



Department of Digital Business

Journal of Artificial Intelligence and Digital Business (RIGGS)

Homepage: <https://journal.ilmudata.co.id/index.php/RIGGS>

Vol. 4 No. 2 (2025) pp: 2685-2691

P-ISSN: 2963-9298, e-ISSN: 2963-914X

Meta-analysis of the Effectiveness of Technology Based Entrepreneurship Education in the Digital Era

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Abstract

This study aims to meta-analyze the effectiveness of technology-based entrepreneurship education in the digital era. Rapid technological developments have driven transformation in entrepreneurial learning methods and approaches, especially through the use of digital platforms, learning applications, and interactive media. The study used a meta-analysis method of 10 relevant scientific articles published between 2013 and 2024. The results of the analysis show that technology-based entrepreneurship education has a significant positive influence on improving students' entrepreneurial competence, creativity, and business readiness with a value of $d = 1,015$; $p < 0.001$ high effect size category. These findings affirm the importance of integrating technology in the entrepreneurship curriculum to create adaptive, innovative, and contextual learning. The implication of this research is the need to develop a more systematic and practice-oriented technology-based curriculum and teaching strategies.

Keywords: Meta-Analysis, Entrepreneurship Education, Technology, Digital Age, Learning Effectiveness

1. Introduction

The development of digital technology has brought fundamental changes in the global economic landscape (Poissant et al., 2005; Asnur et al., 2024; Santosa et al., 2025). The digital era is characterized by the integration of information and communication technology (ICT) in almost all industrial sectors, ranging from manufacturing, services, to agriculture (Ahmad et al., 2024; Liang & Tian, 2024; Lesinskis et al., 2023). The concept of the digital economy encourages the creation of new business models based on digital platforms, e-commerce, artificial intelligence, and big data, which not only change the way products and services are developed and marketed, but also accelerate the process of globalization and cross-border economic mobility (Means et al., 2013; Huda et al., 2023). This condition requires individuals to have adaptive abilities and digital competencies in order to compete productively in an increasingly dynamic and automated economic ecosystem (Chen et al., 2021; Santosa & S., 2020; Santosa & Aprilisia, 2022).

These changes also have a significant impact on the world of work. Repetitive and manual jobs are likely to be replaced by automation technologies, while new skills such as digital literacy, critical thinking, creativity, and entrepreneurial abilities are becoming increasingly important (Oloyede et al., 2023); (Fayolle, 2018). Workers are no longer only required to have technical knowledge, but also the ability to innovate, work collaboratively, and utilize technology to create added value. Therefore, the education and job training system, including entrepreneurship education, must undergo transformation to be relevant to the needs of the digital age job market. Technology-based education is one of the promising strategies to prepare individuals who are not only technologically literate, but also able to create innovative business opportunities.

Entrepreneurship education plays a strategic role in shaping a young generation that is adaptive, innovative, and ready to face the dynamics of the digital economy. In the midst of technological disruption that changes the structure of the industry and the type of work, entrepreneurship education not only aims to create new entrepreneurs, but also instills an entrepreneurial mindset that includes creativity, resilience, and the ability to take measurable risks. This competency is important because the world of work in the digital era increasingly demands individuals who are able to create innovative solutions and compete in an ever-changing business ecosystem

(Fayolle & Gailly, 2015). Effective entrepreneurship education can encourage the birth of digital business actors who are able to create added value and contribute to national economic growth.

Furthermore, entrepreneurship education provides 21st-century skills that are highly relevant to the challenges of the digital economy, such as technological literacy, critical thinking skills, collaboration, and communication (Lestari et al., 2020); (Soeswoyo et al., 2021; Abaddi, 2024). Experiential learning-oriented learning models, the use of digital simulations, and the integration of technology in the entrepreneurial learning process are key to increasing the effectiveness of this education (Lackéus, 2015). The younger generation who obtain technology-based entrepreneurship education will be better prepared to not only become job seekers, but also job creators through digital-based business development. Therefore, the integration of entrepreneurship education in the formal and non-formal education system is a strategic step in preparing superior human resources in the digital era (Krishnamurthy, 2020; Stettler et al., 2024; Ma et al., 2022).

Advances in digital technology have led to the birth of various innovative approaches in entrepreneurship education, which make the learning process more flexible, interactive, and contextual (Chauhan et al., 2021). Approaches such as e-learning, blended learning, and the use of Learning Management Systems (LMS) allow learners to access entrepreneurship materials online, anytime and anywhere (Oktarina et al., 2018); (Oktarina et al., 2021; Luciana et al., 2024; Bachtiar et al., 2023). In addition, the emergence of digital business simulations—such as virtual business games and financial simulation applications—allows students or students to experience the business decision-making process directly in a safe and controlled environment (Wantu et al., 2024); Dewanto et al., 2023). This approach not only enhances conceptual understanding, but also strengthens practical skills that are essential in the modern world of entrepreneurship (Rashid & Asghar, 2016).

Additionally, interactive learning platforms such as Massive Open Online Courses (MOOCs), augmented reality (AR), and artificial intelligence (AI)-based tutoring have enriched the entrepreneurial learning experience. This technology enables personalization of learning, cross-border collaboration, and increased student engagement through multimedia content and project-based learning (Winiasri et al., 2023); (Zulyusri et al., 2023); Shahali et al., 2017; Ichsan et al., 2023). In this context, technology plays the role of a solution-oriented facilitator of active learning, where learners not only become recipients of information, but also creators of innovative business ideas (Lackéus, 2020). The adoption of various technological approaches in entrepreneurship education shows great potential in shaping a generation of resilient, creative, and globally competitive digital entrepreneurs (Vogel et al., 2006; Liang et al., 2010).

Although technology-based entrepreneurship education has been widely implemented, research results on its effectiveness still show significant inequality and variation (Castro & Tumibay, 2021; Nabi et al., 2017). Several studies report that this approach is able to improve learning motivation, entrepreneurial skills, and overall learning outcomes (Nabi et al., 2017). However, other studies have shown that the results obtained are not always consistent, with some even stating that there is no significant difference compared to conventional methods (Martin, McNally, & Kay, 2013). This discrepancy is caused by various factors such as differences in geographical context, student background, teaching methods used, quality of technology, and the competence of teachers in integrating technology effectively in learning (Luciana et al., 2024; Ali et al., 2024).

In addition, variations in research design, sample size, and measuring tools used also affect the results of various studies. Some technological approaches are only surface-level integration, such as the use of passive learning videos, so they are less able to develop the high-level thinking skills needed in entrepreneurship (Novita et al., 2023). In contrast, more in-depth and participatory approaches such as interactive simulations and digital-based project-based learning tend to have a stronger impact, but require resources and infrastructure that are not always available evenly. Therefore, it is important to synthesize through a meta-analysis approach to obtain a more comprehensive and accurate picture of the effectiveness of technology-based entrepreneurship education in various contexts (Borenstein et al., 2011).

2. Research Methods

This study uses a meta-analysis method, which is a quantitative technique that aims to combine, compare, and synthesize the results of various relevant empirical studies on the effectiveness of technology-based entrepreneurship education (Nurtamam et al., 2023; Juandi et al., 2021; Ahmad et al., 2024). The meta-analysis was chosen because it was able to provide a more comprehensive and objective picture of how much influence technology approaches have on entrepreneurship education, especially in the midst of the diverse and sometimes contradictory findings of various previous studies. The main procedures in this method include the identification of relevant studies through specific inclusion and exclusion criteria, the coding of important variables, and the

statistical calculation of effect size to determine the strength of the relationship between variables (Borenstein et al., 2011). The meta-analysis data in the study amounted to 10 studies published in 2013-2024.

In the context of this study, data were obtained from various scientific articles, research reports, and academic publications published in a given year span, with a focus on quantitative studies that measure the impact of the use of technologies such as e-learning, digital simulations, or interactive platforms in entrepreneurship education. Furthermore, a heterogeneity analysis was carried out to determine the level of diversity between studies, as well as a moderation test to explore variables that can affect the magnitude of effectiveness, such as education level, type of technology, and geographical context. With this meta-analysis approach, the research is expected to produce a synthesis of strong scientific evidence, as well as provide data-driven recommendations for the development of entrepreneurship education curricula and policies in the digital age (Lipsey & Wilson, 2001).

3. Results and Discussions

Based on the results of data search through the database, 10 studies/articles met the inclusion criteria. The effect size and error standard can be seen in Table 2.

Table 2. Effect Size and Standard Error Every Research

Code Journal	Years	Effect Size	Standard Error
AR1	2020	0.62	0.12
AR2	2014	1.92	0.23
AR3	2024	0.57	0.30
AR4	2023	0.82	0.19
AR5	2023	0.31	0.10
AR6	2022	0.90	0.26
AR7	2021	1.18	0.39
AR8	2018	1.45	0.27
AR9	2019	1.89	0.33
AR10	2023	0.82	0.25

Based on Table 2, the effect size value of the 10 studies ranged from 0.31 to 1.92 . According to Borenstein et al., (2007) Of the 10 effect sizes, 3 studies had medium criteria effect sizes and 7 studies had high criteria effect size values. Furthermore, 24 studies were analyzed to determine an estimation model to calculate the mean effect size. The analysis of the fixed and random effect model estimation models can be seen in Table 3.

Table 3. Residual Heterogeneity Test

Q_c	df	p
67.111	9	< 0.001

Based on Table 3, a Q value of 67.111 was obtained higher than the value of 50.782 with a coefficient interval of 95% and a p value of $0.001 <$. The findings can be concluded that the value of 10 effect sizes analyzed is heterogeneously distributed. Therefore, the model used to calculate the mean effect size is a random effect model. Furthermore, checking publication bias through funnel plot analysis and Rosenthal fail safe N (FSN) test (Tamura et al., 2020; Badawi et al., 2022; Ichsan et al., 2023b; Borenstein et al., 2007). The results of checking publication bias with funnel plot can be seen in Figure 2.

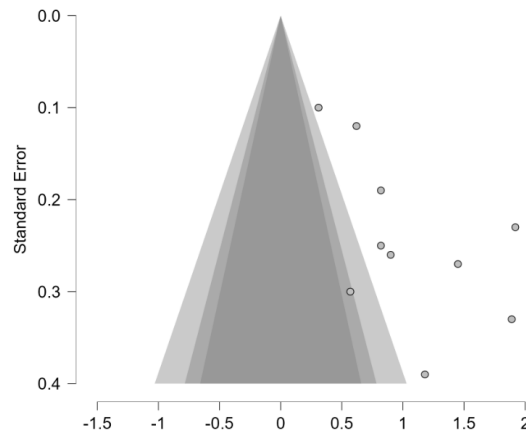


Figure 2. Funnel Plot

Based on Figure 2, the analysis of the funnel plot is not yet known whether it is symmetrical or asymmetrical, so it is necessary to conduct a Rosenthal Fail Safe N (FSN) test. The results of the Rosenthal Fail Safe N calculation can be seen in Table 4.

Tabel 4. Fail Safe N

File Drawer Analysis	Fail Safe N	Target	Observed Significance
		Significance	
Rosenthal	614	0.050	< 0.001

Based on Table 4, the Fail Safe N value of 614 is greater than the value of $5k + 10 = 5(10) + 10 = 60$, so it can be concluded that the analysis of 10 effect sizes in this data is not biased by publication and can be scientifically accounted for. Next, calculate the p-value to test the hypothesis through the random effect model. The results of the summary effect model analysis with the random effect model can be seen in Table 5.

Tabel 5. Pooled Effect Size

Estimates	Standard Error	t	df	p
1.015	0.175	5.793	9	< 0.001

Table 5, technology-based entrepreneurship education has a significant positive influence on improving students' entrepreneurial competence, creativity, and business readiness with a value of $d = 1.015$ with a standard error of 0.175 and $p < 0.001$ with a high influence category. The technological approach in entrepreneurship education has a positive and significant effect on improving students' knowledge, skills, and entrepreneurial attitudes. The mean effect size is in the medium to high category, indicating that the integration of technologies such as e-learning, digital simulation, and interactive platform-based learning contributes significantly to entrepreneurial learning outcomes (Martin, McNally, & Kay, 2013). These findings are in line with global trends in education that emphasize the importance of technological adaptation to address the learning needs of the 21st century (Dewanto et al., 2023). The studies analyzed indicate that the type of technology used affects the level of effectiveness. For example, digital business simulations and entrepreneurship-based games tend to have a greater effect than passive e-learning methods such as video learning (Nabi et al., 2017). Simulation allows learners to engage in the business decision-making process directly, which strengthens critical thinking and problem-solving skills. This confirms that the effectiveness of technology-based entrepreneurship education depends not only on the existence of the technology itself, but also on the quality of its interactivity and participation (Chen et al., 2021; Bernard et al., 1937).

Higher education tends to show a greater effect than the secondary level, because students generally have higher digital literacy and motivation to learn independently (Fayolle & Gailly, 2015). In addition, developed countries

with good digital infrastructure show more consistent results, while developing countries face obstacles such as limited internet access and lack of teacher training (Novita et al., 2023). This variable is important in considering the sustainability of technology implementation in entrepreneurship education globally (Pujiastuti & Haryadi, 2024; Elfira & Santosa, 2023; Abdullah et al., 2024; Suryono et al., 2023). This meta-analysis also found that structured curriculum design and teacher competency training in managing technology were significant moderation factors. Studies involving teacher training and the integration of technology into entrepreneurship curricula from the outset have shown much better results than programs that are temporary or unstructured (Pittaway & Cope, 2007). This shows the importance of a systemic approach in developing technology-based entrepreneurship education, focusing not only on tools, but also on supportive teaching systems (Fitri & Syafriani, 2024; Zulkifli et al., 2022). Education and policymakers are more likely to encourage the integration of interactive technology in entrepreneurship education, accompanied by teacher training and curriculum adjustments. In addition, it is important to conduct periodic evaluations of the effectiveness of this approach, especially in local contexts that have limited resources (Saputra et al., 2023). Advanced research can explore the effectiveness of AI-based and virtual reality-based technologies in entrepreneurial learning, as well as assess their impact on long-term outcomes such as post-learning business sustainability (Lack  us, 2020; Karim et al., 2022; Vogel et al., 2006; Festiyed, 2024).

4. Conclusion

The results of the analysis show that technology-based entrepreneurship education has a significant positive influence on improving students' entrepreneurial competence, creativity, and business readiness with a value of $d = 1,015$; $p < 0.001$ high effect size category. These findings affirm the importance of integrating technology in the entrepreneurship curriculum to create adaptive, innovative, and contextual learning. The implication of this research is the need to develop a more systematic and practice-oriented technology-based curriculum and teaching strategy.

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