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Enhancing Students' Psychomotor Skills through Acid-Base Titration and Electrolyte Experiments at SMA Negeri 1 Sungai Raya

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ABSTRACT

Improving students' psychomotor aspects is a key objective in the learning process, especially in natural sciences such as chemistry. This study, conducted as part of a Community Service Program (PKM), aimed to evaluate the effectiveness of laboratory-based activities in enhancing the psychomotor skills of 30 students at SMA Negeri 1 Sungai Raya. The interventions focused on acid-base titration and testing of electrolyte and non-electrolyte solutions. A quantitative experimental approach was employed, utilizing pre- and post-practicum assessments to measure changes in students' performance. The results showed a significant improvement in psychomotor skills, with an increase of 62.38% after participating in the laboratory sessions. In addition, the effectiveness of the activities was assessed through a satisfaction questionnaire, which yielded an average score of 4.18, categorized as "satisfied." These findings suggest that structured laboratory experiences can significantly contribute to the development of students' practical competencies. It is recommended that educators continue to design and implement interactive, hands-on teaching strategies to foster greater student engagement in science learning.

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INTRODUCTION

Chemistry is a discipline based on both theory and experimentation. If chemistry learning is conducted exclusively through a theoretical approach without practical activities, students' conceptual understanding risks becoming shallow and lacking context. Moreover, a learning method that prioritizes theory alone without practical sessions may feel monotonous, less engaging, and could lead students to perceive chemistry as a difficult subject. The abstract nature of chemical concepts further complicates student comprehension, especially when not accompanied by concrete learning experiences (Junaidi et al., 2017). These challenges contribute to a decline in students' interest and motivation in studying chemistry, which ultimately affects their academic achievement. In addition, teacher-centered approaches such as lectures remain widely used in classrooms. This method tends to render students passive, as the teacher becomes the primary source of information while students are merely listeners. This passivity reduces opportunities for students to engage actively with the material (Hattie & Donoghue, 2016). Thus, there is a pressing need to shift toward more student-centered learning approaches, particularly those that involve direct experience, such as laboratory work.

The enhancement of students' psychomotor skills is one of the key objectives in the learning process, particularly in scientific fields such as chemistry. Chemistry laboratory activities at the senior high school level serve not only as a means to reinforce theoretical concepts but also provide students with opportunities to develop essential practical skills in science. Laboratory work can increase student engagement and strengthen their understanding of the subject matter (Hofstein, 2017).

Integrating chemistry laboratory work into chemistry instruction has been proven to enhance students' abilities in operating laboratory equipment, conducting experiments accurately, and analyzing results effectively. Moreover, research indicates that a chemistry practicum-based learning environment can increase student engagement and motivation, thereby enriching their overall educational experience (Campbell et al., 2022). However, there is limited empirical evidence on how such activities specifically contribute to the development of students' psychomotor skills, particularly in the context of Indonesian senior high schools. This gap underlines the need for context-based initiatives, such as community service programs, to explore this potential.

Despite its known benefits, the implementation of chemistry laboratory activities faces numerous challenges. In addition to the teacher's skills and motivation in managing practical sessions, the availability of adequate facilities and supporting infrastructure is a critical factor that determines the smooth execution of laboratory activities. Another challenge lies in the limited budget, particularly for the procurement of chemical reagents and other consumable equipment. Furthermore, the level of risk or safety considerations during laboratory activities also plays a significant role in determining the feasibility of conducting practical sessions (Munandar & Junita, 2022).

Another revealed fact indicates that the continuity of laboratory activities is highly dependent on the teacher's competence in conducting them. In addition, limited time allocation poses a significant constraint, as there is concern that incorporating additional laboratory sessions may hinder the completion of the required curriculum within the predetermined school schedule (Chala, 2019). In addition to the factors previously mentioned, another noteworthy fact reveals that even when materials and resources for laboratory activities are available, the primary obstacle often lies in the teacher's limited capacity to effectively conduct such activities (Allen, 2012). Given the importance of laboratory work in chemistry education and the various challenges encountered, particularly at the senior highschool level, it is essential to conduct a situational assessment to evaluate the feasibility of

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implementing laboratory activities. In addition, careful consideration must be given to alternative solutions that can address the obstacles faced in the execution of these activities.

In response to these challenges and the identified research gap, this community service program (PKM) was implemented to assess and enhance students' psychomotor skills through structured chemistry practicum activities. The program was carried out at SMAN 1 Sungai Raya, a public senior high school located in Sungai Raya District, Kubu Raya Regency, West Kalimantan. The school was established on January 1, 1970, under a Decree of Establishment issued by the Ministry of Education and Culture. This activity aimed to equip students with knowledge and skills related to chemistry laboratory practices in schools. To achieve this objective, the methods employed included training sessions, the administration of pre-tests and post-tests, as well as the distribution of questionnaires to students of SMAN 1 Sungai Raya, Kubu Raya Regency. Through this program, not only was student performance assessed, but situational data were also collected regarding the condition of laboratory infrastructure, including the availability of equipment, chemical reagents, and the overall feasibility of implementing regular laboratory activities at the school.

METHOD

The implementation of this community service program (PKM) comprised several stages, namely preparation (problem orientation), implementation (action), and evaluation.

Planning

The activity began with the determination of the time and location, agreed upon by the implementing team and the partner institution. In this case, the PKM implementation team collaborated with SMAN 1 Sungai Raya to coordinate the program's execution.

Implementation

Once the time and location were established, the PKM team conducted a site visit. The activity commenced with an opening session, including greetings, introductions, and a presentation by the team on various chemistry laboratory instruments. This was followed by hands-on guidance for students during chemistry practicum sessions. The practical sessions focused on the use of laboratory equipment, particularly titration techniques for determining the concentration of a substance, and testing of electrolyte and non-electrolyte solutions.

Evaluation

The evaluation component of this study aimed to assess the effectiveness of the chemistry practicum in enhancing students' psychomotor skills. Evaluation methods included a pretest, measurement of student satisfaction with the laboratory experience, a posttest, and an analysis of the correlation between satisfaction and the improvement of psychomotor abilities.

The evaluation was carried out using a satisfaction questionnaire based on four main aspects:

- Laboratory Facilities (availability of tools, suitability of laboratory space, and adequacy of equipment);
- Practicum Implementation (clarity of instructions, student engagement, and quality of instructor

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guidance);

- Psychomotor Development (students' ability to use tools, follow procedures, and demonstrate independence in experiments);
- Overall Satisfaction (students' overall satisfaction with the practicum experience).

Respondents rated each aspect using a 5-point Likert scale, where 1 indicated "Very Dissatisfied" and 5 indicated "Very Satisfied." The questionnaire was distributed to students after the practicum sessions. The collected data were then analyzed using descriptive statistics and a reliability test to assess the validity of the instrument. Data analysis was performed using statistical software (SPSS), involving two main steps:

- Descriptive Statistical Analysis (calculating the mean, standard deviation, and distribution of scores for each satisfaction aspect);
- Cronbach's Alpha Reliability Test (assessing the internal consistency of the questionnaire as an evaluation instrument).

The satisfaction categories are presented as shown in Table 1.

TABLE 1. Categories of Participant Satisfaction in the Community Service Program (PKM)

Average Score Range (X)	Satisfaction Category
1,00 - 1,80	Very Dissatisfied
1,81 - 2,60	Dissatisfied
2,61 - 3,40	Moderately Satisfied
3,41 - 4,20	Satisfied
4,21 - 5,00	Very Satisfied

Source: (Santika et al., 2023)

This study utilized a quantitative approach with a pre-experimental one-group pretest-posttest design. The purpose of this design was to measure the effectiveness of chemistry practicum activities in improving students' psychomotor skills before and after the intervention. The research was conducted as part of a community service program (PKM) at SMA Negeri 1 Sungai Raya, involving 30 students from the 11th grade science program.

To measure students' psychomotor skills, the study employed a performance-based observation rubric. This rubric consisted of several indicators, including (1) proper use of laboratory tools and materials, (2) adherence to experimental procedures, (3) application of safety protocols, and (4) accuracy in recording and interpreting experimental results. Observations were conducted during both the pretest and posttest sessions by trained observers using the same rubric to ensure consistency and objectivity. In addition to those four indicators, the rubric also included (5) preparation and organization of work area, which assessed students' ability to prepare tools and materials systematically and maintain a clean, orderly workspace, and (6) analytical thinking and conclusion-making, which evaluated students' ability to analyze experimental outcomes and formulate conclusions based on the observed data. These six indicators provided a comprehensive assessment of students' practical performance and psychomotor development during the chemistry practicum activities.

The data obtained were analyzed using descriptive statistics (mean scores and percentage improvement) to illustrate overall changes in students' performance. In addition, a paired sample t-test

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was performed to determine whether the difference between the pretest and posttest scores was statistically significant.

RESULTS AND DISCUSSION

This Community Service Program (PKM) was carried out in collaboration with SMAN 1 Sungai Raya and targeted 30 twelfth-grade science students. To ensure equal representation, each of the five twelfth-grade science classes was represented by six students. The activity began with an orientation session aimed at identifying appropriate solutions to address the partner school's challenges, determining the implementation timeline, and outlining the PKM activity plan. This orientation process involved the lead researcher and PKM team members, along with the school principal, vice principal for curriculum affairs, and the chemistry teacher at SMAN 1 Sungai Raya. During the session, the PKM coordinator presented the proposed activity plan and formally requested permission from the school, which was later formalized through the signing of the PKM orientation letter. Documentation of the PKM orientation at SMAN 1 Sungai Raya is presented in Figure 1.

FIGURE 1. Orientation of the PKM Activity at SMAN 1 Sungai Raya

Figure 1 illustrates the orientation process that took place at SMAN 1 Sungai Raya. In this figure, the PKM team and school representatives are shown actively engaging in discussions about the goals and structure of the planned activities. The photo captures the formal handover and explanation of the PKM proposal, which demonstrates the mutual commitment between the university and the school to support student skill development, particularly in chemistry practicum. This documentation highlights the importance of coordination and collaboration in ensuring the successful implementation of community-based educational programs.

As a result of the PKM orientation, it was agreed that the implementation would begin on July 16, 2024, through activities aimed at enhancing students' psychomotor skills in chemistry, particularly in acid–base titration and the testing of electrolyte and non-electrolyte solutions. During regular classroom learning, laboratory activities were rarely conducted by the teacher due to limited laboratory facilities and infrastructure, especially regarding the availability of equipment and reagents. Additionally, the acid–base topic was selected because it is considered difficult to grasp without hands-on experience. According to the teacher, many students have misconceptions about acid–base concepts. In this PKM activity, students participated in acid–base testing through titration. Through this activity, they were

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introduced to the use of laboratory equipment, such as the burette, for volume measurements.

FIGURE 2. Opening Remarks Delivered by the Head of the Chemistry Department, FMIPA, Universitas Tanjungpura

The PKM implementation began with participant registration by signing an attendance sheet. A total of 30 twelfth-grade science students were present. Before the practicum activities began, the participants received a welcome speech and opening remarks from the Head of the Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Tanjungpura (Figure 2). Figure 2 captures the moment when the Head of the Chemistry Department delivered the opening speech. The image depicts a formal yet enthusiastic atmosphere, highlighting the significance of practical skills in chemistry education. In his remarks, the department head emphasized the importance of the PKM program as a bridge between higher education institutions and schools in equipping students with hands-on laboratory experience. This moment also marked the official launch of the PKM activity, symbolizing institutional support for improving the quality of chemistry learning at the high school level.

To assess students' initial knowledge and understanding of the practicum topic, participants were given a pre-test consisting of multiple-choice questions. The average pre-test score of the 30 students was 54.5. Following the pre-test, the PKM participants listened to a theoretical explanation delivered by the PKM coordinator regarding the concept of acids and bases (Figure 3). During the session, many students showed interest and enthusiasm, actively asking and answering questions. Based on interviews conducted during the activity, most students had never been directly taught by a university lecturer before. For them, being taught directly by a lecturer was seen as a valuable opportunity to expand their knowledge, particularly in the field of chemistry.

FIGURE 3. Presentation of Material by the PKM Coordinator

Figure 3 visually documents the moment when the PKM coordinator presented core material on acid-base concepts. The setting demonstrates a classroom environment in which students are actively listening and interacting with the lecturer. The presence of multimedia and structured explanation helped students grasp theoretical concepts before conducting the laboratory experiment. This moment reflects an essential pedagogical strategy—providing strong conceptual grounding prior to hands-on practice—to ensure students perform laboratory tasks more confidently and accurately

The core activity of this PKM program was the implementation of a laboratory practicum aimed at

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enhancing students' psychomotor skills. In the laboratory, students were divided into several groups. The competencies students were expected to master in the titration practicum included a range of skills: properly washing glassware, rinsing the burette, mounting the burette using a clamp, pouring the standard solution into the burette, accurately using a volumetric pipette, operating the burette during the titration process, observing the titration endpoint, and calculating the concentration of a substance (Budi & Masriani, 2024). During the practicum, students were taught all of the aforementioned competencies. Inside the laboratory, they showed great enthusiasm for learning and improving their psychomotor skills, as they had never previously engaged in such activities. In addition to the acid–base titration, another practicum conducted as part of this PKM activity involved testing electrolyte and non-electrolyte solutions, where students were required to test and conclude the properties of the solutions based on the brightness of the light bulb and the formation of gas bubbles. Documentation of the laboratory practicum activities is presented in Figure 4.

Interviews were conducted with several students after the practicum was completed. The results indicated that they were highly satisfied and clearly understood the procedures performed during the session. They stated that they had previously struggled to grasp the acid–base concept, as it had only been taught theoretically in class. To confirm that the activity had a measurable impact on student satisfaction, a questionnaire consisting of six statements was distributed. Prior to determining the satisfaction level, the questionnaire was subjected to validity and reliability testing. The analysis was carried out using SPSS software, where Pearson correlation was used to assess validity, and Cronbach's Alpha was employed to evaluate the reliability of the instrument.

Figure 4 showcases students actively participating in the laboratory practicum, engaging in both the acid–base titration and the electrolyte–non-electrolyte solution experiments. The image illustrates students working collaboratively in small groups, handling laboratory equipment with concentration and care. Their involvement in tasks such as rinsing burettes, measuring solutions, and identifying the titration endpoint reflects the hands-on learning process aimed at developing psychomotor competencies. The documentation also captures the moment students observed gas formation and light bulb brightness during the electrolyte tests—key indicators in evaluating solution conductivity. This visual evidence reinforces the impact of laboratory-based activities in fostering students' practical skills, confidence, and engagement with real-world chemical applications.

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FIGURE 4. Laboratory activities conducted by students

TABLE 2. Pearson Correlation Data for the Questionnaire Statements

Statement	Correlation Coefficient (r)	r Table	Validity
1	0,664	0,4670	Valid
2	0,831	0,4670	Valid
3	0,757	0,4670	Valid
4	0,774	0,4670	Valid
5	0,789	0,4670	Valid
6	0,792	0,4670	Valid

Using the formula (df = n – 2), the degrees of freedom (df) is calculated as 30 – 2 = 28. At a 1% significance level, the r table value is 0.4670. Based on the output from the Correlations table (Table 2), the calculated r values exceed the r table value (r calculated > r table), indicating that all statements are valid (Yafi, 2022). All calculated r values range from 0.664 to 0.831, which are greater than the critical value, indicating that all six statements are valid. This means the questionnaire items are strongly correlated with the total score and can reliably measure student perceptions of the practicum activity.

Instrument reliability testing was conducted using Cronbach's Alpha to obtain the average Cronbach's Alpha value, which is used to determine whether the instrument is reliable. The reliability test data were processed using SPSS version 26. The results of the reliability test are presented in Table 3. The Cronbach's Alpha value obtained is 0.816 for six items, which exceeds the commonly accepted threshold of 0.70, indicating high internal consistency. This confirms that the instrument used to assess student satisfaction is reliable and consistent in measuring what it is intended to measure.

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TABLE 3. Reliability Test Data Using Cronbach's Alpha

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded	0	.0
	Total	30	100

Reliability Statistics

Cronbach's Alpha	N of Items
.816	6

Through this activity, students gained an understanding of how to quantitatively determine the concentration of an acid or base. After the practicum session was completed, the students were gathered back in the classroom for a post-test. The purpose of the post-test was to reassess students' understanding after the intervention and to compare the results with the pre-test administered at the beginning of the activity (Shivaraju et al., 2017). The average post-test score of the 30 students was 88.5. When compared with the pre-test results, there was a 62.38% increase in learning outcomes. To determine whether the improvement was statistically significant, a paired sample t-test was conducted using SPSS version 26. The analysis showed that the difference between the pre-test and post-test scores was statistically significant, with a p-value less than 0.05. This result confirms that the practicum-based intervention had a significant effect on enhancing students' understanding of the matter. The results of the descriptive statistical analysis on the average level of student satisfaction with the PKM activity showed a score of 4.18. This score indicates that the PKM activity that was carried out had a satisfaction level categorized as "satisfied."(Table 1) (Santika et al., 2023).

The significant improvement in students' psychomotor skills, as evidenced by both the performance rubric and the learning outcomes (pre-test to post-test), highlights the effectiveness of structured practicum-based interventions in chemistry education. This finding aligns with previous studies that emphasize the essential role of hands-on laboratory activities in developing psychomotor domains. According to (Hofstein, 2017), laboratory experiences are not only critical for reinforcing theoretical understanding but also vital in fostering students' scientific skills, including precision, procedural competence, and safe laboratory behavior. Similarly, (Campbell et al., 2022) demonstrated that a spiral-based, skills-oriented chemistry practicum can significantly enhance students' laboratory confidence and competence, particularly when students are repeatedly exposed to core experimental techniques.

Moreover, this study's success supports the findings of (Munandar & Junita, 2022), who found that psychomotor evaluation through practical sessions—especially when combined with formative feedback—results in measurable improvement in students' procedural and manual skills. The increase in students' post-test scores and their ability to correctly handle titration procedures, measure solutions accurately, and analyze conductivity in electrolytes are consistent with these findings. Furthermore, the study resonates with (Junaidi et al., 2017) who highlighted that in many Indonesian schools, practical work is underutilized due to infrastructural and pedagogical constraints. By addressing these gaps through targeted programs like PKM, this study contributes to filling a notable void in chemistry learning by offering meaningful laboratory experience in under-resourced schools.

The strong student satisfaction (mean score = 4.18) further reinforces the claim that engaging students in meaningful, guided laboratory activities can improve not only their technical skills but also their motivation and interest in science. This supports (Hattie & Donoghue, 2016) model of learning, which states that active, experience-based strategies result in deeper learning and greater student agency. Taken together, these findings provide robust evidence that well-designed laboratory interventions—such as those implemented in this PKM—can serve as an effective means to improve

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psychomotor learning outcomes, especially when students have limited prior exposure to experimental chemistry.

FIGURE 5. Group Photo of the PKM Team and PKM Participants

As a form of togetherness between the PKM Team and the participants, a group photo session was also held (Figure 5). Through this PKM activity, it is expected that students' understanding and skills in conducting experiments will improve. Strengthening the psychomotor aspect is also necessary to support the development of the cognitive aspect. Figure 5 shows a group photo session between the PKM team and the student participants, taken at the end of the activity. This moment symbolizes the spirit of collaboration and shared commitment to enhancing educational experiences through hands-on learning. The photo not only serves as documentation of the event but also reflects the positive response and enthusiasm of the students throughout the activity. It illustrates the sense of achievement felt by both students and facilitators after completing the practicum, highlighting the importance of partnership between higher education institutions and schools in improving students' scientific competencies.

CONCLUSION

Based on the results of the PKM (Community Service Program) activities, it can be concluded that:

- The PKM activity positively contributed to the development of students' psychomotor skills in understanding chemical concepts through laboratory-based learning. The results indicate that chemistry practicum can be recommended as an effective pedagogical approach to foster hands-on competencies in science education.
- The instruments used to measure student satisfaction demonstrated good levels of validity and reliability, confirming their appropriateness for evaluating students' responses to practicum-based learning.
- The overall level of student satisfaction was categorized as "satisfied," reflecting a positive response to the practicum activities and their perceived benefits.

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- Beyond improving students' practical abilities, this PKM activity also reinforced the value of skill-oriented laboratory work as a strategy to enhance the quality of chemistry learning, especially in schools with limited access to laboratory experiences.
- Future programs could consider expanding similar practicum models to other schools, particularly in underserved areas, and conducting longitudinal studies to assess the long-term impact of practicum-based instruction on student learning outcomes and engagement.

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