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Analysis of the Effectiveness of Safety Training Methods

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Abstract: Work safety is an important area of business activity, particularly in industries with the most dangerous risks, such as mining, construction and energy. The aim is to reduce the number of accidents and increase employee awareness of occupational hazards and the principles of safe working practices. One of the most important ways to increase employee awareness and consequently reduce accidents is through training. The effectiveness of training is contingent on proper planning, design and preparation. Design thinking directed towards the use of teaching methods and tools is crucial. Properly planned training is part of the sustainability of companies, which consequently results in higher work safety due to its high efficiency. This article reviews the most common training methods in the area of work safety and evaluates them qualitatively and quantitatively using SWOT and multi-criteria analyses. These analyses can provide important guidance in the selection of training methods, regardless of the business sector. Based on the results obtained, effective training methods included those involving students: active training methods with elements of discussion and gamification, augmented and virtual reality, demonstrations and simulations. However, the best training results can be achieved by combining a number of training methods, while maintaining the right balance to achieve the intended training objectives. This is particularly important in businesses with specific activities such as mining, construction or energy.

Keywords: effectiveness of safety training; training in mining, construction and energy; work safety; safety training as a component of sustainability

Citation: Bęś, P.; Strzałkowski, P. Analysis of the Effectiveness of Safety Training Methods. *Sustainability* **2024**, *16*, 2732. https://doi.org/10.3390/su16072732

Academic Editor: Chaolin Zhang

Received: 29 January 2024
Revised: 20 March 2024
Accepted: 23 March 2024
Published: 26 March 2024

1. Introduction

Worker safety is a necessary and fundamental component of business operations. Occupational safety and health (OSH) encompasses a wide range of activities aimed at identifying, evaluating and managing workplace hazards that could potentially affect the well-being and health of workers [1]. The need to ensure safety in the workplace is a difficult task due to the hazards present, particularly in industries with the most dangerous risks, such as mining and energy. The type and effects of these hazards vary and depend on the nature and scope of the work. Reducing human exposure to hazards is a difficult challenge and is largely dependent on the management system in place and the awareness of workers. Protecting people from hazards seems obvious and straightforward from a management point of view, as it is based on a systemic work organisation that can be modified and adapted to the needs of the company. However, raising people's awareness of OSH and creating a high OSH culture in the workplace becomes a major challenge. This is related to the psychosocial aspects of human functioning. Different levels of knowledge, employee involvement, willingness to learn and openness to change are among the factors that influence the dynamics of creating a high work culture and, consequently, increasing the level of employee safety.

The inclusion of safety management is a crucial aspect that should be prioritised by any organisation [2]. It plays a key role in enhancing the supervision of employees, minimising accidents, near misses and occupational injuries, while simultaneously enhancing overall business operations [3]. The continuous technological advances of today—the

implementation of new work processes that take into account market needs and human capabilities—reinforce the need for worker safety [2]. Therefore, the need to develop health and safety skills becomes crucial and requires the use of innovative forms of teaching and training [4]. OSH training (initial training, periodic training and safety and health awareness training) is the primary form of imparting knowledge and acquiring skills to perform work safely. The success of OSH training in shaping safe worker behaviour needs to be supported by management [5]. Nevertheless, findings from a study conducted by Lafuente et al. [3] indicate that elevated levels of OHS training, when coupled with the acquisition of codified knowledge, have a detrimental impact on workers' safety perceptions. Interestingly, this effect appears to be positive for safety professionals. Laberge et al. [6] point out that most OSH training is based on a cognitive or behavioural training paradigm, which aims to shape workers' attitudes or behaviours so that they comply with OSH regulations. In contrast, the use of the worker's pretraining knowledge and skills is currently given little consideration in the learning process. Knowing the worker's skills and knowledge allows training methods and content to be selected accordingly. However, in workplaces with a high safety and health culture, taking into account the worker's knowledge and skills becomes an important area in the planning and delivery of safety training.

The effectiveness of training becomes evident when it is applied in the work environment through the implementation of enhancements and improvement initiatives [7]. The enduring role of training as a crucial element in fostering and sustaining effective hazard control activities remains steadfast. [8]. It is generally accepted that OSH training has a positive effect on knowledge acquisition and behaviour improvement, but there is weak evidence of improved safety outcomes [9]. A person is only effective if they have the right habits in addition to knowledge and skills. Habits developed in the area of occupational safety can contribute significantly to their improvement. Habit formation should be systematic rather than spontaneous [10,11]. Hence, training should not be confined to one-time events preceding the commencement of work; instead, it should be systematically planned and conducted on a regular basis. It is equally essential to clearly define the role and purpose of the training. According to Hollnagel [12], safety can be characterised either as the absence of harm or other undesirable effects, or as a condition for achieving intended and acceptable outcomes. The former perspective focuses on preventing undesirable situations, while the latter aims to ensure the occurrence of favourable situations. Consequently, the choice of definition becomes pivotal in the planning of training. Ultimately, safety training should encompass appropriate measures and practices that contribute to safeguarding the lives and health of individuals, as well as preserving the integrity of the workplace.

Training has the potential to become a source of competitive advantage when employees gain pertinent new knowledge and skills. This presents a compelling rationale for organisations to invest in their workforce, not only to reap benefits but also to distinguish themselves from competitors [7,13]. The effectiveness of training should be gauged by the participants' ability to apply the knowledge, skills and attitudes acquired during the training [14]. However, the success of training hinges on meticulous planning and preparation. Continuous evaluation and improvement should be integral to the training process. A comprehensive meta-analysis proves to be the most effective method for gathering valuable insights into training evaluation [8,15,16]. Most OSH training evaluation methods are based on the analysis of numerical ratings that determine the level of satisfaction of the participants. The evaluation of training, which is usually the last stage of the training process, most often involves an objective-based approach and a systems-based approach [8,17]. Choosing the best approach to evaluate safety training is very important to ensure that safety training serves a purpose [8].

The effectiveness of training, as determined by evaluation, provides directions for the continuous improvement of its quality. The choice of training method for safety training should be tailored to the group of participants, taking into account their experience, skills and level of knowledge. Additionally, the objective of the training should indicate the training needs. The selection of training methods is an initial stage in the training process,

and it is also challenging and most often depends on the skills and experience of the trainer. Currently, there is a lack of a comprehensive and critical analysis of OSH training methods in the literature. Current scientific work has focused on the analysis of individual training methods with a variable group of trainees, and in different industries. Furthermore, the evaluation of these methods has been mainly based on surveys to assess the quality and acceptance of training [18–22]. This paper reviews the most common OSH training methods and evaluates them based on SWOT and multi-criteria analyses. These qualitative and quantitative analyses can provide important guidance for the selection of training methods at the planning stage, regardless of industry. In addition, the characterisation and comparison of training methods can serve as a guideline to find ways to improve them to increase their level of quality and effectiveness and, consequently, to create a higher awareness of occupational safety among employees.

2. Methods

This paper evaluates the qualitative and quantitative effectiveness of OSH training methods. The main methods currently used include the following: traditional lectures and lectures enriched with multimedia materials (presentations, photos, films, sound, etc.), e-learning and b-learning, active training methods supported by discussions and gamification, methods using modern technologies (virtual reality, augmented reality), as well as demonstrations and simulations. The qualitative and quantitative evaluation was based on the literature review and the authors' experience and knowledge. Specific aspects that relate to only one training method (e.g., modelling skills for the preparation of training in virtual reality technology, and formal requirements for safety training) were not included in the analyses.

A qualitative assessment of the training methods was conducted using SWOT analysis. The SWOT analysis framework was originally designed as a way of analysing market forces that influence the position of companies. However, it can also be successfully applied to the evaluation of training methods [23]. Strengths and weaknesses, as well as opportunities and threats, were identified for each of the training methods analysed. The analyses were based on the authors' observations and the literature, and the identified characteristics were ranked according to their relevance, starting with the most important.

Based on a multi-criteria analysis, a quantitative evaluation of the analysed methods for delivering safety training was conducted. Key areas related to the organisation, planning and delivery of training were characterised. These areas include technical (e.g., required equipment of the training room, use of modern technology, etc.), organisational (e.g., number of trainees, training time, etc.) and social (e.g., required qualifications of the trainer, experience and skills of the trainees, age of the trainees, etc.) aspects. A total of 14 criteria were proposed for these areas, which were used as a whole to evaluate training methods. The criteria were defined on the basis of a qualitative analysis of the training methods. For each criterion, different characteristics were defined and scored accordingly on a scale from 1 to 3.

The quantitative evaluation was carried out by 5 experts who are trainers in health and safety. The detailed characteristics of the experts are presented in the paper later. The experts were individually evaluated on the basis of their own experience and knowledge. Based on the scores assigned to the training methods analysed, the methods with the potentially best effectiveness were identified.

Limitations

In order to maintain the equivalence of each criterion, 3 characteristics were assigned to each criterion. The limitation to only 3 characteristics is related to the equivalence of each criterion. In addition, equal levels of relevance of the characteristics were not taken into account in this study.

The availability of trainers using different safety training methods is limited. The selection of trainers who made quantitative evaluations of safety training methods was

closely related to their experience with different teaching methods. All the trainers had experience with all the methods discussed in this article. The experts did not know each other and did not consult anyone about their evaluations. Nevertheless, the number of experts should be increased in order to strengthen the quantitative evaluation of the training methods obtained.

3. Methods of Performing Safety Training and SWOT Analysis

The aim of safety training is to increase workers' knowledge, improve their motivation to adopt safe behaviours and reduce the occurrence of unsafe behaviours [18,24], as well as to teach workers how to identify hazards and how to engage effectively to eliminate or maximise control of workplace hazards [25]. This is possible through the provision of high-impact workplace safety training.

The approach to training is most often based on the role of the trainer and is one-way—an exchange of knowledge from the trainer to the trainee. Contemporary educational theories propose that acquiring a new job is best achieved through the hands-on experience gained in real workplace settings [6]. In general, the effectiveness of training and learning increases when multiple senses are engaged and participants are involved in the active training process. Dale's cone of learning and experience shows the links between teaching methods used and the senses through which the activities are perceived by the students, and their effectiveness expressed as a percentage after a certain period of time following the training (Figure 1).

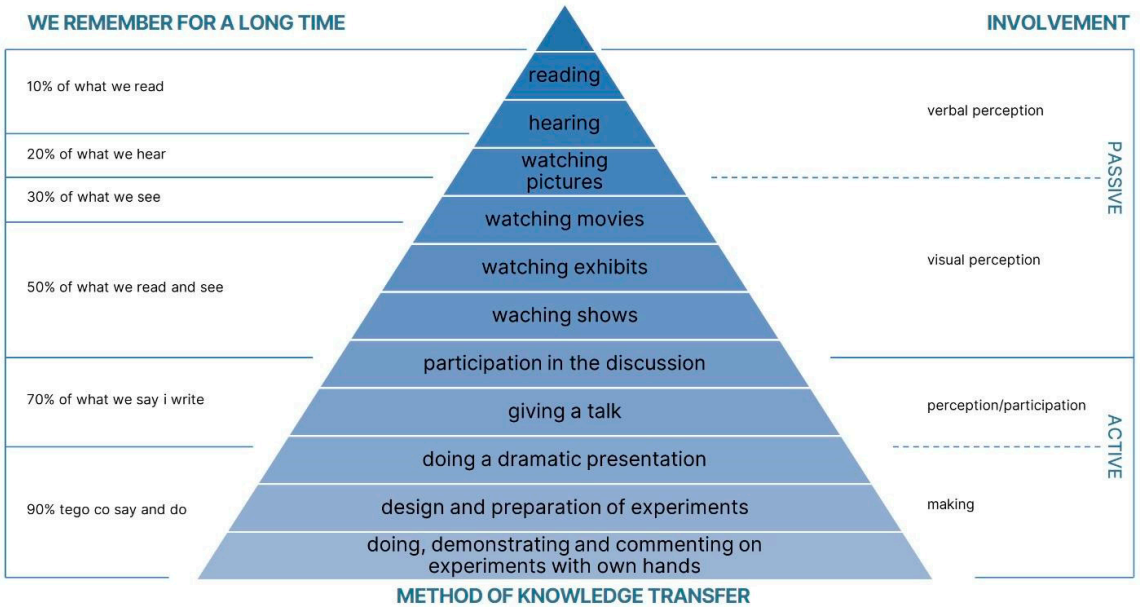

Figure 1. Dale's cone of learning and experience (own elaboration based on [26]).

Hands-on learning is the most effective way to learn anything. This approach is the best solution, but in many cases, beyond basic implementation training, it seems difficult. The nature of workplace safety learning is quite complex and should not be based solely on practice. The provision of theoretical information is also key to achieving an adequate level of knowledge. To achieve this, Cohen et al. [15] point out that appropriate training methods can make a significant difference in the effectiveness of training in improving safety. In the following section, a characterisation and qualitative assessment of training methods that are commonly used or that represent potential developments in teaching methods is made. A summary of scientific publications describing safety training methods is presented in Table 1.

Table 1. Scientific publications on safety training methods.

Safety Training Method	References
Traditional lectures and lectures enriched with multimedia materials	[18,24,27–35]
E-learning and b-learning	[36–47]
Active training methods supported by discussions and gamification	[48–72]
Augmented reality (AR) and virtual reality (VR)	[22,23,73–87]
Demonstration and simulation	[18,88,89]

3.1. Traditional Lectures and Lectures Enriched with Multimedia Materials

Lectures represent one of the oldest teaching methods. However, as information becomes increasingly diverse and complex, relying solely on the traditional lecture-based training model makes it challenging to efficiently achieve training goals within a limited time frame [24]. The majority of lecture-based training follows the conventional classroom model, often perceived as dull and lacking participant engagement [27,28]. The overuse of this teaching method leads to general discouragement among the audience. However, recent developments in information technology have significantly improved the attractiveness of the traditional lecture model by enabling the inclusion of multimedia materials or the use of rapid-response teaching applications.

One significant challenge faced by trainers using the didactic method is sustaining the attention of trainees. In traditional lecture-based training, the trainer takes a central role, and learners adopt a passive stance with minimal participation, leading to suboptimal comprehension of the training material [28]. Furthermore, learners are deprived of the opportunity to engage with both their peers and the instructor, as the flow of knowledge is unilaterally directed from the teacher to the learners [29]. Consequently, the potential for enhancing training effectiveness through collaborative learning among participants is limited, and the teacher's evaluation of content based on learners' insights is disregarded.

In general, despite the critical perception of the lecture as a form of training, it allows the training to be delivered to a large group of participants with different backgrounds and ages. Several studies suggest that the inclusion of examples in lecture content facilitates concept learning and skill acquisition [30,31]. Specifically, incorporating examples of both safe and unsafe behaviours has proven to enhance learning compared to training that features only one example of a behaviour [32]. Moreover, there is supporting evidence that videos can be a highly effective means of safety training, leading to increased knowledge [18,33]. The accessibility of videos through smartphones adds to their advantage [34]. Visualisation aids in comprehending content intricacies and facilitates the implementation of preventive measures. Consequently, by engaging various senses, learners become more receptive to assimilating the material presented during training.

The trainer who delivers the lecture should be an expert in the training being delivered. For better effectiveness of this didactic form, the trainer should have adequate didactic preparation, as well as the skills of appropriate voice emission [35]. Additionally, it is important to carefully plan the content and to maintain a schedule for each topic. The main features of the lecture are characterised in Table 2 in the form of a SWOT analysis.

Table 2. SWOT analysis of the training method—traditional lectures and lectures enriched with multimedia materials.

STRENGTHS	large amount of knowledge transferred; option to train a large group of participants at one time; using the authority of the lecturer; focus on various topics, including specialised ones; increasing the interest of the audience by using multimedia materials in the lecture content	WEAKNESSES	monotony and loss of concentration with the traditional lecture model; lack of interaction between participants and between participants and the lecturer; lack of individualisation; lack of feedback and progress assessment during training; poor quality of training with a lack of didactic skills of the trainer

Table 2. *Cont.*

OPPORTUNITIES	possibility to use new technologies; possibility to complement with other methods including dialogue and interaction; use of real-life examples can facilitate learning and acquisition of skills; possibility to use own knowledge and experience	THREATS	lack of opportunity to apply knowledge in practice; possibility of losing interest of participants; possible lack of adaptation to other learning styles; possibility of limited retention of information

3.2. E-Learning and b-Learning

Modern training methods have received a significant boost from the development of e-learning, as it is a modern complement and sometimes even an alternative to traditional education [36]. E-learning, understood as distance learning, allows knowledge to be delivered through IT tools using text, voice, images, video, data and metadata. The widespread use of tablets and smartphones, multimedia platforms, software and other technologies creates new opportunities for effective and cost-efficient delivery of learning materials based on real-world evidence [37]. In addition, e-learning offers unparalleled accessibility, unlimited location and no time or user cost constraints [38,39]. Satisfaction with online learning correlates with perceived effectiveness [40]. E-learning serves to stabilise the learning process by overcoming geographical distances and reaching a broader audience. Its primary advantage lies in the integration of diverse instructional events that cater to groups or individuals, whether working offline or online, synchronously or asynchronously, and utilising stand-alone or networked computers and other electronic devices [41]. The concept of e-learning extends beyond online learning alone; it encompasses a virtual, simulated and distributed learning system that occurs in real-time, either on-site or off-site, fostering a dynamic educational experience [42,43]. The primary objective of e-learning is to minimise the time required for the learner to learn by providing specialised and up-to-date information [44]. On the other hand, the learning process is shifted to the learner, who has to assimilate the knowledge provided at a distance. Learning is primarily a social-cognitive activity and not every student will find e-learning suitable for their learning style [43]. Additionally, instructors and users must have the technical capabilities.

The most difficult task is undoubtedly the implementation of e-learning, which requires the acquisition of a platform for the delivery of the material, as well as the appropriate planning of the content. The preparation of high-quality materials for self-learning requires a lot of experience and time on the part of the author, especially if the course is to include elements that require students to complete tasks.

E-learning emerges as a promising substitute for traditional classroom instruction, particularly suitable for distance education and continuous learning and training. This became particularly evident during the closed-world situation prompted by the COVID-19 pandemic, necessitating a swift transition to remote training and education. However, Goyal [43] emphasises that although e-learning can be as effective as traditional classroom teaching in specific scenarios, there is no assurance that it can completely replace traditional methods. In many instances, e-learning serves as a valuable complement to classroom learning, leading to a blended learning approach, often referred to as b-learning.

Blended learning or b-learning, strategically combines both online and face-to-face learning methods to optimise the benefits of each learning environment. Online learning can occur synchronously or asynchronously and can the capability to replace traditional face-to-face sessions [45]. B-learning integrates both online and in-person learning, offering a flexible and socially interactive educational experience through the use of digital platforms alongside classroom attendance. During B-learning training, it is very important for the trainer not to have both classroom and online training at the same time. Two formats of training taking place at the same time can reduce the effectiveness of the training for both face-to-face and online audiences. A key challenge for trainers is ensuring synchronisation between online content and face-to-face sessions, as well as fostering interaction and

collaboration among trainees in both contexts [46]. B-learning proves to be an effective approach for developing practical and theoretical competences. Importantly, it demonstrates comparable outcomes to traditional face-to-face learning, making it a viable alternative, especially in challenging circumstances like a pandemic where physical presence is constrained. This approach provides confidence that future challenges can be addressed without compromising the trainee's competence. Consequently, b-learning emerges as an effective solution for maintaining educational progress and cultivating practical skills in difficult situations. These findings offer new perspectives in education, encouraging educators and trainers to view b-learning as a valuable tool for ensuring the quality and continuity of multidisciplinary education [47].

In e-learning and b-learning, especially in the synchronous version, the quality of this training method can be enhanced by the appropriate involvement of training providers in supporting the teacher-in-training. This could be, for example, people responsible for technical or content aspects.

A SWOT analysis for the e-learning and b-learning methods is presented in Table 3.

Table 3. SWOT analysis of the training method—e-learning and b-learning.

STRENGTHS	flexibility of learning; flexibility in time and space; no (e-learning) or limited (b-learning) presence of the trainer in the whole learning process; global reach of the training method; training of a large group of participants at one time	WEAKNESSES	requirement to use IT tools and learning platforms; requirement for self-discipline on the part of the learner; lack of direct interaction between trainer and learner; lack of practical experience
OPPORTUNITIES	possibility to develop technology resulting in increased training efficiency; possibility to exchange knowledge and views at a distance; possibility to conduct training during unfavourable conditions for face-to-face contact	THREATS	risk of digital exclusion; potentially high cost and time-consuming implementation of e-learning; lack of control over the learning and knowledge acquisition process; transfer of responsibility for the learning process to the learner

3.3. Active Training Methods Supported by Discussions and Gamification

Safety training programmes can be made more effective by using more engaging, participatory and practical training methods that encourage the application of safety knowledge and skills [48,49]. Additionally, active participation in training sessions enhances student interest [50]. This principle holds true in various fields where there is a need to enhance students' knowledge and skills. Following the principles of andragogy [51], incorporating examples, adopting a participatory approach and connecting the content to everyday practices contribute to facilitating the learning process for adults and experienced workers. This aligns with the experiential learning model [52], which breaks down the acquisition of new knowledge, skills and attitudes into four stages: concrete experience, reflective observation, abstract conceptualization and active experimentation.

Active training based on strong trainee involvement is important not only to significantly increase knowledge and skills [53–56], but also to build relationships between trainees, to encourage reflection and also to learn different perspectives on the issues covered in the training. One of the relevant and commonly used active training methods is discussions or brainstorming sessions. Of course, the way they are carried out can be variable and based on the analysis of a case study or a chat on a specific topic. Although each of these methods is different, some are believed to be more effective than others [57]. This statement can be problematic, as the choice of an appropriate active method should depend on the objective and the desired effect. In general, the aim of the active training methods mentioned is to get to know each other's perceptions of the problems and to find

the best solutions together. In this approach, it is also expected that the trainees develop higher skills [58], which is guaranteed by the critical thinking of the learners. Discussions or brainstorming sessions force active participation in the debate, in an interaction between teacher and student or between the students themselves [54]. In the early stages of knowledge transfer, the effective use of active teaching methods based on stimulating debate among participants is difficult [59]. The teacher faces a major challenge in guiding the discussion or brainstorming, as it should not deviate from the topic at hand. At the higher levels of learning, the interaction between learners is indeed more dominant than between teacher and lesson. In fact, the form of training is eliminated in favour of teamwork. This is due to the equal knowledge of the participants, and discussions and brainstorming are based on a joint search for solutions.

Active learning methods that incorporate game elements are gaining popularity, with the term 'gamification' describing the integration of game mechanics in various contexts to enhance learning and problem solving [60]. Utilising features from the gaming world has proven to be an effective approach for engaging individuals and achieving predefined goals, such as promoting safety [61–64]. The success of gamification depends largely on how teachers implement it, with active learning through direct experience and problem solving being particularly effective [65]. The primary goal of gamification is to generate interest in the presented content and enhance the learning experience [66,67]. Data indicate that students value narrative material, finding it more enjoyable, engaging and easier to grasp compared to purely descriptive or explanatory text [68]. The use of games in the learning process can take many forms: board games, role plays, operant games, sensory-motor games or quiz applications. The choice of solution depends very much on the objective of the training, the intended outcomes and the group of participants. The application of gamification in teaching is a particularly difficult task in the implementation stage. It requires a complete redesign of the teaching method and content. When using gamification, the aim should be to make the scope of the content taught similar to the structure of a game. The most important element of gamification is the autonomy of the learner, who decides how to pursue his educational goals.

In addition to the predominant positive aspects of using gamification in the learning process, disadvantages can also be identified, e.g., ranking of achieved scores can lead to reverse effects of the learning process or reduce enjoyment and motivation [69–71]. In addition, in many cases, teaching through gamification may only be suitable for a selected group, e.g., young people who are familiar with the world of games and who are comfortable with computer technology. This method, like any other, has its advantages and disadvantages, but the disadvantages can be eliminated. With the appropriate organisation of the training and the trainer's approach to the trainees taking part in the training, the reverse effects of the learning process can be avoided and even the methodological effectiveness of the training can be maintained regardless of age. In this case, it is sufficient to adapt the game used by the trainees.

Gamification and discussion can positively improve learning outcomes, but only with carefully designed training. Poorly designed training will not lead to improvements and may even lead to worse results [72]. Table 4 presents a qualitative assessment of active training methods supported by discussion and gamification.

Table 4. SWOT analysis of the training method—active training methods supported by discussions and gamification.

STRENGTHS	interaction between discussion participants; exchange of views among discussion participants; learning through experience and play increased interest; applying theory to practise; learning through reflection	WEAKNESSES	ease of introduction of gamification design flaws; inadequacy of the teacher; need for strong interpersonal skills of the facilitator; need to organise aspects of gamification

Table 4. *Cont.*

OPPORTUNITIES	possibility to monitor educational progress; possibility to increase effectiveness by interweaving methods; possibility for the trainees involved to come up with their own game ideas	THREATS	possibility of conflicts and loss of control; possibility of unreliable information during discussions; possibility of incompleteness or faults in game elements; possible demotivation of trainees as a result of low scores obtained during the game; possibility of exclusion on grounds of age

3.4. Augmented Reality (AR) and Virtual Reality (VR)

Augmented reality (AR) and virtual reality (VR) incorporate gamification elements, but they offer specific solutions for cultivating safe behaviour. The evolution of VR/AR-related technologies has progressed from visualisation-based training to experience-based safety training [73,74]. In response to the increasingly complex and dynamic business environment, employees within organisations are required not only to possess the necessary professional knowledge and skills but also to adapt these competencies flexibly for application in an ever-changing context [75].

Augmented reality (AR) establishes an environment where computer-generated information is overlaid onto the user's real-world view [76]. Workstation systems based on AR are well-suited for safety-intensive training tasks, enabling the direct translation of safety information from paper-based plans to real work scenarios [77]. As computer technology has made substantial advancements, simulation through AR has evolved into a more realistic and effective experiential learning tool, offering valuable support for organisational training [78].

Consequently, the advancement of virtual reality (VR) technology represents the next significant step. In a broad sense, VR denotes a computer-generated artificial 3D environment [74,79], enabling the creation of vast and intricate training environments. This capability allows training scenarios that would be challenging or excessively resource-intensive to replicate in real life. VR is particularly well-suited for emergency response training [23]. Simulation-based training offers high flexibility in terms of location and time, minimising or eliminating variable costs associated with traditional training. Moreover, simulation-based training provides several advantages, including safer conditions compared to real-life situations, minimal interference from external factors and increased opportunities to practise infrequent situations repeatedly [78,80]. VR has substantial potential to create an exceptionally realistic training environment, enabling participants to actively engage in the training process as if they were in a real-world situation. This immersive approach facilitates repeated practice, pursuit of excellence through error correction and effective feedback and debriefing, allowing trainers to assess and enhance trainee performance.

In comparison to traditional lecture-based safety training, safety training utilising virtual reality (VR) technology has garnered positive responses from participants [22]. It has demonstrated a more pronounced impact on fostering motivation for safe attitudes, enhancing self-efficacy and instilling anticipated safety-related outcomes. Additionally, participants engaged in virtual reality-based safety training exhibited a more substantial increase in self-rated safety in the one-month follow-up period [79]. In immersive virtual reality, users actively interact with a computer-generated environment by physically moving and manipulating objects through motion-tracking devices. While the concept of virtual reality in safety training is not entirely new, the widespread use of immersive virtual reality technology in safety training is still emerging [81].

The demonstrated effectiveness of AR and VR technologies in safety training [82–85] is a valuable indication for further development. However, the use of these advanced tech-

nologies in the training process is somewhat limited. The cost of purchasing equipment and developing simulations can be high. Some people, particularly the elderly, may have some technological limitations and may not feel comfortable training with VR technology [86,87]. In addition, some people may experience unpleasant side effects such as motion sickness or simulation sickness (vagus nerve disorder). Adequate training and support for trainers is also required.

A qualitative assessment of the AR and VR methods is presented in Table 5.

Table 5. SWOT analysis of the training method—AR and VR.

STRENGTHS	safe experience of real incidents in a virtual environment; direct involvement of trainees; increase of participants' awareness of the risks involved; better memorising and assimilating knowledge; consolidation of safe working practices; flexibility of place and time	WEAKNESSES	expensive purchase of hardware and software; long time to prepare the software and for the trainers to learn how to use it; problematic use of goggles by visually impaired people; lack or limitation of the social dimension of learning and the application of acquired knowledge and skills to the real world
OPPORTUNITIES	possibility to monitor training; progress and evaluate its effectiveness; possibility to improve your skills	THREATS	possibility of simulation disease; possibility of technological exclusion; possibility of exclusion on grounds of age; possibility of technical faults making it impossible to continue training; close work in front of a screen

3.5. Demonstration and Simulation

Practical learning of safe behaviour enables the acquisition of appropriate skills to reduce potential accidents. Practical training of students is carried out through demonstrations and simulations and is one of the simplest and most basic training methods. The tasks demonstrated by the teacher should be repeated by the student in the next step to consolidate the knowledge imparted. Demonstration and simulation in training focus on individual and unit learning processes, emphasising the progressive development of knowledge with a focus on the principles of behavioural modelling. Behavioural modelling involves observing a role model, engaging in modelling or practice and receiving feedback to modify behaviour. These methods include practical demonstrations coupled with behavioural simulations that require the active participation of the trainee [18].

In the case of behavioural simulations and practical exercises, the interaction between the trainee and the trainer often goes beyond one-way feedback and involves the trainee in a dialogue with the trainer about the knowledge gained or actions taken. Such a dialogue is important because it aims to improve the quality of reflection (thinking) in relation to the actions taken. This action-orientated reflection is considered to be the key to knowledge acquisition, as it forces the trainee to infer causal and contingent links between events and actions, leading to the development of strategies to cope with unforeseen events [18,88].

As well as learning and capturing attention, the training method discussed provides enjoyment when put into practice. The content can be serious and relevant to the workplace, but it can also be educational entertainment that teaches and entertains. For training to have the desired effect, participants should have a positive impression of it. In addition, the study by Ricci et al. [89] showed that the effectiveness of training methods is achieved through qualified trainers and that the content of the training is closely related to everyday work experience. The effects of training can be maintained by providing retraining over time and by emphasising the relevance of training rather than compulsory attendance.

A SWOT analysis of the demonstration and simulation teaching method is presented in Table 6.

Table 6. SWOT analysis of the training method—Demonstration and simulation.

STRENGTHS	learning by doing; individual approach; feedback on an ongoing basis; interaction between participants and between participants and trainer; effectiveness of transferred knowledge	WEAKNESSES	training results depend primarily on the competence of the trainer; requirement for at least intermediate interpersonal skills
OPPORTUNITIES	high frequency of repetition can result in better learning; possibility to learn fast decision-making in crisis situations; possibility to use modern technology	THREATS	training effects may depend on the personal conditions of the trainees; possibility of stressful situations under social pressure

4. Multi-Criteria Analysis of Training Methods

The wide range of possible methods for delivering OSH training allows flexibility in the choice of methods according to the needs and skills of the trainer. In practice, however, it is often possible to identify errors or low effectiveness in the training provided. Multi-criteria analysis has been used in many areas of occupational safety [90–92]. However, the use of this research method to evaluate the effectiveness of training methods is still limited. The criteria for evaluating the effectiveness of OSH training methods and the results of expert evaluation are described below.

4.1. Characteristics of the Criteria for Evaluating Training Methods

Based on a qualitative assessment of OSH training methods (SWOT analysis) and the experience of the authors, criteria and their classification were distinguished. Points were assigned to each characteristic of the criterion (Table 7). The lowest score indicates some limitations in the application, while the highest score is assigned to the feature that highlights the most important value of the criterion.

Table 7. Criteria for evaluating the effectiveness of training methods.

Criterion	Characteristics	Points
Training room equipment	New technologies (VR goggles, exoskeleton, etc.).	1
	Interactive whiteboard and computers for every user, learning games	2
	Chalkboard and computer with projector	3
Number of participants	Up to 10 persons	1
	Up to 25 persons	2
	Over 25 persons	3
Possibility of mixing the method with other training techniques	Low discretion	1
	Medium discretion	2
	Large discretion	3
Financial input for training preparation	>1000 $	1
	250–1000 $	2
	<250 $	3
Reach of the method	Individual	1
	Group	2
	Global	3

Table 7. *Cont.*

Criterion	Characteristics	Points
Trainer's knowledge	Expert	1
	Specialist	2
	Basic	3
Trainer's soft skills	None or small	1
	Medium	2
	Large or very large	3
Labour input for training preparation	>15 h	1
	5–15 h	2
	<5 h	3
Time during which learners actively participate in the training	<50% of training time	1
	50–75% of training time	2
	>75% of training time	3
Level of memorisation of training content	<30%	1
	30–70%	2
	>70%	3
Monitoring of learning and knowledge acquisition	No control	1
	Part-control	2
	Full control	3
Interactions between trainees or between trainees and the trainer	No	1
	Rare	2
	Frequent	3
Digital exclusion	Large	1
	Medium	2
	No exclusion	3
Number of session overtime	1 h	1
	2–3 h	2
	>3 h	3

The individual criteria should be understood as follows:

- Training room equipment—the provision of tools, equipment and software to enable a particular training delivery method to be used to its full potential, taking into account the level of technological advancement and accessibility to the trainer and the training audience;
- Number of participants—the number of people attending a training course for whom the use of a particular delivery method will result in the achievement of the intended learning objectives;
- Possibility of mixing the method with other training techniques—the degree of freedom to mix training delivery techniques with the first selected method in order to increase the training effectiveness and the interest of its participants, taking into account technical and organisational constraints;
- Financial input for training preparation—the purchase or rental of the necessary tools, equipment or software that enable the preparation of the training and the use of the necessary elements for the implementation of the learning process, while maintaining at least a good quality of the training;

- Reach of the method—the impact of a particular training method on a given unit in terms of a trainee or a group of people participating in the training and the reach of the impact;
- Trainer's knowledge—the range of knowledge in a specific field or broad general knowledge from which the trainer educates participants in an attempt to achieve the intended training objectives;
- Trainer's soft skills—innate or acquired during developmental training, thanks to which difficulties that may arise during the training are skilfully eliminated by means of various psychological techniques applied by the trainer;
- Labour input for training preparation—the time spent in the process of training preparation, starting with the planning of the training, through the development of the didactic material, to its application in the most appropriate delivery techniques used in a particular method of training delivery;
- The time during which learners actively participate in the training—the time during which learners have direct interaction with the trainer or with each other, and the time during which learners are actively involved in the training process as defined top-down in the training method used;
- Level of memorisation of training content—the ratio of memorised content from the training to the total body of knowledge contained in the training, according to Dale's cone of learning and experience;
- Monitoring of learning and knowledge acquisition—the ability to monitor on an ongoing basis whether and to what extent trainees are achieving the intended objectives of the training, and the ability to monitor learning outcomes in the form of meaningful post-training results;
- Interactions between trainees or between trainees and the trainer—interactions between one or more parties to the training which, depending on the choice of training method, do not occur or occur with a certain frequency;
- Digital exclusion—an event where trainees are prevented or restricted from using all the possibilities of a particular training method due to personal technological skills or lack of necessary equipment.
- The number of session overtime—the optimum duration of training translates into effectiveness. The shorter the duration of the training, the better, but in order to balance the delivery of all necessary content while respecting the applicable regulations and at the same time ensuring the level of attractiveness of the training as perceived by the trainees, the excess hours of training duration should not be significantly exceeded.

4.2. Results

Based on the defined criteria, the experts made individual quantitative assessments of the methods used to provide safety training. These are based on their experience, observations and knowledge.

The experts (three women and two men) who conducted the evaluation of safety training methods are between 35 and 55 years old. They have extensive teaching experience in adult education (the experts' teaching experience varies from 10 to 20 years, with an average of 14 years). Experts are active trainers in the field of occupational safety with a variable length of experience ranging from 5 to 17 years (average 9 years). Experts use a variety of didactic methods in their training work and achieve high levels of satisfaction in trainee surveys.

According to the expert assessments of training approaches within the occupational safety domain, comparable values are evident in the assessed criteria (Table 8). This clearly confirms the relevance of the defined criteria, as well as the general view of the experts on the characteristics of the evaluated methods. Based on the ratings of the five experts, an average rating of individual criteria was given for each training method (Table 9). On this basis, summary scores for the evaluated training methods are presented. The results of the evaluations show the highest effectiveness of the methods using practical action elements,

i.e., active training methods supported by discussion and gamification, and augmented and virtual reality. On the basis of expert evaluations of the criteria, their effectiveness is 30% higher than e-learning and b-learning forms. It should be noted that effectiveness may change when other criteria are taken into account. However, the overall relationship between the methods should not change. The reason for this is that, before the expert evaluations, the evaluators indicated the effectiveness of the training methods in the order of the summary results obtained, as shown in Table 9.

Table 8. Expert quantitative evaluation of the effectiveness of training methods.

	Traditional Lectures and Lectures Enriched with Multimedia Materials					**E-Learning and b-Learning**					**Active Training Methods Supported by Discussions and Gamification**					**AR and VR**					**Demonstration and Simulation**				
	Expert					**Expert**					**Expert**					**Expert**					**Expert**				
	I	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**
Training room equipment	3	3	3	3	3	2	2	1	1	2	2	2	1	1	2	1	1	1	1	1	3	3	2	2	1
Number of participants	3	3	3	3	3	3	3	3	3	3	1	2	2	2	1	1	2	2	1	2	2	3	2	1	2
Possibility of mixing the method with other training techniques	2	2	1	3	1	1	1	1	1	1	3	3	2	3	3	3	3	3	3	3	2	2	2	1	1
Financial input for training preparation	3	3	3	3	3	1	1	2	1	1	2	2	1	1	2	1	1	2	2	2	2	1	2	2	2
Reach of the method	2	2	2	2	2	3	3	3	3	3	1	1	2	2	1	1	2	2	1	1	2	1	2	2	1
Trainer's knowledge	1	1	1	1	1	2	2	3	2	2	2	2	2	2	2	3	2	3	3	3	1	1	1	1	1
Trainer's soft skills	2	3	2	1	3	2	2	1	1	2	3	3	2	2	3	2	2	1	2	2	2	1	3	2	3
Labour input for training preparation	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	3	3	3	3	2	2	2	1	3	2
Time during which learners actively participate in the training	1	1	1	2	1	2	3	1	2	2	3	3	3	2	3	3	3	3	3	3	2	3	3	2	2
Level of memorisation of training content	1	1	1	1	1	2	1	1	2	2	3	3	3	2	3	3	3	3	3	3	2	2	2	2	3
Monitoring of learning and knowledge acquisition	1	2	1	1	2	1	1	1	1	1	3	3	2	3	3	3	3	3	3	3	2	2	2	3	3
Interactions between trainees or between trainees and the trainer	2	1	3	2	1	2	1	2	2	1	3	2	3	3	3	1	2	2	1	1	2	2	2	3	2
Digital exclusion	3	3	3	3	3	1	1	1	1	1	2	3	2	2	2	1	1	1	2	2	2	3	3	3	3
Number of session overtime	1	2	1	1	2	3	2	2	2	3	2	3	3	3	2	3	3	2	3	1	1	1	2	2	1

Table 9. Average quantitative evaluations of the effectiveness of training methods.

	Traditional Lectures and Lectures Enriched with Multimedia Materials	**E-Learning and b-Learning**	**Active Training Methods Supported by Discussions and Gamification**	**AR and VR**	**Demonstration and Simulation**
Training room equipment	3.0	1.6	1.6	1.0	2.2
Number of participants	3.0	3.0	1.6	1.6	2.0
Possibility of mixing the method with other training techniques	1.8	1.0	2.8	3.0	1.6

Table 9. *Cont.*

	Traditional Lectures and Lectures Enriched with Multimedia Materials	E-Learning and b-Learning	Active Training Methods Supported by Discussions and Gamification	AR and VR	Demonstration and Simulation
Financial input for training preparation	3.0	1.2	1.6	1.6	1.8
Reach of the method	2.0	3.0	1.4	1.4	1.6
Trainer's knowledge	1.0	2.2	2.0	2.8	1.0
Trainer's soft skills	2.2	1.6	2.6	1.8	2.2
Labour input for training preparation	1.0	1.0	1.4	2.8	2.0
Time during which learners actively participate in the training	1.2	2.0	2.8	3.0	2.4
Level of memorisation of training content	1.0	1.6	2.8	3.0	2.2
Monitoring of learning and knowledge acquisition	1.4	1.0	2.8	3.0	2.4
Interactions between trainees or between trainees and the trainer	1.8	1.6	2.8	1.4	2.2
Digital exclusion	3.0	1.0	2.2	1.4	2.8
Number of session overtime	1.4	2.4	2.6	2.4	1.4
Total	**26.8**	**24.2**	**31.0**	**30.2**	**27.8**

5. Discussion

Teaching work safety is a difficult challenge for teachers. It often requires a high level of expertise on the part of the trainers. In many cases, it is not possible to deliver safety training without the relevant knowledge of the trainers. This is due to the need to refer to current legislation and complex processes to improve safety. In general, OSH training is most often perceived by participants as necessary, boring and time-consuming. In addition to the broad content of the training and the consequent need for trainers to have specialist knowledge, the challenge is to engage the trainees. This has a significant impact on the perception of the training content. Engaging and dynamic health and safety training yields increased levels of participation and successful transfer of safety knowledge [18]. Effectively learning safety concepts and other information is achieved through a combination of definitions and practical examples [32].

A relatively recent development in safety science involves adopting a comprehensive view of human factors in safety training. This perspective is essential in safety training procedures as human behaviour significantly influences the occurrence of most workplace accidents [79,93]. Indeed, if we look at the causes of workplace accidents, which show that human factors are the most common cause of accidents, this statement seems to be correct. Therefore, OSH training should focus on making workers aware of the need to carry out their work in such a way that their health is maintained at the highest level. This is also confirmed in the work of Barati Jozan et al. [94], who show that effectively improving workers' knowledge and skills ultimately leads to fewer accidents and injuries in the workplace.

If we look at the teaching methods used in the field of occupational safety, we can see that their effectiveness varies. Surveys of different methods carried out by a number of researchers indicate the high effectiveness of methods that activate learners in the

learning process (active training methods with elements of gamification, VR, simulations, role plays, etc.). At the same time, it is important to stress that these results refer to participants' perceptions of the specific training. This approach is not comprehensive and does not allow the comparison of different methods due to the different skills of the trainers and the different research groups. In addition, the training was evaluated by the participants and not by the trainers. In this study, a completely different approach is proposed to the evaluation of training methods. Experienced health and safety trainers showed different levels of training effectiveness. Research has confirmed that active training methods with gamification, AR and VR elements, as well as demonstrations and simulations, are the most effective teaching methods. In addition, active methods evoke emotions in learners, allowing them not only to learn better, but also to improve their skills and competencies through the exchange of ideas or healthy competition in a near-realistic, yet safe learning process.

It should be emphasised that it is difficult to find in the literature the results of studies presenting trainers' evaluation of safety training methods. It is therefore difficult to compare them with the results obtained in this study. A quantitative analysis of training methods was carried out based on the opinions of five experts. Their results clearly indicate the effectiveness of the training methods evaluated. The final ratings were determined as the average of their expert ratings, which did not differ significantly from each other.

On average, the safety training methods that are the most captivating tend to be the most effective in mitigating adverse outcomes like accidents. The heightened effectiveness of interactive, hands-on training in minimising negative outcomes and enhancing knowledge acquisition aligns with the recommendations from both researchers and practitioners to establish and execute a learner-centred, participatory approach to safety and health training [18,95,96]. However, activation methods evoke emotions in learners that are helpful in achieving training goals [97]. Although it is sometimes difficult to provide training using only one method, the use of engaging methods is a key element of high-quality and effective training. Active training methods based on gamification include elements that make games fun, which strongly motivates participants [70,98]. The incorporation of games or game elements in education is motivated by the fact that the interactivity inherent in gaming prompts learners to actively engage in the learning process. This, in turn, supports active learning, experiential learning and problem-based learning [65,99]. The advancements in VR hardware and software further make immersive safety training through virtual reality a feasible choice for delivering workplace safety training [79].

Given the variety of knowledge to be conveyed and the need to adapt training formats, it seems that the highest quality and effectiveness of training can only be achieved by using blended didactic methods (Figure 2). The use of a variety of training techniques adds variety to the learning process and also keeps participants' attention for a much longer period of time. The use of different training methods allows participants to better adapt and engage according to their physical, emotional and intellectual predispositions. In addition, different methods support the learning process by exploring multiple senses and going through all stages of the learning process [49]. Utilising Kolb's learning cycle [52], various adult learning techniques can be effectively incorporated. Kolb's learning cycle, recognised as the predominant and highly influential model within experiential learning theory [100,101], presents an optimal dynamic perspective on learning. It is geared towards the dialectical resolution of two contrasting forms of experiencing (reflection/action) and the conversion of experience into knowledge (feeling/thinking) [102]. In Kolb's theory of learning, which is part of the constructivist approach, learnt knowledge is mentally anchored to a specific experience corresponding to that knowledge. This means that different didactic methods must be logically related and address the same issue [103].

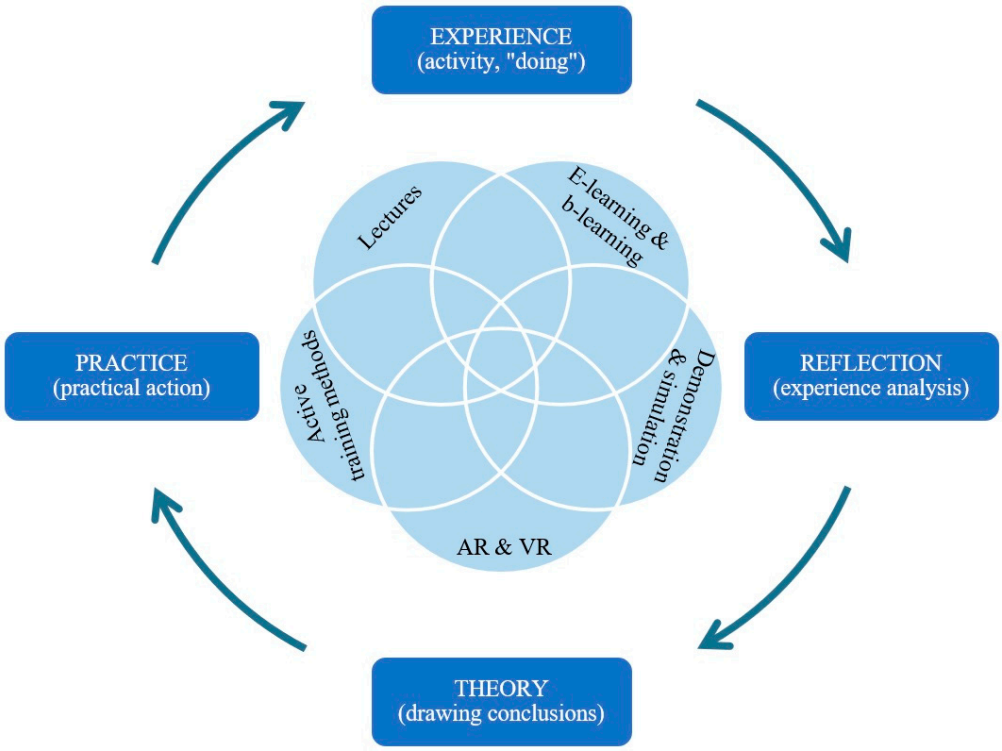

Figure 2. Training methods for safety in the Kolb learning cycle.

6. Conclusions

Workers spend a significant part of their lives at work. Therefore, it is vital to ensure an adequate level of safety and to raise their awareness of occupational hazards. The latter can be achieved through occupational safety training. It should be stressed that the training process is difficult and demanding. The choice of didactic methods, regardless of the type of knowledge to be conveyed, is an important element in the planning of the training process, with the aim of achieving high-quality didactic effects. The quality and effectiveness of training are even more important when considering the current challenges in the field of occupational safety, such as the pursuit of employee well-being, work-life balance or the incorporation of state-of-the-art technology. Therefore, training should be an essential component of occupational safety which is part of a company's sustainability.

This study shows that active teaching methods are among the most effective forms of teaching, enabling learners to achieve the knowledge and skills intended by the training objectives much more easily. However, the highest effectiveness can be achieved with a variety of didactic methods, which should be used interchangeably or simultaneously, depending on the training content and needs, but also on the skills of the trainer and the needs of the group participating in the training. The choice of training methods should be adapted to the physical, emotional and intellectual predispositions of the students and should include the stages of the learning process (experience, reflection, theory and practice).

Evaluations of the effectiveness of training are first carried out by trainers. The choice of training methods should still be analysed in detail and this evaluation should be carried out by experts (trainers) and trainees in order to further improve the training process. In addition, it is still necessary to look for effective training methods to educate and make employees aware of the risks in their work environment and to experience the consequences of dangerous incidents without being harmed. For companies with specific activities such as mining, construction or energy, this is particularly important.

Author Contributions: Conceptualisation, P.B. and P.S.; methodology, P.B. and P.S.; validation, P.B. and P.S.; formal analysis, P.B.; investigation, P.B.; writing—original draft preparation, P.B. and P.S.; writing—review and editing, P.B. and P.S.; supervision, P.B. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Polish Ministry of Education and Science Subsidy 2024 number 8211104160 for the Department of Mining WUST.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Acknowledgments: The authors thank the experts for their contribution to the study.

Conflicts of Interest: No potential conflicts of interest were reported by the authors.

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