

Implementation of Innovative Digital-Based Learning Resources for Teaching Occupational Safety and Health in Mechanical Engineering

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Abstract. Innovation in learning resources through digitalization is a necessity in academic activities, including teaching Occupational Safety and Health (OSH). The problem faced is that there is no OSH digital learning resource available for mechanical engineering courses, and it needs to be developed to meet innovative learning resources according to student characteristics. This research aims to develop and implement digital-based innovative learning resources for OSH teaching. The research involved 30 students of the Mechanical Engineering Education Department, Faculty of Engineering, Universitas Negeri Medan for the 2022/2023 academic year. The results of the research have succeeded in packaging digital OSH learning resources for mechanical engineering. The final evaluation showed that student learning outcomes were in the good category ($M=82.39\pm 8.86$). Implementation of learning resources in OSH teaching is effective in facilitating students to learn actively in achieving competence in the field of occupational safety and health.

Keywords: Digital resources; Occupational Safety and Health; Active learning; Learning outcomes.

1 Introduction

Digital learning resources have brought changes in teaching and learning activities, namely adapting to advances in digital technology and the needs of students [1,2]. Digitalization has become a student's daily life, both for academic activities and in non-academic activities. Thus, the provision of digital learning resources that are adaptive to student activities must be accommodated to make it easier for them to learn. Innovative digital-based learning resources must be provided, namely those that can be accessed by students online, including for teaching Occupational Safety and Health (OSH). Digitizing learning resources will help students access learning resources at any time according to their needs, and can be used for learning without being limited by time and place for OSH courses [3,4].

The problem faced by students in teaching OSH is that there are no learning resources available that contain occupational safety and health material, resulting in low knowledge and practice of OSH. Work accidents related to teaching and learning activities must be minimized through good OSH knowledge and practice [5,6]. Knowledge about OSH can be obtained from learning sources (hard copy or electronic), especially OSH textbooks in digital format. Digital learning resources are very appropriate to use to facilitate students studying OSH actively to be put into practice at work. OSH knowledge becomes real practice in everyday life which is obtained through occupational safety and health teaching.

Occupational Safety and Health courses are very necessary to support the daily activities of engineering students at universities [7]. Occupational safety and health practices are mandatory for students of the Mechanical Engineering Education Department, especially when carrying out academic activities in laboratories, fields, studios, and also when carrying out practical work in industry. Knowledge in the field of OSH must be known and practiced by students in their academic activities to achieve a safe and comfortable learning atmosphere [8]. Students can obtain competency in the field of safety and occupational safety through OSH teaching. Strategies must be carried out to build good habits in OSH practice, and must become a student's daily culture so that incidents of injury at work in laboratories and workshops can be avoided [9]. Through OSH teaching, students will be aware that work accidents can be prevented and predicted, and each individual is required to be responsible for the work he does, while trying to create a sense of security while studying and working [10,11].

The Independent Campus Learning Program (MBKM) is a policy of the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia (Kemendikbud-ristek), which provides opportunities for students to acquire the competencies needed according to their talents and interests as preparation for future careers [12]. The safety of students carrying out academic activities at the University must be protected through OSH knowledge which can be obtained quickly through digital-based learning resources [13-15]. Digital learning resources are media to facilitate students' complete learning so they need to be packaged in a systematic, complete, attractive, easy to carry, and easily accessible way. Digital-based innovative learning resources are very appropriate when designed for teaching OSH [16]. This research aims to develop and implement digital-based innovative learning resources for OSH teaching. Digitization of learning resources is the packaging of learning resources by combining text, media, multimedia and animation, hyperlinks, and contextual cases into a compact electronic form that is connected to technology known as digital learning resources so that they can be used as teaching materials to help students learn.

2 Methods

The study was carried out as described in the previous references by making several modifications to achieve the research objectives [17,18]. Research methods include population and sample and research procedures, briefly explained below.

2.1 Population and Sample

The study population was students of the Mechanical Engineering Education Department, Faculty of Engineering, Universitas Negeri Medan for the 2022/2023 academic year. Samples were selected purposively according to class conditions, namely students who were taking Occupational Safety and Health courses, involving 30 Diploma program students. The research has been carried out according to the research code of ethics in the social and educational fields established by the University. Explanations to students as samples and research objects have been notified, and their consent has been obtained as samples. Samples are given the freedom to withdraw from the research sample at any time and this does not influence the course assessment.

2.2 Research Procedure

The research procedure consists of analyzing learning needs and providing digital learning resources, and implementing learning resources for teaching OSH, as shown in Figure 1. The preparation of teaching materials for learning resources for OSH courses adjusts to the results of the needs analysis, and continues to complete supporting facilities for teaching OSH. Enrichment of teaching materials is carried out according to a competency-based curriculum, followed by integrating media and multimedia in teaching materials, providing project packages, hyperlinking to trusted websites, and packaging digital learning resources. Standardization of learning resources is carried out using experts following the quality criteria for teaching materials set by the Educational Curriculum and Assessment Standards Agency (BSKAP), with questionnaire answer choices (Likert scale) in the strongest score range (4) Very Appropriate to the lowest (1) Very Inappropriate. The implementation of digital learning resources is used to facilitate students in learning OSH. At this stage a pretest is carried out, followed sequentially, namely the implementation of teaching, evaluation of learning outcomes, and measurement of competency achievement in the OSH field. Learning outcomes are measured based on students' ability to answer objective questions, and scores are converted in the range of 0-100. The learning mastery obtained by students is a measure to express competency achievements in the OSH field.

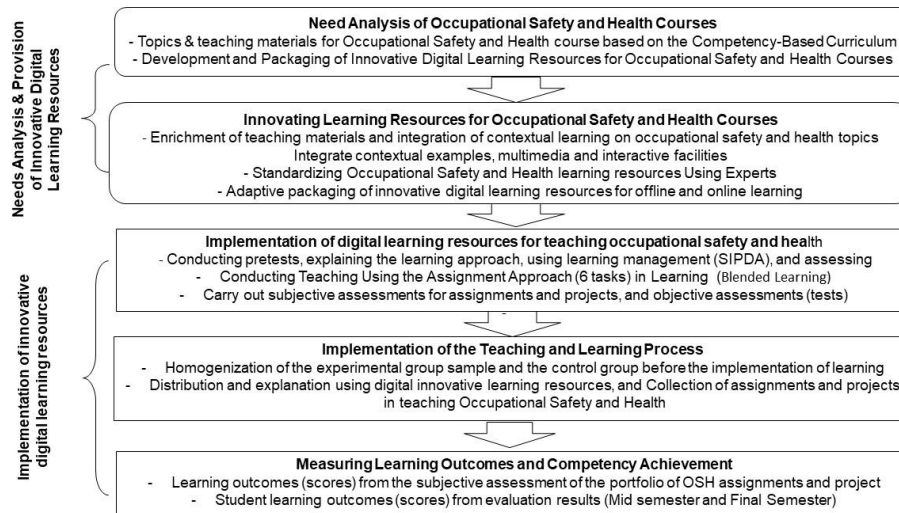


Fig. 1. Research procedures and stages of developing innovative digital-based learning resources for teaching Occupational Safety and Health courses.

3 Results

3.1 Digital Learning Resources for Occupational Safety and Health Course

Learning resources for Occupational Safety and Health courses have been developed according to the needs of students in tertiary institutions (Diploma and Undergraduate Programs) following the competency targets set in the competency-based curriculum. Packages of learning resources are available that are complete, interesting, informative, and adaptive to teaching when done face-to-face and online. Descriptions of digital learning resources supporting textbooks that have been formally published for OSH courses along with their completeness are summarized in Table 1.

Table 1. Main topics and brief description of teaching materials in digital learning resources for the Occupational Safety and Health course.

No	Topic	Brief Description of Occupational Safety and Health teaching materials
1	Occupational Safety and Health Concepts and OSH Law	Teaching materials contain the concept of occupational safety and health according to the competency-based curriculum and the OSH Law, and are equipped with multimedia and powerpoint media
2	OSH Management System	Teaching materials contain the OSH management system, and are equipped with media and powerpoint
3	OSH Hierarchy of Risk Control and Personal Protective Equipment (PPE)	Teaching materials on the hierarchy of OSH and PPE risk control are arranged in a systematic and complete, in-depth manner, equipped with hyperlinks to electronic books and articles from reputable journals, multimedia, relevant videos adopted from Youtube, equipped with case study assignments (case method) given to students

4	Fire and Fire Fighting	Learning resources in the form of special topics for fire and fire fighting are made systematically to reinforce the causes and prevention of fires, equipped with examples, journal hyperlinks, multimedia, and equipped with assignments given to students and project assignment formats (team-based projects)
5	Workshop Layout, Ventilation System, Working Climate, and Lighting	Learning resources for studying workshop layout, ventilation systems, work climate, and lighting are arranged systematically, equipped with examples, materials for discussion, and powerpoint media
6	Environmental Pollution	Teaching environmental pollution is packaged into an interactive learning resource in the form of demonstrations that can help students prevent environmental pollution. Learning materials are equipped with multimedia and assignments
7	Hazardous Materials	Teaching materials are packaged properly, equipped with examples to make it easier to learn about hazardous waste and the work environment. Teaching materials are equipped with multimedia facilities and assignments
8	Occupational Disease	Teaching materials contain information on occupational diseases and their prevention, supplemented by media in the form of PowerPoint
9	Machine Safety and Noise	Teaching materials contain machine and noise safety, supplemented by media in the form of powerpoint
10	Threshold Limit Value (TLV)	Teaching material about threshold values is well packaged, equipped with examples to make it easier to study environmental impacts and TLV. Teaching materials are equipped with multimedia facilities
11	Ergonomics	Teaching materials contain ergonomics concepts arranged in a systematic and complete, in-depth manner, equipped with hyperlinks to electronic books and articles from reputable journals, multimedia, relevant videos adopted from Youtube, equipped with assignments given to students
12	Occupational Nutrition and Health Promotion	Teaching materials on the topic of Occupational Nutrition and Health Promotion are packaged properly, equipped with examples to make it easier to study occupational nutrition and health promotion. Teaching materials are equipped with multimedia facilities

3.2 Standardization of Digital Learning Resources

The digital learning resources developed have been standardized using expert opinions, namely lecturers who are experienced in teaching OSH (internal and external lecturers) and the assessment results are summarized in Table 2. Respondents have given very good assessments of all components of the digital learning resources, in sequence, the results of the assessment of internal experts ($M = 3.47 \pm 0.59$) and external experts ($M = 3.50 \pm 0.51$). From these results, it is stated that OSH learning resources are suitable for use as learning resources for occupational health and safety courses.

3.3 Implementation of Digital Learning Resources for OSH Teaching

The implementation of learning resources in OSH teaching has been carried out following the regulations that apply at the University. Teaching is carried out in a hybrid manner, namely face-to-face and online learning according to the characteristics of the topic being taught. Students actively use digital learning resources in their academic activities. The learning needs

of students have been fulfilled for each subject because it is equipped with theoretical enrichment, examples of implementation, and is supported by multimedia. Learning resources are available online for students to access. Digital learning resources have made it easy for students to implement theory into practice regarding occupational health and safety. Learning activities prove that learning resources are effective in facilitating student learning independently, which is shown by the speed at which students complete the required assignments. The completeness of contextual examples has helped students understand the implementation of theory in OSH practice. Student learning outcomes based on subjective and objective assessments are summarized in Table 3. Subjective scores are from a portfolio of assignments and projects, while objective scores are obtained from the midterm and final semester exams, all of which are classified as good ($M = 82.39 \pm 8.86$). It can be stated that the digital learning resources developed have been effective in helping students learn to achieve competency in the field of occupational health and safety.

Table 2. Lecturer respondents' assessment of the quality of project-integrated digital learning resources for teaching occupational health and safety.

No	Description of learning resource components assessment	Opinions of Respondents	
		Internal (M±SDv, n=6)*	External (M±SDv, n=6)*
1	Content of teaching materials: According to the KKNI-oriented competency-based curriculum, teaching materials support the achievement of Occupational Safety and Health competency targets	3.50±0.55	3.33±0.52
2	Completeness: Integrated examples of theory implementation, available templates for task reports and assignments for each subject of Occupational Safety and Health	3.33±0.82	3.50±0.55
3	Fulfillment of student needs: Completeness and suitability of teaching material topics to the needs of undergraduate and diploma program students	3.50±0.55	3.83±0.41
4	Design and appearance: Learning resources are attractively designed, equipped with illustrations, visualization, narrative text, sound and animation in a compact digital format	3.67±0.52	3.50±0.55
5	Language: Conformity of language and grammar, simplicity of presentation, easy to understand, and gives the impression of long-remembered learning	3.33±0.52	3.33±0.52
Average		3.47±0.59	3.50±0.51

*Likert scale: (4) Very Appropriate; (3) Appropriate; (2) Not Appropriate; and (1) Very Inappropriate

Table 3. Student learning outcomes based on subjective and objective assessments in the Occupational Safety and Health course.

No	Type of assessment	Students mark (n=30)
1	Attendance	93.78±8.58
2	Portofolio assignments (consisting of 6 integrated tasks and projects)	76.15±12.40
3	Mid Semester Examination	74.63±11.62
4	Final Semester Examination	84.98±9.96
Average		82.39±8.86

4 Discussion

Learning resources are key to the success of students studying OSH [19,20]. The digital learning resources that have been developed consist of 12 topics, covering the contents and practices of occupational safety and health in line with OSH laws and regulations. The scope of OSH is the entire work environment including layout, environmental conditions, supporting equipment, safety handling, waste management, ergonomics, risk management and control using personal protective equipment, and health promotion (Table 1). Complementary components of learning resources, such as assignments and projects, contextual examples, and multimedia relevant to the subject matter, have succeeded in guiding students to learn actively to master the theory and practice of occupational health and safety. Respondents' assessment of digital learning resources stated that they were very feasible for use in tertiary institutions, especially engineering. Learning OSH using developed learning resources has provided adequate knowledge for students in identifying and controlling dangers, accidents and illnesses that may arise as a result of activities in the workplace, and ultimately will be free from the risk of work accidents [21,22].

The contents and practices of occupational safety and health is a field of knowledge that is important to understand and apply to students, namely during lectures and when working, as an effort to prevent accidents and occupational diseases [23,24]. Digital learning resources for teaching occupational safety and health are designed to enrich teaching material related to occupational safety and health, and have been combined with electronic, visual, audio and graphic media, and examples of the implementation of occupational safety and health, to make it easier for students to learn and practicing OSH in engineering work [25,26]. The learning message has been easily put into practice and remembered by students, competency in the field of occupational safety and health has been achieved optimally [27].

Learning OSH using digital learning resources has built adequate knowledge and skills about occupational safety and health. Students have practiced OSH directly through learning activities, exercises, and assignments. The availability of digital learning resources has succeeded in helping students learn quickly and efficiently, and OSH skills can become a culture in every aspect of the work they do [28-30]. Completeness in OSH learning has been achieved as evidenced by students' ability to complete assignments related to the OSH topics they are studying [31-33]. Students have been directly involved through the implementation of their assignments and projects, and the final product is the achievement of competency in the field of OSH [34-36]. It is recommended that the development of digital learning resources be carried out in other courses that require mastery of theory and practice, and become a strategy for achieving competencies as required in the competency-based curriculum [37].

5 Conclusion

From the results of this study, it was concluded that digital learning resources for the teaching of Occupational Safety and Health have been successfully developed consisting of 12 topics of discussion complemented by multimedia, contextual examples, and assignments. The assessment of expert respondents shows that learning resources are appropriate for teaching OSH in the engineering field. The digital learning resource package contains material that is

complete, easy to learn, and guides students to active learning in achieving competence in the field of occupational safety and health. The implementation of learning resources in teaching OSH shows that students have mastered theory and practice in the field of OSH which is shown from the learning outcomes obtained from subjective assessments and objective assessments which are in the good category. Digital learning resources are very suitable for implementation in higher education, and are adaptive for use in online and offline learning.

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