Academic Performance of Students with and without Stem Education

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Abstract

This research work was designed to know academic performance of students with and without STEM education. It was a quasi-experimental research and non-equivalent control group design was used. Self-developed achievement test in the subject of General Science were used as research tool. Grade eight textbook was used as the instrument of the study. The sample was selected using a simple random sampling technique. Two sample classes and their students were randomly selected from public sector girls' schools of District Jhang. Selected classes were randomly assigned as control group and experimental group. Academic achievement of students was checked before the treatment using pretest and after the treatment using posttest. Collected data was analyzed using statistical techniques (i.e., Mean, SD and t-test) using Statistical Package for Social Sciences. The objectives of the study were; (a) to find out academic performance of students in grade 8. (b) to find out effectiveness of STEM education in improving academic performance of students of grade 8. It was concluded that the academic performance of students was almost same before the treatment while, after the treatment, the academic performance of students of experimental group was higher than the academic performance of control group. It was found that equal ability students when taught through STEM education performed better after the treatment. Hence STEM education method proved as better alternative as compared to the traditional method for teaching science.

Keywords: STEM education; Academic performance; critical thinking skills; Problem solving skills.

Introduction

The academic performance of students with STEM (science, technology, engineering, and math) education is an important topic of study, as STEM education has become increasingly important in the modern economy. STEM education refers to the teaching and learning of science, technology, engineering, and mathematics subjects in an integrated and interdisciplinary approach. With the rapid advancements in technology and science, STEM education is seen as a critical pathway to develop a skilled workforce, drive innovation, and promote economic growth. STEM was developed to answer challenges in the 21st century. The goal of STEM education is to prepare students for competition and job readiness in their chosen fields. Students' critical thinking abilities will develop as a result of using STEM education, and they will also become more inventive, rational, productive, and directly related to actual conditions (Widya et al., 2019).

Many nations view STEM method as significant, and they have initiatives to incorporate it into their curricula (Tunc and Bagceci 2021). STEM education has grown in importance as a strategy and method for the development of scientific and technical innovation skills and the reform of education and teaching in numerous nations throughout the world due to the rapid development of the global economy, science, and technology (Hali et al; 2021). For middle school students to develop their critical thinking abilities and STEM vision, STEM education is essential in the twenty-first century (Hacioglu and Gulhan 2021). Overall academic performance of students of District Jhang, Pakistan is not so good as compared to the world. The academic performance of students in Pakistan varies depending on a number of factors including socioeconomic status, gender, location, and access to quality education. While there are many talented and high-achieving students in Pakistan, the country faces a number of challenges that can make it difficult for students to perform to their full potential. Recently, numerous programs have been started throughout Pakistan to increase students' interest in STEM fields of study (Aslam et al 2022).

One of the biggest challenges which students face in Pakistan is access to quality education. Many schools in Pakistan are under-resourced and understaffed, with inadequate facilities and shortage of qualified teachers. This can make it difficult for students to receive high-quality education that prepares them for higher education and professional careers. For students to be motivated to learn and to be better prepared for real-world difficulties, teachers must use an integrated strategy of STEM education with realistic scenarios (Costa et al; 2022). There can be several reasons for weak academic performance among students. It is important to note that each student is unique, and the factors influencing their academic performance can vary. When students lack motivation, they may struggle to engage in their studies and perform poorly. Motivation can be influenced by various factors, such as a lack of interest in the subject matter, low self-confidence, or a lack of clear goals (Vallerand 2007).

STEM education can improve academic performance of students in both natural sciences and social sciences, but the impact may vary depending on the specific subject and the teaching approach used. In natural sciences, STEM education provides students with a strong foundation in scientific principles and concepts, as well as practical skills such as observation, experimentation, and data analysis. This can help students understand and apply the

scientific method to various real-world problems, and ultimately improve their academic performance in subjects such as biology, chemistry, and physics. STEM education can aid in the development of students' analytical, problem-solving, and critical thinking abilities in the social sciences. Students can build the skills necessary to do research and evaluate data by integrating technology and data analysis tools into the study of subjects like economics, psychology, and sociology. This helps students better grasp complicated social phenomena. This may ultimately help them perform better in school (Yunus 2018).

As researchers have been working in education department for more than 10 years, so according to their personal experiences, academic performance of students is not satisfactory especially in public schools. So, researchers wish to enhance academic performance of students by teaching STEM education. Overall, while there is still much work to be done to enhance the academic performance of Pakistani students, particularly in subjects of STEM, the initiatives of the government are beginning to have an impact. With continued focus on STEM education, and with sustained investment in resources and facilities, it is possible that we will see even greater improvements in academic performance in the years to come.

Statement of the Problem

The purpose of the study was to examine the connection between eighth-grade students' academic performance and STEM education. It is important to understand the effects of STEM education on academic performance of students and its possible advantages. Significance of STEM education is increasing in the modern economy. While some research studies have suggested that STEM education can enhance academic achievement, other research studies have revealed no conclusive link between STEM education and academic performance. Therefore, further research study was required to understand the connection between STEM education and academic achievement as well as to pinpoint the elements that influence academic success in both groups, one taught through STEM education and other taught without STEM education. It is important to comprehend the potential benefits of STEM education for students who may not have access to such opportunities and to identify strategies that can promote academic success among all students. Therefore, there was a need to assess the academic performance of students. This study also aimed to compare the academic performance of students with and without STEM education to determine if there were significant differences between the two groups.

Justification of the Study

Teachers are expected to have a deep understanding of their subject matter, but they also need to be equipped with the necessary pedagogical and technical skills to engage and motivate their students to improve their academic performance. However, many teachers lack this knowledge and may be using outdated teaching methods. This not only affects the quality of education provided to students but also hinders their ability to apply their knowledge and skills in real-world scenarios. As the job market becomes more competitive and globalized, it is becoming increasingly important for teachers to implement STEM education to prepare students for the workforce. Therefore, there was need to conduct an experimental study to check the academic performance of students with and without STEM education to identify areas of improvement and develop strategies to implement STEM

education effectively and enhance academic performance of students. The findings of this research can be used to inform teachers, department, policy makers and other stake holders to implement STEM education and improve academic performance of students.

Objectives of the Research Study

The objectives of the study were following;

1. To find baseline academic performance of students of grades 8 of district Jhang in science subject.
2. To find out difference in academic performance of students of grade 8 in District Jhang when treated with and without STEM education.

Hypothesis of the Research Study

H0: There is no significant difference in academic performance of students when treated with and without STEM education.

H1: There is significant difference in academic performance of students when treated with and without STEM education.

Research Questions

The research questions of the study were following;

1. What was the baseline academic performance of students of grade 8 in general science in district Jhang?
2. Was there any significant difference in academic performance of students of grade 8 in District Jhang when treated with and without STEM education?

Variables of the Research Study

1. Independent Variables: STEM Education
2. Dependent Variables: Academic Performance (measured by test scores)

Limitation of the Research Study

The study was delimited to;

1. Only District Jhang schools.
2. Only girls' schools were the population of the study.
3. Data collected from two schools within the district Jhang.

Research Methodology

The research study approach examined how STEM education affects students' academic performance. Quasi-experimental design was considered for this study. The approach was chosen because it mitigated a disproportionately greater number of internal and external threats to the research's validity (Fraenkel et al., 2012). The pre-test/post-test control group design was used. The distinction was that it included assigning groups at random to treatment rather than assigning individuals at random (Gay and Castano 2010). The population of this study consisted of female grade 8 students attending elementary and secondary schools in the district of Jhang in the academic year 2023–2024. Eighth-grade students from two public girls' high schools in district Jhang were chosen at random to make

up the sample of the research study. The schools were assigned as experimental group and a control group at random. The 8th graders from only female high schools were chosen. There were 25 students in the control group and 23 students in the experimental group. Students in the experimental group were taught by the researcher herself. A teacher with a similar background to the researcher taught the control group in a normal setting. The teacher in the control group and the teacher in the experimental group were both employed by the government, work in a remarkably comparable setting, and have similar backgrounds in education. Additional factors were taken into account to ensure the experiment's generalizability, including the fact that the chosen schools were typical government schools in terms of their facilities, school climate, socioeconomic status of the students, their family backgrounds, the qualifications of the teachers, the procedures for hiring and promoting them, the availability of AV aids, etc.

Research Tool

A self-developed achievement test for grade 8 general science was the tool employed in the study. The multiple-choice question (MCQ) format was used in the development of the questions. The test's questions were made to assess the students' factual knowledge, their ability to apply what they learned to problems outside of the text, their ability to make connections between what they learned and their daily lives, and their problem-solving skills.

Process of Developing Research Tool

The eighth-grade general science textbook's "Force and Pressure" and "Cell Division" units led to the creation of an achievement tests. Both pretests and posttests were made for the units. For the students' evaluation, 25 questions from each unit were selected.

Pilot Testing

Pilot testing involved selecting a small group of students from the population and treating them with and without STEM education and administering the selected instruments to them. The pilot test helped in identifying issues with the instruments and data collection procedures, such as unclear instructions, difficult questions, or technical problems. Before beginning the main study, the study design, data collection technique and instruments was adjusted in light of the pilot test's findings.

Validity and Reliability

The validity and reliability of the research tool (self-made achievement tests) was checked by subject experts and by the pilot testing. The researcher made lesson plans from the chosen unitss of the general science text book for the eighth grade before beginning the treatment. Before a learned committee of three faculty members, the researcher presented a lesson. The researcher improved the lecture and re-delivered. The committee proposed some additional adjustments. The researcher went through the procedure once more, taking into consideration the committee's recommendations. The committee then gave the researcher permission to use the lesson plans for STEM education.

Procedure of the Study

First of all, pre-tests were conducted from unit 1 "Force and Pressure" and unit 2 "Cell Division" of general science of grade 8 from control as well as experimental group. Then control group was taught according to routine teaching while experimental group was taught according to STEM education by the researcher. This teaching time span was for 2 weeks. After that, post tests were conducted for unit 1 "Force and Pressure" and unit 2 "Cell Division" of general science of grade 8 from control as well as experimental group. Data on the students' test results and academic performance was gathered. Each correct response received one point, while errors received 0 points. In order to identify the current level of academic performance of students, pretest was taken. Data was gathered by giving out pretests and posttests. Students with and without STEM education were compared academically using statistical approaches. The data from the research study was analyzed using the statistical approaches like central tendency measures such as the mean, variability measures such as Standard Deviation, significance tests such as the independent sample t-test. The statistical package for the social sciences (SPSS) was used to analyze the quantitative data. Data was described using tables.

Table 1: Comparing experimental and control groups on pretest

Unit	Total Scores	Group	N	Mean	SD	*T*	Df	*P*
1	25	Control	25	3.40	1.190	.025	46	.29
		Experimental	23	3.39	1.234			

Pretest results for unit 1 "Force and Pressure" are compared in Table 1 between the experimental and control groups. Levene's Test for Equality of Variances for Unit 1 "Force and Pressure" yielded a value of significance equal to.923, which was greater than.05, hence equal variance was assumed. p value was.29, [N = 25, Mean = 3.40, SD = 1.19 for the control group and N = 23, Mean = 3.39, SD = 1.234 for the experimental group] at p >.05 so there was no statistically significant difference in the academic performance of the students between the groups before treatment because the p value was greater than .05.

Table 2: Comparing experimental and control groups on the Unit 2 "Cell Division" pretest

The mean scores on a pretest for unit 2 "Cell Division" for the control and experimental

Unit	Total Scores	Group	N	Mean	D	*T*	Df	*P*
2	25	Control	25	1.80	.913	-1.069	46	.290
		Experimental	23	2.13	1.217			

groups are compared in Table 2. Levene's Test for Equality of Variances resulted in a significance value of.477 which was greater than.05, leading to the assumption of equal variance. N = 25, Mean = 1.80, SD =.91 for the control group and N = 23, Mean = 2.13, SD = 2.13 for the experimental group; p value for both groups was.29; t (46) = - 1.06 at p >.05. There was no statistically significant difference in the academic performance of the students

in the unit "Cell Division" between the groups prior to treatment, as the p value was greater than.05.

Table 3: Comparing the experimental and control groups on the posttest for Unit 1 "Force and Pressure"

Unit	Total Scores	Group	N	Mean	D	*t*	Df	*P*	Eta²
1	25	Control	25	17.60	1.936	-12	40.506	.000	.77
		Experimental	23	23.43	1.199				

A comparison of the mean scores on the posttest for unit 1 "Force and Pressure" for the control and experimental groups is shown in Table 3. Levene's Test for Equality of Variances results in a value of significance for unit 1 "Force and Pressure" of.039, which is less than.05, hence equal variance was not assumed. N = 25, Mean = 17.60, SD = 1.936 for the control group, and N = 23, Mean = 23.43, SD = 1.199 for the experimental group, yielding a p value of.000 for both groups. T (46) = - 12 at p< .05. After treatment, there was a statistically significant difference in the academic performance of the students in the "Force and Pressure" unit between the groups, as the p value was less than.05.

Both groups were statistically distinct from one another after the treatment since the p value was less than .05. The effect's strength (Eta²) was .77. This was a fairly significant result, indicating that students in the experimental group performed better academically than the control group.

Table 4: Comparison of the experimental and control groups on the Unit 2 "Cell Division" posttest

Unit	Total Scores	Group	N	Mean	SD	*T*	df	*p*	Eta²
2	25	Control	25	18.68	2.155	-9.051	42.134	.000	.63
		Experimental	23	23.43	1.441				

Table 4 shows the comparison of the mean results of the experimental and control groups on a posttest for unit 2. Levene's Test for Equality of Variances results in a significance value for unit 2 "Cell Division" of .025, which is less than .05, indicating that equal variance was not assumed. N = 25, Mean = 18.68, SD = 2.155 for the control group, and N = 23, Mean = 23.43, SD = 1.44, for the experimental group, yielded a p value of.000; t (46) = - 9 at p<.05. After treatment, there was a statistically significant difference between the groups as the p value was less than .05.

Both groups were statistically distinct from one another after the treatment since the p value was less than .05. The effect's strength (Eta²) was .63. This was a very significant result that demonstrates the experimental group students' superior academic performance than the control group students' academic performance.

Findings

The key outcomes of the study conducted prior to the treatment are described here. In the units "Force and Pressure" and "Cell Division" of the eighth-grade general science curriculum, it was discovered that there was no statistically significant difference between the mean achievement scores of the control and experimental groups prior to the treatment which showed that students had almost equal academic performance. Following the application of the "Force and Pressure" and "Cell Division" treatments, the mean achievement score of the experimental group was discovered to be statistically greater than the mean accomplishment score of the control group.

Conclusions

According on the study's findings, the following conclusions were made:

Before the treatment, the performance of the students in the "Force and Pressure" and "Cell Division" components of the eighth-class general science was comparable between the control and experimental groups. After receiving treatment, pupils of equal ability in the experimental group showed better academic performance. After treatment, their performance in the eighth-grade general science subjects "Force and Pressure" and "Cell Division" was higher than that of the students in the control group. Students in the experimental group discovered new ways of thinking or different approaches to problems while responding to questions. Additionally, the experimental group outperformed the control group on tests of critical thinking abilities.

High test scores in the experimental groups showed that STEM education helped students use what they had learned about general science in their daily lives. Additionally, it improved students' capacity for critical analysis and material evaluation. They performed better on topics requiring analysis, synthesis, and evaluation because of this. This shows that STEM education was more effective way to foster higher-order learning skills.

Discussion

To facilitate education and strengthen the link between the science learning process and technology, engineering, and mathematics, instruction used inquiry-based learning. After the treatment, the experimental group's students' achievement was significantly greater than the control group's students' achievement, with a larger effect size. The experimental group's students had high academic accomplishment because of the STEM-focused instruction they received. Additionally, this had pushed numerous governments to expand the use of STEM education-based instruction (Zhao et al., 2022).

Students used their everyday experiences as they engaged in STEM-related activities. They were motivated and showed a lot of interest. It enhanced their capacity for critical thought. This made general science an engaging topic and significantly increased the high achievement of the experimental group's students. The experimental group's high mean achievement made this clear. Students improved group interaction throughout instruction using STEM activities. The level of interaction between students, teachers, and learning materials was at its highest. Before the treatment, there were no appreciable differences in the academic performance of the students between the control and experimental groups. Prior to treatment, both groups performed essentially the same. Reading, listening, and group

discussion were the traditional group's methods of teaching (Hasanah 2020).

Recommendations

It is recommended for policy makers to develop evidence-based policies and initiatives. Students are recommended to make well-informed judgments regarding their career pathways, improve their academic performance, and acquire STEM-related skills and knowledge. Teachers are encouraged to help pupils develop their critical thinking, problem-solving, collaboration, and teamwork abilities while also promoting lifelong learning, creativity, and innovation. The institutions' staff may receive training in STEM-related teaching techniques. It is suggested that the education department give STEM education programs top priority and funding. By evaluating the availability of STEM resources and opportunities and their impact on academic performance, the study can also guide resource allocation in schools. Additionally, it can assist schools in figuring out where their STEM programs need work. It is recommended that other interested parties use the availability of STEM resources and opportunities and their effects on academic performance to inform resource allocation in schools. It is also advised to assist schools in determining where their STEM programs need to be improved.

References

1. Aslam, S., Saleem, A., Kennedy, T. J., Kumar, T., Parveen, K., Akram, H., & Zhang, B. (2022). Identifying the Research and Trends in STEM Education in Pakistan: A Systematic Literature Review. *SAGE Open*, *12*(3), 21582440221118545. https://doi.org/10.1177/21582440221118545.
2. 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. https://doi.org/10.3390/math10213944
3. Fraenkel, L., Peters, E., Charpentier, P., Olsen, B., Errante, L., Schoen, R. T., & Reyna, V. (2012). Decision tool to improve the quality of care in rheumatoid arthritis. *Arthritis care & research*, *64*(7), 977-985. doi: 10.1002/acr.21657.
4. Gay, R. K., & Castano, E. (2010). My body or my mind: The impact of state and trait objectification on women's cognitive resources. *European Journal of Social Psychology*, *40*(5), 695-703. https://doi.org/10.1002/ejsp.731
5. HACIOĞLU, Y., & GÜLHAN, F. (2021). The effects of STEM education on the students' critical thinking skills and STEM perceptions. *Journal of Education in Science Environment and health*, *7*(2), 139-155. https://doi.org/10.21891/jeseh.771331
6. Hali, A. U., Aslam, S., Zhang, B., & Saleem, A. (2021). An overview on STEM education in Pakistan: Situation and challenges. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, *12*(1), 1-9. http://doi.org/10.14456/ITJEMAST.2021.20
7. Hasanah, U. (2020). The Impacts of STEM Instruction on Strengthening High School Students' Reasoning Skills. *Science Education International*, *31*(3), 273-282. https://doi.org/10.33828/sei.v31.i3.6
8. Tunc, C., & Bagceci, B. (2021). Teachers' Views of the Implementation of STEM Approach in Secondary Schools and the Effects on Students. *Pedagogical Research*, *6*(1). https://doi.org/10.29333/pr/9295
9. Vallerand, R. J. (2007). *A hierarchical model of intrinsic and extrinsic motivation for sport and physical activity*. In M. S. Hagger & N. L. D. Chatzisarantis (Eds.), *Intrinsic motivation and self-determination in exercise and sport* (pp. Human Kinetics.

https://doi.org/10.5040/9781718206632.ch-017
10. Widya, W., Indrawati, E. S., Muliani, D. E., & Ridhatullah, M. (2019). Design of Integrated Science Learning Materials Based on Creative Problem Solving Model Integrated with Anti-Corruption Characters. *Kasuari Physics Education Journal (KPEJ)*, *2*(2), 62-69. https://doi.org/10.37891/kpej.v2.103
11. Yunus, M. M. (2018). Innovation in education and language learning in 21st century. *Journal of Sustainable Development Education and Research*, *2*(1), 33-34. https://doi.org/10.17509/jsder.v2i1.12355
12. Zhao, J., Wijaya, T. T., Mailizar, M., & Habibi, A. (2022). Factors influencing student satisfaction toward STEM education: Exploratory study using structural equation modeling. *Applied Sciences*, *12*(19), 9717. https://doi.org/10.3390/app12199717