Motivation, Laboratory Activities, and Self Regulated Learning: How Are They Related

Agus Abhi Purwoko[1,*], *Yu nita* Arian Sani Anwar[1], *Saprizal* Hadisaputra[1], and *Burhanuddin* Burhanuddin[1]

[1]Program Studi Pendidikan Kimia, Fakultas Keguruan dan Ilmu Pendidikan, Universitas Mataram, Indonesia

Abstract. This study aims to determine the effect of Self-Regulated Learning (SRL) and motivation on laboratory activities of Chemistry Education students. Three theoretical hypotheses are proposed, namely (1) SRL has a direct effect on laboratory activities of Chemistry Education students; (2) SRL has a direct effect on the motivation of chemistry education students; and (3) SRL has an indirect effect on laboratory activities through motivation as a mediator. The instrument was a questionnaire distributed to respondents totaling 268 chemistry education students. Filling out the questionnaire is carried out after students have carried out practicum for one semester. The research results show that SRL has a significant effect on laboratory activities and motivation. The influence of motivation as an intervening SRL was found to be insignificant on laboratory activities.

1 Introduction

Higher education is required to equip students with various skills to answer future challenges [1, 2]. Data literacy skills, critical thinking, independence and mastery of technology are demands that need to be mastered by students, including chemistry education students [3, 4]. Improvements to the chemistry curriculum are carried out continuously in order to achieve quality chemistry learning. At the higher education level, the use of cases that occur in the environment around students is currently being developed a lot [5]. Apart from that, laboratory activities to train communication and problem solving skills are also part of improving the chemistry curriculum [6, 7].

Until now, there are still many problems in implementing chemistry practicum; These include unclear practicum objectives and procedures, minimal reflection activities, and the use of complex procedures without adequate prior knowledge. The things mentioned make investigative activities less meaningful [7-10]. The impact is reduced student interest in studying chemistry [11]. Investigations regarding factors influencing chemistry learning in the classroom and in the laboratory have been widely reported. Environmental support and motivation are reported to help students succeed in learning [12]. Likewise, effective communication is a factor that influences the success of learning chemistry, both in the classroom and in the laboratory [13]. Several research reports show the importance of

* Corresponding author: agus_ap@unram.ac.id

feedback in the learning process in the laboratory, especially to increase student independence, motivation, interest and self-confidence [14-18].

Laboratory activities in higher education are an integration of pre-lab, lab-work and post-lab activities. These three activities require strategies from students to measure their learning process so that the three activities can be carried out optimally. Until now laboratory activities focus more on data collection and analysis activities [19, 20]; Pre-lab and post-lab activities receive less attention. In fact, investigation activities (data collection) will be successful if pre-lab activities as part of preparation, and post-lab activities as part of reflection activities, can be carried out well [4, 9, 18].

Laboratory activities as part of chemistry learning involve three domains, namely cognitive, affective and psychomotor [21]. It should be noted that the factors that influence laboratory activities are aligned with the factors that influence the learning process. So far there has not been much analysis of factors that specifically influence laboratory activities; Research reports analyze the implementation of pre-lab, lab-work and post-lab activities.

Research on the analysis of factors that influence learning has been widely reported. External and internal factors within students that influence the learning process are of much concern to educational experts [22]. In further developments, it is known that self-regulated learning (SRL) has become the attention of researchers because SRL makes a major contribution to learning success. Apart from that, SRL is needed by students, not only in activating the learning process but also in the reflection process regarding the process they have carried out [23].

Self-regulated learning (SRL) is defined as a metacognitive process carried out by students to explore thought processes and evaluate the results of their actions and plan alternative actions for success in learning [24]. Several experts define SRL as a strategy that students consciously control their own learning process to achieve learning goals [25, 26]. There are 3 perspectives that can be used as expert thinking in defining SRL, namely metacognition, motivation, and behavior. The metacognition perspective states that SRL can help individuals regulate themselves in planning and evaluating the learning process. A motivational perspective increases student self-confidence and independence. Behavioral perspective is the activity of selecting and organizing an optimal learning environment [24]. Panadero [27] stated that SRL covers broader aspects, namely cognitive, metacognitive, behavioral, motivational and emotional/affective aspects. The relationship between SRL and motivation has not been specifically explained to date. Onwunyili & Obi [28] reported that SRL and motivation have a relationship in improving student academic achievement. Motivation as a complex process is believed to be a factor that determines SRL and learning outcomes, but the interaction of the two, especially in laboratory activities, has not been specifically reported [29, 30]. Theory reveals that SRL has a direct relationship with the learning process, in this case laboratory activities, and motivation. However, SRL also has an indirect relationship with laboratory activities through motivation. The relationship model for SRL variables, laboratory activities and motivation is shown in Figure 1.

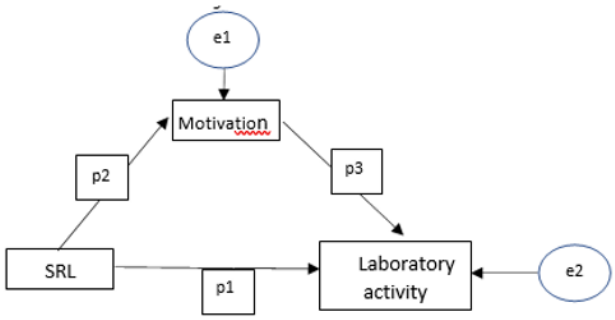


Fig. 1. The relationship model for SRL variables, laboratory activities and motivation

Notes:
α = constant
p = direct influence
e = indirect influence

Research Hypothesis includes 1) SRL has a direct effect on student laboratory activities, 2) SRL has a direct effect on student motivation, 3) SRL has an indirect effect on laboratory activities through motivation as a mediator. The proposed hypothetical model is as follows:

Motivation = α + p2 SRL + e1
Laboratory Activity = α + p1 SRL + p3 motivation + e2

2 Methods

2.1 Sample

This research involved 268 Chemistry Education student respondents divided into 3 classes, namely classes 2022, 2021, and 2020 with the following demographics.

Table 1. Demographics of the smpale (N = 268)

	Group I	
	Number	%
Gender		
Man	38	14.2
Woman	230	85.8
Class		
Class 2022	90	33.6
Class 2021	89	33.2
Class 2020	89	33.2

2.2 Instruments

This research uses three types of instruments (questionnaires), namely instruments to measure laboratory activities, self-regulated learning (SRL) instruments, and motivation instruments. Laboratory activity instruments measure indicators of procedural skills, observation skills and interpretation skills. The SRL instrument measures indicators of metacognitive skills, time management, learning environment organization, persistence,

and seeking help (Jansen et al., 2017). Motivational instruments measure indicators of values, expectations and social support (You et al., 2018).
The laboratory activity rubric consists of 9 assessment aspects with a rating scale of 1-5. This instrument has been validated using the Cohen Kappa consistency test with a Cohen's Kappa Index (CKI) value of 0.7 which indicates the instrument is suitable for use. The SRL and motivation questionnaires each contain 20 valid statements ($p < 0.05$) with five rating scales. Meanwhile the SRL and motivation questionnaires had Cronbach's alpha reliability of 0.857 and 0.839 respectively.

2.3 Data Collection

Measurement of laboratory activities was carried out in line with the practicum implementation by respondents during one semester. Each student receives an assessment from an observer who has been trained on how to use the assessment rubric. Measurement of SRL variables and Motivation is carried out twice, namely before the practicum and after the practicum is completed. The questionnaire was filled out in the form of a Google form with the help of an observer.

2.4 Data Analysis

This research aims to examine the influence of SRL and motivation variables on laboratory activity scores. Data for the three variables were tabulated and analyzed using path analysis with the help of IBM SPSS 21. Based on the hypothetical model proposed previously, SRL has a direct relationship with laboratory activities and also has an indirect relationship through motivation. To prove this, the p1 and p2 values are calculated to determine the magnitude of the influence between variables. The amount of unexplained variance between variables is calculated using the formula:

$$e = \sqrt{(1 - R)^2} \tag{1}$$

To determine the significance of the influence of the mediating variable (Sp2p3), a further test was used with the Sobel test with the formula:

$$e = \sqrt{P3^2SP2^2 + P2^2SP3^2 + Sp2^2Sp3^2} \tag{2}$$

Next, the t statistical value of the mediation effect is calculated using the formula:

$$t = \frac{p^2p^3}{Sp^2p^3} \tag{3}$$

3 Results and Discussion

The average score for chemistry education students' laboratory activities shows varying values for each class. The class of 2022 had a higher average (M = 77.38) compared to the classes of 2021 (M = 74.81) and 2020 (M = 74.80). The same thing is shown by SRL and motivation scores. The SRL scores for the classes of 2022, 2021, and 2020 are 3.06 respectively; 3.04; and 3.02 while the motivation scores were respectively 3.03; 2.90; and 2.88. Hypothesis 1 test shows that SRL has a significant effect on laboratory activities with a standardized beta SRL value of 0.455 as shown in Table 2.

Table 2. Regression Analysis of the Effect of SRL on Laboratory Activities

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	147835.943	1	147835.943	405.572	.000[b]
Residual	96960.307	266	364.512		
Total	244796.250	267			

[a]Dependent Variable: Aktivitas Laboratorium
[b]Predictors: SRL

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 Constant	166.585	6.935	.777	24.022	.000
SRL	0.455	.023		20.139	.000

Hypothesis 2 test shows that the standardized beta SRL value is 0.245 and laboratory activity is 0.344 and both have a significant influence (Table 3).

Table 3. Regression analysis of the influence of SRL and motivation on laboratory activities

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	127024.272	2	63512.136	893.803	.000[b]
Residual	18830.444	265	71.058		
Total	145854.716	267			

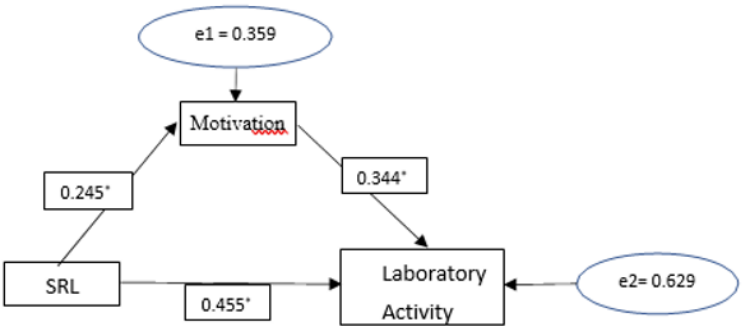
[a]Dependent Variable: Motivation
[b]Predictors: SRL, Laboratory Activity

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 Constant	110.727	5.451		20.314	.000
Akt. Lab	.344	.027	.446	12.713	.000
SRL	.245	.016	.544	15.498	.000

[a]Dependent Variable: Motivation

Based on the R square value from hypothesis equations 1 and 2, an e1 value of 0.359 and an e2 value of 0.629 can be obtained, which shows the magnitude of the indirect relationship between variables. Based on the analysis results shown in tables 1 and 2, the influence between SRL variables, motivation and laboratory activities can be arranged as follows:



The results of path analysis show that SRL has a direct effect on laboratory activities and SRL also has an indirect effect on laboratory activities through motivation as an intervening agent. To determine the influence of motivation as a significant intervening or not, a Sobel test was carried out. The Sobel test shows the t value is smaller than the t table, which shows that the influence of motivation as a mediator is not significant.

Laboratory activities are part of the learning process which involves three learning domains. The pre-lab stage as the initial stage of practical activities is dominated by the cognitive and affective domains. The cognitive domain is needed when students create an investigation plan or understand the practicum agenda, while the affective domain is more about students' collaboration abilities and motivation in carrying out the pre-lab [20, 31, 32]. Lab-work activities involve all learning domains, namely cognitive, psychomotor and affective. The cognitive domain can be seen from students' efforts to understand work procedures, analyze and interpret investigation results and develop conclusions. Psychomotor can be seen from the implementation of practical procedures and affective can be measured from students' feelings when carrying out investigations [4, 18, 33]. Like lab-work activities, post-lab activities also involve all three learning domains. However, the evaluation and reflection process is more dominant in this activity {16, 17].

In line with this research, there is a tendency for students who have high laboratory activity scores to have high motivation in participating in laboratory activities. The highest overall laboratory score can be ensured in students with high pre-lab, lab work and post-lab scores. In pre-lab activities, the results of the observer's observations showed that students who tended to be active had better lab work and post-lab scores compared to students who were less active. A more specific analysis of laboratory activities on motivation and SRL needs to be tested further to determine the factors that influence each other.

The involvement of the three learning domains in laboratory activities is connected to students' self-regulated learning. In principle, SRL is broadly covered in cognitive, psychomotor and affective aspects [27]. The results of this study are in line with several research which found that SRL has a positive effect on the learning process [30, 34-36]. Although there has been no research studying the relationship between learning in the laboratory and SRL, the connection between laboratory activities and the three domains can be paralleled with learning in the classroom.

SRL development occurs in three phases, namely the planning, performance and assessment phases. In the planning phase, the dominant SRL component is task understanding; strategic setting and planning. The performance phase is connected with the implementation of strategies and regulations for the assigned tasks. The assessment phase becomes part of the reflection in determining the next strategy [37]. If you look at the sequence of laboratory activities, the SRL phase is in line with the three laboratory activities which are the connection between SRL and laboratory activities.

The answer to the next hypothesis states that SRL has a direct effect on motivation. Although motivation is said to be a complex process, the process involves a biological system connected to the brain [29]. In line with Galloway & Bretz [33] who found that the psychomotor domain in laboratory activities is very dependent on the cognitive and affective domains. This means that lab-work and post-lab activities which contain the psychomotor domain are connected to pre-lab activities which contain the cognitive and affective domains. That is why pre-lab activities determine the success of the laboratory activities as a whole [9, 18]. However, this claim needs to be substantiated to confirm the relationship of SRL and motivation with pre-lab, lab-work, and post-lab.
Motivation as a mediator of the influence of SRL on laboratory activities has not been clearly revealed so far. Ilishkina et al. [38] found that SRL has a strong correlation with all motivation elements. In line with the study of E-Adi & Alkhusi [39] which states that SRL statistically has a positive relationship with intrinsic, extrinsic motivation, task value, the construct of learning beliefs, self-efficacy and academic achievement. This is different from Onwunyili & Obi [28] who stated that extrinsic motivation and SRL can improve students' academic achievement. However, motivation is not a significant predictor of problem-solving abilities [40]. In writing ability, motivation and SRL can act as stable predictors [41]. Our research results show that SRL through motivation has an insignificant effect on lab activities, but together the effect is significant. A more in-depth study as an analysis of the causes of this happening needs to be investigated further.

4 Conclusion

The research results show that SRL has a significant direct effect on laboratory activities and the motivation of Chemistry Education students. The influence of motivation as a mediator of SRL in influencing laboratory activities was found to be statistically insignificant.

Acknowledgement. We express highest appreciation to the University of Mataram for awarding a research grant with a research implementation contract number: 1926/UN18.L1/PP/2023.

References

1. Y.A. Kim, E. Monroe, H. Nielsen, J. Cox, K.M. Southard, L. Elfring, et al., J. Chem. Educ. 97(12), 4245 (2020)
2. M. Pandee, S. Tepsuriwong, P. Darasawang, Issues in Educ. Res. 30(4), 1442 (2020)
3. A. Jackson, G.A. Hurst,. Chem. Educ. Res. Pract. 22, 855 (2021)
4. S. Altowaiji, R. Haddadin, P. Campos, S. Sorn, L. Gonzalez, S.M. Villafan, M.N. Groves, Chem. Educ. Res. Pract 22, 616 (2021)
5. C.E.S. Alvaro, A.M. Abad, N.S. Nudelman, Int.J. Sustainable High Educ. 20(5), 951 (2019)
6. J. Hoper, K.M. Jegstad, K.B. Remmen, Chem. Educ. Res. Pract. 23, 361 (2022)
7. D.B. Oliveira, R. W. Becker, C. Sirtori, C. G. Passos. Chem. Educ. Res. Pract. 22, 653 (2021)
8. S.L. Bretz, J. Chem. Educ. 96(2), 193 (2019)
9. K. Ho, S.R. Smith, C. Venter, D.B. Clark, Chem. Educ. Res. Pract. 22, 973 (2021)
10. J. Wei, D.F. Treagust, M. Mocerino, V.R. Vishnumolakala, M.G. Zadnik, A.D. Lucey, E.D. Lindsay, Res. Sci. Educ. 51, 1039 (2020)
11. J. Musengimana, E. Kampire, P. Ntawiha, EURASIA J. Math. Sci. Tech. Educ. 17(1), 1 (2021)

12. F.M. Mangubat, M.T. Picardal, Int. J. Instruc. 16(2), 15 (2023)
13. J. Cho, W. Baek, Sustainability 11, 3958 (2019)
14. H.S. You, K. Kyungun Kim, K. Black, K.W. Min, EURASIA J. Math. Sci. Tech. Educ. 14(4), 1161 (2018)
15. A. Anderson, E.K. Kollmann, M. Beyer., O. Weitzman, M. Bequette, G. Haupt., H. Velázquez, J. Chem. Educ. 98 (6), 1841 (2021)
16. E.L. Atieh, D.M. York, M.N. Muñiz, J. Chem. Educ. 98 (2), 281 (2021)
17. D. Read, S.M. Barnes, J. Hyde, J.S. Wright, Nurturing reflection in science foundation year undergraduate students, in C. McDonnell, Murphy V. L. (ed.), Teaching Chemistry in Higher Education: A Festchrift in Honour of Professor Tina Overton, pp. 23–38 (2019)
18. J. Tashiro, D. Para, J. Pollard, V. Talanquer, Chem. Educ. Res. Pract. 22, 662 (2022)
19. G. Reynders, E. Suh, R.S. Cole, R.L. Sansom, J. Chem. Educ. 96(10), 2109 (2019)
20. M.K. Seery, J. Chem. Educ. 97(6), 1511 (2020)
21. A. Touroutoglou, K.A. Lindquist, B.C. Dickerson, L.F. Barrett, Soc. Cog. Affect. Neurosci. Adv. 10(9), 1257 (2015)
22. P.H. Anthony, V. Emiliana, C-R, Rohan, An Analysis of COVID-19 Student Learning Loss," Policy Research Working Paper Series 10033, The World Bank. (2022)
23. M. Gavriushenko, R. Lindberg, O. Khriyenko, Smart educational process based on personal learning capabilities. 9th International Conference on Education and New Learning Technologies, Barcelona (2017).
24. B.J. Zimmerman, Theory into Pract. 41(2), 64 (2002)
25. E. Sautelle, T. Bowles, J. Hattie, D.N. Arifin, Australian J. Teach. Educ. 40(4), 54 (2015)
26. J. Hattie, Visible Learning: A Synthesis of over 800 Meta-Analyses Relating to Achievement. London: Routledge (2009)
27. E. Panadero, Review 8(422), 4 (2017)
28. F.C. Onwunyili, I. Obi, Soc. Sci. Educ. Res. Rev. 7(2), 107 (2020)
29. E.H. Simpson, D.P. Balsam, Behavioral Neuroscience of Motivation, Current Topics in Behavioral Neurosciences, Volume 27 (2016)
30. H. Çivril, A.E. Özkul, Int. Review of Res. Open Distributed Learn. 22(2), 143-165. (2021)
31. M.C. Box, C.L. Dunnagan, L.A.S. Hirsh, C.R. Cherry, K.A. Christianson, R.J. Gibson, M.I. Wolfe, M.T. Gallardo Williams, J. Chem. Educ. 94(2), 164 (2017)
32. J.A. Schmidt-McCormack, M.N. Muniz, E.C. Keuter, S.K. Shaw, R.S. Cole, Chem. Educ. Res. Pract. 18, 749 (2017)
33. K.R. Galloway, S.L. Bretz, J. Chem. Educ. 92(12), 2019 (2015)
34. L.S. Teng, L.J. Zhang, Metacogn. Learn. 13, 213 (2018)
35. C.G. Karacan, M. Yıldız, D. ve Atay, Mextesol J. 46(3), 1 (2022)
36. S. Xiao, K. Yao, T. Wang, The Relationships of Self-regulated Learning and Academic Achievement in University Students. SHS Web of Conferences 60, 01003 (2019)
37. R.S. Jansen, A.V. Anouschka van Leeuwen, J. Janssen, L. Liesbeth Kester, M. Kalz, J. Comput. High. Educ. 29, 6 (2017)
38. D.I. Ilishkina, A. de Bruin, A.I. Podolskiy, M.I. Volk, J.J.G. Merri¨enboer, J.J.G. Int. J. Educ. Res. 113, 1 (2022)
39. A. El-Adl, H. Alkharusi, Cypriot J. Educ. Sci. 15(1), 104 (2020)
40. M. Baars, L. Wijnia, F. Paas, Front. Psychol. 8, 1346 (2017)
41. Y. Zhang, L. Dong, Front. Psychol. 13, 938346 (2022)