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Assessing the Effectiveness of a Research-Driven Biochemistry Laboratory Manual in Enhancing Student Cognitive Learning Outcomes and Business Awareness

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Abstract: This study examines student responses upon the implementation of Biochemistry Laboratory Manual which focused on science-economics. The manual was implemented on Biochemistry poracticum classes for 3 consecutive schedules. Students' cognitive, affective, and psychomotor learning outcomes were recorded that implies their responses to the topic. Validated questions and questionnaires were used and were administered before the first and after the third round of practicum classes. Data analysis employed Student T-tests. It was revealed that the implementation of the Laboratory Manual moderately enhances biochemistry learning achievements (N-Gain) and the students responded positive and very positive toward the topic at 80% and 18% respectively.

Keywords: Economic Prospects; Implementation; Laboratory Manual; Lipase; Practicum

Introduction

Practicums have been proven to have a positive effect on teaching and learning achievements, including physical skills, thinking skills, science process skills, and understanding of concepts, where classes with practicums are superior in understanding concepts compared to control classes (Shana & Abulibdeh, 2020). Scientific process abilities, intellectual skills and social abilities also develop with practicum (Yulianingsih, 2017). Lee & Sulaiman (2018) reported that practicum classes showed better interest in learning physics compared to non-practicum classes. The implementation of guided inquiry-based practicum instructions increased scientific work skills with a high N gain category (Widyaningrum & Wijayanti, 2019). From those reasons, therefore, practicum has important role in enhancing learning achievement, particularly for subjects that are perceived abstract and difficult bay students, such as Biochemistry subject.

One of the outcomes of PNBP 2020 research at FKIP Unram is the teaching materials in this case practical instructions (Laboratory manual). The manual topic was about lipase enzymes that was chosen among others due to lipase has economic prospect as the demand is increasing annually either globally or locally. This increase is because lipase can be applied in various industries, so its market share is very broad and very large. The increasing demand for enzymes occurs in line with the level of public awareness toward environmental issue, switching the use of unfriendly industrial processes such as the use of high temperatures, high pressure and dangerous chemicals into enzymatic industrial processes that is environmentally friendly (Hamid et al., 2022; Mesbah, 2022).

These prospects and opportunities need to be disseminated to the younger generation, especially students who will face an increasingly competitive situation. This practicum with an economic prospect that

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may give an insight about opportunities supports the Independent Campus Program (Program Kampus Merdeka), one of which is entrepreneurship. The General Directorate of Higher Education (Ditjen Dikti) of the Ministry of Education and Culture shared knowledge and ideas as an effort to restore our economy and future particularly for young people due to the crisis caused by the Covid-19 pandemic so that they can rebuild the economy in Indonesia and create changes. Practicum using the laboratory manual may disseminated the insight to the younger generation, especially for those who are interested to do business in the field.

Lee & Sulaiman (2018) reported that the control class had lower interest, understanding, and enthusiasm for the subject than the treatment class, therefore through practicum interest, enthusiasm and understanding can be built. If we expect students are interested on entrepreneurship, therefore practicum class must provide topics that economically prospective and provide the related skills. By implementing the Laboratory Manual Outcome from PNBP 2020 research, students are given a direct experience the processes leading to enzyme production, so it is hoped that skills will be obtained that can foster their confidence to try in the future (Gallou et al., 2023). The question is however, how effective is the implementation of such laboratory manual for such purpose?

This research was conducted to reveal student's responses toward science-economic topic instructed within the Laboratory Manual and if the implementation contributes to learning outcomes in Biochemistry subject particularly on lipid degradation. The responses in this experiment refers to learning outcomes in terms of cognitive, affective and science processes that implied their interest to the topic.

Method

This study utilized a quasi-experimental design involving students who attended the Biochemistry lecture at the Biology Education Faculty of Teacher Training and Education (FKIP) at Mataram University in the year 2022. The study included a total of 6 classes as subjects consisted of 130 students.

The assessment tools included questions designed to evaluate students' cognitive achievements and a questionnaire to assess their affective and process science skills; where cognitive and affective aspect may reflex the enthusiasm toward such topic. Both tools were validated using validation program available on excel accordingly.

The cognitive achievement assessment comprised 20 questions to gauge their understanding of lipid degradation. Following validation using an Excel-based validation program, one question was found to be invalid and subsequently removed. Data was collected through pretests and posttests. To determine if there were any significant differences between the posttest and pretest results, the data was analyzed using the Student's T-test, which is also available in Excel. Cognitive achievement was measured using N-Gain, calculated using the following Formula 1.

$$N - gain = \frac{\text{Post test score} - \text{Pretest score}}{Score\ Maximum - Pretest\ score} \quad (1)$$

The questionnaire instrument utilized a Likert scale (5-point scale) to assess students' enthusiasm and interest in the practical class topic, as well as their scientific processes. It contained 33 items, three of which were deemed invalid based the validation program and removed. Data collection took place at the final round of the practical class, which consisted of three rounds.

Result and Discussion

The research conducted on the Cognitive Student's Achievement upon Implementation of Laboratory Manual Outcome of PNBP 2020 yielded significant findings

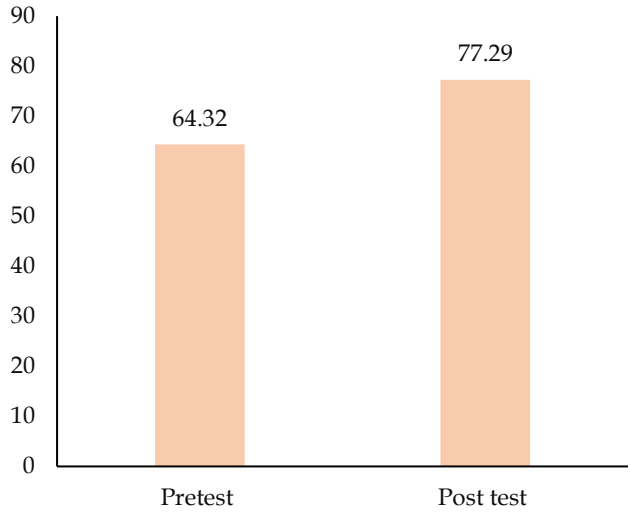

Figure 1. Pretest and Posttest of entire population (6 classes)

The cognitive achievement after 3 rounds of practicum was calculated from the value of pre-test and that is presented in Figure 1 and Table 1. The pretest scores are relatively high, ranging from 55.45 to 79.9 across the six classes with the average of 64.33. After the implementation of the laboratory manual, there was a noticeable improvement in student performance. Post-test scores ranged from 71.25 to 77.9 across the six classes, with an overall average of 77.29. This suggests a

substantial increase in cognitive achievement following the implementation of the Laboratory Manual.

Tabel 1. Pretest and Post Test Score of every class

Class	Pretest			Post tset		
	Min	Max	$\bar{X}$	Min	Max	$\bar{X}$
A	50.0	85.0	67.2	70.0	95.0	79.4
B	55.0	90.0	70.8	60.0	95.0	82.9
C	40.0	85.0	68.7	70.0	85.0	79.7
D	25.0	80.0	57.0	45.0	85.0	71.3
E	40.0	75.0	55.5	45.0	95.0	71.5
F	50.0	80.0	66.7	70.0	95.0	79.0
$\bar{X}$	43.3	82.5	64.3	60.0	91.7	77.3

The pretest and post-test data underwent statistical analysis using the Pair Student T Test. The results revealed a highly significant difference between the pretest and post-test scores, with a p-value of 0.00011 (a = 0.05). This indicates that the improvement in scores was not due to chance but rather a result of the intervention.

The increase in cognitive achievement is quantified as N-Gain score. The proximity of pretest and posttest scores undoubtedly influences the N-Gain achieved. Table 2 presents the N-Gain scores for each class. The N-Gain scores range from 0.31 to 0.46, with overall average of 0.37 for the entire population. According to Hake (1999) categorization, this score places the N-Gain in the moderately high range.

However, based on Meltzer & David (2002) classification, it falls into the ineffective category. Table 3 and Table 4 present the distribution of N-Gain scores for each class according to both categorizations. This seemingly low N-Gain scores can be attributed to the moderately high pretest scores. Since practical classes typically follow theoretical class, students already possess some knowledge about lipase from lecture discussions. This familiarity with the topic likely contributed to the lower N-Gain achievement.

Tabel 2. Student's N-Gain of each class

Test	Class score						$\bar{x}$
	A	B	C	D	E	F	(%)
Pretest	67.3	70.8	68.7	55.3	66.7	64.3	66.8
Posttest	79.6	82.9	79.6	71.3	70.8	77.2	76.9
N-Gain	0.37	0.46	0.38	0.31	0.4	0.37	0.37 ± 0.06

In the case of the Biochemistry class, the N-Gain score is understandable given the inherent challenges of the subject. Biochemistry involves complex concepts, such as molecular structures, metabolic pathways, and enzyme functions and their mechanism, which students often find difficult to comprehend. Previous research (Bukhari & Nasruddin, 2019; Juwita et al., 2023; Lang & Bodner, 2020; Salame et al., 2022) has highlighted the struggles students face in grasping abstract biochemical principles. Additionally Elhousni et al. (2022); Hasanah & Ansyah (2022) suggested that memorization and assimilation of biochemistry concepts require highly structured thinking (Dewi, 2021; Mowbray et al., 2021). Therefore, the N-Gain score resulting from this experiment is reasonable, especially considering the practical nature of the classes following lecture sessions.

Tabel 3. The Distribution N-gain of each category based on Hake (1999) Category

Category	Class						$\bar{x}$
Class	A	B	C	D	E	F	(%)
Ineffective	51	35	69	58	9	56	46
Less effective	38	42	26	42	59	25	39
Faily Effective	11	21	5	0	32	19	15
Effective	0	0	0	0	0	0	0

Based on these findings, it can be interpreted that the implementation of the Laboratory Manual Outcome of PNBP research 2020 led to a significant enhancement in cognitive student achievement. This conclusion is further supported by a previous report by Shana & Abulibdeh (2020), which found differences in achievement between classes with and without practical components, and Sikumbang et al. (2020) suggest that practicum facilitated student's concept understanding.

Tabel 4. The distribution N-Gain (%) of each category (Meltzer & David, 2002)

Category	Class						$\overline{X}$(%)
Class	A	B	C	D	E	F	
Low	51	35	58	69	9	56	46
Moderate	38	42	42	26	59	25	39
High	11	21	0	5	32	19	15

Overall, the study provides strong evidence supporting the effectiveness of incorporating the laboratory manual outcome into the practical class for improving student cognitive achievement. This has implications for educational practice and underscores the importance of practical, hands-on learning experiences in enhancing student learning outcomes.

Affective Responses of Students to the Implementation of the Laboratory Manual Outcome of PNBP 2020 Research

Numerous factors influence learning achievements, such as personal integrity, family background, preferences towards the topic and or to the teacher, as well as future orientation. The Laboratory Manual Outcome of PNBP 2020 research focuses on practical topics with economic prospects, providing insights for

student's post-graduation. Specifically, the practical class focused on lipid degradation, particularly lipase, involving activities such as screening lipid-producing microbes, detecting lipase activity, and selecting microbes based on specific characteristics like their optimum growth and enzyme activity on pH and temperature (Jahn et al., 2020).

The affective condition of students following the practical class was assessed, encompassing their enthusiasm and curiosity towards the topic, as well as their discipline, honesty, and responsibility. The results of this assessment are presented in Table 5.

The Table illustrates that students responded positively in terms of their affective aspects, with overall (6 classes) at average score of 78 indicating a good overall affective response. Their enthusiasm and curiosity also scored well, with an average of 74. These results suggest that students responded positively to the implementation of the Laboratory Manual. The cultivation of student enthusiasm, honesty, responsibility, and discipline is crucial for educational achievements. While it is challenging to attribute these aspects solely to the implementation of the Laboratory Manual, the enthusiasm and curiosity towards the topic might be attributed to it.

Tabel 5. Affective student response upon the implementation of Laboratory Manual Outcome of PNBP 2020 of the whole population.

Aspect	$\bar{x}$ (6 classes)	Category
Antusiasm	74	Good
Quriousity	74	Good
Honousty	85	Very good
Discipline	74	Good
Responsibility	83	Very good
$\bar{x}$	78	Good

While affective aspects develop over human lifetime and influenced by various factors, nevertheless, Table 5 indicates that students exhibited positive affective characteristics, including honesty, discipline, and responsibility. They displayed enthusiasm and curiosity towards the economically prospective topic of lipase.

Student's Scientific Process Assessment following the Implementation of the Laboratory Manual Outcome of PNBP 2020 Research

The data collected from questionnaires regarding students' scientific processes are presented in Table 6. This assessment encompasses their proficiency in observation, equipment usage, data interpretation, and articulation. Table 6 demonstrates that students scored well in scientific processes, with an average score of 79.75 falling within the "good" category.

Tabel 6. Student's Process Science Skill of each class after The Implementation of PNBP 2020 Research

Aspects Observed	Score	Category
Observation	97	Very good
Operating Equipment	71	Good
Interpretation	73	Good
Articulation/communicate	78	Good
$\bar{X}$ score	79.75	Good

This finding is consistent with a study by Aulia et al. (2023), which also observed that classes with practical components achieved higher scores in terms of process science performance compared to classes without practical components. This finding also in line with report by Walil et al. (2021) that practical-based inquiry learning enhanced not only on cognitive but also on process science skill, though that research applied practicum-based inquiry learning. While Rini & Aldila (2023) report that lack of training of students in direct experience makes students' science process skills less developed which affects their critical thinking skills.

Combining all the findings from the student responses, it is evident that the implementation of the Laboratory Manual in practical classes enhances cognitive achievement. The assessment of affective and scientific processes post-implementation indicates that students exhibit enthusiasm and curiosity towards economically prospective topics (Reyes et al., 2024). Additionally, they demonstrate good affective attitudes and proficient scientific processes (Chan & Lay, 2021; Fortus et al., 2022). Diagram 2 illustrates that 81.6% of students provided good responses, while 18.6% gave very good responses. Only 1.4% responded fairly to the implementation of the Laboratory Manual Outcome of PNBP 2020 research. This suggests that the Laboratory Manual is suitable for application in practical classes, as it not only supports cognitive achievement but may also enhances affective and scientific process skill performance. Moreover, it provides new insights into the link between science and economic prospects.

Conclusion

From the results and discussion, it can be concluded that the implementation of the Laboratory Manual Outcome of PNBP 2020 supports the achievement of learning outcomes in the Biochemistry course. In terms of cognitive aspects, the average N-Gain of 0.37 falls within the moderate category. The aspect of process skills yielded an average score of 80, indicating a good category, while the affective aspect garnered an average score of 78, also classified as good. Furthermore, 80.6% and 18.60% of students respectively responded positively and very positively to the implementation of the laboratory manual instructions.

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Author Contribution
Conceptualization, Sedijani; methodology, Kusmiyati; data collection and analysis, Nathania and Sedijani; writing—original draft preparation, Sedijani dan Rasmi; writing—review and editing, Sedijani and Rasmi; visualization, Rasmi; project administration, Sedijani and Kusmiyati; rasmi

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Conflicts of Interest
The authors declare no conflict of interest.

References

Aulia, H., Ramdani, A., & Sedijani, P. (2023). Pengaruh Pembelajaran Sistem Pernapasan Pada Manusia Berbasis Praktikum Terhadap Keterampilan Proses Sains Peserta Didik. *Journal of Classroom Action Research*, *5*(3), 55–60. https://doi.org/10.29303/jcar.v5i3.4925

Bukhari, M., & Nasruddin. (2019). Proses pengajaran biokimia di SMA berbasis bahan ajar yang terdapat dalam kehidupan sehari-hari. *Jurnal Dedikasi Pendidikan*, *8848*(2), 87–90. https://doi.org/10.30601/dedikasi.v3i2.268

Chan, S. H., & Lay, Y. F. (2021). Effects of Attitude, Self-Efficacy Beliefs, and Motivation on Behavioural Intention in Teaching Science. *Eurasian Journal of Educational Research*, *93*, 219–262. Retrieved from https://eric.ed.gov/?id=EJ1299618

Dewi, R. K. (2021). Innovation of biochemistry learning in welcoming the super smart society 5.0 era. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *2*(2), 197–208. https://doi.org/10.21154/insecta.v2i2.3507

Elhousni, Z., Laamech, J., Zerhane, R., & Janati-Idrissi, R. (2022). Difficulties in learning biochemistry: Case of 1st year medical students. *Tangier Journal for Educators, Teachers and Trainers*, *14*(1). Retrieved from https://jett.labosfor.com/

Fortus, D., Lin, J., Neumann, K., & Sadler, T. D. (2022). The role of affect in science literacy for all. *International Journal of Science Education*, *44*(4), 535–555. https://doi.org/10.1080/09500693.2022.2036384

Gallou, F., Gröger, H., & Lipshutz, B. H. (2023). Status check: biocatalysis; it's use with and without chemocatalysis. How does the fine chemicals industry view this area? *Green Chemistry*, *25*(16), 6092–6107. Retrieved from https://pubs.rsc.org/en/content/articlelanding/2023/gc/d3gc01931d/unauth

Hake, R. (1999). *Analyzing Change/Gain Scores.AREA-D American Education Research Association's Devision.D, Measurement and Reasearch Methodology*. Retrieved from https://web.physics.indiana.edu/sdi/AnalyzingChange-Gain.pdf

Hamid, B., Bashir, Z., Yatoo, A. M., Mohiddin, F., Majeed, N., Bansal, M., Poczai, P., Almalki, W. H., Sayyed, R. Z., Shati, A. A., & others. (2022). Cold-active enzymes and their potential industrial applications—a review. *Molecules*, *27*(18), 5885. https://doi.org/10.3390/molecules27185885

Hasanah, Q., & Ansyah, E. (2022). Learning Difficulties and Learning Expected by Students in the Biochemistry Course at Department of Science Education UIN Fatmawati Sukarno Bengkulu. *Tadbir*, *16*(1), 1–11. https://doi.org/10.29240/jsmp.v6i1.4541

Jahn, M., Zerr, A., Fedorowicz, F. M., Brigger, F., Koulov, A., & Mahler, H.-C. (2020). Measuring lipolytic activity to support process improvements to manage lipase-mediated polysorbate degradation. *Pharmaceutical Research*, *37*, 1–13. https://doi.org/10.1007/s11095-020-02812-0

Juwita, R., Kadarohman, A., Abdullah, N., & Munawaroh, H. S. H. (2023). Challenge in Biochemistry Courses: A Snapshot of Student Learning Difficulties. *JTK (Jurnal Tadris Kimiya)*, *8*(2), 123–132. https://doi.org/10.15575/jtk.v8i2.26611

Lang, F. K., & Bodner, G. M. (2020). A review of biochemistry education research. *Journal of Chemical Education*, *97*(8), 2091–2103. https://doi.org/10.1021/acs.jchemed.9b01175

Lee, M. C., & Sulaiman, F. (2018). The effectiveness of practical work on students' motivation and understanding towards learning Physics. *International Journal of Humanities and Social Science Invention*, *7*(8), 2319–7714. Retrieved from https://shorturl.asia/yJVCb

Meltzer, & David, E. (2002). The Reactionship Between Mathematics Preparation and Conceptual Learning Gains in Physics: A possible Hidden Variable in Diagnostic Pretest Scores. *American Journal of Physics*, *70*(12), 1259–1268. https://doi.org/10.1119/1.1514215

Mesbah, N. M. (2022). Industrial biotechnology based on enzymes from extreme environments. *Frontiers in*

Bioengineering and Biotechnology, *10*, 870083. https://doi.org/10.3389/fbioe.2022.870083

Mowbray, M., Savage, T., Wu, C., Song, Z., Cho, B. A., Del Rio-Chanona, E. A., & Zhang, D. (2021). Machine learning for biochemical engineering: A review. *Biochemical Engineering Journal*, *172*, 108054. https://doi.org/10.1016/j.bej.2021.108054

Reyes, R. L., Isleta, K. P., Regala, J. D., & Bialba, D. M. R. (2024). Enhancing experiential science learning with virtual labs: A narrative account of merits, challenges, and implementation strategies. *Journal of Computer Assisted Learning*, *40*(6), 3167–3186. https://doi.org/10.1111/jcal.13061

Rini, E. F. S., & Aldila, F. T. (2023). Practicum Activity: Analysis of Science Pocess Skill and Student's Critical Thinking Skill. *Integrated Science Education Journal*, *4*(2), 54–61. https://doi.org/10.36681/tused.2023.023

Salame, I. I., Abid, M., & Simms, S. (2022). Examining some of the challenges that students face in learning about metabolic pathways in a traditional biochemistry course. *International Journal of Instruction*, *15*(4), 277–292. Retrieved from https://e-iji.net/ats/index.php/pub/article/view/262

Shana, Z., & Abulibdeh, E. S. (2020). Science practical work and its impact on high students' academic achievement. *JOTSE*, *10*(2), 199–215. https://doi.org/10.3926/jotse.888

Sikumbang, D., Lengkana, D., & R, F. (2020). The Effect of Practicum Method on Representationm Ability and Cognitive Learning Outcome. *Jurnal Pena Sain*, *7*(1), 25–32. https://doi.org/10.21107/jps.v7i1.6730

Walil, K., Suryawati, I., & Akmal, N. (2021). Practicum-Based Inquiry Learning to Improve Learning Outcome of Students at Senior High School Kamalliansyah. *Al-Ishlah: Jurnal Pendidikan*, *13*(2), 1504 1512. https://doi.org/10.35445/alishlah.v13i2.741

Widyaningrum, D. A., & Wijayanti, T. (2019). mplementasi buku petunjuk praktikum biokimia berbasis inkuiri terbimbing untuk meningkatkan kemampuan kerja ilmiah. *Edubiotik : Jurnal Pendidikan, Biologi Dan Terapan*, *4*(2), 58–67. https://doi.org/10.33503/ebio.v4i02.437

Yulianingsih, L. T. (2017). Kinerja Mengajar Guru sebagai Faktor Determinan Belajar Siswa. *Jurnal Pendidikan Manajemen Perkantoran*, *2*(2). https://doi.org/10.17509/jpm.v2i2.8105