	60	35	15	3.88	2.294
		%	22.8	48.4	15.6	9.1	3.9		
17	STEM Education has positive impacts on students' learning.	F	120	186	45	26	7	4.01	.931
		%	31.3	48.4	11.7	6.8	1.8		
18	STEM Performance is related to students' competency.	F	132	175	44	19	14	4.02	.993
		%	34.4	45.6	11.5	4.9	3.6		
19	STEM Education focuses on students' critical thinking skills.	F	70	192	64	39	19	3.66	1.044
		%	18.2	50.0	16.7	10.2	4.9		
20	Students' Critical thinking approach helps them learn STEM concepts.	F	94	180	61	38	11	3.80	1.010
		%	24.5	46.9	15.9	9.9	2.9		
21	The current STEM Education program in Pakistan is meeting the needs of learners.	F	80	180	55	49	20	3.65	1.102
		%	20.8	46.9	14.3	12.8	5.2		
22	STEM Education boosts an independent approach among students.	F	89	190	50	38	17	3.82	1.437
		%	23.2	49.5	13.0	9.9	4.4		
23	STEM Education promotes the cognitive skills and abilities of learners.	F	126	187	35	22	14	4.01	.989
		%	32.8	48.7	9.1	5.7	3.6		
24	STEM Education helps to develop the problem-solving approach.	F	91	182	61	34	16	3.78	1.038
		%	23.7	47.4	15.9	8.9	4.2		
25	STEM Education influences the development of society.	F	104	180	53	37	10	3.87	.997
		%	27.1	46.9	13.8	9.6	2.6		
26	STEM Education prepares learners for a better future.	F	138	173	41	24	8	4.07	.950
		%	35.9	45.1	10.7	6.3	2.1		
27	Awareness of STEM Practice promotes students ' interest in exciting careers.	F	101	195	52	26	10	3.91	.948
		%	26.3	50.8	13.5	6.8	2.6		
28	STEM Education is based on modern technology-supported learning.	F	126	169	57	21	11	3.98	.977
		%	32.8	44.0	14.8	5.5	2.9		

Results and Discussion

Majority of students (89.4%) agreed with the statement that they were eager to learn new things. Majority of students (85.2%) agreed with the statement that they were always seeking information that supports their viewpoints. Majority of students (85.7%) agreed with the statement that they enjoyed trying to understand how things work. Majority of students (78.4%) agreed that they have abilities to solve problems. Majority of students (85.7%) agreed with the statement that they were focusing on questioning to understand things. Majority of students (75.8%) agreed with the statement that they can understand the ideas of their class fellows. Majority of students (80.2%) agreed with the statement that they check its usability before decision-making.

Majority of students (69.3%) agreed with the statement that problem problem-solving approach enhances their critical thinking. Majority of students (82.0%) agreed with the statement that they always find new ideas to solve difficult problems. Majority of students (74.5%) agreed with the statement that critical thinking improves problem-solving skills by practicing it.

Majority of students (74.0%) agreed with the statement that STEM Education is project-based learning. Majority of students (69.8%) agreed with the statement that STEM Concepts help me in explaining my thoughts. Majority of students (69.8%) agreed with the statement that the STEM Approach involves the active participation of students. Majority of students (79.9%) agreed with the statement that STEM Education helps to complete a task innovatively. Majority of students (64.9%) agreed with the statement that STEM Education is against rote learning. Majority of students (87.3%) agreed with the statement that STEM Education practices give better solutions.

Majority of students (71.2%) agreed with the statement that STEM Education is based on real-life approaches. Majority of students (79.7%) agreed with the statement that STEM Education has positive impacts on students' learning. Majority of students (80.0%) agreed with the statement that STEM Performance is related to students' competency. Majority of students (68.2%) agreed with the statement that STEM Education focuses on students critical thinking skills. Majority of students (71.4%) agreed with the statement that Students' critical thinking approach helps them learn STEM concepts. Majority of students (67.7%) agreed with the statement that the current STEM Education program in Pakistan is meeting the needs of learners. Majority of students (72.7%) agreed with the statement that STEM Education boosts an independent approach among students. Majority of students (81.5%) agreed with the statement that STEM Education promotes the cognitive skills and abilities among learners.

Majority of students (71.1%) agreed with the statement that STEM Education helps to develop problem problem-solving approach. Majority of students (74.0%) agreed with the statement that STEM Education influences the development of society. Majority of students (81.0%) agreed with the statement that STEM Education prepares learners for a better future. Majority of students (77.1%) agreed with the statement that awareness of STEM Practices promotes students' interest in exciting careers. Majority of students (76.8%) agreed with the statement that STEM Education is based on modern technology-supported learning.

References

Achieve, I. (2013). Next-generation science standards. The Next Generation Science Standards.

Adabor, J. K. (2008). ,An investigation into elementary school mathematics teachers and the high school mathematics teachers' attitude towards the use of calculator in mathematics instruction and learning. http://www.etd.ohiolink.educ/view/adabor. Retrieved 11 August 2011.

Adler, J. and Reed, Y. (2002). Challenges teacher development: An investigation of take-up in South Africa. Pretoria: Van Schaik Publishers.

Akgunduz, D., Ertepinar H., Ger M. A., Kaplan Sayi A., & Turk Z. (2015). STEM Training Workshop Report A Comprehensive Assessment on Turkey STEM Training. Istanbul Aydin University STEM Center and Education Faculty.

Akhtar, Z. (2010). The Effects of Learning Styles and Socio-economic Status on Learning Achievement of Secondary School Students. Unpublished) Ph. D. thesis. NUML, Islamabad.

Albergaria Almeida, P. (2010). Questioning patterns, questioning profiles and teaching strategies in secondary education. International Journal of Learning, 17(1), 587-600. Retrieved from http://thelearner.com/journal/

Al-doulat, A. S. (2017). The impact of teaching using the STEM approach in the acquisition of scientific concepts and developing scientific thinking among Classroom-Teacher students at the University of Jordan The impact of teaching using

the STEM approach in the acquisition of scientific. *International Journal of Instructional Technology and Distance Learning, 14*(7), 29–38.

Ali, A. (2006). Role of Educational Technology in designing and implementation of teaching-learning process. Unpublished M.Phil. Dissertation, AIOU Islamabad.

Ali, M. Q., Nargis, N., Yasmeen, R., & Iqbal, Z. (2015). ICT is used for effective teaching-learning processes in secondary schools in the Punjab province. *Asian Journal of Social Sciences & Humanities*, *4*(3), 138-143.

Altan, E.B., Ozturk, N., & Turkoglu, A.Y. (2018). Socio-scientific issues as a context for STEM education: A case study research with pre-service science teachers. European Journal of Educational Research, 7(4), 805-812.

American Association for the Advancement of Science (AAAS) (2012). Describing and measuring undergraduate STEM teaching practices. Washington, DC: American Association for the Advancement of Science.

Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. New York: Longman.

Baldwin, R. G. (2009). The climate for undergraduate teaching and learning in STEM fields. New Directions for Teaching and Learning, 2009(117), 9-17.

Barker, B. S., & Ansorge, J. (2007). Robotics as a means to increase achievement scores in an informal learning environment. Journal of Research on Technology in Education, 39(3), 229-243.

Baron, J. (2008). Thinking and Deciding (4th ed.). New York: Cambridge University Press.

Berg, B. L., & Lune, H. (2011). Qualitative research methods for the social sciences (8th ed.). Boston: Pearson.

Beyer, B. (2008). How to teach thinking skills in social studies and history. Social Studies, 99(5), 196-201. Retrieved from http://www.socialstudies.org/

Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. *Journal of Gifted Education and Creativity*, *2*(2), 71-80. https://doi. org/ 10. 18200/ JGEDC.2015214253.

Blue, E.V. (2014). In: Green, S.L. (Ed.), Effective STEM Instruction in K-12 Setting. Hauppauge: Nova Science Publisher.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., & Rothstein, H.R. (2013). Introduction to meta-analysis. United Kingdom: John Wiley and Sons, Ltd. Publication.

Capraro, R. M. & Slough, Scott W. (2013). Why PBL? Why STEM? Why Now? An introduction to STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics Approach. AW Rotterdam: Sense Publisher.

Capraro, R. M. et. al. (2013). STEM Project Based Learning: An integrated science, technology, engineering, and mathematics (STEM) approach. AW Rotterdam: Sense Publisher

Case, R. (2004). Preconceptions of critical thinking. Retrieved July 2, 2004

Cathy, R. & Kelley, L. (2002). *A Learning Return on Our Educational Technology Investment* San Francisco: West Ed.

Chapman, J. (2018, March 21). Commentary: Where STEM Context and Careers Meet. U.S. News and World Report.

Chen, J., & Mensah, F.M. (2018). Teaching contexts that influence elementary preservice teachers' teacher and science teacher identity development. *Journal of Science Teacher Education*, 29(5), 420-439. DOI: 10.1080/1046560X.2018.1469187

Chen, X. (2013). STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001. National Center for Education Statistics.

Chiu, A., Price, C. A., & Ovrahim, E. (2015, April). Supporting elementary and middle school STEM education at the whole school level: A review of the literature. In NARST 2015 Annual Conference, Chicago, IL.

Dugger, W. E. (2010). Evolution of STEM in the United States. Presented at the 6th Biennial International Conference on Technology Education Research, Gold Coast, Queensland, Australia.

Dunning, D. (2011). The Dunning–Kruger effect: on being ignorant of one's own ignorance. In Advances in experimental social psychology (Vol. 44, pp. 247–296). Academic Press.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An integrated critical thinking framework for the 21st century. *Thinking Skills and Creativity*, *12*, 43–52. https:// doi. org/ 10. 1016/ j.tsc.2013.12.004.

Eijkelhof, H. M., & Krüger, J. (2009). We are improving the quality of innovative science teaching materials. ESERA 2009 conference. Istanbul. Retrieved from: https://dspace.library.uu.nl/handle/1874/42591.

Ellis, P. D. (2010). The essential guide to effect sizes: Statistical power, meta-analysis, and the interpretation of research results. Cambridge: Cambridge University Press.

Emir, S. (2009). Education Faculty Students' Critical Thinking Disposition According to Academic Achievement. World Conference Education Science, 1.

Engineering. (n.d.). Dictionary.com Unabridged. They were retrieved on May 20, 2012, from Dictionary.com website: http://dictionary.reference.com/browse/engineering.

English, L.D. (2016). STEM education K-12: Perspectives on integration. International Journal of STEM Education, 3(3), 1-8.

Erwin, T. D., & Sebrell, K. W. (2003). Assessment of critical thinking: ETS's tasks on critical thinking. The Journal of General Education, 52(1), 50-70.

Estapa, A. T., & Tank, K. M. (2017). Supporting integrated STEM in the elementary classroom: a professional development approach centered on an engineering design challenge. International Journal of STEM education, 4(1), 6.

Facione, P. A. (1990). Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction. Research Findings and Recommendations.

Fahim, M., & Eslamdoost, S. (2014). Critical Thinking: Frameworks and Models for Teaching. *English Language Teaching*, *7*(7), 141-151. https://doi.org/10.5539/elt. v7 n7p141.

Fairweather, J. (2008). Linking evidence and promising practices in science, technology, engineering, and mathematics (STEM) undergraduate education.

Felix, A. L. (2010). Design-based science for STEM Student recruitment and teacher Professional development. Mid-Atlantic ASEE Conference, Villanova University.

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

Graham, M.J., J. Frederick, A. Byars-Winston, A.B. Hunter, and J. Handelsman. (2013). Increasing persistence of college students in STEM. Science, 341(6153), 1455–1456.

Guevarra, J. D., Marquez, J. A. V, & Pecson, R. R. (2017). Development of students' critical thinking skills at public secondary schools. *Dinalupihan District: An Assessment*. *2*, 1450–1458.

Guven, M., &Kurum, D. (2004). The relationship between teacher candidates' Learning Styles and Critical Thinking Dispositions. An investigation on the Students in the Faculty of Education in Anadolu University, 1.

Guzey, S.S., Harwell, M., & Moore, T. (2014). Development of an instrument to assess attitudes toward science, technology, engineering, and mathematics (STEM). School Science and Mathematics, 114(6), 271-279.

Habashi, M. M., Graziano, W. G., Evangelou, D., & Ngambeki, I. (2008, July). Age-related gender differences in engineering. Paper presented at the Research in Engineering Education Symposium, 54 Journal of STEM Teacher Education Vol. 49 No. 1, spring 2014 Davos, Switzerland.

Harkema, J., Jadrich, J., & Bruxvoort, C. (2009) Science and Engineering: Two models of laboratory investigation. The Science Teacher, 76(9), 27-31.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. Journal of Research in Science Teaching, 48(8), 952-984.

Kelley, T.R., & Knowles, J.G. (2016). A conceptual framework for integrated STEM education. International Journal of STEM Education, 3(11), 1-11.

Kennedy, T. J., & Odell, M. R. L. (2014). Engaging Students In STEM Education. *Science Education International*, *25*(3), 246–258.

Kettler, T. (2014). Critical thinking skills among elementary school students: Comparing identified gifted and general education student performance. *Gifted Child Quarterly*, *58*(2), 127-136.https://doi.org/10.1177/0016986214522508.

Khan, S., B & Jumani, N., B. (2008).Teaching of Basic Concepts at Secondary School Level. Pakistan Journal of Education, 25(1): 109-121

Khine, M. S. (Ed.). (2015). Science Education in East Asia: Pedagogical Innovations and Research-informed Practices. Springer.

Levine, A. (2006). Educating school teachers. The Education Schools Project: New Jersey.

Lin, M. C., Yang, M. F., & Chou, C. H. (2011). High self-efficacy belief with high critical thinking ability. *2nd International STEM in Education Conference.* Retrieved from http://stem2012.bnu.edu.cn/data/long%20paper/stem2012_09.pdf.

Lipsey, M., & Wilson, D. (2001). Practical meta-analysis. Beverly Hills, CA: Sage Publications.

Manan, S. A., & Mehmood, T. (2015). Culture and Critical Thinking in Classroom: Narratives from University Students in Pakistan. *Asia Pacific Journal of Social Science*, *1*(3), 110-134. https://doi.org/10.16962/EAPJSS/issn.2394-9392/2014.

Marulcu, I., & Sungur, K. (2012). Investigation of engineer and engineering perceptions of science student candidates and engineering-design aspects as a method. Afyon Kocatepe University Science Journal. 12, 13-23.

McGregor, D. (2006). Developing thinking developing learning. McGraw Hill Professional.

Mensah, J. K., Okyere, M., & Kuranchie, A. (2013). Student attitude towards mathematics and performance: Does the teacher's attitude matter? Journal of Education and Practice, 4(3), 132–139.

Mergendoller, Maxwell & Bellisimo. (2006). The effectiveness of problem-based instruction: a comparative study of instructional methods and student characteristics. Interdisciplinary Journal of Problem-Based Learning 1(2).

Mervis, J. (2010). Innovations in STEM Education: A Conversation with PCAST's Jim Gates. Retrieved June 7, 2011 from http://news.sciencemag.org/scienceinsider/2010/04/innovations-in-stem-education-a-.html.

National Research Council [NRC]. (2012). A Framework for k-12 science education: practices, crosscutting concepts, and core ideas. Washington DC: The National Academic Press.

National Research Council. (2013). Monitoring Progress Toward Successful K-12 STEM Education: A Nation Advancing? National Academies Press.

National Research Council. 2011. Successful K-12 STEM Education; Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics. Washington, DC: The National Academies Press. http://doi.org/10.17226/13158

Palmer, D. (2004). Situational interest and the attitudes towards the science of primary teacher education students. International Journal of Science Education, 26(7), 895–908.

Parker, J., & Lazaros, E. J. (2014). Teaching 21st-century skills and STEM concepts in the elementary classroom. Children's Technology & Engineering, 18(4), 24-27.

Paul, R. & Elder, L. (2008) Critical thinking: tools for taking charge of your learning and your life. Pearson/Prentice Hall.

Rao, V. K. (2005). *Instructional Technology*. New Dehli: A. P. H Publication.

Redmann, D. H. & Kotrilk, J. W. (2004). Technology integration into the teaching-learning process. *Delta Pi Eplison Journal*, Vol. 46 p 76 .Retrieved on July 7th, 2007) from http://www.dpe.org

Rickman, A. (2011). Youth and technology as "the problem". Retrieved September 10, 2015, from https://www.hastac.org/blogs/aimee/2011/09/30/youth-andtechnology-proble

Shazia, P. (2007). *Impact of Educational Technology in Teaching Learning Process of Formal and Informal Education.* Unpublished M.Phil. Dissertation, AIOU Islamabad.

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education International Journal of STEM Education, 4(1), 13.

Tang, X., Coffey, J. E., Elby, A., & Levin, D. M. (2009). The scientific method and scientific inquiry: Tensions in teaching and learning. Science Education, 94: 29-47.

Tank, K., Moore, T., Babajide, B., & Rynearson, A. M. (2015). Evidence of Students' Engineering Learning in an Elementary Classroom. School of Engineering Education Faculty Publications. *Paper 32.* http://docs.lib.purdue.edu/enepubs/32.

Tella, A. (2008). Teacher Variables as predictors of academic achievement of primary school pupils' mathematics. International Electronic Journal of Elementary Education, 1(1), 17-33.

Watkins, J., & Mazur, E. (2013). Retaining students in science, technology, engineering, and mathematics (STEM) majors. Journal of College Science Teaching, 42(5), 36-41.

Wegerif, R. (2000). *Literature Review in Thinking Skills, Technology Thinking and Learning*. Bristol: Futurelab Series.

Yildirim, B., & Altun, Y. (2015). Investigation of the effects of STEM education and engineering applications in the science laboratory course. El-Cezeri Journal of Science and Engineering, 2(2), 28-40.

Yoder, J. D., & Hochevar, C. M. (2005). Encouraging active learning can improve students' performance on examinations. Teaching of Psychology, 32(2), 91-95.

Zhang, L., & Sternberg, R. J. (2009). Thinking styles across cultures: their relationships with students‟ learning. In J. S. Robert & L. Zhang (Eds.), Perspectives on thinking, learning and cognitive styles (pp. 167–192). New York: Routledge.

Zimmerman, C. (2005). The Development of Scientific Reasoning Skills: What Psychologists Contribute to an Understanding of Elementary Science Learning? United States: Illinois State University