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**SCAFFOLDING LEARNING AND ITS APPLICATION TO
ENERGY CONSERVATION FIELD TRAINING: A
BIBLIOMETRIC ANALYSIS**

**TOWARD INNOVATION HUB EXCELLENCE: A
SCIENTIOMETRIC ANALYSIS OF SCIENCE TECHNO
PARKS WORLDWIDE (1982-2023)**



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SCAFFOLDING LEARNING AND ITS APPLICATION TO ENERGY CONSERVATION FIELD TRAINING: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Scaffolding learning in training provides effective and efficient support to learners gradually according to their dynamic assessment achievements. Our contribution is exploring the trend of scaffolding learning in training research that has not been done in previous studies - bibliometric analysis using the Scopus scientific database for two decades (2004-2023). Data analysis used performance analysis, co-word analysis, and network visualization analysis. The results of research theme mapping show that instructional scaffolding has yet to be widely explored. Instructional scaffolding is a topic that provides a challenge for facilitators as a training solution in energy conservation using a combination of learning forms, i.e., one-to-one, peer, and computer-based scaffolding.

ABSTRAK

Pembelajaran scaffolding dalam pelatihan memberikan dukungan yang efektif dan efisien kepada peserta didik secara bertahap sesuai dengan pencapaian penilaian mereka yang dinamis. Kontribusi kami adalah mengeksplorasi tren pembelajaran scaffolding dalam penelitian pelatihan yang belum pernah dilakukan dalam penelitian sebelumnya. Analisis bibliometrik menggunakan basis data ilmiah Scopus selama dua dekade (2004-2023). Analisis data menggunakan analisis kinerja, analisis co-word, dan analisis visualisasi jaringan. Hasil pemetaan tema penelitian menunjukkan bahwa instructional scaffolding belum banyak dieksplorasi. Instructional scaffolding merupakan topik yang memberikan tantangan bagi fasilitator sebagai solusi pelatihan di bidang konservasi energi dengan menggunakan kombinasi bentuk pembelajaran one-to-one scaffolding, peer scaffolding, dan scaffolding berbasis komputer.

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INTRODUCTION

Our contribution in this study discusses the bibliometric analysis of scaffolding learning in training using Scopus indexing database data sources that other studies still need to do. Previous research is only on scaffolding learning in science education or education and learning topics in general. (Lin et al., 2022) in research that focused on mapping scaffolding research trends in science education in physics, chemistry, biology, earth science, mathematics, environmental science, medical science, STEM, and STEAM using the Web of Science database over two

decades (2000-2019). Meanwhile, other bibliometric analysis research in the context of education and learning using more general topics has been carried out, such as the topic of education quality (Brika et al., 2021), internationalization of higher education (Ghani et al., 2022), physical learning (Perdima et al., 2022) and language (Liu & Zhang, 2021), blended learning (Raman et al., 2021), and e-learning (Djeki et al., 2022; Gao et al., 2022).

Therefore, research mapping scaffolding learning research in training is essential for organizations to develop human resources. Training is generally more job-specific in learning outcomes of knowledge, skills, and attitude than education, which is more general or not specific to one's career or job (Blanchard & Thacker, 2013). Training has always been linked to the term development as a way to promote individual and organizational excellence by providing opportunities to develop skills in the workplace (Laird, 2003). Therefore, everyone in the organization must follow it so that their competence meets the standard requirements of their job by integrating knowledge, skills, attitudes, and other factors (Blanchard & Thacker, 2013). The findings align with another understanding that competence is also referred to as competent performance to improve performance in the workplace (Hoffmann, 1999).

Research Questions

The research questions posed as guidelines for determining the scope, objectives, selection of data analysis techniques, search strategies, and interpretation of research data are as follows: What is the development of research performance conducted from year to year (RQ1)? What is the distribution of the most used keyword items in different periods? (RQ2) What are the most frequently and still less explored themes and topics related to the study of scaffolding learning in training in the last year? (RQ3) How is applying scaffolding learning as a solution in training in energy conservation based on our practice? (RQ4).

METHOD

This research analyzes the development trend of learning research using the bibliometric method. Bibliometric analysis can rigorously explore large amounts of science data with a complex and broad scope of review topics (Donthu et al., 2021). Bibliometric analysis has expanded to a wide range of disciplines as the number of publications has proliferated and developed so fragmentarily that the task of accumulating knowledge has become complex (Aria & Cuccurullo, 2017).

The stages of bibliometric analysis consist of several stages (Aria & Cuccurullo, 2017; Donthu et al., 2021). i.e., The first is to define the question, objectives, and scope of the research as presented in the introduction of this paper. Secondly, they are selecting bibliometric analysis techniques, which, in this research, uses the main techniques of performance analysis, co-word analysis, and network visualization analysis. Performance analysis to map the performance of research development based on publication year and country. The analysis and results were visualized with Flourish. Flourish is a platform for data visualization that is easy to use, and the results can be animated. (<https://app.flourish.studio/projects>).

Furthermore, co-word analysis or keyword co-occurrence is used to find the relationship between items or keywords written. For enrichment analysis, this research uses network

analysis. Bibliometric analysis using VOSviewer to determine the trend of research development maps based on keywords (co-occurrence) includes network visualization, overlay visualization, and density visualization analysis. Functionally, VOSviewer helps display large and easily interpretable bibliometric maps (Van Eck & Waltman, 2010, 2023).

Third, collecting data on scientific publications of scaffolding learning research using a scientific data search strategy from Scopus databases such as those used by (Al-Khoury et al., 2022; Gao et al., 2022; Ghani et al., 2022; Prahani et al., 2022; Raman et al., 2021) (Table 1). The results of the search for scientific data on scaffolding learning related to topics in general obtained 418 articles. Meanwhile, the results of scientific data searches that focused only on training or education and training obtained 48 articles. Then, the last stage is to run and interpret the data and submit a report on the findings of the bibliometric analysis. Secondary data to support the discussion of scaffolding learning applications in energy conservation training, namely curriculum documents or syllabi for education and training in electricity, new energy, renewable energy, and energy conservation.

Table 1. Scientific data search strategy

Criteria	Description
Database	Scopus Indexer
Search	Title, abstract, keywords
Term	- "scaffolding learning" OR "scaffold learning" OR "instructional scaffolding" (scaffolding learning search in general) - "scaffolding learning" OR "scaffold learning" OR "instructional scaffolding" AND "training" OR "education and training" (scaffolding learning search in training)
Time span	2004-2023 (two decades)
Language	English
Article type	Journals, conference proceedings, books, book series
File type	CSV (Comma delimited values)
Search time	February 12, 2023

RESULTS AND DISCUSSIONS

Performance analysis

The performance analysis of the development of scaffolding learning research published from Scopus-indexed scientific articles in the last two decades (2004-2023) is presented in Figure 1. The findings of scaffolding learning research publications related to topics in general were published, such as journals, international conference proceedings, and books, which amounted to 418 publications. However, after the topic of scaffolding learning is associated with training, a comparison between the two results can be seen. Research on scaffolding learning on the topic of training is only about 11% (48 publications) of the 418 publications on scaffolding learning associated with other topics in general.

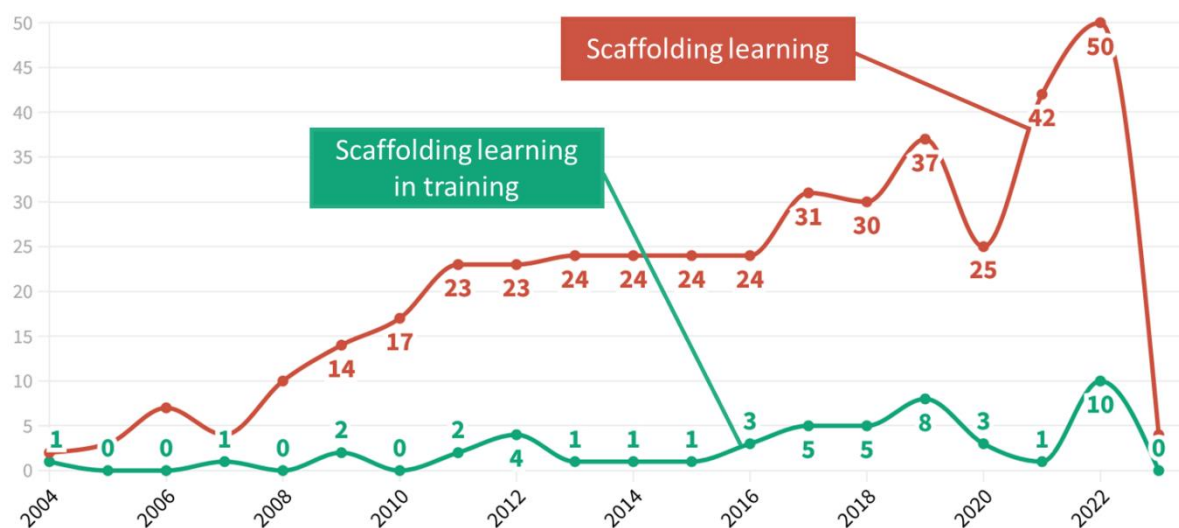
Regarding the performance analysis of the development trend of scaffolding learning research on training topics, it can be seen that the trend of research development from 2004 to before

the occurrence of the Covid-19 pandemic (2019) has consistently increased. However, entering the 2020-2021 period, there was a decline. However, in the 2022 period, it increased again to as many as ten publications, compared to the 2019 period of 8. Meanwhile, in the 2023 period, at the time of this data collection, no publications had been identified. Cumulatively, more than half (67%) or 32 out of 48 publications were identified in 2017-2022.

Regarding the downward trend in research over two years during the pandemic with reduced learning time, this is in line with previous research (Hurajova et al., 2022). His research findings are based on the perceptions of teachers that the learning process during a pandemic is generally not carried out on a full-time basis due to the closure of various educational institutions. During the pandemic, teachers are trying to find communication patterns for instructional delivery that utilize information and communication technology media online using modern technology that contributes to the sustainability of the education process during emergencies and will be an integral part of university education even after the emergency ends.

However, another study by (Sarah et al., 2022) on online scaffolding learning during the pandemic found that students' understanding of the physics concept of centre of mass using web-based E-Scaffolding Enhance Learning (ESEL) proved to be an effective self-learning tool for online physics classes. The findings align with the application of scaffolding learning in science learning, where learners can engage in tasks that are more complicated than they can do without assistance. Thus, learning becomes more effective and efficient (Davis, 2015).

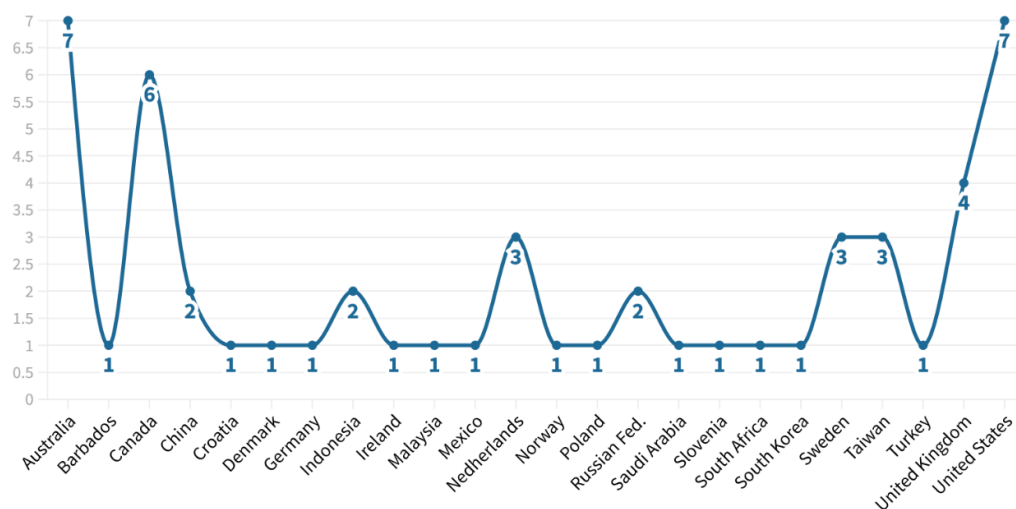
Figure 1 Scaffolding learning research in training and in general (2004-2023)



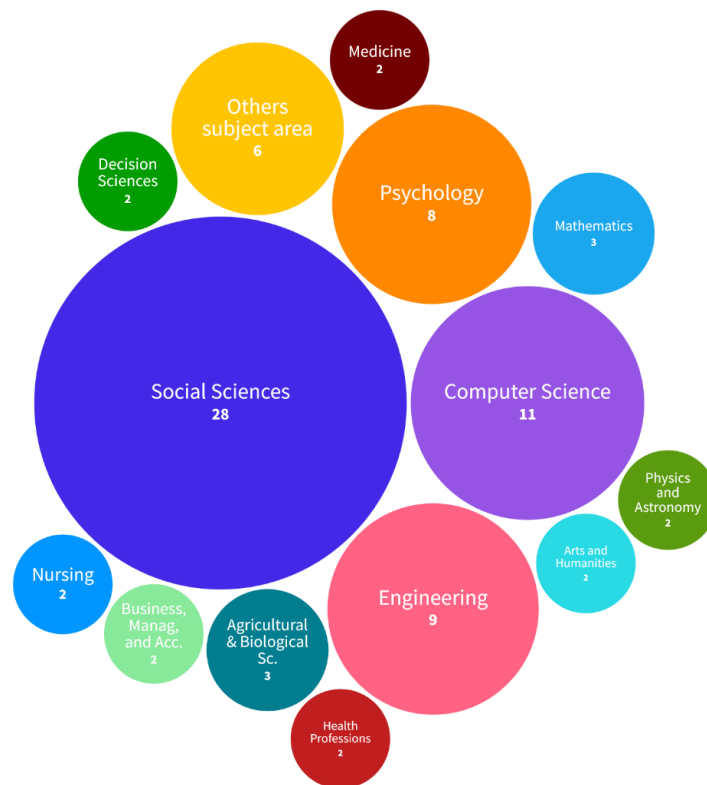
The source of research publications on scaffolding learning in training mostly comes from scientific journal articles, around 67% (32 publications), and only a few from books in both book series and non-series formats (Figure 2).

Figure 2. Source publication of scaffolding learning in training

The performance analysis of the development of scaffolding learning research in training in various countries is presented in Figure 3. Australia, Canada, and the United States have the highest number of publications at around 6-7 compared to other countries with only 1-3 publications.

Figure 3 Research progress by country

The findings identified 13 subject areas of research and six other subject areas. Based on these results, the most scaffolding learning research was conducted in the subject areas of social science (34%), computer science (13%), engineering (11%), and psychology (10%). While other subject areas only once consisted of 6 subject areas with a total of 7% (Figure 4). Based on the review results, studies on the concept of scaffolding in general have attracted the interest of many researchers in social science and psychology conducted from 1988-2017 (Shvarts & Bakker, 2019).

Figure 4 Research development by subject area**Co-word analysis and network visualization analysis**

Based on the results of descriptive analysis, we obtained 2 clusters with 17 keywords of scaffolding learning research in training. The results of sorting 17 keyword items were obtained that appear at least five times from 512 keywords. So, 49 keywords were selected with at least five times their appearance. The first and second clusters have the most keyword items related to education and training related to scaffolding learning research. That is, this result is in line with the initial use of the term scaffolding, which was first used by Wood, Bruner, and Ross in 1976 and is often associated with the zone of proximal development theory. Its use was initially for teaching, learning, and development, and motor control development (Davis, 2015; Shvarts & Bakker, 2019).

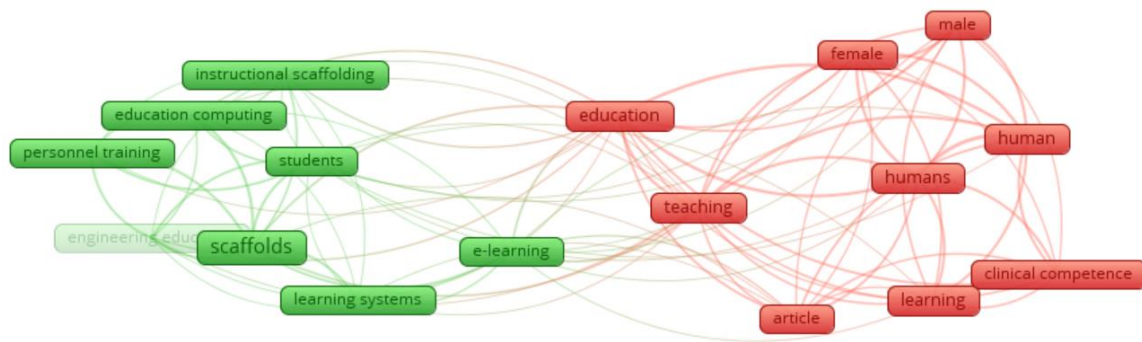
Table 2 Keyword clusters and items

Cluster	Colour	Number of keyword items	Keyword items
1	Red	9	Article, clinical competence, education, female, human, humans, learning, male, teaching
2	green	8	e-learning, education computing, engineering education, instructional scaffolding, learning systems, personnel training, scaffolds, students

The results on all keywords provide a visual description of the strengths and weakness of the network or relationship between keywords in scaffolding learning research, as presented in

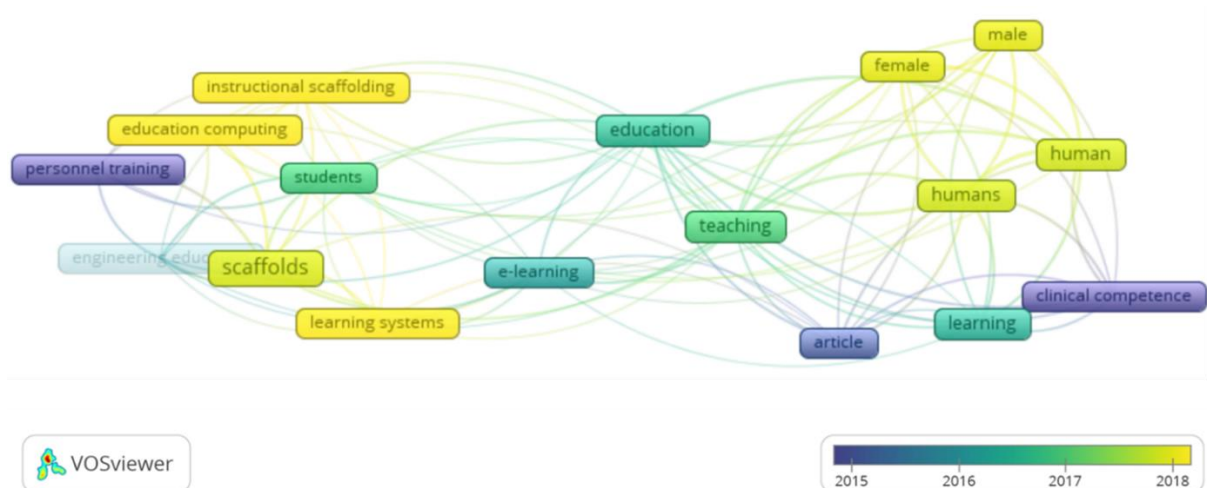
Figure 5. This figure explains that the keyword scaffold has the closest relationship in a row with the keyword items learning system, students, e-learning, personnel training, education computing, and instructional scaffolding. This shows that the closer two keyword items are located to each other, the stronger the relationship. The connecting line also represents the strength of this linkage.

Figure 5 Network visualization analysis

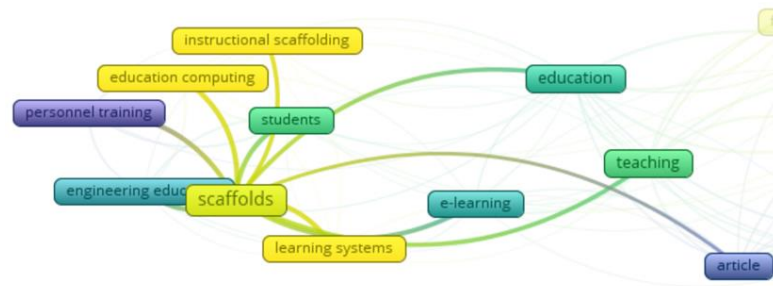


Furthermore, based on the research findings in the overlay visualization analysis, visually obtained historical traces of research publication years as presented in Figure 6. These results can be a reference to identify and detect the state of the art of scaffolding learning research. In this visualization, the color of the nodes represents keywords that indicate the year of publication.

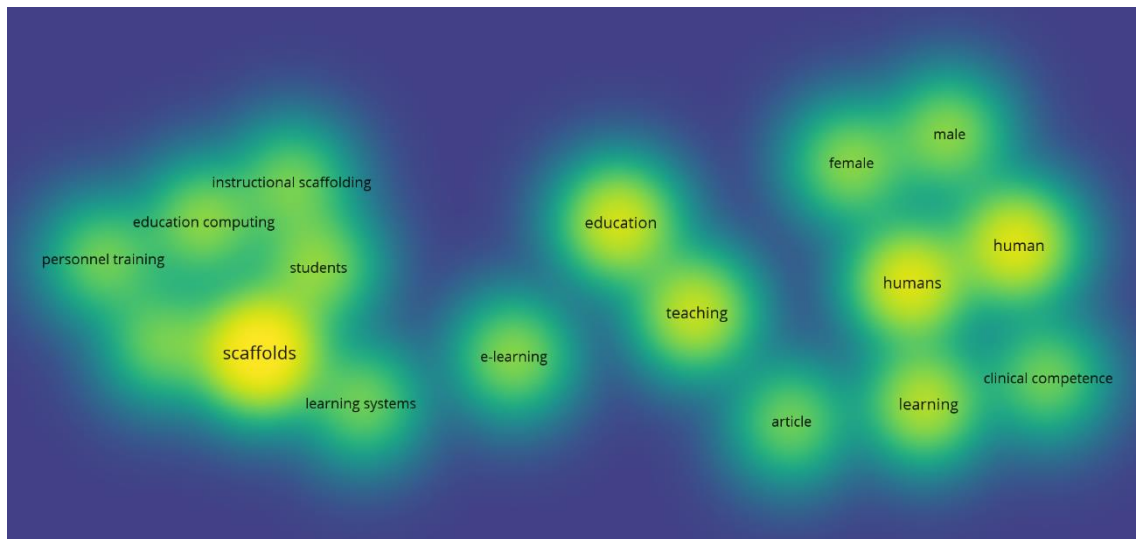
Figure 6 Overlay visualization analysis



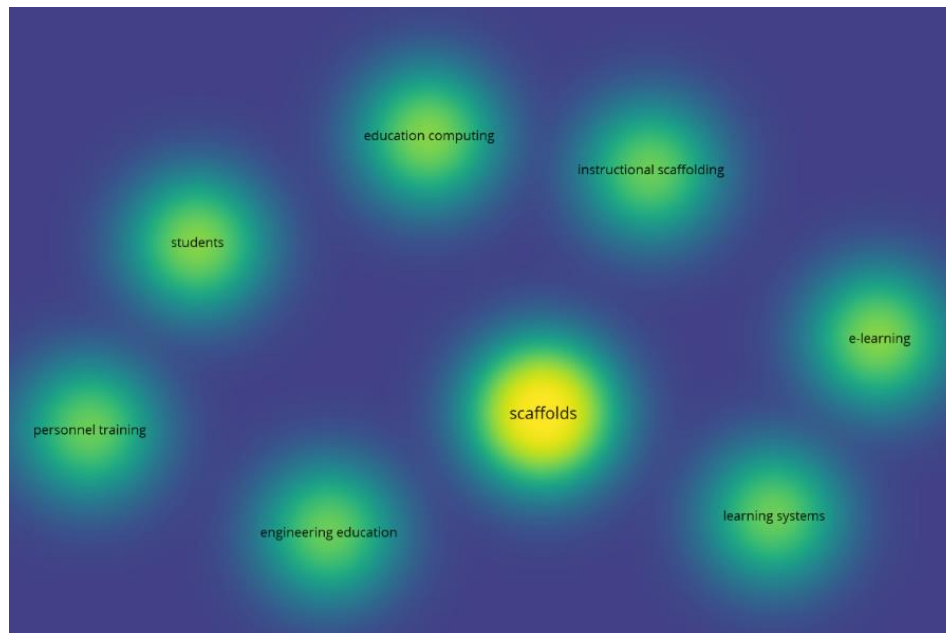
In more detail, we can see the keywords only discussed in the period above 2018. For example, scaffolding learning research on the keyword item scaffold is related to the keyword item learning systems, instructional scaffolding, and educational computing (Figure 7), reflected in the bright node or bright yellow colour.

Figure 7 Overlay visualization analysis of scaffolds keyword items with other items

Related to the research findings on density visualization analysis, which is divided into two analyses: item and cluster analysis. Figure 8 is a display of item density analysis of scaffolding learning research. The results of item density analysis show that the keyword scaffolds have a density or the highest number of research topic items. This is indicated by the width of the bright yellow color surrounding the keyword. Meanwhile, the second calculator shows that the keywords learning systems, instructional scaffolding, and education computing show a narrow bright yellow dot. This means these keywords have not been given much attention as research topics related to scaffolding learning.

Figure 8 Item density visualization analysis

Related to the cluster density analysis findings, it is focused on the second cluster, as presented in Figure 9. The analysis process is done by sorting the keyword items of this cluster so that they are separated from the keyword items of the first cluster, as mapped in Table 2. The results of the cluster density analysis show that the research on scaffolding learning in training related to the linkage of items between keywords in this cluster needs to look tight, and more needs to be done. Each keyword item is not tightly spaced, as reflected by the dark blue color.

Figure 9 Cluster density visualization analysis

Based on the presentation of these findings, the theme of instructional scaffolding can be a research topic that needs to be explored in the context of training in the field of energy conservation. In the ADDIE (analysis, design, development, implementation, and evaluation) training model (Allen, 2006). The delivery of learning instruction to trainees is an essential stage after the planning process of curriculum analysis, design, and development. It, therefore, requires active learning strategies that seek things out, want answers to questions, need problem-solving information, or find ways to do work in a participatory way (Silberman, 2006). One method that emphasizes this is scaffolding learning, which is rooted in the tradition of social constructivism theory (Jin et al., 2020) developed by Lev Vygotsky by criticizing the progressive tradition of learner-centered and individualistic learning.

The developmental basis for the zone of proximal development learning refers to the cognitive gap between what learners can do or practice without assistance and what they can do together in the coordination of several skilled experts as models. Practice and modelling are essential elements of scaffolding learning. Learners learn gradually through part of the activities to the most challenging part and can eventually do it independently without needing more help (Gibson, 2015). Thus, scaffolding has a contingent nature, which includes two critical concurrent, iterative, and interconnected events. Learners are given support based on the results of their dynamic assessment. Support is reduced when the learner can perform independently. Another trait is intersubjectivity, which provides an understanding of the independent performance measures that must be completed (Belland, 2017).

Scaffolding learning in practice is not only done by teacher or expert guidance to one learner (one-to-one) but can also be done by fellow learners (peer) and computer assistance (computer-based). Of course, the three forms have advantages and disadvantages (Belland, 2017). Based on previous research findings, scaffolding learning is proven to improve critical thinking habits, creativity, and self-regulation (Susilowati et al., 2019). In addition, (Gutiérrez et al., 2022), in



their research on the physics of electrical forces, found that learners often feel stressed because they do not have a temporary structure as a buffer to build their knowledge. With scaffolding and discovery-based learning, his experimental study found that learners felt less stressed and successfully discovered their knowledge compared to conventional learning. In building information modelling/integrated project delivery training.

Scaffolding learning integrated with other constructivist, collaborative learning processes (flipped learning, project-based learning, problem-based learning, and role-playing learning) positively impacts learning (Jin et al., 2020). In problem-based learning, combined with scaffolding, learning can be an interactive support that utilizes what learners already know to help them participate meaningfully together. To generate solutions, artifact designs, and project completion to complex problems (Belland, 2017). Another study on lean production training, which uses many simulator tools, stimulated knowledge transfer with instructional scaffolding. According to the trainees, learning lean production with simulators is considered severe, complex, and abstract (De Vin et al., 2019).

Application to Energy Conservation Field Training

Technical Training on Energy Audit of Office Buildings for State Civil Servants within the Ministry of Energy and Mineral Resources is conducted to produce State Civil Servants who can perform energy audits on buildings, especially office buildings within the Ministry of Energy and Mineral Resources. The training was carried out for 40 learning hours or four days with training subjects on policies and regulations related to energy conservation and energy efficiency; introduction to energy audits in office buildings; secondary data collection of office buildings; energy audits on office building envelopes; energy audits on office building air systems; energy audits on office building lighting; energy audits on utilities/plugins/other equipment; energy audits on energy management; energy audit practices in office buildings; energy audit data analysis in office buildings; energy audit reports and presentations. These courses include a practical approach to energy auditing in office buildings for eight learning hours.

However, in the training subjects of energy audit data analysis in office buildings and energy audit reports and presentations carried out after practice, participants are asked to conduct analysis activities after obtaining data in practical exercises. Likewise, in preparing the report, participants are asked to compile a description of the entire energy audit activity. Thus, the output of this training, in addition to producing state civil servants who can conduct energy audits on buildings, especially office buildings in the Ministry of Energy and Mineral Resources, is the preparation of energy audit reports on office buildings.

The implementation of learning using scaffolding instructions for training subjects carried out before doing practice is in the form of a fundamental theory about energy audits. This learning must be transferred as a basis for participants to recognize and understand energy audit activities. This theory also introduces the equipment used to conduct energy audits and how to use the equipment. Energy audit equipment in office buildings includes power quality analyzers, amperemeters, hygrometers, thermogenic, infrared cameras, luxmeters, and distance meters.

After understanding activities are obtained, practical exercises for eight hours of learning are considered insufficient. However, at least they can provide direct experience to participants to



implement the theory accepted and find out the obstacles faced so that by themselves or discussions with other participants or even guidance from practical assistants can get a solution to the problems that arise.

Therefore, in this energy conservation training, the form of scaffolding learning emphasizes the involvement of mentors from facilitators and fellow trainees. Thus, the combination of instructional scaffolding uses three forms, i.e., one-to-one, peer, and computer-based, as a measurement tool for energy audit practice. The strategy for implementing scaffolding success and failure is influenced by the number of training participants so that facilitators provide intensive guidance to participants so that their understanding of theory and practice can be optimized. Training participants are usually limited to fifteen to twenty participants.

CONCLUSIONS

The topic of scaffolding is widely applied in the field of social sciences. In a review of its origins, the concept of scaffolding is used in the field of Education for teaching and learning. The mapping results identified instructional scaffolding as an under-explored topic in the context of training in energy conservation. The training involved three combinations of instructional scaffolding. Thus, the instructional message is expected to be effective and efficient to achieve the learning objectives of creating an energy audit report and conducting, practising, and presenting the results.

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