

*Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

## Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students

Sabir Hussain

Ph.D. Scholar, Department of Educational Training, The Islamia University of Bahawalpur, Punjab, Pakistan.

Email: [sabirjanmarri@gmail.com](mailto:sabirjanmarri@gmail.com)

Sabir Hussain

M.Phil. Scholar, Department of Education, Institute of Southern Punjab, Multan, Punjab, Pakistan.

Email: [sabirhussain148@gmail.com](mailto:sabirhussain148@gmail.com)

Zarina Khan

M.Phil. Education, Department of Education, University of Education Lahore, Faisalabad Campus, Punjab, Pakistan.

Email: [k.zari59@gmail.com](mailto:k.zari59@gmail.com)

Rai Muzammal Ali Khan

M.Phil. Education, Department of Education, University of Education Lahore, Faisalabad Campus, Punjab, Pakistan.

Email: [rai.muzamilkhah@gmail.com](mailto:rai.muzamilkhah@gmail.com)

Received on: 02-01-2024

Accepted on: 04-02-2024

### Abstract

With the passage of time, changes in the way of life of man have taken place and are taking place. Likewise, new inventions are increasing day by day. The use and role of these inventions in human life has been very important in every age. Many researchers are conducting research in the field of education, and new teaching methods are being discovered, which are not only making teaching learning easier but also increasing the mental performance of students. Educational psychologists are conducting new experiments daily to better understand students' cognitive abilities so that students can easily switch to science, technology, engineering, and math. For this purpose, present experimental research was conducted with the aim to increase students' creative thinking through an integrated curriculum. For this experiment, two groups of seventh-grade students were made; one group was taught the traditional curriculum, and the other group was taught the STEM integrated curriculum; this treatment continued for six months. After that, the post-test of both groups was conducted, and the creative thinking of the students treated through the STEM-integrated curriculum increased to a surprising level. Based on the results of this research, it is recommended that a STEM-

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

integrated curriculum should be taught instead of a traditional curriculum to develop creative thinking abilities in students.

**Keywords:** Students creative thinking, STEM integrated curriculum, Elementary school students, New trends in education, Students performance.

### **Introduction**

STEM education places a strong emphasis on the subjects like math, science, engineering, and technology. Schools and programs that focus on STEM encompasses a multidisciplinary learning process around the subjects of Science, Technology, Engineering and Mathematics. It helps the students to understand how concepts from one field can be applied to another field. It also depends on the resources available in a particular school district or region, STEM-focused learning programs can range from preschool to master's degree programs (Abu et al., 2022).

Science, technology, engineering, and mathematics (STEM) education is on the rise across the globe. Increasing students' interest in STEM-related higher education and job paths is one goal of STEM-based learning programs. In science, technology, engineering, and mathematics (STEM) classes, students often participate in a combination of classroom instruction, online resources, and hands-on projects. Students try to learn new approaches and solve problems with this model (Eugenijus, 2023).

Biology, Ecology, Chemistry, and Physics are some of the science subjects offered by STEM programs. Math, engineering, and technology are integral to STEM (science, technology, engineering, and mathematics) courses (Sulaeman et al., 2022).

In the recent years, technology classes have undergone a remarkable transformation. Alam (2022) lists digital modeling and prototyping, 3D printing, mobile tech, computer programming, data analytics, the IoT, machine learning, and game development as some of the topics covered in today's tech classes.

Robotics, electronics, mechanical, electrical, and civil engineering are all possible subjects covered in an engineering curriculum (Boya et al., 2022).

Math is a STEM field similar to science and contains courses that may sound familiar, like calculus, geometry, and algebra. However, in STEM math, students learn more complex concepts at younger ages; some students, including those not in STEM programs, begin learning introductory algebra and geometry as early as third grade. According to So (2023), STEM math is a body of work that integrates mathematical ideas with those from science, technology, and engineering.

STEM is now a cliché in the classroom. Many people have a surface-level knowledge of STEM education programs, but some really get how they affect American education. Through STEM education, students are brought up to speed on the most relevant skills and knowledge in today's society, which modernizes the learning process (Allam et al., 2023). STEM programs emphasize diversity, equality, and inclusion in their pursuit of talent. Javed (2024) found that STEM fields saw increased innovation, creativity, productivity, and revenue when diversity and inclusion were prioritized.

Thanks to STEM education, careers in engineering, computer networking, and information technology are on the rise. Despite the high demand for STEM jobs, there is a severe shortage of qualified professionals (Wong et al., 2022).

Critics of STEM education are concerned that the in-depth focus on science, technology,

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

engineering, and math shortchanges students' learning and experiences with other subjects that are also important, such as art, music, literature, and writing. According to Amelink et al. (2024), these subjects outside of STEM help with cognitive development, critical thinking, improve reading, and communication skills.

Another issue with STEM education is the lack of defined standards and programs for teachers. One example is the lack of a universally accepted credential for educators in the STEM fields. There is little opportunity for enjoyable classes or exposure to new ideas in the rigorous STEM curriculum students face in high school and beyond (felder & Brent, 2024).

A branch of STEM that broadens the scope of education to include the arts is known as STEAM, which stands for Science, Technology, Engineering, Arts, and Mathematics. According to Bowser (2023), the goal is to foster critical thinking skills by combining theoretical knowledge with practical application.

Some argue that children don't benefit enough from STEM education due to its narrow focus; the STEAM movement aims to change that. STEAM broadens the learning palette for children and young adults by adding creativity and innovation to STEM. Holt (2022) states that it offers a blended learning environment incorporating scientific thinking into every facet of life.

Among the most well-liked and sought-after STEM occupations are:

- Many different types of software engineers, systems analysts, statisticians, and others work in the computing field.
- Engineering and physical sciences: Careers in this broad category include civil, electrical, and mechanical engineers. Cartographers, orthodontists, and biochemists are just a few examples of the surprising professions represented.
- There is much opportunity for advancement in the life sciences and mathematics, although the number of available jobs is smaller. A few examples of people working in clinical research, mathematics, and economics.

The ability to think creatively is a skill that people need in the modern world. It involves coming up with ideas, making assumptions, testing those ideas, and finally, effectively communicating the results (Abdulla et al., 2020). According to Wahono et al. (2020), students should be encouraged to think creatively throughout their schooling and be given the necessary skills to tackle future challenges.

STEM-based curricula integrate multiple teaching and learning approaches, such as problem-based learning, adaptation skills to solve real-life problems and project-based learning, requiring inquiry and technological skills to develop students' creativity (Apriyani et al., 2019; Hamad et al., 2022). Several factors, including gender and grade level, may influence how students' creativity develops after implementing a STEM-based curriculum, even though several STEM-based curriculum approaches impact students' creativity (Bambang, 2022).

In contrast, research has demonstrated that students' capacity for creative thinking is enhanced through integrating STEM subjects in the classroom (Han et al., 2021; Rasul et al., 2018). Creativity is an essential part of growing up. Incorporating creative thinking into the classroom helps kids develop personally, emotionally, and intellectually, making them better people overall. Thus, it is crucial to promote creativity in the school so that students can adapt to an ever-changing world, develop their unique perspectives, learn about other cultures, and

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

think critically and innovatively, all to the benefit of themselves and society as a whole. Thinking creatively and solving problems are essential skills for the modern world, and STEM education helps cultivate both. The necessity for a curriculum that promotes creativity, critical thinking, and problem-solving has been brought to light by the poor results in international tests (TIMSS and PISA) (Kasza & Slater, 2017). In order to close the achievement gap on standardized tests, several studies have called for a better STEM-based curriculum (Costa et al., 2022). On the other hand, some have stressed the need to encourage pupils' imaginative capacities to raise their academic outcomes (Lynch et al., 2018). Accordingly, by exploring the effects of a STEM-based curriculum on Pakistani elementary school students' levels of creative thinking, this study addresses a significant research gap.

Research from various nations shows that STEM education programs help students develop their creative thinking abilities. These countries include the US, Canada, the UK, the EU, Indonesia, Japan, China, and the Middle East. Asghar et al. (2012) found that students who took part in STEM programs had better creative thinking skills. Among Indonesian students who participated in STEM programs, researchers discovered a marked improvement in their ability to think creatively (Adams et al., 2011). Similarly, research in Finland, China, and Japan has shown that STEM education significantly boosts students' creative thinking (Fang, 2020). These worldwide results highlight the importance of STEM education in fostering students' creative thinking, highlighting the need to examine the effect of a STEM-based curriculum on Pakistani primary school students.

### **Justification of the Study**

Human beings are continuously developing in every field, and every field has evolved, and education has also developed a lot. The role of psychology in education has been seen to be very important; students' critical thinking is being emphasized towards solving real-life problems. Educators and psychologists have done a lot of research on students' critical thinking, one of them being the STEM integrated curriculum. In this method, children are taught by integrating the science, technology, engineering, and mathematics curriculum, which has yielded excellent results. With students' performance, it has been possible to see an immense increase in their critical thinking. The present research was experimental research of this series, the purpose of which was to see the effect of STEM integrated curriculum on students' critical thinking and whether this integrated curriculum has any impact on student's critical thinking. The results of this research will create a new way of thinking for teachers, parents, and educationists on how to teach children through the STEM-integrated curriculum in the future to increase students' creativity and critical thinking. The results of this research will be equally valuable for educational psychologists.

### **Limitations of the Study**

There are several caveats that should be considered when extrapolating the results from this study, even though it has added substantially to our knowledge of STEM education. The results may not be generalizable to other populations due to the study's narrow focus on a single school and its curriculum. It is possible that the TTCT, or Torrance Tests of Creative Thinking, do not fully capture the complexities of students' creative thinking. There is cause for concern regarding the subjectivity of test results, which can be swayed by participants'

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

mistakes and lack of effort. Furthermore, concerns regarding the representativeness of results over different time frames are raised when data collection and analysis are conducted in the same term. In the context of STEM education, these limitations highlight the importance of exercising caution when interpreting results.

### **Objectives of the Study**

The following were the objectives of the study;

1. To increase students' creative thinking ability through STEM integrated curriculum.
2. To give suitable recommendations about the STEM Integrated Curriculum.

### **Hypothesis of the Study**

The following was the hypothesis of the research;

Ho.1 STEM Integrated Curriculum does not affect students' creative thinking.

### **Theoretical Framework**

According to Piaget's cognitive constructivism theory, which is the theoretical basis of this study (Le et al., 2023), learners build knowledge by utilizing their prior knowledge and engaging in self-directed learning. Cognitive constructivism emphasizes student-centered learning and suggests that teachers act as facilitators rather than primary sources of information (Rasul et al., 2018). Students' intrinsic motivation, critical thinking skills, and capacity for self-directed learning are all enhanced through the constructivist method's emphasis on their active engagement in knowledge construction (Guzey et al., 20214).

According to Qureshi et al. (2023), cognitive constructivism theory emphasizes the importance of students working together to engage in collaborative learning activities such as debating, reflecting, and discussing what they have learned. Students' environmental awareness and knowledge are both enriched by this method. A STEM-based curriculum is structured around cognitive constructivism, emphasizing student-led learning through collaborative projects and active knowledge construction (Hamad et al., 2022; Sellami et al., 2022).

Learning to solve complicated problems and make connections to real-life situations is an excellent way for students to develop self-regulation, creativity, and critical thinking; this is something that STEM education and cognitive constructivism theory both stress (Kasza & Slater, 2017). When integrated into STEM education, cognitive constructivism theory can help students develop their innovative competencies by teaching them to solve real-world problems using information from multiple disciplines (Le et al., 2023).

Curriculum frameworks in the STEM fields have close ties to the tenets of cognitive constructivism. According to Sarı et al. (2018), these methods emphasize students' active knowledge construction rather than teachers' passive knowledge transmission. Additionally, collaborative learning activities promote students' interaction, teamwork, and collaboration toward a shared academic objective (Kayan-Fadlelmula et al., 2022).

Students are encouraged to be self-reflective, creative, and critical thinkers in both paradigms as they work to solve complex classroom problems and make connections to real-world situations (Guzey et al., 2014).

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

### **Literature Review**

Whether STEM education is an umbrella term for interdisciplinary study or a set of core competencies with broad applicability is an open question (Siekmann & Korbel, 2016). The STEM education debate has intensified due to the diverse viewpoints and definitions surrounding the topic. However, there is broad consensus on the following assertions: According to Costa et al. (2022), integrated STEM instruction does three things: (a) encourages students to learn by doing in real-world contexts; (b) uses student-centered pedagogies like design thinking and inquiry-based learning; and (c) helps them develop skills that are relevant in the modern world. There is still a problem, though, that the education sector does not fully grasp the significance of technology in STEM education initiatives.

Whether considered singularly or as part of a more extensive set of competencies known as “21st-century skills” (Di et al., 2021), the importance of teaching students to think creatively and independently has been increasingly acknowledged in recent years. There is agreement that creative thinking is essential, but different schools of thought and measurement methods have led researchers to disagree on what it means and how to define it (Said et al., 2020). According to researchers, academics still need to come to a consensus on what constitutes creative thinking (Bart et al., 2017).

According to recent studies aiming at a precise definition of creativity, TTCT has become very popular (Alabbasi et al., 2022). (Papili, 2022) emphasized the value of TTCT as a quantitative indicator of students’ levels of creative thinking.

To succeed in the modern world, students must think outside the box and develop original solutions to problems (Lee & Carpenter, 2015). Developing one’s creative thinking skills begins in the first year of college and continues throughout a person’s academic career, according to research (Sabir et al., 2021; Bart et al., 2017). As a result, creative thinking should be developed by preparing learning environments that influence the number of experiences that young learners have in their core classes.

Research from various sources (e.g., Kasza & Slater, 2017; Devi, 2019; Asunda, 2014) highlights the beneficial effects of STEM-based education on developing abilities such as critical thinking, creativity, problem-solving, mental flexibility, and practical application. Scientific studies have demonstrated that students of all grade levels benefit from STEM education regarding increased cognitive flexibility and self-exploration (Hussain et al., 2022; Amir et al., 2022; Shernoff et al., 2017). By fostering analytical thinking, originality, and imagination in various classroom settings, this corpus of work aligns with the STEM education principles highlighted by (Millar, 2020). At the same time, researchers discovered that STEM experiences had a substantial influence on students’ environmental awareness, which in turn impacted their learning attitudes, motivation, and capacity for adaptive thinking (Hafeez et al., 2023; Umar et al., 2023; Morrison et al., 2015). On a related note, researchers found that students in 10th grade outperformed those in 12th grade on the Torrance Tests of Creative Thinking’s (TTCT) flexibility metric, and they concluded that this difference was due to students’ increased curiosity about the unknown (Belbase et al., 2022). On the other hand, Khali et al. (2023) found that high school students who participated in STEM education programs exhibited more cognitive flexibility. Unexpectedly, their results pointed to the necessity for a more significant enhancement of cognitive flexibility throughout high school, potentially due to intrinsic factors like motivation and prior knowledge

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

superseding the influence of the curriculum. Similarly, Leonard et al. (2016) observed no significant improvement in the originality of students enrolled in high school STEM education programs. Based on these results, the STEM curricula seem less critical than personal characteristics when encouraging creativity. There has been much research into gender differences in creativity in behavioral studies. According to earlier studies, gender does affect creativity levels (Hussain et al., 2023; Ahmad et al., 2023; Oberle et al., 2012).

In addition, research has shown that biological differences between the sexes may manifest as creative differences (Toraman et al., 2020). Because women are more naturally curious and open to new information, they perform better on the TTCT than men (Constantine et al., 2015). Also, according to Hidayat et al. (2018), while men did better on the originality subtest, females did better on the overall TTCT score and the fluency and flexibility subtests.

On the other hand, a meta-analysis found no significant gender differences in creative abilities in the general population (Bart et al., 2015). However, when looking at children's divergent thinking, which is a part of innovative thinking, the impact of gender becomes less significant (Hirnstein et al., 2019). The study also highlighted that age and parental education shape gender-related variations in creative thinking among children.

Society benefits from creative thinking because it generates original concepts, ideas, principles, and goods (Kousoulas & Mega, 2009). If we want our students to show creativity in the future, we need to foster it in them now. Abraham (2016) lists creative thinking, creative writing, and creative arts as forms of creativity. Proper communication and expression of these ideas in later life requires instruction and support for students. Due to a gradual improvement in students' capacity for detailed and reflective thought, students' grade level may impact their creative thinking (Reilly et al., 2022). Researchers have shown that students' ability to think creatively and imaginatively could be significantly enhanced if they were exposed to different learning scenarios as they progressed through the grades (Suwandari et al., 2019; Runco & Jaeger, 2012).

### **Methods and Procedures**

The purpose of the research was to check the creative ability of students through a STEM-integrated curriculum. For this purpose, experimental research was conducted on the students of class VII. An integrated curriculum was prepared, then pilot tested, and some changes were made into a final composed book with a STEM syllabus; this book consisted of 200 pages and was to be taught for six months. Two groups of students were formed for the experiment of STEM integrated curriculum; one was taught through traditional curriculum, and the other was given treatment through STEM integrated curriculum; this treatment lasted for six months; after that, both groups were taken post-test and both of them the results were compared, and the effects of the STEM integrated curriculum on the students were checked. These effects were checked using statistical tools by extracting the mean value and then the standard deviation. The independent sample t-test was applied to see the difference in mean values between these two groups. The alpha value was set to 0.05 for significance.

### **A sampling of the study**

It was true experimental research. Its sampling was done in two phases. In the first stage, the Class VII Abdul Aziz Section of Rafiq Public High School District Dera Ghazi Khan was selected

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

using the cluster sampling method; were 68 students in this section. The medium of instruction in this section was English. All 68 students were given the (TTCT) test as a pre-test with 50 marks. Only those students whose test scores ranged between 30 to 40 were taken from this entire class for research; all high scorers and low scorers were skipped from the research sampling; thus, only an average scorer of 60 students was selected for this experiment. In the second phase, these 60 students were divided into two groups by fishbowl simple random sampling, making two groups of 30 and 30 students each; this is a very effective way for experimental research (Singh & Masuku, 2014). In this way, two groups were formed: one was a control group, and the second was an experimental group. The experimental group was given treatment.

### **Experimental Content**

For this experiment, a unique curriculum including a STEM syllabus was set up, the help of expert teachers was taken to create this syllabus, integrated notes were made by including all the components of STEM in this syllabus, and this syllabus was prepared in the form of a beautiful book containing 200 pages which would be taught in 6 months. The curriculum was examined from various angles to meet the requirements of the STEM integrated curriculum. This curriculum has been specially designed considering the IQ level and age of the children of class 7<sup>th</sup>. This syllabus was designed in English medium. After creating this curriculum, it was taught as a pilot test for one month to the children of Class VII Section Al-Rafiq. After that, it was finalized for the experiment by making a few changes.

### **Pre and Post-test Instrument**

The present research primarily used the Torrance Tests of Creative Thinking (TTCT). TTCT has been a widely used test for measuring creativity since its development in the 1960s (Kim, 2011; Ren et al., 2012). The study used a modified version of the Torrance Test, initially called the Figural TTCT, to ensure it was appropriate for the research content. Two tests were made first for pre-test and second for post-test. The validity and reliability of the tests had improved through multiple rounds of revisions and updates. Two academics with backgrounds in STEM education were among the experts consulted to determine the TTCT content's construct validity.

### **Validity and Reliability of the Tools**

Both pre (TTCT) and post (TTCT) tests were validated by experts, who also ensured the reliability of the tests. The pre (TTCT) reliability was .92, and the post (TTCT) test was .89.

### **Data Analysis Procedure**

Two TTCT tests were conducted in this experimental research. One test was used as a pre-test to select the sample, then the second was used as a post-test. Post-test (TTCT) was taken after the treatment. In this experiment, only the post-test results were compared to check the student's creative thinking through STEM integrated curriculum. The difference was checked by extracting the mean value and standard deviation of the post-test, and then an independent t-test was applied to check the difference between the mean values of the two groups. The purpose of this experiment was to check the creative thinking level of the

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

students between two groups treated with different modes of curriculum.

Table No. 1

*Ho1. STEM Integrated Curriculum does not affect student's creative thinking.*

| Groups       | Independent Sample t-test |         |          |          | Sig. |
|--------------|---------------------------|---------|----------|----------|------|
|              | <i>f</i>                  | $\mu$   | $\sigma$ | <i>t</i> |      |
| Controlled   | 30                        | 22.8667 | 2.19957  | -25.404  | .000 |
| Experimental | 30                        | 41.8667 | 1.88478  |          |      |

Table No. 1 describes the results of the study. It was found that the experimental group's mean was higher than the control group, and a significant difference between both mean scores was found. The mean value of the control group was (22.8667), and the standard deviation was (2.19957). The mean value of the experiment group was (41.8667), and the standard deviation was (1.88478). The t-test value was (-25.404),  $p < .05$ ; the null hypothesis was not accepted.

### Conclusions

In this experimental research, an attempt was made to build creative thinking among students through a STEM-integrated curriculum. Students were checked by taking (TTCT) test. The creative thinking of the students treated through the STEM integrated curriculum had increased surprisingly.

### Recommendations

According to the conclusions of this experimental research, it is recommended that STEM integrated curriculum should be taught to school-level students instead of the general traditional curriculum; this will significantly increase the students' creative thinking, and students in any field of STEM in the future will switch easily. Creative thinking helps children in the academic field and in real life.

### References

1. Abdulla, A. M., Paek, S. H., Cramond, B., & Runco, M. A. (2020). Problem finding and creativity: A meta-analytic review. *Psychology of Aesthetics, Creativity, and the Arts*, 14(1), 3.
2. Abraham, A. (2016). Gender and creativity: an overview of psychological and neuroscientific literature. *Brain imaging and behavior*, 10(2), 609-618.
3. Abu Khurma, O., Al Darayseh, A., & Alramamneh, Y. (2022). A framework for incorporating the "learning how to learn" approach in teaching STEM education. *Education Sciences*, 13(1), 1.
4. Adams, A. E., Miller, B. G., Saul, M., & Pegg, J. teachers to teach STEM through place-based teaching and learning experiences. *Electronic Journal of Science Education*, 18 (5), 1-22. Ainley, M. & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Journal of Science Education*, 18(5), 1-22.
5. Ahmad, M., Hussain, S., & Qahar, A. (2023). Learning Outcomes by Integrating Blended Learning Flipped Classroom Model: An Experiment on Secondary School Students. *International Research Journal of Management and Social Sciences*, 4(3), 566-578.
6. Ahmad, M., Hussain, S., Mehmood, M. A., & Qahar, A. (2023). Learning Outcomes by Integrating Virtual Reality: An Experiment on Secondary School Students. *International Research Journal of Management and Social Sciences*, 4(4), 473-484.
7. Alabbasi, A. M. A., Paek, S. H., Kim, D., & Cramond, B. (2022). What educators need to know

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

about the Torrance Tests of Creative Thinking: A comprehensive review. *Frontiers in psychology*, 13, 1000385.

8. Alam, A. (2022). Employing adaptive learning and intelligent tutoring robots for virtual classrooms and smart campuses: reforming education in the age of artificial intelligence. In *Advanced computing and intelligent technologies: Proceedings of ICACIT 2022* (pp. 395-406). Singapore: Springer Nature Singapore.
9. Allam, H., Dempere, J., Akre, V., Parakash, D., Mazher, N., & Ahamed, J. (2023, May). Artificial intelligence in education: an argument of Chat-GPT use in education. In *2023 9th International Conference on Information Technology Trends (ITT)* (pp. 151-156). IEEE.
10. Amelink, C. T., Grote, D. M., Norris, M. B., & Grohs, J. R. (2024). Transdisciplinary Learning Opportunities: Exploring Differences in Complex Thinking Skill Development Between STEM and Non-STEM Majors. *Innovative Higher Education*, 49(1), 153-176.
11. Amir, M., Hussain, S., & Muhammad, S. (2022). Identification of the need for teacher training at the primary school level. *International Research Journal of Education and Innovation*, 3(1), 165-176.
12. Apriyani, R., Ramalis, T. R., & Suwarma, I. R. (2019). Analyzing Students' Problem Solving Abilities of Direct Current Electricity in STEM-Based Learning. *Journal of Science Learning*, 2(3), 85-91.
13. Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-Based Learning*, 6(2), 4.
14. Asunda, P. A. (2014). A conceptual framework for STEM integration into curriculum through career and technical education. *Journal of STEM Teacher Education*, 49(1), 4.
15. Bambang, S. A. (2022). The Comparison of STEM approach and SSCS Learning Model for Secondary School-Based on K-13 Curriculum: The Impact on Creative and Critical Thinking Ability. *Revista de Educación a Distancia*, 22(70), 1-26.
16. Bart, W. M., Hokanson, B., & Can, I. (2017). An investigation of the factor structure of the Torrance Tests of Creative Thinking. *Educational Sciences: Theory and Practice*, 17(2), 515-528.
17. Bart, W. M., Hokanson, B., Sahin, I., & Abdelsamea, M. A. (2015). An investigation of the gender differences in creative thinking abilities among 8th and 11th grade students. *Thinking Skills and Creativity*, 17, 17-24.
18. Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2022). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology*, 53(11), 2919-2955.
19. Bowser, Z. (2023). *Art History in STEAM: Integrating Art Historical Content and Pedagogy into High School Mathematics Curricula* (Doctoral dissertation, Drew University).
20. Boya-Lara, C., Saavedra, D., Fehrenbach, A., & Marquez-Araque, A. (2022). Development of a course based on BEAM robots to enhance STEM learning in electrical, electronic, and mechanical domains. *International Journal of Educational Technology in Higher Education*, 19(1), 7.
21. Constantine, N. A., Jerman, P., Berglas, N. F., Angulo-Olaiz, F., Chou, C. P., & Rohrbach, L. A. (2015). Short-term effects of a rights-based sexuality education curriculum for high-school students: a cluster-randomized trial. *BMC Public Health*, 15, 1-13.
22. Costa, M. C., Domingos, A. M. D., Teodoro, V. D., & Vinhas, É. M. R. G. (2022). Teacher professional development in STEM education: An integrated approach with real-world scenarios in Portugal. *Mathematics*, 10(21), 3944.
23. Devi, K. S. (2019). Constructivist approach to learning based on the concepts of Jean Piaget and lev Vygotsky. *the NCERT and no matter may be reproduced in any form without the prior permission of the NCERT*, 44(4), 5-19.
24. Di, C., Zhou, Q., Shen, J., Li, L., Zhou, R., & Lin, J. (2021). Innovation event model for STEM education: A constructivism perspective. *STEM Education*, 1(1), 60-74.
25. Eugenijus, L. (2023). Integrating blended learning and STEM education: Innovative

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

- approaches to promote interdisciplinary learning. *Research and Advances in Education*, 2(9), 20-36.
26. Fang, Z. (2020, June). Review and Prospect of Research on Innovation Thinking at Home and Abroad. In *Journal of Physics: Conference Series* (Vol. 1549, No. 3, p. 032044). IOP Publishing.
  27. Felder, R. M., & Brent, R. (2024). *Teaching and learning STEM: A practical guide*. John Wiley & Sons.
  28. 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.
  29. Hafeez, A., Hussain, S., Muhammad, S., & Hussain, S. (2023). Effect of PEC Exams on Quality Education in Public and Punjab Education Foundation Funded Secondary Schools. *International Research Journal of Management and Social Sciences*, 4(3), 358-374.
  30. Hamad, S., Tairab, H., Wardat, Y., Rabbani, L., AlArabi, K., Yousif, M., ... & Stoica, G. (2022). Understanding science teachers' implementations of integrated STEM: Teacher perceptions and practice. *Sustainability*, 14(6), 3594.
  31. Han, J., Kelley, T. R., Mentzer, N., & Knowles, J. G. (2021). Community of practice in integrated STEM education: A systematic literature review. *Journal of STEM Teacher Education*, 56(2), 5.
  32. Hidayat, T., Susilaningsih, E., & Kurniawan, C. (2018). The effectiveness of enrichment test instruments design to measure students' creative thinking skills and problem-solving. *Thinking Skills and Creativity*, 29, 161-169.
  33. Hirnstein, M., Hugdahl, K., & Hausmann, M. (2019). Cognitive sex differences and hemispheric asymmetry: A critical review of 40 years of research. *Laterality: Asymmetries of Body, Brain and Cognition*, 24(2), 204-252.
  34. Holt, D. (2022). *Successful STEAM Schools with a Focus on Improving Innovation and Ideation: A Case Study* (Doctoral dissertation, California State Polytechnic University, Pomona).
  35. Hussain, S. (2021). Quality of Education in Public and Daanish Schools at Secondary Level. *International Research Journal of Education and Innovation*, 2(2), 160-169.
  36. Hussain, S., Abbas, Q., & Ahmad, A. (2022). Comparative analyses of environmental risk management at secondary schools level in punjab and its effect on students' academic achievement. *International Research Journal of Education and Innovation*, 3(4), 36-49.
  37. Hussain, S., Ahmad, M. S., & Hussain, S. (2022). Relationship of teacher-student interaction, learning commitment and student learning comfort at secondary level. *International Research Journal of Education and Innovation*, 3(2), 156-169.
  38. Hussain, S., Ahmad, M., Altaf, H. S., & Ahmad, M. F. (2022). Quality of Education in Public and Punjab Education Foundation Funded Schools at Secondary Level. *Journal of Research & Reflections in Education (JRRE)*, 16(2).
  39. Hussain, S., Ahmad, M., Ul Zaman, F., & Ahmad, A. (2023). Comparative Study of Administrators' Supervisory Skills and Teachers' Pedagogical Skills Towards Quality Education in Public and Punjab Education Foundation Funded Schools at Secondary Level. *Journal of Education & Educational Development*, 10(2).
  40. Hussain, S., Hafeez, A., Zaman, F. U., & Seerat, S. S. (2023). Why Quality of Education is Low at the Secondary Level in Pakistan: A Group Discussion. *International Research Journal of Management and Social Sciences*, 4(4), 190-205.
  41. Hussain, S., Zaman, F. U., Muhammad, S., & Hafeez, A. (2023). Analysis of the Initiatives taken by HEC to Implement Associate Degree Program: Opportunities and Challenges. *International Research Journal of Management and Social Sciences*, 4(3), 193-210.
  42. Javed, H. (2024). Creating a Positive Workplace Culture: Diversity, Equity, and Inclusion Initiatives. In *Innovative Human Resource Management for SMEs* (pp. 367-394). IGI Global.
  43. Kasza, P., & Slater, T. F. (2017). A survey of best practices and key learning objectives for successful secondary school STEM academy settings. *Contemporary Issues in Education Research*

## *Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

(CIER), 10(1), 53-66.

44. Kayan-Fadlelmula, F., Sellami, A., Abdelkader, N., & Umer, S. (2022). A systematic review of STEM education research in the GCC countries: Trends, gaps and barriers. *International Journal of STEM Education*, 9, 1-24.
45. Khalil, R. Y., Tairab, H., Qablan, A., Alarabi, K., & Mansour, Y. (2023). STEM-Based Curriculum and Creative Thinking in High School Students. *Education Sciences*, 13(12), 1195.
46. Kim, K. H. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. *Creativity research journal*, 23(4), 285-295.
47. Kousoulas, F., & Mega, G. (2009). Students' divergent thinking and teachers' ratings of creativity: Does gender play a role?. *The Journal of Creative Behavior*, 43(3), 209-222.
48. Le, H. C., Nguyen, V. H., & Nguyen, T. L. (2023). Integrated STEM approaches and associated outcomes of K-12 student learning: a systematic review. *Education Sciences*, 13(3), 297.
49. Lee, S., & Carpenter, R. (2015). Creative thinking for 21st century composing practices: Creativity pedagogies across disciplines. *Across the Disciplines*, 12(4), 1-24.
50. Leonard, J., Buss, A., Gamboa, R., Mitchell, M., Fashola, O. S., Hubert, T., & Almughyirah, S. (2016). Using robotics and game design to enhance children's self-efficacy, STEM attitudes, and computational thinking skills. *Journal of Science Education and Technology*, 25, 860-876.
51. Lynch, S. J., Burton, E. P., Behrend, T., House, A., Ford, M., Spillane, N., ... & Means, B. (2018). Understanding inclusive STEM high schools as opportunity structures for underrepresented students: Critical components. *Journal of Research in Science Teaching*, 55(5), 712-748.
52. Millar, V. (2020). Trends, issues and possibilities for an interdisciplinary STEM curriculum. *Science & Education*, 29(4), 929-948.
53. Morrison, J., Roth McDuffie, A., & French, B. (2015). Identifying key components of teaching and learning in a STEM school. *School Science and Mathematics*, 115(5), 244-255.
54. Oberle, E., Schonert-Reichl, K. A., Lawlor, M. S., & Thomson, K. C. (2012). Mindfulness and inhibitory control in early adolescence. *The Journal of Early Adolescence*, 32(4), 565-588.
55. Papili, S. (2022). *A Quantitative Correlational Study of Creative Thinking Level and Grade Point Average Among High School Students* (Doctoral dissertation, Northcentral University).
56. Qureshi, M. A., Khaskheli, A., Qureshi, J. A., Raza, S. A., & Yousufi, S. Q. (2023). Factors affecting students' learning performance through collaborative learning and engagement. *Interactive Learning Environments*, 31(4), 2371-2391.
57. Rasul, M. S., Zahriman, N., Halim, L., Rauf, R. A., & Amnah, R. (2018). Impact of integrated STEM smart communities program on students scientific creativity. *Journal of Engineering Science and Technology*, 13(11), 80-89.
58. Reilly, D., Neumann, D. L., & Andrews, G. (2022). Gender differences in self-estimated intelligence: Exploring the male hubris, female humility problem. *Frontiers in psychology*, 13, 812483.
59. Ren, F., Li, X., Zhang, H., & Wang, L. (2012). Progression of Chinese students' creative imagination from elementary through high school. *International Journal of Science Education*, 34(13), 2043-2059.
60. Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity research journal*, 24(1), 92-96.
61. Said-Metwaly, S., Kyndt, E., & Van den Noortgate, W. (2020). The factor structure of the Verbal Torrance Test of Creative Thinking in an Arabic context: Classical test theory and multidimensional item response theory analyses. *Thinking skills and creativity*, 35, 100609.
62. Sari, U., Alici, M., & Şen, Ö. F. (2018). The effect of STEM instruction on attitude, career perception and career interest in a problem-based learning environment and student opinions. *The Electronic Journal for Research in Science & Mathematics Education*, 22(1).
63. Sellami, A., Ammar, M., & Ahmad, Z. (2022). Exploring Teachers' Perceptions of the Barriers to Teaching STEM in High Schools in Qatar. *Sustainability* 2022, 14, 15192. *Rebuilding Education*, 184.

*Building Students Creative Thinking Ability Through STEM Integrated Curriculum: An Experiment on Elementary School Students*

64. 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, 1-16.
65. Siekmann, G., & Korbel, P. (2016). Defining "STEM" Skills: Review and Synthesis of the Literature. Support Document 1. *National Centre for Vocational Education Research (NCVER)*.
66. Singh, A. S., & Masuku, M. B. (2014). Sampling techniques & determination of sample size in applied statistics research: An overview. *International Journal of economics, commerce and management*, 2(11), 1-22.
67. So, W. W. M. (2023). Does computation technology matter in science, technology, engineering and mathematics (STEM) projects?. *Research in Science & Technological Education*, 41(1), 232-250.
68. Sulaeman, N. F., Putra, P. D., & Kumano, Y. (2022). Towards integrating STEM education into science teacher preparation programmes in indonesia: A challenging journey. In *Concepts and Practices of STEM Education in Asia* (pp. 237-252). Singapore: Springer Nature Singapore.
69. Suwandari, S., Ibrahim, M., & Widodo, W. (2019). Application of discovery learning to train the creative thinking skills of elementary school student. *International Journal of Innovative Science and Research Technology*, 4(12), 410-417.
70. Toraman, Ç., Özdemir, H. F., Aytuğ Koşan, A. M., & Orakçı, Ş. (2020). Relationships between cognitive flexibility, perceived quality of faculty life, learning approaches, and academic achievement.
71. Umar, Z., Hussain, S., Khan, I., & Perveen, F. (2023). Parents' Involvement Effect on Students' Academic Achievement and Quality Education in Public and Private Schools at Elementary Level. *International Research Journal of Management and Social Sciences*, 4(3), 400-411.
72. Umar, Z., Sadiqi, T., Hussain, S., & Qahar, A. (2023). Compare the Quality of Infrastructure on Student Outcomes in Public and Punjab Education Foundation Funded Schools at Secondary Level. *International Research Journal of Management and Social Sciences*, 4(4), 26-39.
73. Wahono, B., Lin, P. L., & Chang, C. Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, 7(1), 36.
74. Wong, B., Chiu, Y. L. T., Murray, Ó. M., & Horsburgh, J. (2022). End of the road? The career intentions of under-represented STEM students in higher education. *International Journal of STEM Education*, 9(1), 51.