

DEVELOPMENT OF DIGITAL ASSESSMENT OF SCIENCE PROCESS SKILLS ON OCCUPATIONAL SAFETY AND HEALTH TOPICS IN CHEMICAL LABORATORIES

Muhammad Bayu Kusuma, Nahadi

Universitas Pendidikan Indonesia, Indonesia

Email: bayukusuma@upi.edu, nahadi@upi.edu

ABSTRACT

Employee performance and discipline in public universities are critical for institutional success, yet determinants like remuneration, job rotation, and work environment remain underexplored in academic settings. This study analyzes how these factors influence work discipline and performance among civil servants at Udayana University's Rectorate, including their mediating relationships. A quantitative approach using PLS-SEM (SmartPLS 4.1.0) was applied to data from 170 staff across four bureaus, collected via questionnaires and interviews. Remuneration ($\beta=0.988$, $p<0.05$), job rotation ($\beta=0.990$, $p<0.05$), and work environment ($\beta=0.990$, $p<0.05$) significantly enhance both discipline and performance. Work discipline partially mediates these relationships, explaining 97.6–98.1% of performance variance. The study offers policymakers evidence-based strategies to optimize HR practices in public universities, emphasizing equitable remuneration, structured rotation, and conducive workplaces. It advances theoretical frameworks by validating mediation dynamics in a novel context.

KEYWORDS *work discipline, remuneration, employee performance*



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INTRODUCTION

Chemistry laboratories are an important learning environment in science education, especially chemistry. Practicum activities not only demand conceptual understanding but also high practical skills (Agbonifo et al., 2020; Aliyu & Talib, 2019; Ismail & Pernadi, 2022; Teshome et al., 2021; Viitaharju et al., 2023). One of the crucial aspects of laboratory activities is occupational safety and health (K3). Although there have been many regulations and guidelines that regulate safety in the laboratory, the facts

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in the field show that there are still many students who do not have adequate awareness and skills in applying the principles of K3.

Awareness of the risks of chemicals and the safe use of laboratory equipment must be instilled from an early age (Han & Park, 2018; Kelly et al., 2020; McEntaggart et al., 2019; Naidu et al., 2021; Papadopoli et al., 2020; Sim et al., 2019). In this context, science process skills (PPP) are an important basis in shaping students' ability to think scientifically, observe, and act systematically in practicum situations. However, assessments of PPP are often still manual and ineffective in reaching the needs of modern technology-based education.

To answer these challenges, this study developed a digital assessment instrument that can measure student PPP on laboratory K3 topics. The use of digital technology allows for more interactive, efficient, and can be carried out assessments before practicum is carried out as a preventive measure (Artanayasa et al., 2023; Cantabrana et al., 2019; De Lorenzo et al., 2023; Divayana et al., 2021; Mattar et al., 2022).

Previous studies such as Lestari & Fatimah (2019) and Taufiq & Aini (2020) have emphasized the importance of science process skills (SPS) and safety behavior in chemistry laboratories. Lestari & Fatimah highlighted the low awareness of laboratory safety among high school students, while Taufiq & Aini developed traditional assessment tools for SPS. However, there has been limited integration of digital technology in assessing science process skills specifically related to occupational safety and health (K3) in chemistry labs. This study introduces a novel approach by developing a digital assessment instrument that not only evaluates student comprehension of K3 principles but also facilitates early intervention before practical work.

The objective of this research is to design and validate a digital instrument to assess students' science process skills (PPP) in the context of laboratory safety. The expected benefits include improved awareness of K3 principles, enhancement of students' readiness for practical activities, and contributions to digital-based pedagogical innovations. This research provides educational institutions with a preventive and efficient solution to promote laboratory safety culture through modern assessment techniques.

RESEARCH METHOD

This research uses a Research and Development (R&D) approach with the ADDIE development model consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. At this stage, the focus of research is at the Analysis to Development stage. The subject of the study is the class of 2024 students from the Chemistry Education Study Program. Data collection techniques include digital surveys through Google Forms, expert validation of assessment question items, and initial trials for selected respondents. Instruments are developed based on PPP indicators, including: observation, inference, identifying variables, formulating hypotheses, and scientific

communication. The assessment was carried out using rubrics on a scale of 1–4 which reflected the depth of understanding and application of K3 in the context of practicum.

The data analysis in this study was conducted using a quantitative descriptive approach in line with the Research and Development (R&D) method, particularly focusing on the Analysis, Design, and Development stages of the ADDIE model. The first step involved expert validation of the digital assessment instrument developed to measure students' science process skills (SPS) related to occupational safety and health (OSH) in the laboratory. The validation results were analyzed using the Content Validity Index (CVI), where each item was reviewed by experts in chemistry education and laboratory safety. Items with a CVI score of ≥ 0.80 were considered valid and retained for further development.

Following validation, a pilot test was conducted on a small group of 2024 chemistry education students using digital forms. The responses were analyzed descriptively by calculating mean scores, score ranges, and frequency distributions to identify students' understanding and ability to apply OSH principles in laboratory contexts. This analysis also provided insight into which items were effective and which required revision.

RESULTS AND DISCUSSION

Initial data was obtained from 100 students who responded to the digital assessment. The results show:

- 1) 92% of students were able to answer correctly regarding the main objectives of K3.
- 2) 88% mentioned PPE in full.
- 3) 96% understand chemical spill handling procedures.
- 4) 100% states that the location of the emergency equipment is near the exit.
- 5) 95% answered correctly how to dispose of chemical waste.
- 6) 98% know how to know what hazardous chemicals are.
- 7) The average perception of the importance of K3 is at a score of 5 (very important).

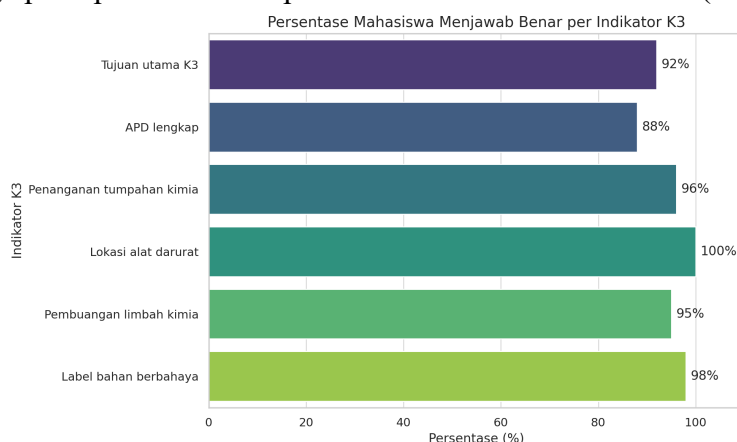


Figure 1. The Results

However, some responses showed a lack of in-depth understanding in formulating hypotheses or attributing the risk factors of the experiment as a whole. This shows that a more exploratory and real-context-based assessment instrument is needed.

Initial data collection was conducted with 100 students from the Chemistry Education Study Program using the developed digital assessment instrument. The results indicate that students generally possess a strong foundational understanding of occupational safety and health (K3) in the laboratory context. Specifically, 92% of students correctly identified the main objectives of K3, 88% were able to list all necessary personal protective equipment (PPE), and 96% demonstrated understanding of chemical spill response procedures. Furthermore, 100% of students correctly indicated the location of emergency equipment, 95% accurately described chemical waste disposal methods, and 98% understood how to identify hazardous chemicals. The overall perception score of the importance of K3 averaged 5, indicating a very high level of awareness.

Despite these encouraging results, further analysis of open-ended responses and rubric-based items revealed some gaps in students' higher-order thinking skills, particularly in formulating hypotheses and identifying complex risk factors related to laboratory activities. This suggests that while declarative knowledge is well-developed, procedural and analytical competencies still require enhancement. Such findings support the need for more in-depth, contextual, and exploratory assessment methods that not only test factual knowledge but also challenge students to think critically and apply safety principles in realistic scenarios.

Expert validation was conducted by three senior lecturers with expertise in chemistry education and laboratory safety. The experts confirmed that the assessment items were relevant and linguistically clear. However, they also recommended that the instrument could be further improved by enriching question contexts, incorporating visual simulations, and using digital platforms that support interactive engagement. These recommendations underscore the importance of continuous development and iterative testing to ensure that the assessment instrument remains effective and responsive to evolving educational needs.

CONCLUSION

The development of a digital assessment instrument for science process skills (SPS) on occupational safety and health (K3) topics in the chemistry laboratory represents a meaningful innovation in improving the quality of practicum-based learning. This instrument has effectively measured students' initial conceptual and procedural understanding, offering valuable insights into their preparedness for safe laboratory practice. The findings demonstrate that digital assessment can serve not only as an evaluative tool but also as a preventive approach to enhance students' awareness and application of laboratory safety principles. For future research, it is recommended to expand this instrument by integrating interactive simulations and real-time feedback to

increase student engagement and learning outcomes. Additionally, conducting broader trials with pre-test and post-test designs, along with comprehensive reliability and effectiveness testing, will help refine the instrument and support its wider implementation across various science education contexts.

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