



Improving Students' Cognitive and Psychomotor Performance through the Development of Project-Based Clinical Chemistry Learning Modules

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Abstract

The present study aimed to enhance students' cognitive and psychomotor performance through the implementation of a project-based learning module in clinical chemistry. The module was developed using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model and was tailored to address real-life clinical problems, possessing characteristics of self-instructional, self-contained, stand-alone, adaptive, and user-friendly. Validation by media and subject matter experts revealed a strong eligibility of the module with a media expert assessment score of 87.7% and a subject matter expert score of 90.4%. The students' response, as measured using the Likert scale, indicated a "Very Good" rating with a score of 92.85%. The results showed a significant improvement in both cognitive and psychomotor performance, with increases of 14.24% and 24.78%, respectively.

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INTRODUCTION

Project-based learning (PjBL) is a widely adopted teaching method at the tertiary level and has been shown to fulfill learning outcomes through the development of innovative modules (Irman & Waskito, 2020; Kiong et al., 2012). PjBL entails complex tasks centered around problem-solving, enabling students to carry out activities that involve designing, mitigating, solving problems, and drawing conclusions.

A case study by Tamim and Grant (2013) demonstrated that PjBL activities can support, facilitate, and improve the quality of the learning process, as well as enhance student creativity. PjBL provides students with opportunities to design tasks, infer information, and apply their newfound knowledge to real-life situations (Handayani, 2020). The PjBL model aligns with the philosophical constructivism approach, where knowledge is built through student activities that encompass scientific skills and attitudes, allowing students to construct their own knowledge through hands-on experience. Previous studies have shown positive results in improving students' psychomotor performance through PjBL (Lesmana & Arpan, 2017; Mulyatiningsih, 2011).

As per the Regulation of the Minister of Education and Culture Number 3 of 2020, third-year bachelor students are expected to have a good theoretical understanding and possess specific skills in a given field. In light of this, the development of a project-based clinical chemistry learning module is deemed necessary as a means of achieving the desired graduate learning outcomes.

METHOD

This study employed a research and development method to produce and evaluate a project-based learning (PjBL) module for clinical chemistry. The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model was used as the development framework (Branch, 2009).

Research Instruments

Three variables were measured in this study using three research instruments: students' interest in the delivery of learning materials using PjBL-based modules, the feasibility of PjBL-based modules, and student responses after the application of module. The research instruments used were field study questionnaires, expert validation questionnaires, and student assessment tests.

Field Study Instruments

Student responses to the modules were collected through questionnaires and observations during the learning process.

Expert Validation Instruments

The feasibility of PjBL-based practicum modules was evaluated by a team of experts using a questionnaire.

Student Assessment Instruments

Students' cognitive and psychomotor performance was measured through pre- and post-tests. The pre-test served as a baseline measure of students' learning outcomes before the implementation of the PjBL-based module, while the post-test was conducted after the implementation.

Data Analysis Techniques

Qualitative Analysis

Qualitative data was collected from observation, questionnaires, expert advice, and documentation. The data was then analyzed descriptively.

Quantitative Analysis

Quantitative data from expert validation questionnaires and student assessments were transformed into Likert scales, which consisted of five categories detailed in Table 1.

Table 1. Likert scale

Score	Category
5	Excellent
4	Great
3	Fair
2	Poor
1	Bad

The next step after converting the statement to a score with a Likert scale was to calculate the percentage of values of all components, according to the following equation (Arikunto, 2016).

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

Note:

- P : percentage of respondents
- $\sum x$: Total response
- $\sum xi$: Maximum score

Data analysis in the form of qualitative assessment percentages is then describe descriptively (Table 2).

Table 2. Module feasibility assessment table

Interval	Qualification	Follow up
85% - 100%	Strongly eligible	No revision
75% - 84%	Fairly eligible	No revision
65% - 74%	Poor	Need revision
55% - 64%	Improper	Need revision
0 - 54%	Awkward	Need revision

RESULTS AND DISCUSSION

The results of the analysis of students indicated that during the COVID-19 pandemic, students experienced difficulty in comprehending the material in the existing clinical chemistry module due to online lectures and video shows from YouTube. This prevented students from applying psychomotor skills to clinical cases and led to a failure to meet the learning outcomes of the course. The module design was established based on learning outcomes and PjBL-based semester learning plans. It was prepared by a team of lecturers considering the compatibility of the material with graduate learning outcomes, learning syllabus, and lesson plan (RPS).

The intended learning outcomes of the course were that students should be able to understand and analyze the theoretical concepts of clinical chemistry material and demonstrate psychomotor skills by exhibiting proficiency in solving clinical chemistry cases. The development stage involved the preparation of draft modules, which began with determining the learning objectives and indicators and collecting materials. The modules were designed to be self-instructional, self-contained, adaptive, and user-friendly. The topics in the clinical chemistry course were adjusted to the students' skill requirements, including urine examination and blood examination. A project was assigned to each topic, which was to be completed by groups of four students.

The feasibility of the module was evaluated by a team of experts during the implementation stage, assessing four aspects: content, suitability of presentation with learning approaches, language, and technical requirements. The results of the media expert validation showed a feasibility of 87.7% and material expert validation was 90.4%, indicating no need for revision. The module prototype was deemed eligible for testing on students in clinical chemistry courses.

Based on the results of the analysis of students, information was obtained, especially during the Covid-19 pandemic, students had difficulty understanding the material from the existing clinical chemistry module because lectures were held online, using lecture methods and viewing video shows from Youtube so that students were not able to apply psychomotor performance to a clinical case, so that the learning outcomes of the course could not be fulfilled. Literature study that aims to examine concepts and theories from various literature that are in accordance with the applied learning materials and also the learning tools needed in module development.

The module design is determined based on learning outcomes (CPL) and PjBL-based semester learning plans (RPS) that have been prepared by a team of subject lecturers by taking into account the suitability of the material with graduate learning outcomes, learning syllabus, and course RPS. The expected learning outcomes of the course (CPMK) are that students have cognitive abilities able to understand and explore theoretical concepts of clinical chemistry material and are able to have psychomotor performance shown by the existence of good skills in solving clinical chemistry cases.

At the development stage, draft is carried out which includes the preparation of module drafts. It was begun with determining the achievements and learning indicators to be developed in the module, collecting materials, typing modules and preparing materials in accordance with the expected competencies. Modules are created by applying the characteristics of self-instructional, self-contained, stand alone, adaptive, and user friendly. The selection of topics in clinical chemistry courses is adjusted to the needs of students' skills, namely urine examination which includes analysis of protein, glucose, bilirubin, urobilin and urobilinogen and blood examination including blood type analysis, blood sugar analysis, uric acid, fiber cholesterol analysis of hemoglobin levels in the blood. In each topic, a project is given that must be done by students in groups or groups of 4 students per group.

At the implementation stage, module product validation is carried out by a team of experts. The assessment in the practicum module tested by this expert includes 4 aspects, namely content, suitability of presentation with learning approaches, language, and technical requirements. The results of media expert validation of module feasibility were 87.7%, and material expert validation was 90.4%. Based on the results of expert material validation, there is no need for revision. The module prototype strongly eligible to be tested on students in clinical chemistry courses.



Figure 1. Trial of module drafts to students

Table 3. Pre-test and post-test of student cognitive and psychomotor performance

Cognitive		Psychomotor	
<i>Pre-test</i>	<i>Post-test</i>	<i>Pre-test</i>	<i>Post-test</i>
68,56%	82,8%	60,47%	85,25%

An evaluation was performed to assess the attainment of the research objectives, and the learning tools declared eligible by the expert team were tested on students. The results of a student product eligibility questionnaire indicated that the average student believed the module aided in more active learning, with a Likert scale calculation result of 92.85%.

The pre-test and post-test results of student abilities showed an increase in cognitive abilities by 14.24% and psychomotor performance by 24.78%. Cognitive abilities were measured by students' understanding of projects and clinical problems, while psychomotor abilities were measured by students' proficiency in solving projects and clinical problems. The findings of the pre-test and post-test assessments showed that PjBL was effective in enhancing cognitive, psychomotor, and other learning outcomes such as critical thinking, science process skills, and creative thinking. Project learning facilitated students playing a more active role in the learning process, making it more meaningful.

CONCLUSION

In conclusion, the development and implementation of a clinical chemistry module based on CPL and PjBL principles have shown positive results. The results of expert validation indicated the feasibility of the module with a high average score of 89.05%. The results of student evaluations also showed high levels of satisfaction and effectiveness in increasing both cognitive and psychomotor abilities. The increase in students' cognitive abilities by 14.24% and psychomotor performance by 24.78% demonstrate that the module and PjBL-based approach are effective in enhancing learning outcomes and student engagement. This study supports the use of PjBL principles in the development of clinical chemistry modules and emphasizes the importance of considering student needs and active engagement in the learning.

RECOMMENDATIONS

Based on the results of this study, it can be recommended that the PjBL-based module developed for clinical chemistry courses be adopted for future classes. The module was found to be highly feasible based on expert validation results and was also seen to improve students' cognitive and psychomotor abilities through the pre- and post-test assessments. The implementation of PjBL in teaching clinical chemistry can lead to a more meaningful and active learning experience for students, as shown by the high satisfaction score from the product eligibility questionnaire. The existence of research on the use of this project-based module is expected to increase students' interest in learning both in cognitive and psychomotor terms. In the next research, it is better to pay more attention to the characteristics of students, so that all students are able to follow project-based learning well.

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