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SWOT Analysis of Development Strategies for Welding Learning Using Virtual Reality

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KEY WORDS

Virtual Reality, Welding, SWOT Analysis, Vocational Education

ABSTRACT

This study aims to analyze the development strategy of welding learning using Virtual Reality (VR) with the quantitative SWOT method. Using a score-based SWOT analysis, the study found that the development of VR welding learning was in the I Quadrant (Aggressive), which means the strategy to be carried out is to leverage strengths to capture the available opportunities. The quantitative SWOT chart shows that the strategy position is in the coordinates (2.38, 1.12), which supports the development of VR as an innovative solution in welding training.

1. Introduction

Virtual Reality (VR) technology has been widely used in the world of education, especially in the fields of engineering and vocational. In welding learning, VR offers innovative solutions that allow students to practice without the risk of physical harm, save on material costs, and enhance a more interactive learning experience. However, the implementation of this technology also faces various challenges, such as high initial costs and the readiness of teaching staff. Therefore, a SWOT analysis is needed to understand the potential and obstacles in the development of VR-based welding learning.

SWOT analysis is the systematic identification of various factors to formulate a company's strategy. A strategic planning method used to evaluate strengths, weaknesses, opportunities, and threats in a project or a business speculation. These four factors form the acronym SWOT (strengths, weaknesses, opportunities, threats). SWOT stands for Internal Strengths and Weaknesses as well as Opportunities and Threats faced by the business world (Rangkuti 2008, 19).

According to Jogiyanto (2005, 46), SWOT is used to assess the strengths and weaknesses of the company's resources and external opportunities and challenges. (1) Strengths, are resources, skills, or other weaknesses related to welding using welding (2) Weakness, is a limitation or deficiency in resources, skills, and capabilities that effectively hinder the implementation of virtual reality welding. These limitations can be in the form of facilities, resources. (3) Opportunities, is an important situation that is advantageous in the implementation of welding learning using virtual reality. (4) Threats, is an important situation that is not advantageous in learning welding using virtual reality.

Strategy is the long-term goal of a company, as well as the formulation of utilization and allocation of resources that are essential to achieve those goals. In general, strategy can be interpreted as a set of critical options for the planning and implementation of a series of action plans and resource allocation that are important in achieving goals and objectives, taking into account the competitive, comparative, and synergistic advantages of sustainable ideals towards the ideal overall long-term scope and perspective of the individual or organization (Ramadhan and Fivi 2013, 4).

This study aims to analyze the development strategy of welding learning using Virtual Reality (VR) with the quantitative SWOT method.

2. Methodology

The research method used is a quantitative descriptive method. The SWOT analysis used is the descriptive analysis method, SWOT matrix and SWOT diagram analysis.

The method used in this study is a quantitative SWOT analysis with a score approach. The score is given based on the identification of the Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) factors. The SWOT value is calculated by the scale comparison method, so that the coordinates of the strategy to be visualized in the SWOT graph are obtained.

The population in the study was carried out on academics and practitioners who are active in vocational education. The sample used was a full sample of 30 people. 15 people from vocational schools and polytechnics teachers and 15 people from industrial practitioners and training institutions. The data collection techniques in this study are interviews and questionnaires.

3. Result and Discussion

SWOT Analysis in Welding Learning Development Strategy Using Virtual Reality

Strengths

1. Interactive and Immersive Learning – VR technology creates a more engaging and realistic learning environment, increasing student

engagement in understanding welding techniques.
2. Higher Safety – With virtual simulations, the risk of accidents due to heat exposure, sparks, or technical errors in real welding can be minimized.
3. Reduced Operational Costs – VR reduces the need for real materials such as metals and gases, saving on training costs in the long run.
4. Flexibility and Accessibility – VR-based learning can be done from a variety of locations, allowing more participants to take part in the training without having to be in a physical workshop.
5. Real-time Monitoring and Evaluation – VR technology allows instructors to monitor participant performance in real time, providing instant feedback to improve techniques and improve learning efficiency.
6. Eco-Friendly – By reducing the use of physical materials and production waste, this technology contributes to more sustainable and environmentally friendly learning practices.

Weaknesses

1. High Initial Investment Costs – The procurement of VR devices, specialized software, and supporting infrastructure requires large costs that may be a barrier for small educational or training institutions.
2. Lack of Familiarity with Technology – Not all participants or instructors have experience in using VR technology, so additional training is required before full implementation.
3. Limitations of Real Experience – Although VR simulations are highly realistic, there is still a gap between the skills acquired in the virtual world and the application in real-world situations.
4. Infrastructure Limitations – Not all institutions have access to a stable internet network and supporting hardware, which can hinder the adoption of VR technology on a large scale.
5. Potential Health Effects – Prolonged use of VR can cause side effects such as eye strain, dizziness, or disorientation, which can affect participants' learning comfort.

Opportunities (Peluang)

1. Support for the Industrial Revolution 4.0 – The adoption of VR in welding learning is in line with the development of Industry 4.0 which demands a skilled workforce in digital technology and automation-based manufacturing.
2. Collaboration with Industry – Collaboration between educational institutions, training centers, and manufacturing companies can accelerate the adoption of VR in learning and increase the relevance of the curriculum to industry needs.
3. Technology Funding and Grants – Governments and research institutions are increasingly providing grants and funding for the development of digital-based educational technologies, including VR.
4. VR-Based Curriculum Development – The integration of VR in vocational and higher education curricula can raise learning standards and expand access to technology-based training.
5. Continuous Innovation in VR Technology – Advancements in VR hardware and software are constantly evolving, creating better learning experiences at an increasingly affordable cost.

Threats (Ancaman)

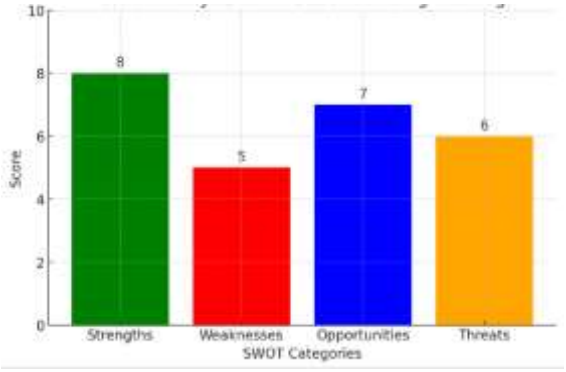
1. Rapid Technology Developments – VR technology innovations are rapidly evolving, which can lead to initial investments becoming obsolete in a relatively short period of time if not balanced with continuous updates.
2. Resistance to Change – Some instructors and participants may still be reluctant to switch from conventional learning methods to VR-based methods, mainly due to habitual factors and lack of trust in the effectiveness of new technologies.
3. Infrastructure Constraints in Some Regions – Not all institutions have access to adequate digital infrastructure, such as high-speed internet

and quality VR devices, which can hinder the widespread adoption of these technologies.

4. Uneven Industry Adoption Rate – Although VR has great potential, many traditional welding industries still rely on conventional methods and have not integrated this technology in the workforce training process.
5. Reliance on Technology Developers – The sustainability of the use of VR in learning is highly dependent on software and hardware developers, which means in the event of a policy change or discontinuation of support, institutions may face major challenges in maintaining their training programs.

By understanding this SWOT analysis, education and training institutions can develop more effective strategies in integrating Virtual Reality in welding learning, so that they can maximize its benefits and overcome existing challenges.

Graph 1. SWOT Analysis of VR-Based Welding Training



Tabel 1. Internal Factor Analysis Summary (IFAS)

Internal Factors	**Weight**	**Score**	**Weight × Score**
Strengths			
Interactive and immersive learning	0,18	5	0,90
Higher security	0,16	5	0,80
Reduced long-term operational costs	0,12	4	0,48
Flexibility & accessibility	0,10	4	0,40
Real-time monitoring and evaluation	0,08	4	0,32
Environmentally friendly	0,06	4	0,24
Total Strengths	**0,70**		**3,14**

Internal Factors	**Weight**	**Shoes**	**Weight × Score**
Weaknesses			
High initial investment costs	0,10	2	0,20
Lack of familiarity with technology	0,07	3	0,21
Limitations of real sensations	0,06	3	0,18
Infrastructure limitations	0,04	2	0,08
Potential health effects (motion sickness, eye fatigue)	0,03	3	0,09
Total Weaknesses	**0,30**		**0,76**

Internal Factors Score = Strengths - Weaknesses = 3.14 - 0.76 = +2.38 (positive, indicating the opportunity is greater than the threat)

Tabel 2. Eksternal Factor Analysis Summary (EFAS)

External Factors	**Weight**	**Shoes**	**Weight × Score**
Peluang (Opportunities)			
Support for the Industrial Revolution 4.0	0,15	5	0,75
Collaboration with industry	0,12	4	0,48
Technology funding and grants	0,09	4	0,36
VR-based curriculum development	0,08	4	0,32
Continuous innovation in VR technology	0,06	4	0,24
Total Opportunities	**0,50**		**2,15**

External Factors	**Weight**	**Shoes**	**Weight × Score**
Ancaman (Threats)			
Rapid technological development (VR can be obsolete)	0,10	3	0,30
Resistance to change	0,09	2	0,18
Infrastructure constraints in some regions	0,08	2	0,16
The rate of industrial adoption has not been evenly distributed	0,07	3	0,21
Dependency on technology vendors	0,06	3	0,18
Total Threats	**0,40**		**1,03**

External Factors Score = Opportunities - Threats = 2.15 - 1.03 = +1.12 (positive, indicating the opportunity is greater than the threat).

Using the results of internal and external factor scores:

- Internal factor score (Strengths - Weaknesses) = +2.38
- External factors score (Opportunities - Threats) = +1.12

Graphic Images:

This position is in Quadrant I (Growth/Aggressive Strategy), which shows that VR development for welding learning has more advantages and opportunities than weaknesses and threats. Therefore, the strategy that must be implemented is a strategy of further expansion and investment.

ST (Strengths-Threats) – Risk Strengthening and Mitigation Strategies

Regularly upgrade technology to avoid the risk of obsolete VR systems. Prepare training for instructors to be better prepared to adopt new technologies.

Using a hybrid learning approach (a combination of VR with hands-on practice) to improve industry readiness. Establish partnerships with more than one

technology vendor so that you don't rely on just one supplier.

WO (Weaknesses-Opportunities) – Infrastructure Repair and Strengthening Strategy

Seeking external funding sources such as grants or cooperation with VR providers to reduce initial investment costs. Increasing technology literacy for teachers and students to overcome resistance to VR technology. Expanding VR access by procuring equipment in multiple regional training centers so that it is not only concentrated in one location.

WT (Weaknesses-Threats) – Defensive and Contingency Strategies

Develop a roadmap for VR implementation in stages so that adaptation runs more smoothly and does not directly burden infrastructure. Conduct feasibility studies and regular evaluations of the effectiveness of VR learning prior to large-scale implementation. Identify barriers at the industry level and ensure VR-based curriculum remains relevant to work needs.

4. Conclusion

The results of the quantitative SWOT analysis show that the development strategy of VR-based welding learning is in Quadrant I (Aggressive). This shows that the application of VR in welding training has great potential to be developed by leveraging existing strengths and capturing available opportunities. The implementation of this technology can improve the quality of learning in the field of welding and support technology-based vocational education.

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