To Study the Impact of a STEM OER Course on Enhancing Teachers' STEM Knowledge And Skill Competencies

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Abstract

The world is confronted with numerous global issues such as climate change, terrorism, gender inequality, human rights violation, poverty, scarcity of fresh water and so much more. To address these problems, we require innovative solutions and integrated STEM knowledge. To enhance teacher's STEM knowledge and skills, the researcher created a 5 -week STEM OER Course, 'Build your STEM competency' consistent of four modules. The course was developed using the ADDIE model of Instructional Design and STEM Theoretical Frameworks. A quasi-experimental design was employed, with school educators assigned to experimental and control groups to assess the course's effectiveness for classroom teaching. Data collection tools for descriptive and inferential analysis indicated that the STEM OER course effectively built STEM competencies among teachers in the experimental group. Posttest competency results were statistically significant at 0.05 and 0.01 levels though not significant for STEM Knowledge, suggesting participants might have gained knowledge through in-house trainings or independent study. The quantitative data showed a large effect size (0.777) and a gain score of approximately 3, attributed to the course tasks and content material.
Participants found the course structure based on the ADDIE model, easy to follow and enjoyed the videos and interviews. Tasks submitted by participants addressed gender disparities in STEM by promoting the inclusion of girls in STEM fields. Challenges included time management, number of tasks and language barriers with STEM terminologies. Recommendations included extending the course from 5 to 6 weeks to allow sufficient time to review materials and reduce the number of tasks.

Keywords: *#STEMcompetency #educators #STEMeducation*

Introduction

Take a moment to observe the world around you, and you will notice that we are confronted with numerous global issues such as climate change, terrorism, gender inequality, human rights violation, poverty, scarcity of fresh water and so much more. Addressing these problems requires innovative solutions, and only the integrated knowledge of STEM disciplines can support the construction and implementation of impactful results. It empowers individuals and communities to offer solution to real-world challenges, encourages reliance on data as evidence, and fosters the use critical thinking and problem-solving skills to develop innovative solutions.
STEM is the acronym for Science, Technology, Engineering and Mathematics. Sometimes, people use the acronym STEAM where Arts is integrated and also STREAM where research is integrated. "STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply Science, Technology, Engineering, and Mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, 2009)."
William (2011) defines STEM education as an approach that supports student participation using engineering and technology and improves students' learning in science and mathematics. Israel, Maynard, and Williamson (2013) describe it as student-centered and collaborative learning beyond the contexts of four STEM domains. STEM education is an approach that eliminates the boundaries between disciplines by enabling students to understand the world as a whole rather than parts (Lantz, 2009).

Significance of the Study

The course, **'Build your STEM Competency'** is aimed for school teachers teaching at Primary and Secondary levels and available on all digital devices.
It aims in helping teachers to connect the daily technology, tools and materials to classroom concepts and inculcate STEM mindset of research and development. The course helps them to understand the

meaning of STEM, the interdisciplinary approach of STEM subjects, creation of STEM lesson plans and development of STEM teaching learning practices and assessment through the modules. It also seeks to measure the efficacy of the course so that regular review of the course by the participants elevates the course to offer quality STEM education.
In the STEM OER Course, the STEM competency will be comprised of knowledge, skills and attitudes. For the research purposes, STEM knowledge will be epistemology, procedural, technical knowledge of the STEM topics covered in the OER Course.
For the present study, the following STEM skills will be considered i.e. critical thinking, problem solving, collaborative, communication, digital skills and analytical skills.

Review of Related Literature

The 'Review of Related Literature' chapter serves as a critical foundation for the current research as it provides a comprehensive analysis of existing studies, theories and concepts relevant to STEM Education and building STEM competency in teachers for classroom teaching.
The chapter aims to contextualize the research problem by investigating the research conducted in the past, analyzing the results, identifying the gaps in the existing body of knowledge and justifying the need for the present research.
Berisha F and Vula E (2021) at the University of Prishtina organized a STEM professional development workshop for 40 pre-service teachers teaching Mathematics and Chemistry. The STEM workshop activities were designed to introduce practices that support STEM education. For 5 weeks in a row, the STEM professional development workshop was attended by pre-service teachers on Saturdays. In the eighth week, pre-service teachers presented and discussed their group STEM projects. During the workshop, participants had a dual role: as learners-involved in the learning process while engaging in the STEM workshop and as teachers-involved in discussions and perspectives on pedagogical processes. After the professional development workshop, open-ended, post-reflective questions were emailed to all participants to inquire about their experiences. A total of 26 responses were collected from all participants in the workshop. The methodology used in the study was qualitative content analysis. The researchers used an inductive approach to analyze the data from the post-reflective questions. They read the responses separately, performed initial coding, discussed the results, and decided on a final coding method. Constant comparative analysis was used to prevent research bias, and the patterns and themes were reported in a separate table. This study found that pre-service teachers effectively conceptualize STEM and STEM pedagogical practices when university professors work together in STEM disciplines. The STEM workshop activities introduced helped the pre-service teachers better understand and reflect STEM concepts and practices.
Halliburton P (2024) in Australia highlights the use of Makerspaces to build confidence in STEM among Primary Preservice Teachers (PSTs). Makerspaces are collaborative environments that encourage creative use of tools and technology. In the study, 240 teachers were divided into groups to create STEM kits for their schools, with only 24 opting to use the Makerspace for their assignments. Observations and design portfolios were analyzed using Nvivo software, focusing on 'confidence' and 'Makerspace Influences'. The study found that while all participants felt more confident in teaching STEM after using the Makerspace, this confidence was less pronounced compared to their overall STEM skills and knowledge. Collaboration was also seen as a key factor in boosting confidence. The research underscores the potential of Makerspaces to enhance PSTs' confidence in STEM, though it primarily relied on interviews for data analysis and could benefit from additional variables and pre- and post-intervention measurements.
Anita Juškevičienė's (2024) case study in Lithuania explores STEM teachers' motivation and engagement in professional development and career advancement. The study examines teachers' perceptions of career progression, professional development, and collaboration, using both qualitative and quantitative data analyzed with MAXQDA Analytics Pro. Key findings reveal that 80% of teachers view collaboration as essential, yet face challenges such as communication difficulties, lack of trust, and time constraints. Additionally, 60% report challenges in implementing STEM reforms and technology in classrooms. The study highlights the importance of innovative teaching methods to stimulate student curiosity, with 70% of teachers interested in non-traditional educational roles. It suggests that collaboration during working hours can improve work-life balance and emphasizes the need for strategies to enhance teacher engagement and motivation in STEM education, ultimately fostering an effective teaching environment.
Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., Kalogiannakis, M. and Vassilakis, K. (2021) paper examines factors that hinder in-service teachers from incorporating educational robotics

into their daily or future teaching practice. The study used a survey or interview methodology to examine preschool educators' views, perceptions, attitudes, and technological competencies regarding the factors that hinder them from incorporating educational robotics into their daily teaching practice. Their main findings were preschool educators' lack of knowledge, views, and attitudes towards educational robotics hinder them from incorporating it into their daily teaching practice.Preschool educators' perceptions, attitudes, and technological competencies are the primary barriers to adopting educational robotics in their curriculum and pedagogy. Preschool educators face problems with the utility and acceptance of educational robotics in their classrooms.

Components of the STEM OER Course

For the present study, the researcher has developed four modules for the OER course. The modules cover the following knowledge, skills and attitudes needed by teachers to develop STEM competencies for classroom teaching:

Module 1 -

1. Knowledge of STEM Education
2. STEM is everywhere.
3. Need for STEM Education

Module 2 -

1. Integration of STEM disciplines through real-life problems.
2. Strategies and methodologies to enhance STEM learning within our classrooms.
3. Introduction of a STEM lesson plan.

Module 3 -

1. Exploration and experimentation in STEM classroom teaching.
2. Enhancing STEM competencies through technologies.
3. Building STEM skills

Module 4 -

1. Create a variety of assessments to evaluate STEM competencies in teachers and students.
2. Building STEM attitudes and ethics.
3. Integrating STEM & SDGs
4. Feedback and closure.

Tasks offered within the course

1) Task 1- Share your perspective on STEM education
2) Task 2 – Incorporation of STEM into everyday activities
3) Task 3 – Create an image using any three concepts from UNESCO STEM article and the need to build these concepts within our school curriculum.
4) Task 4 – Game on types of knowledge (content, procedural, epistemic)
5) Task 5 – Read an article on Climate Change and analyse how STEM disciplines are interwoven
6) Task 6 - Find a video that uses STEM concepts to solve a real-life problem
7) Task 7 – Create a Plan of action
8) Task 8 - Design a rough draft of a one-week STEM course promoting girls in STEM
9) Task 9 - Add a link to a movie that can be used within the classroom to promote STEM competencies within the classroom
10) Task 10 – Create a 1-minute video enhancing STEM Competencies through Technologies within their classroom
11) Task 11 – Create a STEM lesson plan that fosters STEM competencies among students and uses SDG goals.

Aim of the Study

The broad aims of the present study are as follow:

1. To design a STEM OER Course for school teachers.
2. To study effectiveness of an OER Course for school teachers in enhancing their STEM competencies for classroom teaching.

Research Questions

1. What is the impact of the STEM OER Course on enhancing teacher’s STEM competencies?

2. How does STEM competency development differ between teachers in the experimental group versus the control group?

Objectives of the Study

1. To study the pre- test and posttest scores of STEM Competencies for the control group.
2. To study the pre- test and posttest scores of STEM Knowledge quiz for the control group
3. To study the pre- test and posttest scores of STEM Competencies for the experimental group.
4. To study the pre- test and posttest scores of STEM Knowledge quiz for the experimental group.
5. To compare the pre-test and post- test scores of STEM Competencies between the experimental group and control group.
6. To compare the pre-test and post- test scores of STEM Knowledge Quiz between the experimental group and control group
7. To compute and compare the gain scores of STEM Competencies in Teachers from the experimental and control groups.
8. To calculate the effect size of the OER Course treatment on building STEM competencies among school teachers in the experimental group.

Hypothesis of the Study

1. There is no significant difference in the pre-test scores of STEM Competencies between the experimental and control groups.
2. There is no significant difference in the post-test scores of STEM Competencies between the experimental and control groups.
3. There is no significant difference in the mean pre-test scores of the STEM Knowledge Quiz between the experimental and control groups.
4. There is no significant difference in the mean post-test scores of the STEM Knowledge Quiz between the experimental and control groups.
5. There is no significant difference between the pre-test and post–test scores of the STEM Quiz for the experimental group.
6. There is no significant difference between the pre-test and post–test scores of STEM Competency in the experimental group.
7. There is no significant difference between the pre-test and post–test scores of STEM Competencies in the control group.
8. There is no significant difference between the pre-test and post–test scores of the STEM Knowledge Quiz in the control group.
9. There is no significant difference in the gain scores of STEM competencies between the experimental and control groups.
10. There is no significant difference in the gain scores of STEM Knowledge between the experimental and control groups.
11. The OER Course treatment does not have a significant effect size on building STEM competencies among school teachers in the experimental group compared to the control group.
12. The OER Course treatment does not have a significant effect size on building STEM knowledge among school teachers in the experimental group compared to the control group.

Methodology

To address these questions, a quasi-experimental quantitative design study was deemed most appropriate. This approach ensured that the research questions were addressed comprehensively and that the findings are robust and reliable.
It involved assignment of participants to experimental Group A and control Group B without random assignment using quasi -Experimental design (figure 3). Both groups were administered a pretest and a posttest but the treatment X i.e course learning was offered only to the experimental group A. Test scores to measure STEM knowledge, online survey and course tasks to measure STEM competencies were collected from experimental participants. Also, test scores and online survey were collected from control participants at online platform to assess whether the online STEM OER course relates to STEM competencies.

Group A Experimental O_1 ____________X______________O_2
Group B Control O_3____________________________O_4
Experimental design adapted from Creswell, J. W., & Creswell, J. D. (2023)
where, O_1 and O_3 = Pre-test Scores; O_2 and O_4 = Post -test Scores; X: Experimental Group (treatment given).
A treatment of the course along with synchronous weekly online meetings was given to experimental group as shown in Figure 1. No treatment was given to the control group and were subjected to only pretest and post-test.

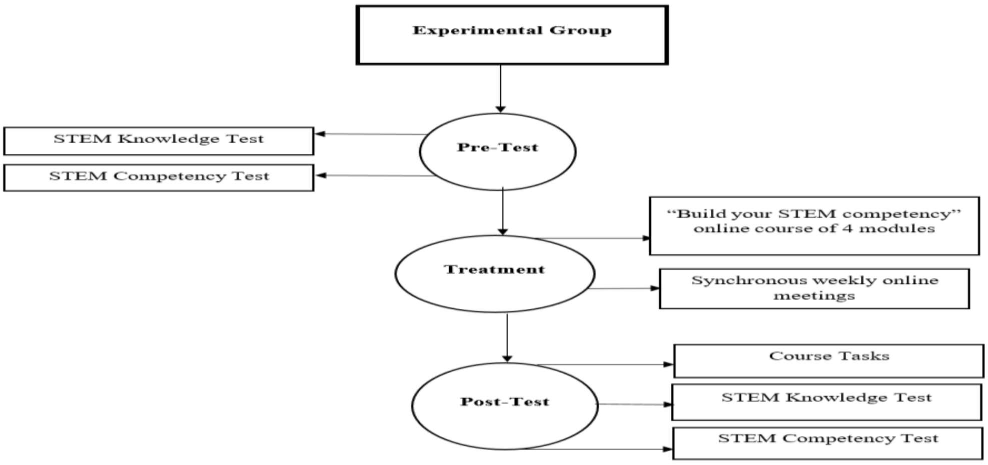

Fig. 1. Experimental Group design

Variables

Variables are defined as characteristics of the sample that are examined, measured, described, and interpreted. Variables are so called because they vary in value from subject to subject in the study (Andrade C.2021). In this study, there are two types of variables, viz, dependent variable and independent variables.

1. Independent variables are conditions which the experimenter influence or affect, outcomes in studies. The researcher manipulates them to ascertain their relationship to the observed phenomena. The dependent variables depend on the independent variables and are outcomes or results of the independent variables.
   In this research, the treatment i.e STEM OER course is the independent variable which the researcher will manipulate in order to determine its effect on the dependent variables.
2. Dependent variables: Given that the course aims to build teachers' STEM competencies, the **dependent variable** could include detailed measures such as:
   STEM Competency: Assessment of teachers' knowledge and skills in STEM subjects, including content knowledge, problem-solving, and application of STEM concepts in classroom settings.
   Capacity to create STEM Lesson plan and STEM Course: Evaluation of teachers' ability to implement STEM-based instructional strategies, such as inquiry-based learning, project-based learning, and technology integration in designing lessons plans and STEM course for classroom teaching.

Sample Study

Selection Criteria - School teachers teaching either in Primary and Secondary Sections or both were selected. Teachers had to fill a registration link. The participant breakup is shown in Figure 2.

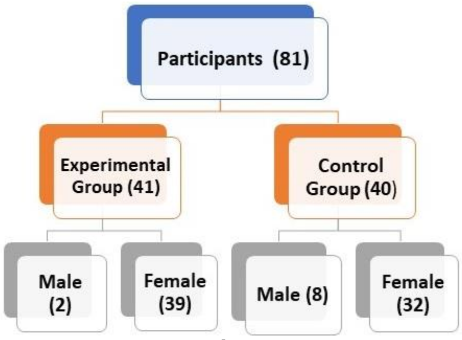

Fig. 2.

Data Collection Tools

1. **To measure STEM Competencies -** The self-assessment tool from Teach STEM has 35 questions that helps educators detect their strengths and weaknesses as a teacher when working on STEM topics in the classroom or other learning environment. The Artifex SAT was built and tested by university researchers.
   The researcher conducted validity and reliability of the tool. The validity of the tool was calculated after receiving feedback from a panel of 12 experts. The content validity ratio (CVR) was calculated for each item. For an expert panel of 12 members, the CVR ratio accepted is 0.667. All questions met the minimum acceptable CVR threshold, indicating strong agreement among experts on their essentiality. This suggests that the tool has good content validity.
   The reliability of the test was measured using the test -retest method with 36 participants. The correlation was evaluated and the result is 0.761.
   A test-retest correlation of **0.76134234** indicates good reliability. This suggests that the test is stable and reliable.
2. **To measure STEM Knowledge:** Participants in both Control and Experimental group were given the Silver Zone Foundation STEM Olympiad Sample Test Paper Class 7 from AglaSem. The test is conducted for Indian students aligned to the Indian national curriculum. The validity of the tool was calcuated after receiving feedback from a panel of 12 experts. The content validity ratio (CVR) was calculated for each item. For an expert panel of 12 members, the CVR ratio accepted is 0.667. All questions met the minimum acceptable CVR threshold, indicating strong agreement among experts on their essentiality. This suggests that the tool has good content validity. The test was offered in the form of Google Form converted into a quiz where questions were added and participants had to select the correct answer. Points were assigned to the questions; responses were collected and the researcher received the marks. The reliability was assessed using the split half method with Indian school teachers who are currnetly teaching the national curriculum. The items were divided into two halves, and each half was tested with 42 school teachers. **The value of (r) calculated using Spearman-Brown formula is 0.8375.**

   Consistency: A reliability coefficient of 0.8375 suggests that the tool is consistent in measuring the intended construct.

Data Analysis and Results

Microsoft Excel were used to record the test scores, competency scores and tasks scores of participants. It was used for data manipulation and analysis.
To address the research question 1 (impact of the STEM OER Course on enhancing teacher's STEM competencies) and research question 2 (Difference in STEM competency development between teachers in the experimental group versus the control group) both descriptive and inferential statistical methods were employed.
Hypothesis 1 states there is no significant difference in the mean pre-test scores of STEM Competencies between the experimental and control groups.
Hypothesis 2 states there is no significant difference in the mean post-test scores of STEM Competencies between the experimental and control groups
Technique used: t-test
Groups: Experimental and Control Group
Variables: STEM competency

Table 1. shares analysis of Pretest and Posttest Competency Tests for the Control and the Experimental Group

Variables	Groups	N	Mean	S.D.	't' value	p value	Level of Significance (0.05)
STEM Competency	Control pretest	34	28.454	7.290	-1.987	>0.0001	NS
	Experimental Pretest	34	29.954	3.530			
STEM Competency	Control posttest	34	27.448	7.350	-5.089	<0.0001	S
	Experimental Posttest	34	32.242	3.139			

For Table 1, for N=68, df= 66, tabulated t=1.997 at 0.05 level and 2.652 at 0.01 level
S = Significant, NS = Not Significant

Findings and Conclusion

Pretest - The absolute value of the calculated t-value (1.987) is less than the critical t-value at the 0.05 level (1.997) and at the 0.01 level (2.652). The conclusion is that the difference in means between the control pretest and the experimental pretest scores for STEM Competency is not statistically significant. **Hypothesis 1 accepted.**

Post-test - The critical t-Value (two-tailed, $\alpha = 0.01$) is 2.652. The absolute value of the calculated t-value (5.089) is greater than the critical t-value at the 0.05 level (1.997) and at the 0.01 level (2.652). Since the absolute value of the calculated t-value exceeds both critical values, the result is statistically significant at both the 0.05 and 0.01 levels. This indicates that the OER treatment did impact the STEM competency in participants from experimental group. **Hypothesis 2 is rejected.**

Hypothesis 3 states there is no significant difference in the pre-test scores of STEM Knowledge Quiz between the experimental and control groups.

Hypothesis 4 states there is no significant difference in the post-test of STEM Knowledge Quiz between the experimental and control groups.

Technique used: t-test

Groups: Experimental and Control Group participants

Variables: STEM Knowledge Skills

Table 2. shares the analysis of Pretest and Posttest Quiz Test for the Control and the Experimental Group

Variables	Groups	N	Mean	S.D.	't' value	p value	Level of Significance (0.05)
STEM Knowledge Quiz	Control pretest	40	6.15	2.381	2.987	<0.0001	S
	Experimental pretest	40	4.55	2.159			
STEM Knowledge Quiz	Control posttest	40	8.45	2.630	-0.138	>0.0001	NS
	Experimental posttest	40	8.525	2.062			

For Table 2, for N=80, df= 78, tabulated t=1.991 at 0.05 level and 2.640 at 0.01 level
S = Significant, NS = Not Significant

Findings and Conclusion

Pretest - The absolute value of the calculated t-value (2.987) is greater than the critical t-value at the 0.05 level (1.991) and at the 0.01 level (2.640). Since the absolute value of the calculated t-value exceeds both critical values, the result is statistically significant at both the 0.05 and 0.01 levels. There is a difference between the content levels in both groups. **Hypothesis 3 is rejected.**
Post-test - The absolute value of the calculated t-value (0.138) is much less than the critical t-value at the 0.05 level (1.991) and at the 0.01 level (2.640). Since the absolute value of the calculated t-value does not exceed either critical value, the result is not statistically significant at both the 0.05 and 0.01 levels. **Hypothesis 4 is accepted.**
The non-significant p-values (greater than 0.0001) and small t-ratios for both groups indicate that the intervention did not result in a significant increase in STEM knowledge skills between the control and experimental group.

Hypothesis 5 states there is no significant difference between the pre-test and post-test scores of the STEM Competency for the experimental group.
Hypothesis 6 states there is no significant difference between the pre-test and post-test scores of the Knowledge Quiz for the experimental group.

Table 3. shares the analysis of Pretest and Posttest Competency and Knowledge Quiz Tests for the Experimental Group

Variables	Groups	N	df	Mean	S.D.	't' value	p value	Level of Significance (0.05)
STEM Competency	Experimental pretest	36	35	29.646	3.531	-4.741	<0.0001	S
	Experimental posttest	36		32.243	3.139			
STEM Quiz	Experimental pretest	41	40	4.55	2.159	-10.295	<0.0001	S
	Experimental posttest	41		8.525	2.062			

For Table 2, for Competency N=36, df= 35, tabulated t=2.030 at 0.05 level and 2.724 at 0.01 level
For Table 2, for Quiz N=41, df= 40, tabulated t=2.021 at 0.05 level and 2.704 at 0.01 level
S = Significant, NS = Not Significant

Findings and Conclusion

STEM competency - Since the absolute value of the calculated t-value (4.741) is greater than both the critical t-values at the 0.05 level and the 0.01 level the result is statistically significant at both levels. **Hypothesis 5 is rejected.**
STEM knowledge - The absolute value of the calculated t-value (10.295) is also much greater than the critical t-value at the 0.05 and 0.01 level . Since the absolute value of the calculated t-value exceeds both critical values, the result is statistically significant at both the 0.05 and 0.01 levels. The statistically significant increases in both the competency and knowledge quiz scores suggest that the course provided valuable learning experiences and enhanced the participants' understanding and skills in STEM subjects. **Hypothesis 6 is rejected.**

Hypothesis 7 states there is no significant difference between the pre-test and post–test scores of the STEM Competency for the control group.
Hypothesis 8 states there is no significant difference between the pre-test and post–test scores of the STEM Knowledge Quiz for the control group.

Table 4. shares the analysis of Pretest and Posttest Competency and Knowledge Quiz Tests for the Control Group

Variables	Groups	N	df	Mean	S.D.	't' value	p value	Level of Significance (0.05)
STEM Competency	Control pretest	34	33	28.454	3.167	-1.126	>0.0001	NS
	Control posttest	34		29.062	2.992			
STEM Quiz	Control	40	39	6.15	2.3810	-6.064	<0.0001	S

	pretest							
	Control posttest	40		8.45	2.630			

For Table 2, for Competency N=34, df= 33, tabulated t=2.035 at 0.05 level and 2.733 at 0.01 level
For Table 2, for Quiz N=40, df= 39, tabulated t=2.023 at 0.05 level and 2.708 at 0.01 level
STEM Competency - The absolute value of the calculated t-value (1.126) is less than the critical t-value at the 0.05 level and at the 0.01 level. **Hypothesis 7 is accepted.**
STEM Knowledge - The absolute value of the calculated t-value (6.064) is also greater than the critical t-value at the 0.05 and at 0.01 level. There is an improvement in STEM knowledge which could be attributed to in-house school trainings or content development. **Hypothesis 8 is rejected.**

Hypothesis 9 state there is no significant difference in the gain scores of STEM competencies between the experimental and control groups.
Hypothesis 10 states there is no significant difference in the gain scores of STEM Knowledge between the experimental and control groups.

Table 5. shares the Gain Scores for the Control and Experimental Group

Variables	Groups	N	Post - test scores	Pre-test scores	Average Gain Score	Gain Scores SD	‘t’ value (gain scores experimental, gain scores control)	p value	Level of Significance (0.05)
STEM competency	Control Group	34	29.062	28.454	0.608	3.08	2.597	<0.001	S
	Experimental Group	36	32.243	29.646	2.597	3.27			
STEM Knowledge Quiz	Control Group	40	8.45	6.15	2.3	2.37	3.075	<0.001	S
	Experimental Group	41	8.525	4.55	3.975	2.38			

Findings and Conclusion
Table 5 indicates the impact of the STEM OER course on teachers gain scores in STEM competency and STEM knowledge. In the Experimental Group, significant positive changes were observed across all two variables. In STEM Competency, the Experimental Group displayed a remarkable mean gain score of 2.597, significantly higher than the Control Group (mean gain score = 0.608, $p < 0.0001$). **Null hypothesis 9 is rejected**.
STEM Knowledge - Similarly, in STEM Knowledge, the Experimental Group demonstrated a significant mean gain score of 3.975 higher than the Control Group mean score (2.3, $p < 0.0001$).. **Null hypothesis 10 is rejected.**
In both cases, the results suggest that the OER Course treatment has a significant positive effect on building STEM competencies and knowledge among school teachers in the experimental group compared to the control group.

Hypothesis 11 states that the OER Course treatment does not have a significant effect size on building STEM competencies among school teachers in the experimental group compared to the control group.
Hypothesis 12 states that the OER Course treatment does not have a significant effect size on building STEM knowledge among school teachers in the experimental group compared to the control group.

Table 6. shares the Effect Size for the Control and Experimental Group

Dependent Variable	Mean of Experimental Group	Mean of Control Group	SD of Control Group	Magnitude of the Effect	Effect Size
STEM Competency	32.243	29.062	2.992	1.06	Maximum
STEM Knowledge	8.463	8.45	2.630	0.004	Minimum

Findings and Conclusion
STEM Competency - The effect size of 1.06 for experimental group versus control group is considered a large effect. **Hypothesis 11 is rejected.**
STEM Knowledge - The effect size for the STEM Knowledge Quiz in the experimental group versus the control group is 0.004 which is considered very low. **Hypothesis 12 is accepted.**

Conclusion and Recommendations

The critical t-Value (two-tailed, α = 0.05) for STEM competency and STEM Knowledge for experimental group is greater than critical t-values at the 0.05 level and the 0.01 level making the result statistically significant at both levels. This indicates that the STEM OER course was effective in building STEM competencies among teachers in the experimental group. Between the control and experimental group, the result for posttest competency was statistically significant at 0.05 and 0.01 levels but not significant for STEM Knowledge indicating that the participants might have gained knowledge through in-house trainings or personal research. The quantitative data indicates that the large effect size (0.777) and a gain score of approximately 3 can be attributed to the course tasks and content material, which significantly improved STEM competencies. During the execution of the course, the researcher observed participants' engagement and evaluated their task submissions. Amid synchronous meetings, the researcher recorded attendance and gathered feedback from participants. The findings revealed that participants found the course structure which used the ADDIE model for course design easy to follow and enjoyed the videos and interviews. The tasks submitted by participants specifically addressed gender disparities in STEM by promoting the inclusion of girls in STEM fields. Additionally, the tasks focused on solutions to climate change and the creation of lesson plans that integrated Sustainable Development Goals (SDGs) with STEM concepts, resulting in teachers submitting commendable work. Teachers reported increased student engagement after implementing STEM learning in their classrooms. They utilized a variety of technological tools to upload their work, making it easily accessible on the website. Teachers appreciated the contributions of other educators, shared positive feedback on the tasks, and were inspired to use their peers' lesson plans in their own classrooms.
However, there were some challenges during the course. The researcher had to send continuous reminders to participants to complete their tasks. Additionally, some participants needed assistance understanding the course language, they had issues of time management and number of tasks allotted and also language as not all were fluent with STEM terminologies. They recommended that the course be extended from 5 weeks to 6 weeks to get sufficient time to review the materials and reduction in number of tasks. The participants requested for more synchronous meetings. Post the feedback, the researcher suggests that a blended learning approach that combines online and face-to-face instruction can enhance the flexibility and accessibility of the course. Also, utilizing various technological tools, use of AI and platforms can improve engagement and interactivity.
The researcher advocates other researchers to review the course and conduct long -term studies to monitor the progress of participants who have completed the course. It can reveal the sustained impact on thier STEM competenices and career trajectories. To promote girls in STEM, the researcher suggests that other researchers establish mentorship programs within the course and connect female participants to experienced mentors who can be role models and encourage persistence in STEM fields.

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