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Analysis of Chemistry Students' Critical Thinking and its Relationship to Self-Regulated Learning in Online Learning

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Abstract. This study aims to analyze students' critical thinking skills and examine the relationship with self-regulated learning (SRL) in online learning. The research sample was active chemistry students with a total of 85 people consisting of 3 age groups, namely, freshmen (N = 30), sophomore (N = 33), and junior (N = 22). Critical thinking indicators analyzed are accuracy, making assumptions, developing hypotheses, testing hypotheses, and developing conclusions. Meanwhile, 5 SRL indicators are metacognitive skills, time-sharing, environmental management, persistence, and seeking help. The results showed that the average score of juniors' critical thinking (X = 85.91; SD = 3.22) was higher than sophomore (X = 81.67; SD = 3.02) and freshmen (X = 57.97; SD = 14.68). The same trend is shown in SRL, where juniors have higher SRL scores on all indicators than sophomores and freshmen. The analysis of each SRL indicator shows the highest score on the metacognitive skills indicator, and the lowest score is the finding help indicator. Students with high SRL scores tend to have high critical thinking scores. The findings strongly suggest the need for designing learning scenarios that can improve the interaction between students and lecturers and interaction among students in the online learning process.

INTRODUCTION

Critical thinking and communication skills are the primary skills that need to be exercised on students to face the job market [1]. The previous survey results showed that both skills play an essential part in the job market [2,3]. Universities must prioritize learning activities that can train students to adapt to all the changes that students will encounter when entering the job market.

Online learning is one form of change in education that has occurred due to the COVID-19 pandemic [4-6]. For more than a year, lecturers and students have faced the challenge of implementing a learning process that has changed from previous learning. It has a significant impact not only on lecturers but also on students. The implementation of online learning causes students' learning motivation to decrease, which impacts excessive anxiety and decreased learning achievement [7,8]. This condition requires real action from education practitioners to achieve the expected educational goals even though learning is carried out online [9].

The implementation of online learning at the University of Mataram has been ongoing from March 2020 until now. The results of a survey of students indicate that the learning process carried out is still limited to providing course contents and independent assignments through the university's online facilities or WhatsApp media. The evaluation results of the learning process indicate that students have not been able to follow the learning process optimally. In addition to technical reasons, students feel burdened with piles of assignments and restrictions on interaction to complete assignments well. Overall, students think that online learning taking place so far has not been comfortable for them.

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External and internal factors influence the success of the implementation of online learning. External factors are related to acceptable content, facilities, infrastructure, and interactions. Internal factors include students' motivation and independence in participating in the learning process [10,11]. These two factors may influence directly or indirectly the success of online learning.

Critical thinking in online learning has several criteria, namely:

1. Identify the problem as background information that may trigger questions [12].
2. Elucidate questions regarding content clarification or personal interpretation of content [13].
3. Develop arguments [14].
4. State the evidence as a reason for submitting an argument [12].
5. Synthesis of ideas as integration related to proof of argument [13].
6. Reference readings that show that the argument is accompanied by supporting evidence [15].
7. Troubleshooting [12].

The criteria stated above may be met by preparing good quality content, independent assignments, and the use of discussion forums on online learning platforms [16].

Interaction is vital in developing critical thinking in online learning. In general, there are five aspects of interactions in online learning. First, learner-interface interaction, namely the ease with which students may access learning information online. Second, learner-self interaction, namely the ease with which students may monitor their learning progress through reflection facilitated by online learning. Third, learner-content interaction, where students may access content in online learning. Fourth, learner-instructor interaction, where students may interact with instructors through online learning facilities. Fifth, learner-learner interaction, where students may interact with other students through online learning facilities [16]. The interaction of students with other students is known to have a more decisive influence than other interactions [11].

Based on social learning theory, interactions between students indicate that they are better involved in the learning process [17]. This theory is ubiquitous as a reference in explaining the factors that influence online learning and its relationship in developing critical thinking. The interaction between students is more focused on discussions and reflections related to the lecture topics discussed [18]. Through discussion, students can convey ideas and ideas to develop a more thorough understanding of the lecture topic [19]. The information posted by the instructor more or less determines the course of the discussion, so it is expected to develop an instructional design that may stimulate the discussion [20].

Critical thinking in online learning is determined by four main factors, namely instructional design, institutional management and leadership, local evidence, and belief systems. The instructional design and management of institutional leadership are planned and manipulated to promote critical thinking in the short term. Local evidence is a modifiable factor to promote critical thinking in the medium term. The belief system is considered a static factor that is constant and unchangeable during online learning [21]. Specifically, Lu et al. [22] revealed that the interaction between students and learning motivation directly impacted the development of critical thinking. In contrast, teaching methods and learning environment had an indirect effect.

Self-regulated learning (SRL) is a metacognitive process carried out by students to explore thought processes, evaluate the results of their actions, and plan alternative actions for success in learning (Zimmerman, 2002). Some experts define SRL as a strategy that students consciously have to control their learning process to achieve learning goals [24,25]. Several factors influence SRL, namely motivation, self-confidence, and goals to be achieved. More motivated students tend to use SRL to a higher degree than less motivated students [26]. Factors such as self-concept, task goal orientation, achievement, understanding, and self-efficacy are regarded as latent factors related to SRL [27].

This study aims to analyze students' critical thinking skills and see their relationship with their self-regulated learning.

METHODS

Research Sample

The research sample was, randomly selected, three batches of chemistry education students. All students take lectures online using the online platform unram.ac.id. The age of students is between 19-22 years. The demographic data of the sample is in Table 1.

TABLE 1. The demographic data of the sample.

Background	Subtotal	
	N	%
Gender:		
Man	12	14
Woman	73	86
Rank:		
Freshmen	33	39
Sophomore	30	35
Junior	22	26
Age:		
19	24	28
20	21	25
21	19	22
22	21	25

Data Collection

There are two types of data analyzed in this study: critical thinking data and self-regulated learning data. Critical thinking data uses a written test sent to participants in the form of a google form. Respondents' SRL data were obtained from questionnaires given to students after carrying out critical thinking tests. Interviews were also conducted with several chemistry lecturers to get an overview of student activities during lectures.

Instrument

The first data collection instrument used was a written test of critical thinking. A total of five indicators were measured, including accuracy, making assumptions, developing hypotheses, testing hypotheses, and developing conclusions [28]. Each indicator has 3-4 developed items. It also has sample questions and working instructions. The developed questions have been tested for validity and reliability to be suitable for data collection.

The SRL questionnaire consists of metacognitive skills, time management, environmental structuring, persistence, and help-seeking [29]. Each developed component has 3-7 positive and negative statements. Each item has an answer on a 5 Likert scale that ranges from never to very often.

Data Analysis

Critical thinking and SRL data were tabulated, and the average of each component in each batch was calculated. The difference in average critical thinking scores and SRL from the three age groups was analyzed using the Mann-Whitney U test with the help of SPSS 21. Each component and age group's tendencies were analyzed and linked to interview data related to student activities during online learning.

RESULTS AND DISCUSSION

Critical Thinking Analysis of Chemistry Students in Online Learning

The results of the critical thinking analysis of chemistry students in the three age groups showed different averages. Overall, the junior has the highest average critical thinking, 85.91 (SD = 3.22). The sophomore and first-year students have average critical thinking of 81.67 (SD = 3.02) and 57.97 (SD = 14.67). The Mann-Whitney U test showed that the critical thinking scores of the three classes were significantly different ($p < 0.05$). The average critical thinking of students in the three batches is shown in Figure 1.

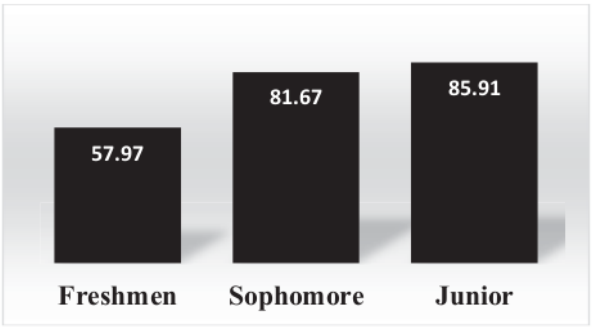

FIGURE 1. Chemistry student critical thinking score (average).

The analysis of the five indicators shows different trends in the three batches of students. In the freshmen, the accuracy and making assumptions indicators showed the highest scores, while the other indicators showed lower average values. In the sophomore and junior, the average value of the accuracy indicator shows the highest average value. In contrast, the average score of the other four indicators gives an average that is not significantly different (Table 2).

TABLE 2. Students' critical thinking scores on each indicator.

Indicator	Freshmen		Sophomore		Junior	
	X	SD	X	SD	X	SD
Accuracy	58.13	1.26	79.15	0.87	85.27	0.88
Making assumptions	58	1.07	82.54	0.43	85.82	0.64
Developing a hypothesis	57.73	1.06	82.67	0.42	86.18	0.63
Test the hypothesis	58.67	1.02	81.51	0.40	83.18	0.68
Developing conclusions	57.56	1.10	82.82	0.45	88.48	0.56

The accuracy indicator represents basic chemistry questions to test students' understanding and analytical skills. The low score in freshmen is evidence that they do not develop their initial knowledge yet in contrast to sophomore and junior who have developed their initial knowledge in advanced courses. The development of initial knowledge becomes the main foundation in developing critical thinking skills. Giving concepts in stages may allow students to develop initial knowledge and construct new concepts as part of critical thinking [30].

Indicators of making assumptions may help students improve their analytical skills and problem solving [31]. The pattern of student answers shows that students who have high scores on assumptions tend to have high scores on indicators of developing hypotheses. This is in line with previous research that showed that making assumptions affects the ability to develop hypotheses [32,33].

In the indicators of testing hypotheses and developing conclusions, the lowest score is in freshmen. It is because they are not accustomed to doing scientific writings. This finding is different for sophomores and juniors who are used to compiling investigative reports on practical activities. In line with Saeger's research [33], testing hypotheses and developing conclusions are the lowest indicators for freshmen. This inability is caused by the high complexity of the two indicators, so they need to be trained often, especially in scientific preparation [34,35].

The activities and interactions of students influence the quality of the implementation of online learning. The results of interviews with lecturers who teach courses in each batch show that students' interactions with other students tend to be less during the implementation of learning. Freshmen tend to be more passive, and it may be supposed that they are getting to know the world of campus for the first time, so they require a more extended adjustment than sophomores and juniors. The success of online learning in exercising critical thinking is strongly influenced by adaptability, learning methods, interactions, and academic support [36]. Sophomore and junior may have adapted to the learning process in higher education so that it is possible to show higher critical thinking scores than freshmen.

Self-Regulated Learning Analysis of Chemistry Students in Online Learning

Data on students' self-regulated learning (SRL) from three batches showed the same tendency to critical thinking scores. The average SRL score of freshmen has a lower value than sophomore and junior. The Mann-Whitney U test showed that the SRL scores of the three batches were significantly different ($p < 0.05$). The SRL scores of each indicator of the three classes of chemistry students are shown in Table 3.

TABLE 3. Student SRL scores on each indicator.

Indicator	Freshmen		Sophomore		Junior	
	X	SD	X	SD	X	SD
Metacognitive skills	1.96	1.09	3.1	0.50	3.2	0.42
Time management	1.9	1.04	3.2	0.53	3.42	0.50
Environmental structuring	1.89	1.03	3.22	0.49	3.79	0.41
Persistence	1.92	1.05	3.21	0.56	3.28	0.49
Help seeking	2.36	0.59	2.47	0.66	3.32	0.56

For freshmen, technical responses related to participating in online learning are still an obstacle. The introduction of a new campus world causes students to find it challenging to determine learning strategies to seek help when experiencing difficulties. The statement on the SRL questionnaire that has the lowest score is the interaction between students and lecturers. This data is in line with interviews with course lecturers and student responses regarding online learning. Learning activities that are still low and the lack of discussion forum platforms on the online system are problems experienced by freshmen in the implementation of online learning.

Sophomore and junior show a better ability to determine learning strategies and seek help when experiencing difficulties. Although some students experience technical problems such as signaling and other disturbances, they can interact with their classmates if they have difficulty.

The results of the analysis of critical thinking and SRL show that there is a relationship between students' critical thinking scores and SRL. Students who have high critical thinking scores tend to have good SRL scores. This is in line with the research of Tee et al. [37], which revealed that SRL is the dominant factor in the development of critical thinking in online learning. Students with excellent SRL tend to find it easier to set strategies to succeed in their learning activities.

The success of the online learning process is possible as students develop SRL in 3 phases, namely planning, performance, and assessment [23]. The analysis of each statement in the SRL questionnaire shows that students experience more obstacles in the guessing and performance phases. In the rehearsal phase, students have difficulty following the lecture schedule and finding a comfortable place during the learning process. Determining learning strategies, concentrating, and seeking help when experiencing difficulties are obstacles students face in the performance phase. This difficulty makes it hard for students to achieve the desired learning goals [38,39]. Finally, innovations related to learning methods that can induce SRL in the three phases need to be done in developing critical thinking [37].

CONCLUSION AND RECOMMENDATION

This study concludes that chemistry students' critical thinking scores and SRL in the three classes were significantly different. Junior has higher scores on both variables than sophomores and freshmen. Students with high SRL scores tend to have high critical thinking scores and vice versa, so that there is a relationship between critical thinking scores and SRL.

The recommendation formulated from this finding is the need for learning innovations that can develop student SRL. It can be conducted by integrating with the implementation of laboratory work that may be carried out at home or using cases connected to concepts so that they are allowed to practice their analytical skills as part of developing critical thinking. This innovation needs to be put into learning scenarios that can trigger interactions between students and their lecturers to improve student SRL, even in online learning.

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REFERENCES

1. R. D. Gomathi, S. Radhika and V. Radhakrishnan, European Journal of Molecular & Clinical Medicine. **7**, (3), 2183-2190, (2020).
2. D. Davis, G. Chen, C. Hauff, and G-J, Houben, Computers & Education. **125**, 327-344, (2018).
3. M. Sarkar, T. Overton, C. Thompson, and G. Rayner. J. Innov. Sci. Math. Educ. **24,** (3), 31–48, (2016).
4. D. D. Preiss, J. Castillo, P. Flotts and E. San Martin, Learn. Individ. Differ. **28**, 193-203, (2013).
5. K. Lowden, S. Hall, D. Elliot, and J. Lewin, *Employers' Perceptions of The Employability Skills of New Graduates,* (The Edge Foundation, London, 2011).
6. J. L. Hsu, and M. Rowland-Goldsmith, Biochem. Mol. Biol. Educ. **0**, 1–11, (2020).
7. V. Schaeffler, *INASP,* Oxford. pp. 1-10, (2020).
8. W. Cao, Z. Fang, G. Hou, M. Han, X. Xu, J. Xong, et al., Psychiatry Res**. 287**, 112934, (2020).
9. L. Liberman-Martin andO. M. Ogba, J Chem. Educ. **97**, 3188–3193, (2020).
10. M. D. B. Castro and G. M. A. Tumibay, Educ. Inf. Technol. 0, (2019).
11. W. N. T. W. Hussin, J. Harun andN. A. Shukor, Journal of Technology and Science Education **9,** (1), 4-12, (2019).
12. W-Y. Hsiao, M. Chen, and H-W. Hu, The International Journal of Technology, Knowledge, and Society **9**, 15-25, (2013).
13. S. J. Wegmann and J. K. McCauley, Journal of Asynchronous Learning Networks.**18,** (1), 17-26, (2014).
14. R. Rezaei and M. Lovorn, Assessing Writing. **15**, 18–39, (2010).
15. B. Frey, Rubric for asynchronous discussion participation, (2006).
16. Chou, H. Peng, and C. Chun-Yu, Computers & Education. **55**, 1004–1017, (2010).
17. M. Raspopovic, S. Cvetanovic, I. Medan, D. Ljubojevic, The International Review of Research in Open and Distributed Learning **18,** (1), 141-160, (2017).
18. R. Swart, Nurse education in practice **23**, 30-39, (2017).
19. J. R. Morrison, G. S. Watson, and G. R. Morrison, Quarterly Review of Distance Education **13,** (3), 167-176, (2012).
20. M. Eccarius, The QuarterlyReview of Distance Education **12,** (4), 265-268, (2020).
21. M. Gharib, M. Zolfaghatri, R. Mojtahedzadeh, A. Mohammadi and A. Gharib, Advances in Medical Education and Practice **7**, 271–279, (2016).
22. K. Lu, H. H. Yang, Y. Shi, and X. Wang, Int J Educ Technol High Educ. **18,** (1), 1-23, (2021).
23. B. J. Zimmerman, Theory into Practice **41,** (2),64–70, (2002).
24. J. Hattie, *Visible Learning* (Routledge, London, 2009), pp. 1-13.
25. E. Sawtelle, T. Bowles, J. Hattie, and D. N. Arifin, Australian Journal of Teacher Education **40,** (4), 54-71, (2015).
26. S. Rieser, A. Naumann, J. Decristan, B. Fauth, E. Klieme andG. Buttner, British Journal of Educational Psychology **86**, 1-20, (2016).
27. E. L. Usher and F. Pajares, Educational and Psychological Measurement **68,** (3), 443-463, (2008).
28. S. M. Danczak, C. D. Thompson, and T. L. Overtoon, Chemistry Education Research and Practice. **21**, 62-78, (2020).
29. R. S. Jansen, A. V. Anouschka van Leeuwen, J. Janssen, L. Liesbeth Kester, M. Kalz, J Comput High Educ. **29**, 6-27, (2017).
30. F. J. King, L. Goodson, and F. Rohani, *Higher Order Thinking Skills,* (Washington DC, 2011), pp. 4-11.
31. D. Fortus, Sci Ed**. 93**, 86-108, (2009).
32. R. H. Ennis, *Critical Thinking*, (Prentice Hall, New Jersey, 1996), p 7-13.
33. Saeger and J. Karla, Education Administration. **1**, 1-10, (2014).
34. K. P. Greenberg, Teaching of Psychology. **42,** (3), 211−217, (2015).
35. J. W. Wackerly, Journal of Chemical Education **95,** (1), 76-83 (2018).

36. J. Valverde-Berrocoso,M. C. Garrido-Arroyo,C. Burgos-Videla and M. B. Morales-Cevallos, Trends in Educational Research about e-Learning:A Systematic Literature Review (2009–2018), Sustainability **12**, 2-23 (2020).
37. K. N. Tee, K. E. Leong, and S. S. A. Rahim, International Journal of Science and Mathematics Education. **19**, 619-637 (2021).
38. J. Mackness, S. Mak and R. Williams, *The Ideals and Reality of Participating in a MOOC*. 7th International Conference on Networked Learning, edited by L. Dirckinck-Holmfeld, V. Hodgson, C. Jones, M. de Laat, D. McConnell and T. Ryberg (University of Lancaster, Lancaster, England, 2010), pp. 266-275.
39. A. Margaryan, M. Bianco, and A. Littlejohn, Computers & Education **80**, 77–83 (2015).

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