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# Teachers' Mindful Conception about the Use of STEM Education at Secondary School Level

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**Abstract:** *A nation's progress rests on its people, and current economic growth conditions demand high-quality education. Modern science education has been superseded by STEM education. The objectives were 1) to find out secondary school teachers' awareness about the use of STEM-based education and its challenges and the relationship between teachers' understanding and use of STEM at the secondary school level. It was descriptive research and used a self-developed questionnaire for data collection from the respondents. A sample of secondary school teachers (350) was selected through a simple random sampling technique. Statistical tests of minimum, maximum, mean score, standard deviation, and Pearson correlation were applied to the collected data. The study concluded that teachers are aware of STEM-based education, and in line with their awareness, they make the most exclusive use of STEM-based education to enhance students' critical and creative thinking abilities.*

**Key Words:** STEM Education, Secondary School Level, Education,

## Introduction

The progress of a nation is dependent on its people, and the current economic growth conditions necessitate the provision of high-quality education. STEM education has supplanted traditional science education in the modern era. A growing trend in STEM education is teaching STEM subjects (Science, Technology, Engineering, and Mathematics) through cooperative learning, which emphasizes the importance of teamwork. Its goal is to prepare students for careers as inventors by providing them with hands-on experience (Akran & Asiroglu, 2018). Technology is changing at a breakneck pace in this age of research and technology. We must improve education to maintain our technological leadership position in the global marketplace. STEM education exists to help people solve problems. We foster creativity by making use of our strengths. According to projections, many STEM jobs will be created domestically and internationally. Eighty percent of employment necessitate STEM knowledge and skills (Akran & Asiroglu, 2018).

A STEM-based education is unquestionably the essential driver of today's low-cost countries' economies. As a result, countries worldwide are increasing their investments in STEM to spur economic growth and long-term success. It has been proposed as a national educational reform program in Europe, the United States, and other parts of the world. STEM education aims to increase the number of STEM workers and increase STEM knowledge to address 21st-century challenges (Yata, Ohtani, and Isobe 2020).

According to the National Science and Technology Council Committee on STEM Education's report, a highly competent STEM workforce is required to maintain American innovation dominance in the global marketplace. According to the Royal Society, "Making Education, Your Business" was published to assist

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businesses in educating STEM education to promote employment and interest. STEM education in K-12 schools must be improved as part of a national strategy to ensure that the next generation is prepared to work in these professions (Yata, Ohtani, Isobe, 2020). STEM programs are critical in education because they prepare students for the skills they will need in the twenty-first century (Knowledge, Skills, and Values).

STEM instructors must first establish new identities in their home nation and school context before teaching in that country. Furthermore, STEM education is essential to improve skills such as problem-solving and reading comprehension. When it comes to making better judgments and solving difficulties in real-world situations, STEM education can be beneficial. Activities in STEM are intended to develop abilities such as creativity, critical thinking, problem-solving, and decision-making; but, they can also help students develop skills in the humanities such as politics, economics, and social studies (Banks & Barlex, 2014; Daugherty, 2013).

When combined with other forms of education, STEM education can assist the future generation of students in solving complicated issues, assessing consequences, thinking critically, collaborating across disciplinary boundaries, developing and creating, and competing with the world's best. It entails recognizing the relationship between STEM and everyday life, society, and decision-making to problem-solve creativity in various settings. Because of this, STEM education must include, in addition to knowing each topic, the development of STEM knowledge and abilities about various other disciplines (Yata, Ohtani, and Isobe, 2020).

The study of STEM subjects teaches students how to develop and build new goods and systems and conduct research and discovery. STEM education can assist students in learning and applying STEM-related knowledge and skills, observing scientists and engineers in action, and thinking about problem-solving from both sides, among other things (Yata, Ohtani, and Isobe, 2020). However, stakeholders, notably those in the educational institution administration and classroom practitioners, are still disputing what STEM education is and how it should be applied in schools.

In Pakistan, it is a huge deal to be elected. This organization aspires to engage with the Higher Education Commission and universities in Pakistan to promote STEM education in Pakistan. STEM education has piqued the interest of people all around the world in recent years. In both the United Kingdom and the United States, a global approach to STEM education appears to be gaining hold. At the moment, STEM education in Pakistan is only marginally recorded. Several Pakistani universities offer STEM-related courses and programs. However, they were short-lived; this study aims to evaluate STEM education in Pakistan (Hali, Aslam, Zhang, & Saleem, 2021).

Technology has made teaching more exciting and adaptive, and individuals tend to learn depending on the implications of their actions in the future. Science and technology, working together, have contributed to the development of new educational trends. STEM learning has been adopted as one of the most recent trends in education by the majority of the world's leading educational systems. STEM is an acronym that stands for 'Science, Technology, Engineering, and Mathematics,' and was coined by one of the directors of the National Science Foundation in 2001. STEM is a tightly interwoven curriculum in which four courses are inextricably linked. Researchers have stressed the relationship between STEM and national economic development throughout history.

Science, technology, engineering, and mathematics (STEM) education are essential for Pakistan's development in the twenty-first century (Awan, Sarwar, Mehdi, Noureen, and Anwar, 2017), and our students require essential STEM education to tackle the demands of an ever-changing technological environment. The demand for skills has moved considerably, and standard manual procedures have given way to non-routine interactive jobs in the process. The progress of STEM fields is vital to our long-term success. Closing the educational and employment skills disparities is crucial to the country's success. As a developing country, we will only be successful if we can deliver highly skilled workers to the market. According to the Global Gender Report 2017, Pakistan was placed 136th. Education in Pakistan is plagued by gender stereotyping, a severe problem.

This study will actively encourage teachers and students to contribute to the country's

economic success. Education in the STEM fields can help people become better problem-solvers, inventors, competent innovators, and technologically educated individuals in the future. The advancement of technology directly impacts the country's economic success (Kennedy, Lyons, & Quinn, 2014). Integrating STEM subjects into the curriculum will equip instructors and students to actively participate in the technological workforce (Rehman & Butt, 2020). Islamabad requires science education, which is the statement's pedagogical implication. We require a comprehensive global strategy to address economic growth and education issues. It can control the expansion of knowledge. It is a must-do now, and mathematics and science instruction will be introduced shortly as well. The education of youngsters in STEM subjects is becoming increasingly popular worldwide. This investigation was carried out in the Pakistani province of Punjab.

Pakistan is a developing country with a pressing need to advance scientific knowledge. Our national strategic plan must be updated to reflect the current global environment to overcome obstacles in the education and economic sectors. Every one of these options is feasible to maintain tight control over the advancement of knowledge. As a result, STEM education is essential for both the present and the future. STEM (Science, Technology, Engineering, and Mathematics) is a new concept of globalization (science, technology, engineering, and mathematics). STEM education is a global trendsetter in the field of science and technology. This study aimed to investigate the level of teacher awareness and the use of STEM education at the secondary school level.

Many instructors are unconvinced of STEM education, and the majority of them do not have a comprehensive understanding of the subject area (Breiner, Harkness, Johnson, & Koehler, 2012). Teachers who have received STEM education training are not the only ones unsure of what they are meant to be teaching their students in this subject area. These lecturers do not share a common understanding of STEM disciplines. Specifically, Brown, Brown, and Merrill (2011) assert that a lack of awareness about STEM education and related methodologies is a crucial impediment to meeting global education standards in the United States. The implementation of standards-based, meta-discipline reading at the school level where all teachers, mainly STEM teachers, educate using an integrated technique in which discipline-specific content is not divided but addressed and treated as one dynamic, the fluid study of the subject at hand (Brown et al., 2011). When teaching numerous subjects simultaneously rather than one at a time, an integrated approach is used.

## Research Objectives

1. To find out secondary school teachers' awareness about the use of STEM-based education and its challenges.
2. To find out the relationship between Teachers' awareness and use of STEM at the secondary school level.

## Review of Related Literature

Every nation must innovate to reduce unemployment and boost output by creating both valuable and creative jobs. It will reduce unemployment and increase output by adding value and creating jobs. Technology changes impact schooling (Williams & Kingham, 2003). As a result of the solid economic growth in the STEM fields and a growing awareness of the necessity of STEM education is becoming increasingly widespread since, without STEM education, no progress in the majority of sectors will be feasible. STEM education strives to provide students with scientific and technological knowledge and abilities. STEM Education is a source of innovation and creativity that we require to make better use of our resources and make forward-thinking progress (Corlu, Capraro, & Capraro, 2014). STEM education is naturally intelligent, motivated, and ready to learn and explore. Because of this, the primary purpose of STEM education is to give students an appropriate platform and channel for developing creative skills that will benefit them in their future jobs. A curriculum of this nature is intended to prepare students for the future and the economy's expansion. Current STEM Education reforms emphasize the acquisition of applicable skills and the pursuit of possibilities offered by the modern market. It is a program that aims to harness the power of business and all future-related industries. The vast majority of schools worldwide are working on STEM programs, inspiring students, and acknowledging the importance of STEM education.

Pakistan must make long-term investments in industrial expansion to increase the number of STEM-related jobs available to its citizenry. As a result, Pakistan's STEM education system is underprepared and poorly coordinated, and the government must act consistently and solely to support the efforts of all stakeholders, including public and private sector organizations, to improve the situation. In order to address Pakistan's most pressing challenge, which is a lack of access to safe drinking water, it is essential to invest in STEM education. Firstly, we intended to reflect the reality of STEM education in Pakistan as accurately as possible in our study for various reasons: to illustrate the relevance of STEM education in Pakistan. We intended to portray the reality of STEM education in Pakistan for various reasons, one of which was to demonstrate the necessity of STEM education in Pakistan to the general public. Taking Pakistan as an example, its government has built that kind of education and mandated far too much research into the subject to ensure high-quality education and long-term success for its citizens. If the decision is favorable, it may pave the way for beneficial ties between Pakistan's administration and other countries worldwide. STEM education should be made available to students at all levels of learning for the second time, and a customized curriculum should be developed depending on the availability of suitable equipment and labs in each location. Third, according to the World Economic Forum, to stay up with the rapid growth of the world economy, the Pakistani government must enhance its financing for science, technology, engineering, and mathematics education in the country. The fourth step is to support research in this field while also making data and information available to academics interested in development activities.

In STEM education (science, technology, engineering, and mathematics), a strong emphasis is placed on the development of 21st-century abilities in pupils. According to research, pupils who use these tactics are more likely than other students to achieve academic achievement in the STEM fields. According to one expert who advocates teaching 21st-century skills to students, children can work together to solve real-world problems and interact with their classmates utilizing problem-based learning approaches such as project-based learning, which are becoming increasingly popular (Rotherham & Willingham, 2009).

The socio-political environment has prevented us from concentrating on the most basic educational needs—education in Pakistan's agenda (Education for All National Review Report: Pakistan, 2015). Furthermore, Memon, Joubish, and Khurram (2010) asserted that the quality of education is falling at the primary and secondary school levels in the United States. Not only does schooling need to be improved, but so does scientific research. In Pakistan, the substandard education system is characterized by low budget allocation, incompetent elementary school teachers, and a lack of instructional content that is relevant and meaningful to students. Pakistan is plagued by crises, economic challenges, governance concerns, and security issues consistently (World Bank, 2016). It is necessary to develop Pakistan's education system to meet future inhabitants' needs. He feels that STEM education is an effective tool that may assist Pakistan in achieving economic stability and raising the standard of living for the average Pakistani citizen. Therefore, an organized and long-term policy on STEM education is essential to be implemented. We require a robust industrial system as well as a stable economic environment. In order to do so, highly educated individuals familiar with today's scientific and technical requirements are required. Technology and practical education must be prioritized over theoretical education to achieve our goals. STEM education equips students with the skills and knowledge necessary to address STEM literacy challenges.

Each student has a unique set of interests and requirements, and it is the instructor's responsibility to tailor programs to meet those requirements and interests while also acting as a mentor and mentoring them to deeper levels of understanding (Schlechty, 2011). A strong focus is placed on metacognition, real-world scenarios (including problem-solving), and creative thinking in order for students to learn knowledge. Students are propelled to higher levels of learning through the inquiry process, which ultimately results in a discipline-based mentality (Frechtling, Merlino, & Stephenson, 2015). Bloom's Taxonomy, established by Benjamin Bloom, is a framework for advanced learning that is still in use today. Instructors evaluate students' cognitive

frameworks for organizing their surroundings in greater depth when these learning objectives are used to build learning levels based on these learning objectives (Schlechty, 2011).

Pakistan is a developing country in South Asia that is still in the early stages of development. Starting a new idea or project is not a simple undertaking because it needs a great deal of preparation, training, and planning before being implemented appropriately and successfully implemented. Making time and financial resources committed to a new venture is a must. National Research Council (NRC) reports that when it comes to applying STEM education, several challenges arise, including cultural concerns and government level support; financial aid; scope; training; and content-related issues, among others (Breiner, Harkness, Johnson, and Koeler, 2012). When it comes to using STEM education, several challenges occur. In terms of instructors, the most crucial issue to ask is whether or not they have a diverse range of STEM competencies in various areas. Several authors have discovered content gaps in the literature, including Stinson, Harkness, Meyer, and Stallworth (2009). The establishment of coherent learning is another issue that needs to be addressed in STEM integration. However, it is unclear whether or not STEM topics contributed to more excellent conceptual learning (Guzey, Moore, & Harwell, 2016). We are suffering from an acute lack of motivation, which is characteristic of how people think in our culture nowadays. Adequate information and counseling should be provided to adolescents regarding their future educational and employment options. Teachers' reluctance to change their perspectives and the lack of compelling challenges serve as hurdles to advancement (Ertmer, Lehman, Park, Cramer, & Grove, 2003). Teaching techniques that have been in use for decades have a substantial effect.

Because a curriculum is not being updated to reflect the most current market specifications and requirements, it creates a curriculum challenge that necessitates the restructuring of a curriculum in order to implement STEM education programs in schools (Nadelson & Seifert, 2017). The topic of education-related governance challenges is addressed. There are insufficient family resources available. Compared to salaries at the worldwide level, salaries at the national level are low. Appropriate resources are in short supply (Stohlmann, Moore, & Roehrig, 2012). An insufficient number of educational institutions exists. There are not enough public awareness campaigns, training sessions, or opportunities for professional development. In addition to having a substantial impact on the decision to pursue a STEM career, the characteristics described above impact the establishment of STEM educational institutions and the growth of STEM education. The United Nations Development Program has determined that Pakistan's existing social context does not meet the requirements of a STEM program. Students' interest in science classes is declining, which is another barrier to academic success.

As Sadler and Zeidler (2004) state in their 2004 paper, the need for STEM employees has increased considerably in recent years. However, as previously stated, STEM education is essential for various reasons, including personal, professional, and practical ones. There is a robust innovation culture in place throughout the world. STEM education contributes to reducing racial and gender inequities in math and science education. STEM education is utilized to assist youngsters in understanding the ramifications of their actions. Finally, STEM education is critical to ensuring that America maintains its position as the world's leading economy. The United States will lose its global leadership position in mathematics and science if advancements in STEM education are not made. School Science, technology, engineering, and mathematics (STEM) education are necessary for high school students who intend to pursue STEM occupations. On the other hand, teachers are not solely responsible for the development of STEM knowledge and skills. Parents must also encourage their children to participate in STEM activities and learn about the benefits of STEM education at home and in extracurricular activities if they want their children to succeed in school.

In order to be effective in professional growth, Garet and colleagues (2001) identified the following components: 2) a focus on curriculum knowledge, 3) opportunities for hands-on learning, and 4) a direct connection to the school's everyday activities. Educators who engage in highly effective professional development by modeling inquiry techniques and grounding them in a shared set of professional standards that are tied directly to student performance objectives are

more likely to succeed in their classrooms, according to Supovitz and Turner (2000). In addition to increasing the effectiveness of professional development, these strategies can make it more difficult for participants to practice what they have learned after they have completed the course or workshop. The authors of Buczynski and Hansen (2007) state that when instructors return to the classroom following professional development, they may face various challenges, including limited resources, time constraints, mandated curriculum pacing, language acquisition, and classroom management concerns.

Because of these obstacles, school districts must assist teachers in teamwork and planning when they return from professional development programs (Wee, Shepardson, Fast, & Harbor, 2007). According to the authors, professional development approaches from prior research must be included in professional development programs focusing on integrated STEM education. Huntley (1998) provides an example of how professional development opportunities can emphasize the benefits of curriculum integration and provide instructors with the opportunity to improve their understanding of integrated STEM (Huntley, 1998).

## Research Methodology

Quantitative research collects and analyses numerical data to understand, predict, control occurrences (Gay, Mills, & Airasian, 2012), so researchers used a quantitative research design for the current study and employed descriptive research to address secondary school teachers' awareness about STEM education and challenges in its use. Rather than analyzing the effects of a phenomenon or action, descriptive research provides a "portrait" of it (Bickman & Rog, 1998). The study population was all the secondary school teachers in three districts, i.e., Gujranwala, Sialkot, and Vehari.

The researchers used a simple random sampling technique to choose a sample from the study's overall group of participants. As Cohen, Manion & Morrison (2005) suggested on page 194, the sample size will be 372 if the population size exceeds 10,000 and the population size is less than 10,000. As a result, 350 secondary school teachers from the Gujranwala, Sialkot, and Vehari were randomly selected for the current study. In this way, a sample of 350 secondary school teachers was finalized for the study's data analysis.

The researchers used a questionnaire as a research tool and this tool comprised three parts, i.e., demographic information, close-ended questions, and open-ended questions; the detail is as under:

**Table 1**

| S. No | Category | Number of Items |
|---|---|---|
| 1 | Demographic Information | 07 |
| 2 | Awareness about STEM | 17 |
| 3 | Use of STEM | 10 |
| 4 | Challenges | 13 |
| 5 | Open-Ended Questions | 02 |

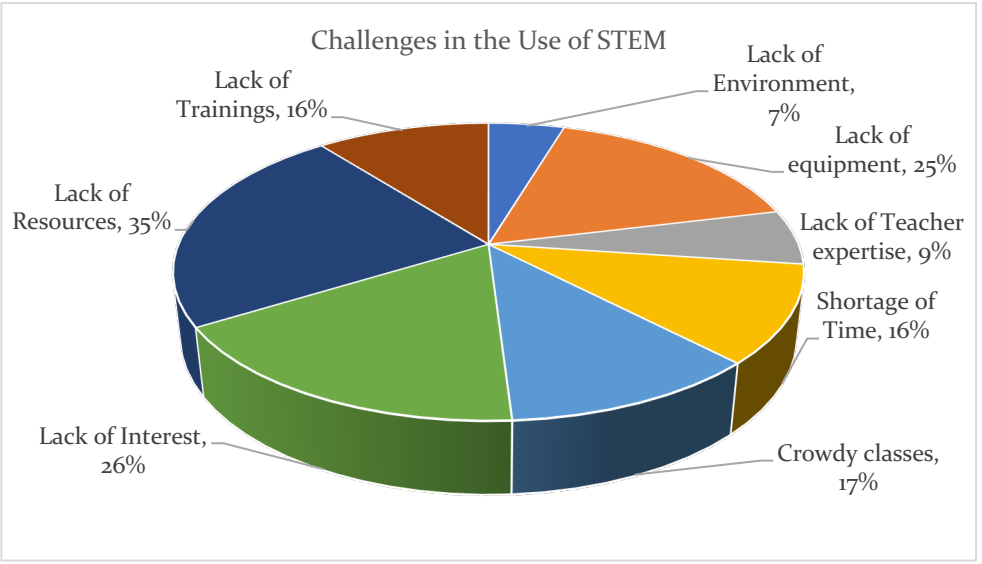
The questionnaires were distributed to the study sample through personal visits, google forms, and postal mail. Finally, the researchers received 350 questionnaires that were filled. The collected data were put in an Excel sheet and then shifted to SPSS for analysis. The statistical test of minimum, maximum, mean score, standard deviation, and Pearson correlation.

## Data Analysis and Interpretation

**Table 2.** Teachers' Awareness, use of STEM-based Education, and Challenges

| | N | Minimum | Maximum | Mean |
|---|---|---|---|---|
| Awareness | 350 | 2.1818 | 4.5455 | 3.515844 |
| Use | 350 | 2.1176 | 5.0000 | 4.060168 |
| Challenges | 350 | 2.2500 | 5.0000 | 3.860179 |

Table 2 mentions the perceptions of secondary school teachers about their awareness and challenges they face in the use of STEM-based education. The mean score value (3.515844) elaborate that most of the teacher responses inclined toward the agree on behavior about the items related to teachers' awareness regarding use of STEM-based education while mean score (4.060168) valued mentioned that teachers admitted the responses, they use STEM-based activities in their teaching-learning process. Related to the challenges in the use of STEM education, teachers' responded that they are facing a variety of challenges in using STEM education.




**Graph 1:** *Challenges in the use of STEM*

The Graph mentioned above refers to the challenges that secondary school teachers face in using STEM education at the secondary school level. Secondary school teachers face a variety of challenges at the secondary school level in using STEM-based education (activities). In their responses, the respondents enlisted the challenges they face; lack of environment, lack of equipment, lack of teachers' expertise, shortage of time, crowdy classes, lack of interest, lack of resources, and lack of training. The respondents (35%) answer that lack of resources is a significant hurdle in using STEM activities; on the other hand, teachers (26%) lack interest in performing the activities. While the respondents (25%) response that there is a lack of equipment in institutions for performing STEM activities. On the other hand, respondents (16%) revealed that they have a shortage of time for STEM activities, and respondents (16%) also mentioned that there is a lack of STEM training program for secondary school teachers while they (9%) responded that there is a lack of teacher expertise in STEM-based education. At last, respondents responded (7%) that there is a lack of environment for the awareness and use of STEM-based education and STEM activities.

**Table 3.** Relationship of Teachers' awareness and use of STEM

| | Mean | SD | Correlation | Sig. |
|---|---|---|---|---|
| Awareness | 3.515844 | .4390122 | .675 | .000 |
| Use | 4.060168 | .4683265 | | |

Table 3 reveals the values of the mean score (3.515844) and (4.060168) about teachers' awareness and teachers' use of STEM, respectively, while the values of standard deviation are

(.4390122) and (.4683265) about teachers' awareness and teachers' use of STEM respectively. Table 2 also reveals the value of Pearson correlation (.675) expressed that there is existed a positive correlation between teachers' awareness about STEM education and teachers' use of STEM education. It was a significant positive correlation between both the factors.

## Conclusions

The study entitled, "Teachers' Mindful Conception about the Use of STEM Education at Secondary School Level "was designed to address the existing use of STEM-based education in secondary schools and find out the challenges and relationship between teachers' perceptions related to their awareness and use of STEM practices at secondary school level.

The study concludes that secondary school teachers who taught STEM subjects have awareness about STEM-based education. In line with their awareness, they make the most exclusive use of STEM-based education to enhance critical and creative thinking abilities among secondary school students. On the other hand, they face many problems implementing STEM-based activities in secondary school classes at different levels.

The secondary school teachers face problems at academic and administrative levels about the use of STEM education. So, the study concluded that the teachers face a lack of conducive environment, lack of equipment, and teacher expertise, whereas they face a crowded classroom. Due to crowded classrooms, teachers cannot perform the activities in a short duration of time (40 minutes per lecture). The study also concluded that there is a most significant hurdle at the administrative level, namely, lack of resources for performing the STEM activities and due to lack of training, teachers also have a lack of interest in delivering STEM subjects through experiential learning or learning by doing. About the second objective, the study concluded a significant positive correlation between teachers' awareness about STEM-based education and the use of STEM-based education.

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