International Journal of Business, Law, and Education
Volume 4, Number 2, 2023

META-ANALYSIS REVIEW OF THE USE OF VIRTUAL REALITY IN SAFETY TRAINING

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Abstract
This study aims to review the use of virtual reality in safety training through a meta-analysis approach. The choice of topics in this study was motivated by the lack of studies related to correlations that discuss Virtual Reality" and "safety amid the high use of Virtual Reality in various aspects. The method in this study follows the Preferred Reporting for Systematic Reviews and Meta-Analysis (PRISMA). PRISMA was created with the aim of helping to ensure clarity and transparency of reporting, systematic reviews, and meta-analyses. The meta-analysis conducted resulted in the discovery of a large-size effect on the relationship between Virtual Reality and Safety. Based on the analysis with Jamovi, the results of the heterogeneity study obtained a value of Q = 170.487, a value of I2 = 96.25%, and Tau2 = 0.3825 (with SE = 0.1937). In addition, the effect size value is 0.67 (RE Model), the Eggers Regression value is -2.104, and in the forest plot image, it is known that the data represented by black dots are located inside the white triangle and are around the triangle.

Keywords: Meta-Analysis, Virtual Reality, And Safety

INTRODUCTION

Virtual Reality (VR) is a technology that is popular today. its ability to make users able to interact with the environment resulting from computer simulations, makes VR widely implemented in various aspects (Hamad &; Jia, 2022). The concept of VR was first introduced in the 1960s, with Morton's creations of the Telesphere Mask and Sensorama. The goal is to make users feel the adrenaline rush in the videos shown.

The development of VR technology began in 2010. Based on historical records, VR was initially seen as a taboo, not considered a renewable technology, and assumed to be stagnant in the industrial market. This opinion becomes stronger when the price of VR is not economical. Both for industry players and the community (Hamad &; Jia, 2022). As time progressed, the negative perspective on VR began to fade. It was precisely in 2012 when Palmer Luckey debuted his prototype to introduce Oculus (Oculus is a headband display device for displaying virtual reality) and received a good reception from several multinational technology companies such as Facebook and Google.

Based on research conducted by Daniel Harley (2019), the use of VR increased sharply after Palmer Luckey introduced his Oculus prototype. VR, which was originally published only as a game, has now developed into a renewable technology that can help many fields in making real visuals about the implementation of a project, because of its ability to make users able to interact with the computer-simulated environment. The implementation of VR in various fields, one of which is used to estimate the occurrence of errors in a project that is directly related to human safety (safety), such as in aviation activities, for example, the use of VR can help estimate the percentage of pilot success when facing certain situations during flight, so as to minimize the risk of aircraft accidents (Kathleen Van Benthem, Chris M. Herdman, 2021). In addition to the aviation industry, the implementation of VR is also quite popular in the health sector. The results of Yewande M. Akinola's research (2020) said that virtual reality

has been applied in the health sector to help medical professionals visualize the inside of the human body that is not reached directly, helping prospective medical professionals conduct training. operation management, patient care, as well as educational facilities for certain diseases.

The results of research conducted by Ziyue Guo (2020) stated that the existence of VR in the industrial world is an answer to the high number of work accidents that occur in various aspects. Both are caused by tools, systems, and work management, or errors in humans themselves (Human Error). The use of VR on safety seems to explain the importance of work safety, as well as in explaining work safety procedures, training on safety induction using VR is considered more able to minimize the possibility of work accidents because it can improve learning outcomes and knowledge retention in a longer period. VR can also replace job training by creating immersive virtual environments Sameeran G. Kanade (2022).

The role of VR in safety is considered quite significant, as described above. However, the correlation between VR and safety still needs to be studied further. In addition to being motivated by the lack of research that discusses this, the study of the correlation between VR and safety is considered important to provide concrete insights related to the correlation value that can be produced. Based on the results of the above exposure, this study aims to systematically investigate the use of VR on safety (safety) to find accuracy, limitations, and future directions. so that VR can be directed to become a technology that can better meet the needs of various industries in order to remain competitive in the upcoming Industry 5.0.

Literature Review

a. Virtual Reality

Virtual reality (VR) is an advanced computer technology that can provide users with a variety of intuitive sensations while simulating mechanisms in the physical or imaginary world. There is no uniform definition of VR. This is because the use of VR in various elements is the background of someone defining VR with different concepts and views.

VR can be considered a natural extension of traditional computer graphics to 3D displays with advanced inputs and outputs. History records that at the beginning of its appearance VR devices seemed complicated, expensive, and inefficient. But with the development of time, VR hardware has become more flexible at a much more economical price, the software has become more efficient, and the entire VR system can provide users with greater spatial immersion. Here's a picture of VR before it developed or at the beginning of its appearance.

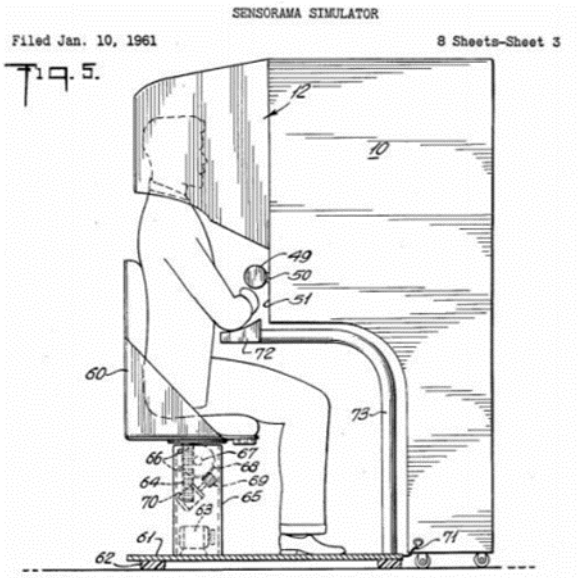


Figure 1: Patent for an immersive VR system by Heilig, 1962 (this image is taken from the journal Heather C. Lum (2020).

VR applications can only provide users with immersive vision beyond reality but also hearing, touch, and even the ability to interact with virtual objects. Through these updates, VR has experienced an acceleration in development in many fields in recent years. Not only in the industrial field but also in the academic field.

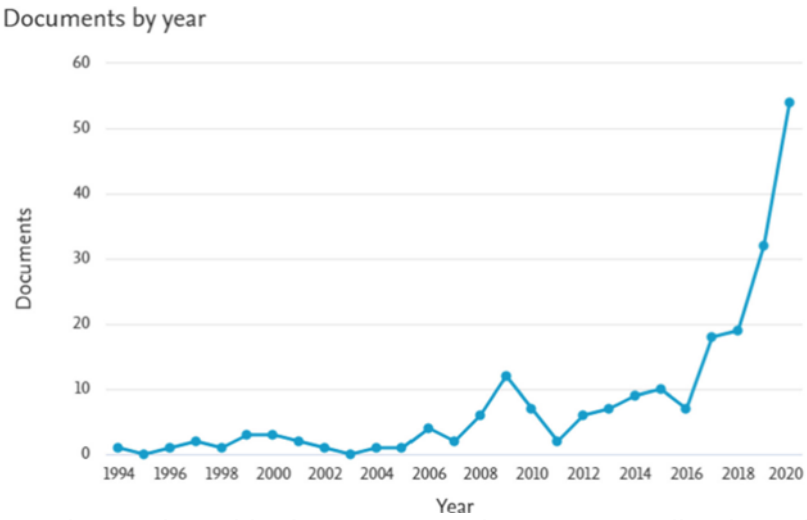
b. Virtual Reality to Safety

As a new technology that has the capacity to provide visuals directly to users, to be able to interact with the environment resulting from computer simulations, VR is widely implemented in various fields. One of them is used to estimate the occurrence of errors in a project that is directly related to human safety (safety)

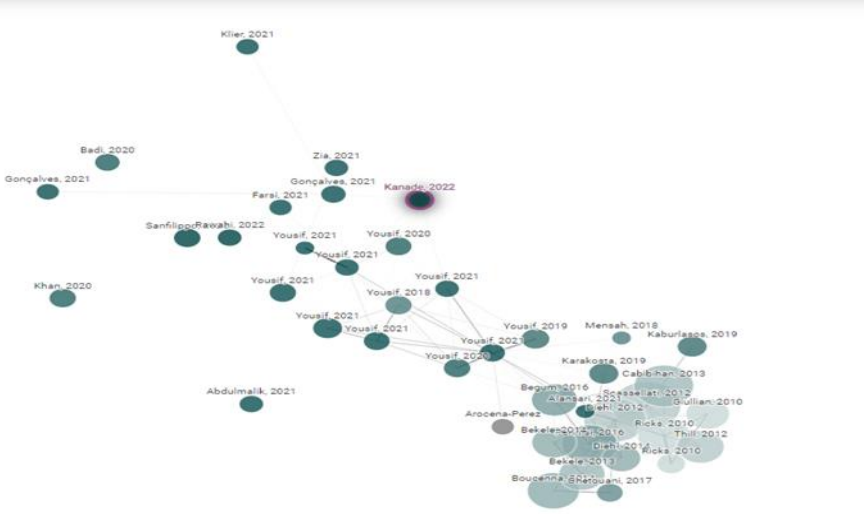
Based on the results of research conducted by Sameeran G. Kanade (2022) stated that the use of VR in reducing accidents and work failures is indeed very significant. This is motivated by the existence of simulation activities that can improve learning outcomes and knowledge retention over a longer period. Robert V. Lindsey (2015) practice-based learning is indeed effective in improving learning outcomes and knowledge retention over a fairly long period of time. This is because practical activities can make someone better understand the real conditions related to what they learn.

DJ Harris (2023) further said that the use of VR should be aimed at producing improvements in skilled performance in the real world, through computer simulations so that the situation displayed will not be truly authentic or the same as conditions in the field. Therefore, a conceptual framework is needed to help VR implementation be realistic to encourage real-world upskilling, especially in relation to safety. In this regard, the Government of Indonesia itself has implemented work safety standards contained in Law No. 1 of 1970. There are 10 clauses that need to be applied in the organization to improve the K3 management system through any means.

Based on the results of research conducted by Sameeran G. Kanade (2022) stated that research related to the number of publications in this topic field continues to increase from year to year. A considerable increase in the number of publications was seen after 2016 which shows that interest in the application of virtual reality for safety has increased in the last five years, following data cited by Sameeran G. Kanade (2022) in his research.



The search results with the connected papers application also support the results of the study, where based on the results of the search conducted, it was found that the results of research discussing the use of VR for safety are indeed more inclined to be in the last five years.



METHOD

The research conducted was a meta-analysis research. Meta-analysis is a method that combines various syntheses of the results of studies that have been carried out related to a particular theme. Meta-analysis will integrate the findings obtained by various previous studies to obtain relationship patterns that can be the basis of further theoretical developments (Card, 2012). Meta-analyses produce information that can be used to generalize (Iaffaldano & Muchinsky, 1985).

Data collection in this study followed the Preferred Reporting for Systematic Reviews and Meta-Analysis (PRISMA). PRISMA was created with the aim of helping to ensure clarity and transparency of reporting, systematic reviews, and meta-analyses. PRISMA is not used as a quality measurement tool for systematic reviews or meta-analyses (Liberati et al., 2009). The PRISMA used in this study is PRISMA 2020 or a change from PRISM 2009. In the prism used, there are 27 checklist items related to detailed reporting and revision of the PRISMA flow diagram.

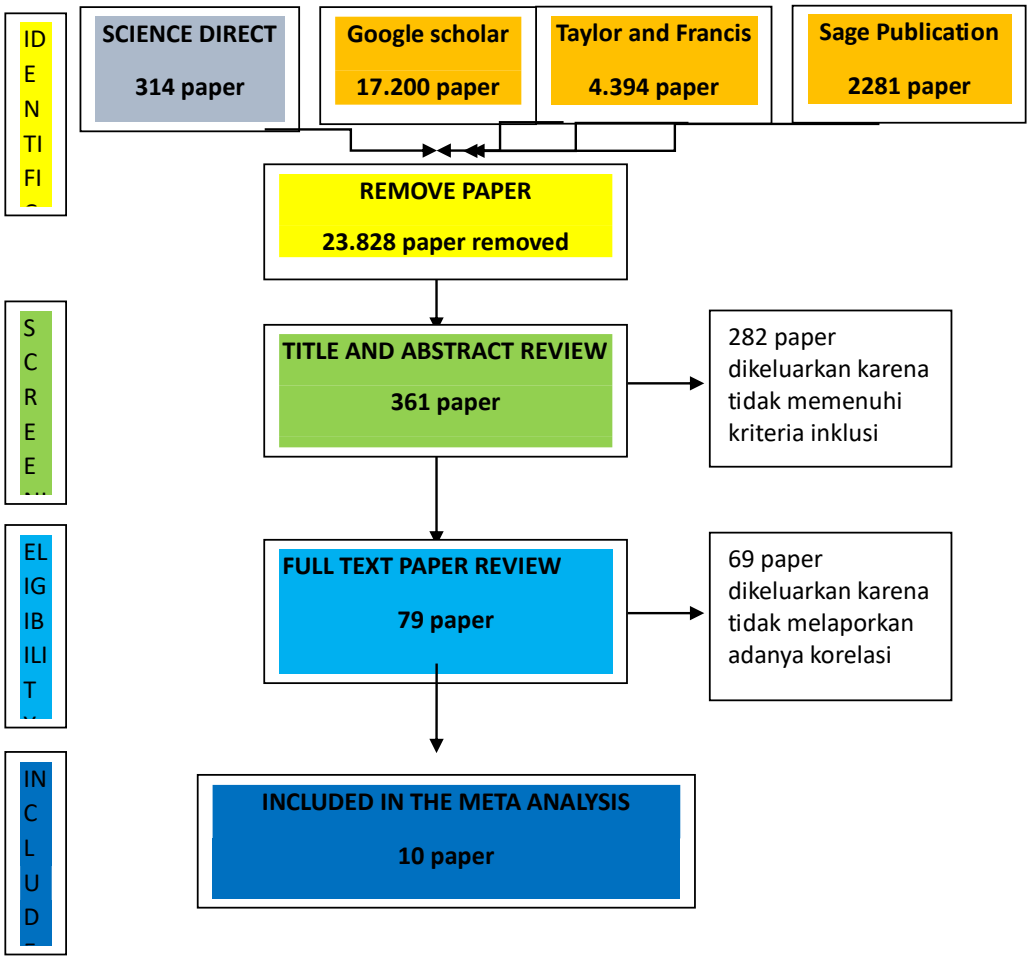
The approach that will be taken to identify research that is relevant to the theme of this research is carried out in several steps. First, the search for relevant literature from various sources or journal databases is carried out using several keywords. Keywords that will be included in the search process include "Virtual reality" and "Safety". The sources or databases of research articles to be used are Science Direct, Taylor and Francis, Sage Publication, and Google Scholar. The search will be conducted during April – May 2023. The following is PRISMA's explanatory table.

RESULTS AND DISCUSSION

a. Protocol Meta-Analysis

The first step of Meta-Analysis is to follow the meta-analysis protocol, The author uses a journal article search strategy from the databases Science Direct, Google Scholar, Taylor Francis, and Sage Publication. The author uses the search string "Virtual Reality Training" AND "Safety" taken from journal publications with a period of 2018 to 2023. The results are from Science Direct. The type of paper sought is in the form of articles. In Science Direct there are 314 papers, Google Scholar has 17,200 papers, Taylor Francis has 4394, and Sage Publication has 2281 papers. The inclusion criteria used include research study design or research is also cross-sectional, with the variables involved are virtual reality variables and safety variables. As for the exclusion criteria used, the reported articles do not use the correlation to be issued.

The second step is to enter the paper data into the Prisma Flow Diagram, which consists of several stages. At the identification stage, similarities were found in the articles searched, so articles with a total of 23,828 articles were issued. The next step is the Screening stage, out of 361 papers a total of 282 papers were issued because they did not meet the inclusion criteria. The next stage is Eligible, where there are 79 papers, and 69 papers must be issued because they do not show any relationship or correlation. So the total final paper at the included stage amounted to 10 papers. The final paper numbering 10 was then carried out meta-analysis using the Jamovi application.



The third step is to extract data. The data extracted is a paper that has been finalized at the included stage. Recording the author's name, publication name, number of samples, correlation coefficient, study design, and measurement method are recorded. The extraction data is entered in an Excel table which is then saved in . .CSV.

The fourth step is to perform data analysis from data extracted in the form of Excel tables using Jamovi analysis. Important to note in the use of Jamovi is to first install the major library, and open the. CSV inserts Ri into the correlation coefficient box, ni is entered into the sample box, and the author is entered into the study label box. Then we get the following results:

b. Correlation Coefficients (r, N)

Random-Effects Model (k = 10)

	Estimate	se	Z	p	CI Lower Bound	CI Upper Bound
Intercept	0.667	0.203	3.29	0.001	0.269	1.064
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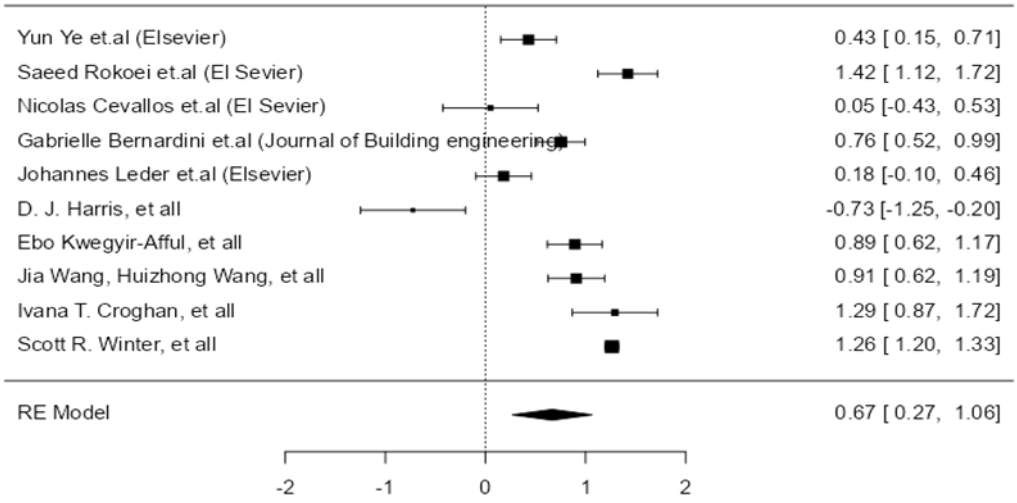
Note. Tau^2 Estimator: Restricted Maximum-Likelihood

Heterogeneity Statistics

Tau	Tau²	I²	H²	R²	df	Q	p
0.619	0.3825 (SE= 0.1937)	96.25%	26.666	.	9.000	170.487	< .001

In the heterogeneity study, the value of Q = 170.487, the value of I2 = 96.25%, and Tau2 = 0.3825 (with SE = 0.1937).
Forest Plot



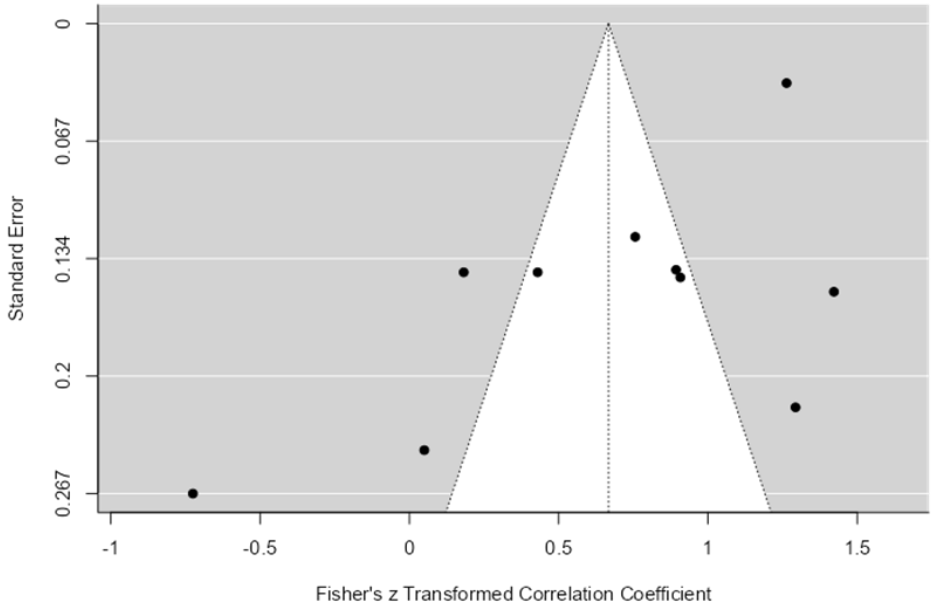
In the forest plot, the effect size value is 0.67 (RE Model).

Publication Bias Assessment

Test Name	value	p
Fail-Safe N	1977.000	< .001
Begg and Mazumdar Rank Correlation	-0.225	0.369
Egger's Regression	-2.104	0.035
Trim and Fill Number of Studies	0.000	.

Note. Fail-safe N Calculation Using the Rosenthal Approach

In Publication Bias, the value of Eggers Regression is -2.104
Funnel Plot



In the forest plot drawing, it is known that the data represented by black dots are located inside the white triangle and are located around the triangle.
The final stage is the interpretation of the data. From the results of the analysis with Jamovi obtained the following information:

The analysis was conducted using Fisher r-to-z transformed correlation coefficient as an outcome measure. A random effects model is installed on the data. The amount of heterogeneity (i.e., tau²), is estimated using a finite maximum likelihood estimator (Viechtbauer 2005). In addition to tau² estimates, Q-tests for heterogeneity (Cochran 1954) and I² statistics were reported. If any amount of heterogeneity is detected (i.e., tau² > 0, regardless of Q-test results), a prediction interval for the actual result is also provided. Student residues and Cook distances were used to examine whether studies might be outliers and/or influential in the context of the model. Studies with student residues greater than 100 x (1 - 0.05 / (2 X k)) the percentile of the standard normal distribution were considered potential outliers (i.e., using Bonferroni correction with double-sided alpha = 0.05 for the k studies included in the meta-analysis). Studies with Cook distances greater than the median plus six times the interquartile range of Cook distances were considered influential. Rank correlation tests and regression tests, using standard errors of observed results as predictors, are used to check funnel plot asymmetry.

A total of k = 10 studies were included in the analysis. Fisher's observed r-to-z change correlation coefficient ranged from -0.7250 to 1.4219, with most estimates positive (90%). Fisher's average estimate of r-to-z change correlation coefficients based on random effects models is \hat{\mu} = 0.6669 (95% CI: 0.2694 to 1.0643). Therefore, the average result differs significantly from zero (z = 3.2884, p = 0.0010). According to the Q-test, the actual results appear heterogeneous (Q (9) = 170.4865, p < 0.0001, tau² = 0.3825, I² = 96.2498%). The 95% prediction interval for the actual result is given by -0.6088 to 1.9425. Therefore, although the average result is expected to be positive, in some studies the actual result may actually be negative. Examination of student residues revealed that none of the studies had values greater than ± 2.8070 and hence no indication of outliers in the context of this model. According to Cook's

distance, no study can be considered too influential. The regression test showed funnel plot asymmetry (p = 0.0354) but not the rank correlation test (p = 0.3692).

CONCLUSION

A total of k = 10 studies were included in the analysis. Fisher's observed r-to-z change correlation coefficient ranged from -0.7250 to 1.4219, with most estimates positive (90%). From these results, there is a positive relationship between training using virtual reality and safety or safety caused. This implies that training using virtual reality has an impact on improving safety.

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