



A Quantitative Study on the Effectiveness of Open Educational Resources (OER) in Enhancing Creative Thinking Skills

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Abstract: This research aims to provide empirical evidence on the effectiveness of Open Educational Resources (OER) in facilitating transformative learning experiences that enhance students' creative thinking skills. A quantitative approach was employed for the study, wherein two groups, experimental and control, underwent pre-tests and post-tests to measure variables such as fluency, flexibility, elaboration, and evaluation of their creative thinking abilities. The study revealed significant differences between pre-test and post-test scores for both groups, particularly in the indicators of flexibility and evaluation. However, diverse outcomes were observed when examining n-gain scores across all indicators of creative thinking skills, suggesting that the effectiveness of OER in facilitating transformative learning varies depending on the specific creative thinking indicators measured. The research emphasizes that while OER can facilitate transformative learning processes, it may not yield uniform results across all dimensions of creative thinking. The obtained results indicate no significant difference in flexibility. Contradictory conditions can be observed in fluency, elaboration, and evaluation indicators, showing significant differences. Therefore, educators should adopt varied approaches when integrating OER into their curricula to maximize the potential benefits of enhancing students' creative thinking skills. For future research, it is highly recommended to focus on the effectiveness of OER based on the type of content or subject matter taught to identify the most effective sources. Further research is also needed to compare the effectiveness of OER with other teaching methods.

INTRODUCTION

In the fast-paced landscape of globalization and information overload, education grapples with unforeseen challenges, tasked with sculpting a new generation that is knowledgeable, profoundly competent, and adaptable. In this context, the role of transformative learning becomes inevitable. As an approach that focuses on fundamental changes in how an individual thinks and interacts, transformative learning equips

students not only with knowledge but also with essential skills such as critical thinking, creativity, adaptability, and the ability to continue learning (Avsec et al., 2022; Baena-Morales et al., 2023; Nada & Legutko, 2022). Unfortunately, many educational systems are still ensnared in traditional teaching methods emphasizing memorization and standardized assessment (Putra et al., 2021; Ulum, 2018), resulting in limited opportunities for transformative learning.

To reform in the face of the changes brought about by the era of globalization, schools must introduce significant changes ranging from curriculum to assessment methods. Students engaged in transformative learning processes are better prepared for academic challenges and life itself (Aboytes & Barth, 2020). They become more empathetic, adaptable to change, and more competent in problem-solving (Alam, 2022). Through transformative learning, students acquire skills and confidence to become resilient learners (Baena-Morales et al., 2023; Tsimane & Downing, 2020). Therefore, transformative learning is not just a concept or theory but a pressing necessity in the current educational landscape.

Transformative learning, as an approach focused on cognitive development, gains additional strength when combined with Open Educational Resources (OER). OER facilitates transformative learning by providing access to various materials and perspectives that can assist students in questioning their assumptions and beliefs. With more dynamic and inclusive materials, OER fosters a more adaptive learning environment that is responsive to students' needs, thus opening wider doors for the transformation process (Bilyalova et al., 2020; Trotter & Hodgkinson-Williams, 2020).

In practice, students often encounter OER as supplementary tools or as complementary sources of course materials (Baas et al., 2019). In practice, Open Educational Resources (OER) are frequently perceived by students as additional tools or supplementary sources of course materials. Despite their significant potential, their implementation often falls short, and one of the reasons is the lack of awareness or understanding of how to effectively leverage these resources (Gurung, 2017; Ramadhan & Riyana, 2022; Zawacki-Richter et al., 2022). For the optimal implementation of OER in schools, educators must play an active role

in integrating them into the curriculum and teaching methods. Teachers can also leverage OER to design activities that encourage enhancing students' thinking skills (Rahayu & Sapriati, 2018; Zulaiha & Triana, 2023). In addition to providing access to more diverse and flexible resources, OER also helps reduce the cost of education, which can be a significant barrier for many students (Hylén, 2016; Kauffman, 2021). Thus, students can explore their interests and talents more deeply, allowing for more individualistic and self-directed learning.

Through implementing OER, students can develop a range of valuable skills, including but not limited to critical thinking, information literacy, and digital collaboration skills (Zawacki-Richter et al., 2022). Ultimately, it can facilitate a more holistic and transformative type of learning that prepares students for success in a complex and ever-changing world. OER provides access to various information sources and perspectives, creating a learning environment rich in stimuli and viewpoints to stimulate students' creativity (Yuan & Powell, 2013). For instance, students utilizing OER can effortlessly transition from studying classical art to exploring quantum physics theory, all within one learning session. This freedom enables them to connect seemingly unrelated fields, which is at the core of creative thinking.

The current creative thinking abilities of students vary considerably, but there is a general tendency to emphasize more structured curricula and standardized test outcomes. This can lead to a diminished emphasis on the development of creativity (Magdalena et al., 2014). Nevertheless, the demand for innovative and creative thinking in the workplace and everyday life makes this a pressing necessity (Zubaidah, 2016). Schools should serve as environments that facilitate knowledge, technical skills, and creative thinking abilities (Amir & Wardana, 2017; Lin et al., 2020). This implies that

education should be directed more towards 'how to think' rather than 'what to think.' OER can be a highly useful instrument in this context, allowing students to explore, test ideas, and make connections on their own. Students with creative thinking skills will be better equipped and more flexible in facing challenges and solving problems (Cahyani et al., 2020). They also tend to be more innovative and capable of discovering new solutions or approaches to longstanding problems (Wahyuni & Palupi, 2022).

Various studies have indicated the positive impact of implementing Open Educational Resources (OER) on students' abilities. For instance, Zulaiha & Triana (2023) found an improvement in students' writing skills, while Morawski & Budke (2023) reported enhancements in teaching competencies. Furthermore, research by Taneja-Johansson et al., (2023) focused on improving the accessibility of OER for people with disabilities, whereas Castro & Tumibay (2021) noted benefits in teaching practices and student learning processes. Bozkurt & Sharma (2020) even emphasized the influence of OER in collaborative practices for teacher professional development.

However, despite extensive literature discussing the benefits of OER in expanding access and enhancing learning outcomes, there remains a significant gap in research—specifically, the impact of OER on students' creative thinking skills. There is a limited body of research about the efficacy of Open Educational Resources (OER) on creative thinking within science. This study aims to fill this void by integrating transformative learning theory with the implementation of OER. The focus is to explore how the two can synergize in facilitating creative thinking through a quantitative methodological approach with a quasi-experimental research design. Therefore, this research aims to assess the extent to which OER is effective in supporting the transformative

learning process for the enhancement of creative thinking abilities.

METHOD

Design

This study adopts a quasi-experimental research design with a nonequivalent control group design. The research design assesses the initial conditions of students through a pre-test, then measures the differences in class conditions after applying different interventions using a post-test, ensuring the homogeneity of both groups at the initial stage (Dahlia et al., 2018). Students' creative thinking abilities are assessed through descriptive tests customized according to the indicators of creative thinking skills. The instructional steps taken can influence each critical thinking indicator, as illustrated in Figure 1.

Participants

The research sample consists of 70 students (43 females and 27 males) from the 10th grade in one of the schools in the Natar District, selected through purposive sampling techniques. Students in the experimental group were exposed to OER, while the control group participated in traditional teaching.

Instruments

The data collection mechanism involves pre-tests and post-tests. The data collection technique utilizes a validated questionnaire or creative thinking test to measure the level of creative thinking before and after the implementation of OER. The indicators used to assess creative thinking skills include fluency, flexibility, elaboration, and evaluation (Dariman, 2019).

Data Analysis

The data are analyzed using SPSS 25 with inferential statistical calculations. An Independent Sample T-test is employed if the data are normally distributed, or the

Mann-Whitney test is used if the data are not normally distributed. The data presented in Table 1 (Zimmerer et al.,

2020) examines the criteria for creative thinking abilities.

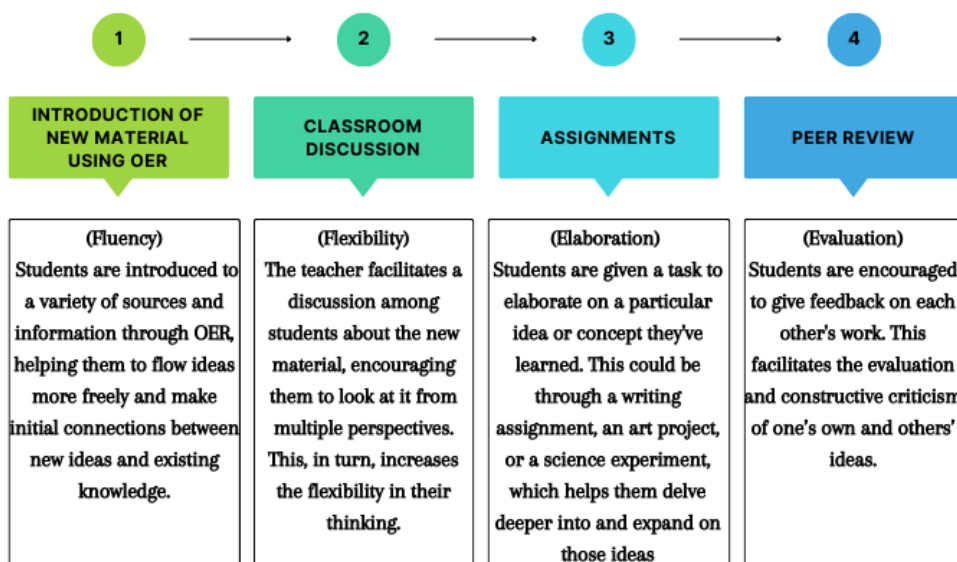


Figure 1. Learning Steps for Each Indicator of Creative Thinking.

Table 1. Criteria for Creative Thinking Skills.

Interpretation	Criteria
81.25 < x ≤ 100	Very creative
62.50 < x ≤ 81.25	Creative
43.75 < x ≤ 62.50	Moderate
25.00 < x ≤ 43.75	Not Creative

RESULT AND DISCUSSION

This study primarily focuses on assessing various dimensions of students' creative thinking abilities, including fluency, flexibility, originality, and elaboration. The research employs evaluative questions in open-ended responses to measure these indicators to

assess each aspect of creative thinking. The scores of student's creative thinking skills are compared between the control and experimental groups, both in the pretest and posttest, utilizing either an independent sample t-test or the Mann-Whitney test. The calculation results are presented in Table 2.

Table 2. The Analysis of Pretest Scores for Creative Thinking Utilized an Independent Sample T-test.

Pretest	Groups	Mean	SD	t	df	p
Creative Thinking Skills	Control	20.19	3.27	4.370	41	0.001
	Experimental	17.21	3.32			

Table 3. Results of the Pretest Analysis for Each Indicator Using the Mann-Whitney Test.

Pretest	Groups	Mean	SD	P
Fluency	Control	1.19	5.81	0.073
	Experimental	0.79	3.23	
Flexibility	Control	3.32	8.73	0.003
	Experimental	1.84	7.34	
Elaboration	Control	1.93	7.83	0.473
	Experimental	2.11	8.84	
Evaluation	Control	2.23	5.21	0.000
	Experimental	1.38	5.46	

Table 2 shows a significant difference between the pretest scores of both groups ($p < \alpha$, $0,00 < 0,05$). The average scores indicate that the control group has a higher mean value than the experimental group. This implies that the level of creative thinking between the control and experimental groups is not at the same level.

Table 3 indicates that in the aspects of fluency and elaboration, neither group shows significant differences. Both groups can be considered equivalent, with p-values of 0.073 for fluency and 0.473 for

elaboration. This means that before the experiment, both groups already had similar capabilities in generating ideas (fluency) and deepening or developing those ideas (elaboration). However, this differs in the aspects of flexibility and evaluation. With p-values of 0.003 for flexibility and 0.000 for evaluation, both α are less than 0.05. The average scores in flexibility and evaluation indicate that the control group has better scores compared to the experimental group in terms of flexibility and evaluation.

Table 4. The Analysis of Posttest Scores for Creative Thinking Utilized an Independent Sample T-test.

Posttest	Groups	Mean	SD	t	df	p
Creative Thinking Skills	Control	16.78	5.72	-4.213	46	0.002
	Experiment	23.21	4.31			

Table 5. The Results of the Analysis of Each Indicator's Posttest Using the Mann-Whitney Test.

Posttest	Groups	Mean	SD	Mann-Whitney p	t-test p
Fluency	Control	1.25	5.87	0.021	-
	Experimental	0.83	3.21		
Flexibility	Control	3.78	8.72	0.037	-
	Experimental	1.85	7.11		
Elaboration	Control	1.89	7.33	0.001	-
	Experimental	2.32	8.78		
Evaluation	Control	2.52	5.20	-	0.000
	Experimental	1.47	5.38		

Table 4 shows a significant difference in the creative thinking scores between the control and experimental groups ($p < \alpha$, $0.02 < 0.05$). From the post-test scores, the experimental group demonstrated superior creative thinking abilities compared to the control group. In Table 5, there is a notable difference in almost all indicators of creative thinking between the control and experimental groups. Across the four creative thinking indicators, there is significant variation between the groups. Specifically, the control group excels in fluency and flexibility, with p-values in the Mann-Whitney test at 0.021 and 0.037, respectively, below the significance level of α , which is less than 0.05. However,

the experimental group stands out in the elaboration category, with a p-value of 0.001, indicating a significant difference.

Additionally, in the evaluation indicator, the control group again shows a highly significant difference, marked by a p-value from the t-test of 0.000. Although each group has certain advantages in various indicators, all these differences are statistically significant. The implementation of OER in this study cannot be solely concluded based on the statistical results of post-test scores, necessitating statistical tests on individual n-gain scores. The results of the statistical tests on student n-gain scores are presented in Table 6 and Table 7.

Table 6. The Analysis of N-gain Scores is Conducted Using an Independent Sample t-test.

Pretest	Groups	Mean	SD	t	df	p
Creative Thinking Skills	Control	0.02	2.78	-8.768	42	0.003
	Experimental	0.63	2.10			

Table 7. The Analysis of N-gain Scores for each Indicator is Conducted Using the Mann-Whitney Test.

Pretest	Groups	Mean	SD	p
Fluency	Control	0.13	2.36	0.000
	Experimental	0.32	1.77	
Flexibility	Control	0.47	5.23	0.521
	Experimental	0.55	4.10	
Elaboration	Control	0.13	5.11	0.003
	Experimental	0.61	5.78	
Evaluation	Control	0.18	5.13	0.001
	Experimental	0.69	3.53	

In Table 6, based on the N-gain scores for all indicators of creative thinking skills, it can be observed that there is a significant difference between the experimental and control groups ($p < \alpha$, $0.00 < 0.05$). However, Table 7 indicates no significant difference in flexibility ($p > \alpha$, $0.521 > 0.05$). Contradictory conditions can be seen in fluency, elaboration, and evaluation indicators (p (fluency) $< \alpha$, $0.00 < 0.05$; p (elaboration) $< \alpha$, $0.00 < 0.05$; p (evaluation) $< \alpha$, $0.00 < 0.05$).

The initial data collected through the pre-test show an average score of 48 for the experimental group and 50 for the control group, indicating that both groups had similar levels of creative thinking abilities before the intervention. However, after the intervention in the form of OER implementation, the post-test results show a significant improvement in the experimental group, with an average score of 73. In contrast, the control group only showed a slight improvement, with an average score of 65.

This indicates that implementing OER positively impacts students' creative thinking abilities. The improvement in scores in the experimental group encompasses various aspects of creative thinking, not only in terms of fluency or flexibility but also in the ability to evaluate and elaborate for more profound clarity. Table 1 in this study will compare creative thinking scores between the experimental

and control groups before and after the intervention. This comparison will be valuable in understanding which aspects of creative thinking benefit most from implementing OER in the learning context.

Overall, there is a significant improvement in N-gain scores in creative thinking skills between the experimental and control groups. This indicates that the intervention provided through OER positively enhances students' creative thinking skills. This aligns with the principles of transformative learning, which encourage students to reflect on and revise their understanding, thereby enhancing creative thinking abilities. There is a different picture for flexibility, with no significant difference between the experimental and control groups. This may suggest that while OER may be effective in improving some aspects of creative thinking skills, transformative learning through OER requires more specific or differential implementation to truly impact all creative thinking skills.

Overall, the findings of this analysis provide evidence that Open Educational Resources (OER), when integrated with the transformative learning approach, can positively impact students' creative thinking abilities. However, the effects seem to vary across all aspects of these skills. Therefore, researchers and educators need to consider how to maximize the potential of transformative

learning and OER in supporting the holistic development of creative thinking skills.

Both Open Educational Resources (OER) and transformative learning are crucial in facilitating a more inclusive and impactful learning experience in modern education. As Hilton III et al. (2010) outlined, OER provides a framework that enables easier access to educational resources, expands the scope of learning, and has the potential for transformation. On the other hand, Taylor (2007) details how transformative learning emphasizes profound changes in perspectives and understanding that can provide significant empirical support. Integrating both paradigms holds promise as a robust approach to enhancing creative thinking skills.

Understanding the effectiveness of OER in supporting the transformative learning process to enhance creative thinking has significant implications. These findings could serve as a foundation for curriculum innovation, expanding access to quality learning materials and improving students' academic outcomes. Additionally, this knowledge is valuable for teachers' professional development and informs education policy.

CONCLUSION

The data analysis results show a significant difference in creative thinking abilities between the group utilizing Open Educational Resources (OER) with the transformative learning approach and the control group at the pre-test stage. N-gain scores reveal significant differences in creative thinking skills between the two groups. However, for the flexibility indicator, there is no significant difference between the two groups. This indicates that the use of OER in conjunction with the transformative learning approach effectively enhances creative thinking abilities. Still, this effectiveness is not uniform across all aspects of creative

thinking. The flexibility indicator does not show significant improvement. Thus, although OER facilitates the transformative learning process and demonstrates improvement in creative thinking, additional strategies or deeper exploration are needed to enhance all aspects of creative thinking, including flexibility.

While effective, OER has not fully been able to facilitate all aspects of creative thinking, such as flexibility. This suggests that an educational approach cannot solely rely on OER and requires a combination of other methods. Therefore, educators should consider integrating principles from the transformative learning theory into the curriculum. For future research, it is highly recommended to focus on the effectiveness of OER based on the type of material or subject taught to determine the most effective sources. Further research is also needed to compare the effectiveness of OER with other learning methods.

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