DOKUMEN KORESPONDENSI KARIL KHUSUS_ADAM MALIK_
KE JURNAL PENDIDIKAN IPA INDONESIA
(https://journal.unnes.ac.id/nju/jpii/author/submission/31442)

1. Letter of statement (22 Oktober 2024)
2. Reply to the statement letter (23 Oktober 2021)
3. Update: Manuscript Review (2 November 2021)
4. Revision Peper (2 November)
5. Submit the Indonesian version of the article
6. Reply the Indonesian version of the article (5 November 2021)
7. Manuscript Update (10 November 2021)
8. Proof of payment transfer for the JPII December 2021 Publication Fee (11 November 2021)
9. Update: Manuscript Review (30 November 2021)
10. The manuscript has been revised (3 Desember 2021)
11. Update: Manuscript Review (6 Desember 2021)
12. The manuscript has been revised (9 Desember 2021)
13. Manuscript Update (24 Desember 2021)
14. I've done what the JPII team asked me (24 Desember 2021)
15. Letter of Acceptance and Publication Receipt (24 Desember 2021)
16. Reply the Tim JPII (24 Desember 2021)
17. Manuscript Update (30 Desember 2021)
18. We've read the manuscript, and we're making revisions (30 Desember 2021)
19. Figure Improvement (4 Januari 2022)
20. Sending Revision (4 Januari 2022)
21. Article Checking (10 Januari 2022)

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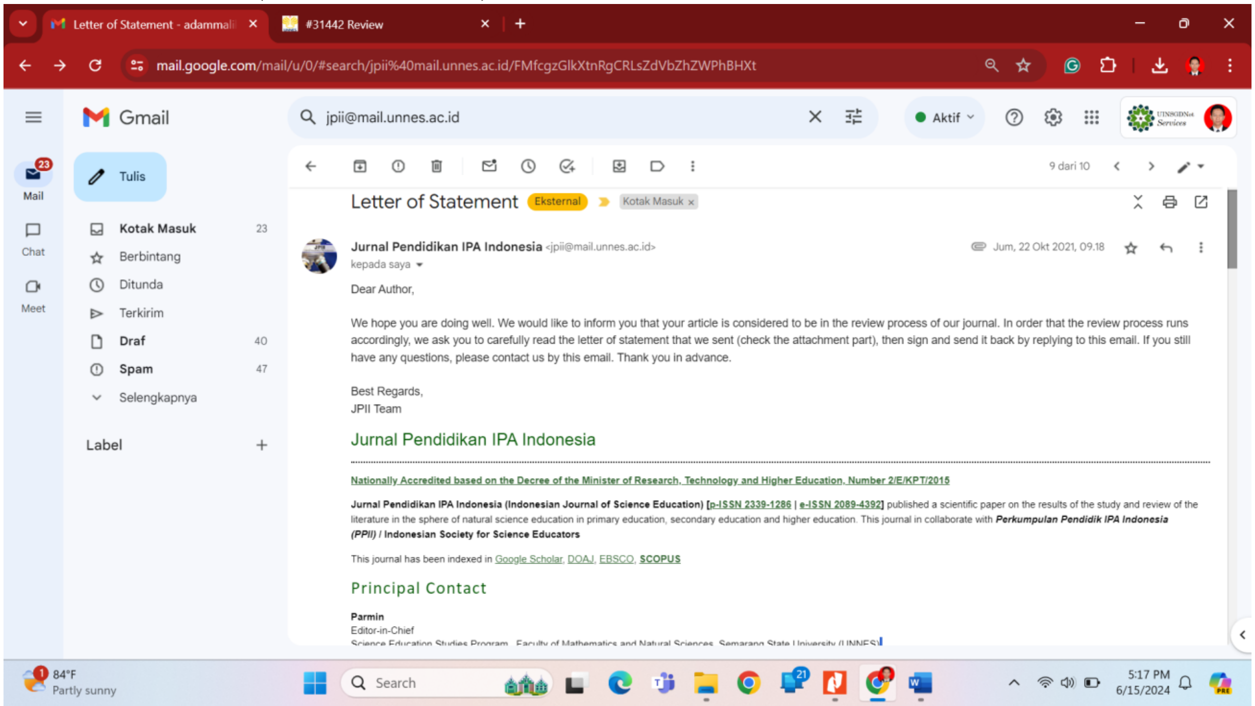

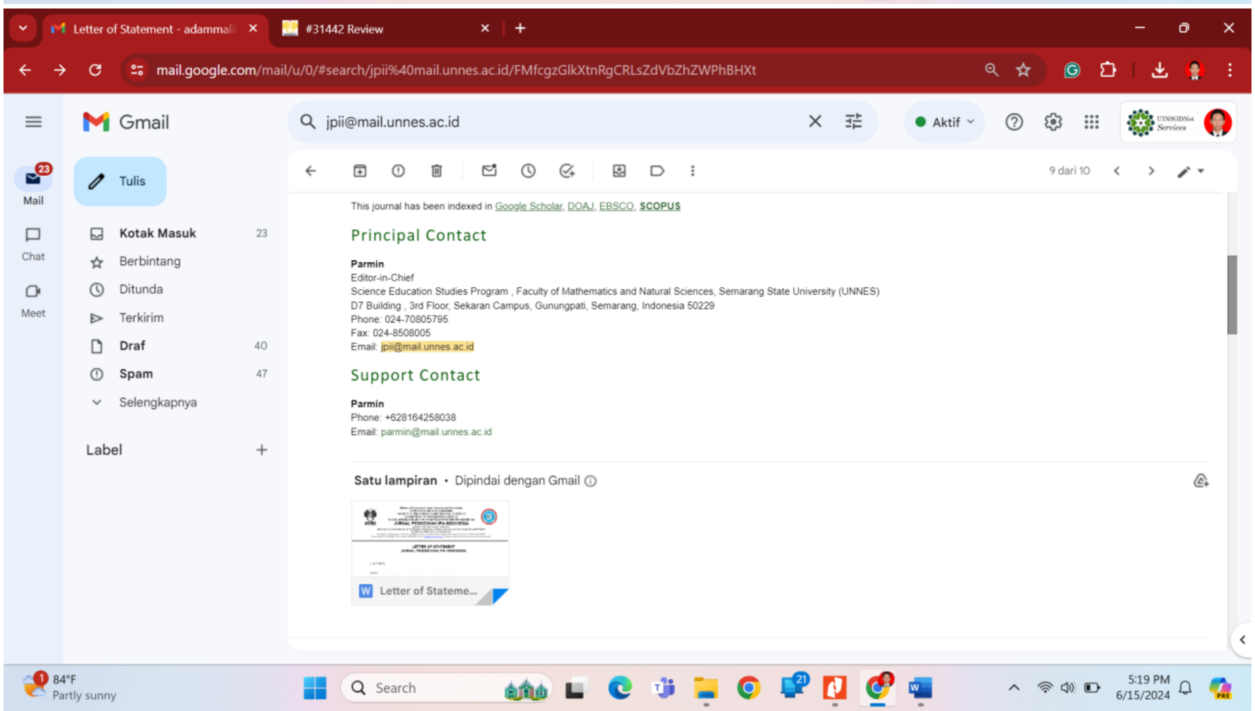

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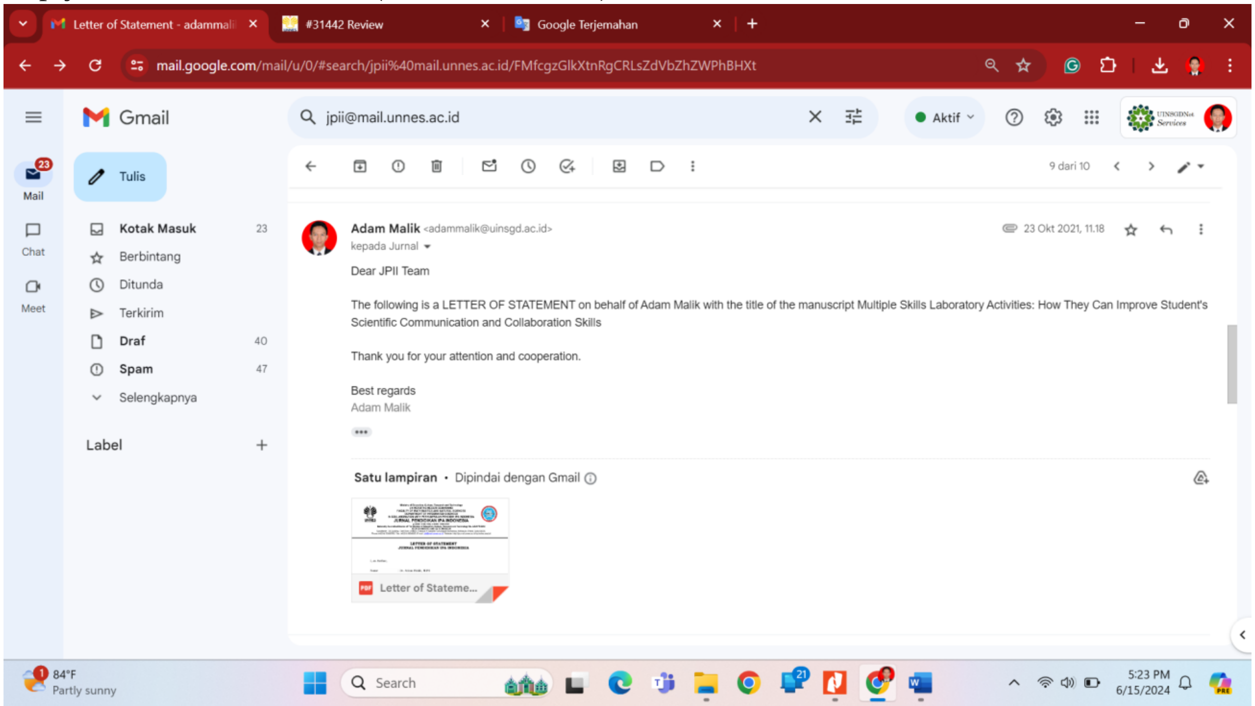

JPII 5 (2) (2016) 247-
255

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills

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DOI:

Accepted:... .Approved: ... . Published: ...

ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 student used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous ability and learning habits who were from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher Order Thinking Laboratory model while the experimental class conducted activities based on the Multiple Skill Laboratory Activity Model. The data of this study were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on the improvement of students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model is more effective to improve student's collaboration skills than communication skills. Moreover, this study reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide a reference of methods for further researchers to optimize students' scientific communication skills and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The very fast dissemination of information and easy access to information from various sources have become the characteristic of the 21st century including education in the 21st century. Nowadays, students can easily access various learning resources that teachers probably do not access. In addition, students and teachers can easily share their findings through various platforms, free or paid platforms. On the basis of the second case, an additional skill is needed to enable students and teachers to convey their findings appropriately. Such an ability is called Scientific Communication Skills (SCS) that become one of the most important competencies in the 21st century (Alpusari, Mulyani, Putra, Widyanthi, & Hermita, 2019; Chung, Yoo, Kim, Lee, & Zeidler, 2016; Gordon & Martin, 2019; Siddiq, Scherer, & Tondeur, 2016; van Laar, van Deursen, van Dijk, & de Haan, 2017) and the scientific contributions have increasingly been accepted in the society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger, Christie, & Carey, 2019; Hansen, Carnett, & Tullis, 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various concepts of physics and to simplify the explanation of the results of complex research (Dannels, Anson, Bullard, & Peretti, 2003; Saleh, Barghuthi, & Baker, 2017). In addition, nowadays, students are in the globalization era that highly demands the ability to convey ideas to the public. However, Table 1 shows that communication skills have not received much attention, especially in the laboratory learning environment.

Table 1 shows that previous studies still generally investigate the issues and have not optimized the experimental learning. SCS is also proved more effectively practiced by employing an experimental-based learning and other experimental models that involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings (Adam Malik et al., 2018; Sapriadil et al., 2019; X. Wang, Schneider, & Valacich, 2015; Yang & Heh, 2007). The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allow students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia, Maneira, Ribeiro, & Maneira, 2009; J. Wang, Guo, & Jou, 2015a). Like SCS, CS is also necessary in the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' ability. However, several efforts to effectively practice CS have started to develop. At least, there are four major scopes as the focus of CS development as shown in Table 2.

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes, Bradford, & Likens, 2018), with creative thinking (J. W. Chang, Wang, Lee, Su, & Chang, 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to investigate experimental-based learning that trains and develops SCS and CS at the same time.

Table 1. The research developments related to scientific communication skills

No	Scopes	Authors
1	Strategy, Method, Approach	(Atasoy, 2013; Chen, Chung, & Wu, 2013; Patent No. U.S Patent 5.387.104, 1995; Hošková-Mayerová, 2014; Klochkova, Komochkina, & Mustafina, 2016; Kusumawati, Marwoto, & Linuwih, 2015; Novita, 2010; Patriot, Suhandi, & Chandra, 2018; Prahani, Iqbal Limatahu, Winata, & Nur, 2016; Rickles, Tieu, Myers, Galal, & Chung, 2009; Triana, Zubainur, & Bahrun, 2019; Woods, Kashinath, & Goldstein, 2004)
2	Model of Teaching	(Alpusari et al., 2019; Lubis, Lubis, & Ashadi, 2018; Spektor-Levy, Eylon, & Scherz, 2008; Yuliardi, 2017)
3	Learning Media	(Elmas, Akin, & Geban, 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland, Noortgate, Vleuten, & Jo, 2012; J. Wang, Guo, & Jou, 2015b; Yang & Heh, 2007; Yuliardi, 2017)
4	Evaluation	(Calhoun, Rider, Peterson, & Meyer, 2010; Dunbar, Brooks, & Kubicka-Miller, 2006; Harasym, Woloschuk, & Cunning, 2008; Hobgood, Riviello, Jouriles, & Hamilton, 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie, Bailey, Aldridge, & Roberts, 1999)

Table 2. The research development related to collaborative skills

No	Scopes	Authors
1	Strategy, Method, Approach	(Khan, 2008; Luo, 2014; McCandliss, Kalchman, & Bryant, 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014)
2	Model of Teaching	(Erika & Prahani, 2017; Liu et al., 2011)
3	Learning Media	(Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018)
4	Evaluation	(Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013)

Another problem that has been encountered especially in experimental-based learning is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not have significant effects in writing practices, however, the student's different abilities are dominated by their adaptability to the technology applied. In the collaboration aspect, gender differences are frequently employed as a determination of a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). When this method is implemented, students tend to be spectators and data writers (like a secretary) during the experimental activities. This result will indirectly affect the students' readiness to be a prospective teacher. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. It is expected that the study can propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with prominent skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than students who conduct experiments by employing the HOT Lab model.

In addition, this study focuses on identifying influences of gender on the experiment-based learning. The assumption that male students are better than female students in terms of experimental activities has a psychological influence on students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are: 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental research method that discussed the effects of the experimental model, HOT Lab, and MSLAM in simultaneously practicing SCS and CS (Ary, Jacobs, Irvine, & Walker, 2018). Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

This study involved 327 students (168 student used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into 10 groups: five groups applied the MSLAM as the experimental class and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on series-parallel circuit on electrical and elasticity.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed in accordance with modern era learning. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the SC instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open minded, respect, and group investigation ability. The instruments were filled by five observers in each university based on a rubric with a range of 1-3 or 1-4 for several indicators.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Sheikh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group conducted an experiment by employing the HOT Lab model as a control class and the other group conducted an experiment by employing the MSLAM model as an experimental class.

The students in the control class did an experiment with 11 stages of HOT Lab while the students in the experiment class did an experiment with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analyzing data, exploration, conclusion, presentation, and evaluation.

MANOVA analysis was employed to determine the contribution of two types of experiment on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables, namely the practicum model and gender. Moreover, gender differences were employed as a review factor in the student's ability. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provide in Table 3. Table 3 shows that the experimental model has a significant influence on SCS and CS shown by the significant value that is less than 0.05. The next analysis employed the Test of Between-Subject Effects data in each skill group as presented in Table 4. This analysis was conducted by referring to intercept and signification values.

Table 4 indicates that intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a less value than 0.05 in SCS and only three subject groups have higher score than 0.05 in CS. Therefore, there are only two subject groups on SCS and seven groups on CS that show a significant effect.

Tabel 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 4. The test of between-subject effects – an experimental model

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.058	0.000	0.068
	Elasticity	0.00	0.013	0.000	0.042
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.184	0.000	0.000
	Elasticity	0.00	0.446	0.000	0.000
UIN Alauddin Makasar	Electric Circuit	0.00	0.851	0.000	0.000
	Elasticity	0.00	0.946	0.000	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.637	0.000	0.006
	Elasticity	0.00	0.003	0.000	0.000
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.112	0.000	0.000
	Elasticity	0.00	0.060	0.000	0.000

Gender Effect

Gender was employed as a factor of analysis. Gender was assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

In Table 5, statistics analysis proved that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are greater than 0.05. Meanwhile, the more calculation is proved in Table 6.

Table 5. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

Table 6. The test of between-subject effects–gender

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.926	0.000	0.793
	Elasticity	0.00	0.395	0.000	0.173
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.182	0.000	0.533
	Elasticity	0.00	0.611	0.000	0.412
UIN Alauddin Makasar	Electric Circuit	0.00	0.706	0.000	0.038
	Elasticity	0.00	0.214	0.000	0.757
IAIN Palangka Raya	Elelctric Circuit	0.00	0.064	0.000	0.540
	Elasticity	0.00	0.164	0.000	0.550
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.422	0.000	0.003
	Elasticity	0.00	0.167	0.000	0.668

Tabel 6 shows that intercept values, in both SCS and CS, are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not bring significant impact to SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the improvement of CS.

The integrated analysis of experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS and CS. Table 7 shows that the p-values of most experimental models are less than 0.05, and it indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

The results of the test of between-subject effects in Table 8 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has small intercept value by 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 7. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

Table 8. The test of between-subject effects –integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.00	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.00	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.00	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.00	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.00	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.00	0.069	0.192	0.000	0.000	0.420

Discussion

The results of the study indicate that the experimental model has significant effects on the improvement of students' SCS and CS that are simultaneously practiced. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; A. Malik, Setiawan, Suhandi, Permanasari, & Sulasman, 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, that is the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity (Zakwandi, Yuningsih, & Setya, 2020). This condition is caused by many factors, and one of them is learning activities as Rubini, et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills (Rubini, Suhartoyo, and Permanasari 2018). Thus, the solution is presenting a variety of activities and providing the students a challenge. Furthermore, most of Indonesian school laboratories have not been optimized. The condition bring several bad impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different abilities to conduct different topics of experiment. The significant average of electrical circuit content is 0.3684 and no subject group has a significant effect. Meanwhile, the average significance of elasticity topic is 0.2936 shown by two significant subject groups. This difference proposes an idea that students have some constraints to conduct experiments on the topic of electrical circuits. Rosidah & Rosdiana (2019) state that students in formal schools in Indonesia consider the electricity topic as a less desirable and difficult topic to learn. However, the students consider elasticity topic easier to learn. Furthermore, the study result shows that CS has more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018) who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing R2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R2 value by 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students, in terms of experiment-based learning, have an equal opportunity to achieve competence. This result comfirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi, He, Wang, & Huan, 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations, for example, female students tend to garrulously work in a minority condition of a group while male students are talkative when they work independently. Shi et al. (2015) add that female students are more likely to play a supporting role while male students more play a prominent role when they collaborate in experimental activities. Furthermore, the results of R2 show a very weak correlations between gender and SCS on electrical circuits topic by 0.02, between gender and SCS on elasticity topic by 0.13, between gender and CS on electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is not suitable because it leads to inconsistent significance values that are possibly caused by several factors including types of variables. The experimental model is an external factor that can be managed in certain ways while gender is an internal factor that cannot be controlled at all. However, indicators that are likely influenced by gender, such as motivation and perspective, can be managed.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each group of subjects. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that specifically measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can give more positive impacts than the HOT Lab. Overall, the communication and collaboration skills improved after conducting the experimental model. The results of the analysis reveal that the experimental aspect shows more significant impacts on the improvement of scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving the collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires more empowerment. The students have a more adaptive learning experience and compatible with the current conditions. Moreover, further research developing an appropriate assessment instrument requires to consider.

ACKNOWLEDGEMENTS

This research was financially supported by the Ministry of Religious Affairs of the Republic of Indonesia via the Directorate General of Islamic Education through the 1967 Grant in 2019 regarding the recipients of global/international applied research assistance in 2019 fiscal to facilitate and fund this research.

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Ministry of Education, Culture, Research and Technology
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FACULTY OF MATHEMATICS AND NATURAL SCIENCES
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IN COLLABORATION WITH PERKUMPULAN PENDIDIK IPA INDONESIA
JURNAL PENDIDIKAN IPA INDONESIA
p-ISSN: 2339-1286; e-ISSN: 2089-4392
Nationally Accredited Decree of The Minister of Education, Culture, Research and Technology No. 2/E/KPT/2015
SCOPUS INDEXED AND Q2 SCIMAGOJR
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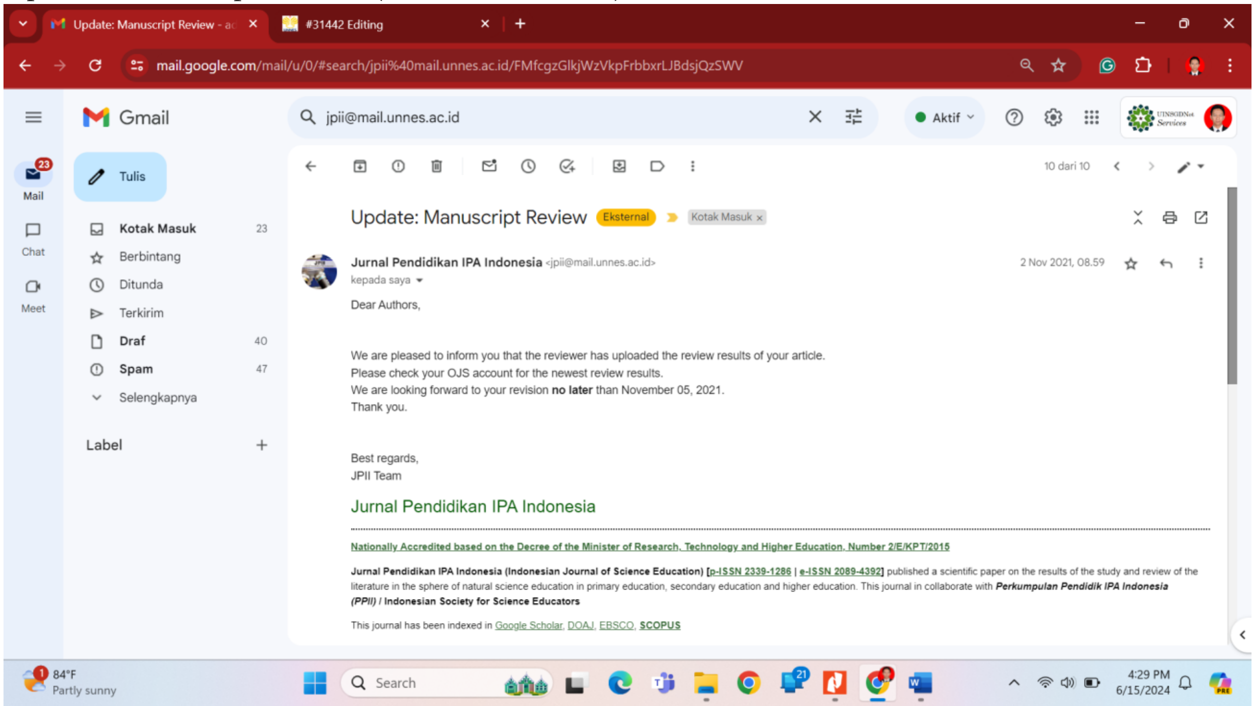

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Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills

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ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 student used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous ability and learning habits who were from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher Order Thinking Laboratory model while the experimental class conducted activities based on the Multiple Skill Laboratory Activity Model. The data of this study were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on the improvement of students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model is more effective to improve student's collaboration skills than communication skills. Moreover, this study reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide a reference of methods for further researchers to optimize students' scientific communication skills and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The very fast dissemination of information and easy access to information from various sources have become the characteristic of the 21st century including education in the 21st century. Nowadays, students can easily access various learning resources that teachers probably do not access. In addition, students and teachers can easily share their findings through various platforms, free or paid platforms. On the basis of the second case, an additional skill is needed to enable students and teachers to convey their findings appropriately. Such an ability is called Scientific Communication Skills (SCS) that become one of the most important competencies in the 21st century (Alpusari, Mulyani, Putra, Widyanthi, & Hermita, 2019; Chung, Yoo, Kim, Lee, & Zeidler, 2016; Gordon & Martin, 2019; Siddiq, Scherer, & Tondeur, 2016; van Laar, van Deursen, van Dijk, & de Haan, 2017) and the scientific contributions have increasingly been accepted in the society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger, Christie, & Carey, 2019; Hansen, Carnett, & Tullis, 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various concepts of physics and to simplify the explanation of the results of complex research (Dannels, Anson, Bullard, & Peretti, 2003; Saleh, Barghuthi, & Baker, 2017). In addition, nowadays, students are in the globalization era that highly demands the ability to convey ideas to the public. However, Table 1 shows that communication skills have not received much attention, especially in the laboratory learning environment.

Table 1 shows that previous studies still generally investigate the issues and have not optimized the experimental learning. SCS is also proved more effectively practiced by employing an experimental-based learning and other experimental models that involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings (Adam Malik et al., 2018; Sapriadil et al., 2019; X. Wang, Schneider, & Valacich, 2015; Yang & Heh, 2007). The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allow students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia, Maneira, Ribeiro, & Maneira, 2009; J. Wang, Guo, & Jou, 2015a). Like SCS, CS is also necessary in the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' ability. However, several efforts to effectively practice CS have started to develop. At least, there are four major scopes as the focus of CS development as shown in Table 2.

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes, Bradford, & Likens, 2018), with creative thinking (J. W. Chang, Wang, Lee, Su, & Chang, 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to investigate experimental-based learning that trains and develops SCS and CS at the same time.

Table 1. The research developments related to scientific communication skills

No	Scopes	Authors
1	Strategy, Method, Approach	(Atasoy, 2013; Chen, Chung, & Wu, 2013; Patent No. U.S Patent 5.387.104, 1995; Hošková-Mayerová, 2014; Klochkova, Komochkina, & Mustafina, 2016; Kusumawati, Marwoto, & Linuwih, 2015; Novita, 2010; Patriot, Suhandi, & Chandra, 2018; Prahani, Iqbal Limatahu, Winata, & Nur, 2016; Rickles, Tieu, Myers, Galal, & Chung, 2009; Triana, Zubainur, & Bahrun, 2019; Woods, Kashinath, & Goldstein, 2004)
2	Model of Teaching	(Alpusari et al., 2019; Lubis, Lubis, & Ashadi, 2018; Spektor-Levy, Eylon, & Scherz, 2008; Yuliardi, 2017)
3	Learning Media	(Elmas, Akin, & Geban, 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland, Noortgate, Vleuten, & Jo, 2012; J. Wang, Guo, & Jou, 2015b; Yang & Heh, 2007; Yuliardi, 2017)
4	Evaluation	(Calhoun, Rider, Peterson, & Meyer, 2010; Dunbar, Brooks, & Kubicka-Miller, 2006; Harasym, Woloschuk, & Cunning, 2008; Hobgood, Riviello, Jouriles, & Hamilton, 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie, Bailey, Aldridge, & Roberts, 1999)

Commented [U1]: INTRODUCTION should:
• contain urgency (importance) to research
• contain a carrying capacity in the form of supporting data and facts
• contain a preliminary study as a basis for the importance of the research conducted
• contain a GAP ANALYSIS Departing from the preliminary study, analysis of published articles formulated in the Gap analysis
GAP ANALYSIS refers to articles published in various internationally reputable journals to emphasize the novelty of research.
• clear limitation of research objectives

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Table 2. The research development related to collaborative skills

No	Scopes	Authors
1	Strategy, Method, Approach	(Khan, 2008; Luo, 2014; McCandliss, Kalchman, & Bryant, 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014)
2	Model of Teaching	(Erika & Prahani, 2017; Liu et al., 2011)
3	Learning Media	(Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018)
4	Evaluation	(Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013)

Another problem that has been encountered especially in experimental-based learning is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not have significant effects in writing practices, however, the student's different abilities are dominated by their adaptability to the technology applied. In the collaboration aspect, gender differences are frequently employed as a determination of a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). When this method is implemented, students tend to be spectators and data writers (like a secretary) during the experimental activities. This result will indirectly affect the students' readiness to be a prospective teacher. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. It is expected that the study can propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with prominent skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than students who conduct experiments by employing the HOT Lab model.

In addition, this study focuses on identifying influences of gender on the experiment-based learning. The assumption that male students are better than female students in terms of experimental activities has a psychological influence on students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are: 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental research method that discussed the effects of the experimental model, HOT Lab, and MSLAM in simultaneously practicing SCS and CS (Ary, Jacobs, Irvine, & Walker, 2018). Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

This study involved 327 students (168 student used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into 10 groups: five groups applied the MSLAM as the experimental class and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on series-parallel circuit on electrical and elasticity.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed in accordance with modern era learning. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the SC instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open minded, respect, and group investigation ability. The instruments were filled by five observers in each university based on a rubric with a range of 1-3 or 1-4 for several indicators.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Sheikh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group conducted an experiment by employing the HOT Lab model as a control class and the other group conducted an experiment by employing the MSLAM model as an experimental class.

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• contain detailed research stages
• Each stage is explained and analyzed by what method
• Data analysis must be with clear references
• The research instruments used were elaborated to the data analysis technique
• It is hoped that there will be a modification in the stages of research from sources referred by the researcher

The students in the control class did an experiment with 11 stages of HOT Lab while the students in the experiment class did an experiment with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analyzing data, exploration, conclusion, presentation, and evaluation.

MANOVA analysis was employed to determine the contribution of two types of experiment on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables, namely the practicum model and gender. Moreover, gender differences were employed as a review factor in the student's ability. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provide in Table 3. Table 3 shows that the experimental model has a significant influence on SCS and CS shown by the significant value that is less than 0.05. The next analysis employed the Test of Between-Subject Effects data in each skill group as presented in Table 4. This analysis was conducted by referring to intercept and signification values.

Table 4 indicates that intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a less value than 0.05 in SCS and only three subject groups have higher score than 0.05 in CS. Therefore, there are only two subject groups on SCS and seven groups on CS that show a significant effect.

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- •Tables or graphs (one selected) must represent different results
- •The results of data analysis must be strong in answering the analysis gap
- •Display of results other than those narrated in table-graph-image-modeling
- •The research novelty has not been clear enough
- •It is recommended not to repeat the references in the introduction, using previous research findings.
- •References used should be taken from reputable journals.
- •It is necessary to explain the specifications of the findings in this study that show

Tabel 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

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2. The pictures/tables must not be consecutive.

Table 4. The test of between-subject effects – an experimental model

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.058	0.000	0.068
	Elasticity	0.00	0.013	0.000	0.042
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.184	0.000	0.000
	Elasticity	0.00	0.446	0.000	0.000
UIN Alauddin Makasar	Electric Circuit	0.00	0.851	0.000	0.000
	Elasticity	0.00	0.946	0.000	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.637	0.000	0.006
	Elasticity	0.00	0.003	0.000	0.000
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.112	0.000	0.000
	Elasticity	0.00	0.060	0.000	0.000

Gender Effect

Gender was employed as a factor of analysis. Gender was assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

In Table 5, statistics analysis proved that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are greater than 0.05. Meanwhile, the more calculation is proved in Table 6.

Table 5. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

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2. The pictures/tables must not be consecutive.

Table 6. The test of between-subject effects–gender

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.926	0.000	0.793
	Elasticity	0.00	0.395	0.000	0.173
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.182	0.000	0.533
	Elasticity	0.00	0.611	0.000	0.412
UIN Alauddin Makasar	Electric Circuit	0.00	0.706	0.000	0.038
	Elasticity	0.00	0.214	0.000	0.757
IAIN Palangka Raya	Elelctric Circuit	0.00	0.064	0.000	0.540
	Elasticity	0.00	0.164	0.000	0.550
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.422	0.000	0.003
	Elasticity	0.00	0.167	0.000	0.668

Tabel 6 shows that intercept values, in both SCS and CS, are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not bring significant impact to SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the improvement of CS.

The integrated analysis of experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS and CS. Table 7 shows that the p-values of most experimental models are less than 0.05, and it indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

The results of the test of between-subject effects in Table 8 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has small intercept value by 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 7. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

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2. The pictures/tables must not be consecutive.

Table 8. The test of between-subject effects –integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.00	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.00	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.00	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.00	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.00	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.00	0.069	0.192	0.000	0.000	0.420

Discussion

The results of the study indicate that the experimental model has significant effects on the improvement of students' SCS and CS that are simultaneously practiced. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; A. Malik, Setiawan, Suhandi, Permanasari, & Sulasman, 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, that is the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity (Zakwandi, Yuningsih, & Setya, 2020). This condition is caused by many factors, and one of them is learning activities as Rubini, et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills (Rubini, Suhartoyo, and Permanasari 2018). Thus, the solution is presenting a variety of activities and providing the students a challenge. Furthermore, most of Indonesian school laboratories have not been optimized. The condition bring several bad impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different abilities to conduct different topics of experiment. The significant average of electrical circuit content is 0.3684 and no subject group has a significant effect. Meanwhile, the average significance of elasticity topic is 0.2936 shown by two significant subject groups. This difference proposes an idea that students have some constraints to conduct experiments on the topic of electrical circuits. Rosidah & Rosdiana (2019) state that students in formal schools in Indonesia consider the electricity topic as a less desirable and difficult topic to learn. However, the students consider elasticity topic easier to learn. Furthermore, the study result shows that CS has more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018) who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing R2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R2 value by 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students, in terms of experiment-based learning, have an equal opportunity to achieve competence. This result comfirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi, He, Wang, & Huan, 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations, for example, female students tend to garrulously work in a minority condition of a group while male students are talkative when they work independently. Shi et al. (2015) add that female students are more likely to play a supporting role while male students more play a prominent role when they collaborate in experimental activities. Furthermore, the results of R2 show a very weak correlations between gender and SCS on electrical circuits topic by 0.02, between gender and SCS on elasticity topic by 0.13, between gender and CS on electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is not suitable because it leads to inconsistent significance values that are possibly caused by several factors including types of variables. The experimental model is an external factor that can be managed in certain ways while gender is an internal factor that cannot be controlled at all. However, indicators that are likely influenced by gender, such as motivation and perspective, can be managed.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each group of subjects. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that specifically measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can give more positive impacts than the HOT Lab. Overall, the communication and collaboration skills improved after conducting the experimental model. The results of the analysis reveal that the experimental aspect shows more significant impacts on the improvement of scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving the collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires more empowerment. The students have a more adaptive learning experience and compatible with the current conditions. Moreover, further research developing an appropriate assessment instrument requires to consider.

ACKNOWLEDGEMENTS

This research was financially supported by the Ministry of Religious Affairs of the Republic of Indonesia via the Directorate General of Islamic Education through the 1967 Grant in 2019 regarding the recipients of global/international applied research assistance in 2019 fiscal to facilitate and fund this research.

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Commented [U14]: 1. Please provide at least **30 references** which 80% of them are taken from **the last 10 years (>2011)** articles of no-predatory journals, written in accordance with the APA Standard. You may go to Google Scholar and find the right format for APA Style provided.

2. For books, please refer to the original/primary book reference no matter the date.

3. All of the listed references must be cited in the body of the article, and vice versa.

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Paper title: **Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills**

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?	√				
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?		√			
	• Is research question of the study clear and understandable?		√			
	• Does the rationale of the study clearly explained using relevant literature?		√			
	• Is the "aim" of the manuscript clear and understandable?		√			
Methods	• Is the methodology chosen suitable to the nature of the topic studied?		√			
	• Is the methodology of the research described clearly?(including study design, location, subjects, data collection, data analysis)		√			
	• Is there adequate information about the data collection tools used? (only for empirical studies)		√			
	• Are the validity and reliability of data collection tools established? (only for empirical studies)		√			
	• Are the data collection tools suitable for the methodology of the study? (only for empirical studies)		√			
Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?		√			
	• Do the data analysis and the interpretation appropriate to the problem and answer the objectives?		√			
	• Does the "discussion" section of the manuscript adequately relate to the current and relevant litarature?		√			
	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
Conclusion	• Is the conclusion clear and in the form of a narration instead of pointers?		√			
	• Isn't the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√		Please provide at least **30 references** which 80% of them are taken from **the last 10 years (>2011)** articles	

					of no-predatory journals	
	• Are the writing of references correct?		√			
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?		√			
	• The quality of the language is satisfactory		√			
	• The work relevant and novel		√			
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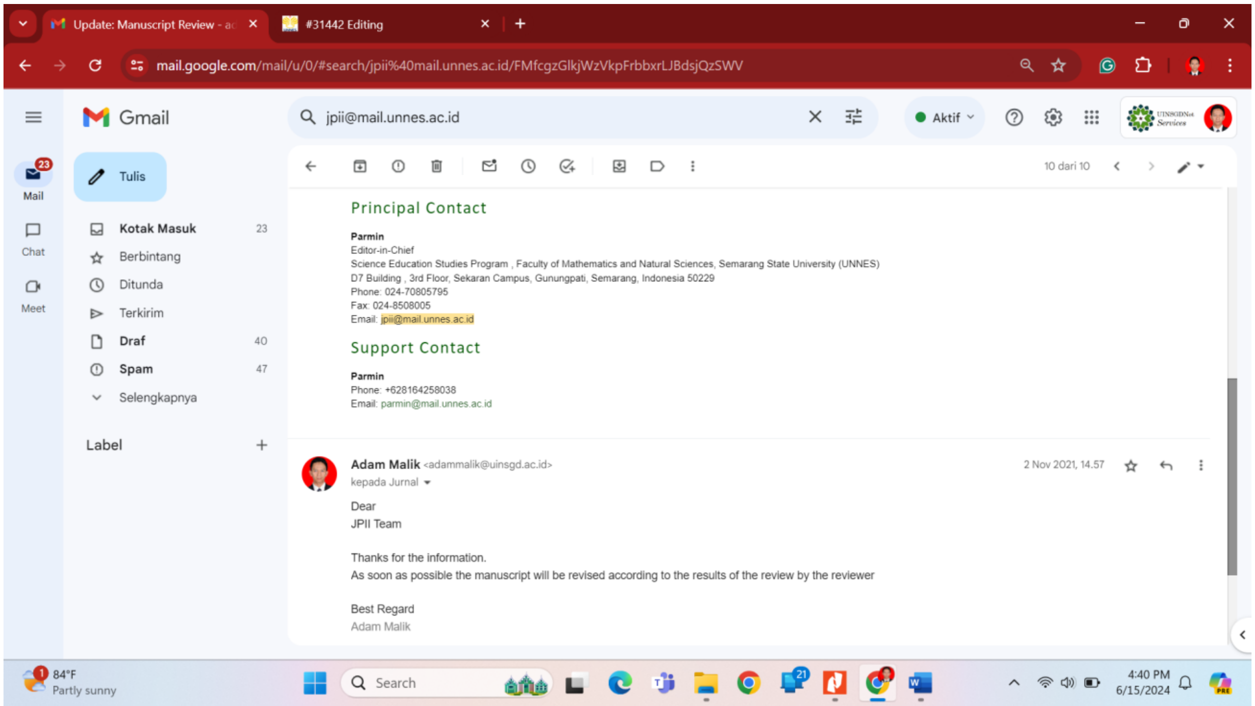
4. Revision Peper (2 November)



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Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills

DOI:

Accepted:... .Approved: ... . Published: ...

ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with the heterogeneous ability and learning habits who were from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher Order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skill Laboratory Activity Model. The data of this study were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model improves students' collaboration skills than communication skills. Moreover, this study reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The fast dissemination of information and easy access to information from various sources has become the characteristic of the 21st century, including education in the 21st century. Nowadays, students can easily access various learning resources that teachers probably do not access. In addition, students and teachers can easily share their findings through various platforms, free or paid platforms. Based on the second case, an additional skill is needed to enable students and teachers to convey their findings appropriately. Such an ability is called Scientific Communication Skills (SCS), that become one of the essential competencies in the 21st century (Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017) and the scientific contributions have increasingly been accepted in the society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the results of complex research (Dannels et al., 2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study showed that communication skills consistently failed to teach science students more than analytical, technical, and problem-solving skills together (Gray et al., 2005). Graduates did not consistently display communication skills when job recruitment (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study showed that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems(Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020)

Previous studies still generally investigate the issues and have not optimized the experimental learning. Researches focused on developing learning strategies, methods, and approaches to improve HOTs (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). In addition, the researchers also focused on improving the model of teaching (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) and learning media (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) or evaluation (Calhoun et al., 2010; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

While SCS and other thinking skills are proved more effectively practiced by employing experimental-based learning (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia et al., 2009; Wang et al., 2015). Like SCS, CS is also necessary for the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' abilities. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategi (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), model of teaching (Erika & Prahani, 2017; Liu et al., 2011), learning media (Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018) and learning evaluation(Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013)

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (J. W. Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to

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GAP ANALYSIS refers to articles published in various internationally reputable journals to emphasize the novelty of research.
• clear limitation of research objectives

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4.research that constructs the combination of communication and collaboration skills is still rarely conducted., Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women

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investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the student's different abilities are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with prominent skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model.

In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental research method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Sheikh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as a control class, and the other group experimented by employing the MSLAM model as an experimental class.

In this study, participants carry out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the ability of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final abilities of the participants.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open-mindedness, respect, and group investigation ability. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring student abilities.

The students in the control class experimented with 11 stages of the HOT Lab, while the students in the experiment class experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment,

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- Data analysis must be with clear references
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2. We focused on analysis of students result, while the data is taken by observation of student competences
3. Data analysis is provided in the las paragraph.
4. We apologies that we not modified any stage of research model. This research adopt all of stage in quasi-experiment, while the learning module used modified form previous research

exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation. MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables, namely the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the student's ability. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

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Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provided in Table 3.

Tabel 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 3 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Table 4. This analysis was conducted by referring to intercept and signification values.

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Table 4. The test of between-subject effects – an experimental model

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.058	0.000	0.068
	Elasticity	0.00	0.013	0.000	0.042
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.184	0.000	0.000
	Elasticity	0.00	0.446	0.000	0.000
UIN Alauddin Makasar	Electric Circuit	0.00	0.851	0.000	0.000
	Elasticity	0.00	0.946	0.000	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.637	0.000	0.006
	Elasticity	0.00	0.003	0.000	0.000
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.112	0.000	0.000
	Elasticity	0.00	0.060	0.000	0.000

Table 4 indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender Effect

Gender was employed as a factor of analysis. Gender was assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 5. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117

	Value	F	sig.
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 5, statistics analysis proved that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Table 6.

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Table 6. The test of between-subject effects–gender

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.926	0.000	0.793
	Elasticity	0.00	0.395	0.000	0.173
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.182	0.000	0.533
	Elasticity	0.00	0.611	0.000	0.412
UIN Alauddin Makasar	Electric Circuit	0.00	0.706	0.000	0.038
	Elasticity	0.00	0.214	0.000	0.757
IAIN Palangka Raya	Elelctric Circuit	0.00	0.064	0.000	0.540
	Elasticity	0.00	0.164	0.000	0.550
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.422	0.000	0.003
	Elasticity	0.00	0.167	0.000	0.668

Tabel 6 shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the improvement of CS

The integrated analysis of the experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS, and CS Table 7 shows that the p-values of most experimental models are less than 0.05. It indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS

Table 7. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

The test results of between-subject effects in Table 8 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it

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is stated that in SCS, the experimental model is more influential than gender.

Table 8. The test of between-subject effects –integrated analysis

Subject Groups	Content	SCS Intercept	SCS Exp.	SCS Gender	CS Intercept	CS Exp.	CS Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.00	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.00	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.00	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.00	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.00	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.00	0.069	0.192	0.000	0.000	0.420

Discussion

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020) Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different abilities to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah & Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve student CS better than SCS simultaneously. While the result also shows that student SCS can not be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each group of subjects. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improved after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research developing an appropriate assessment instrument requires to consider.

ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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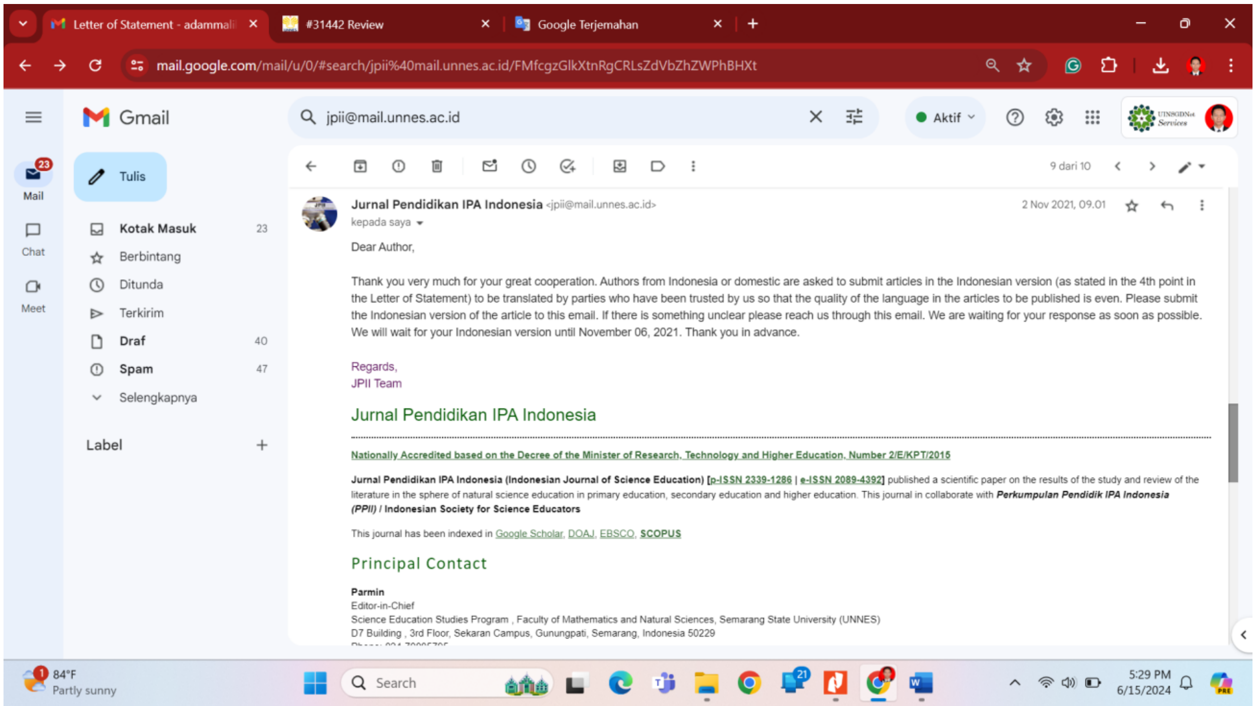

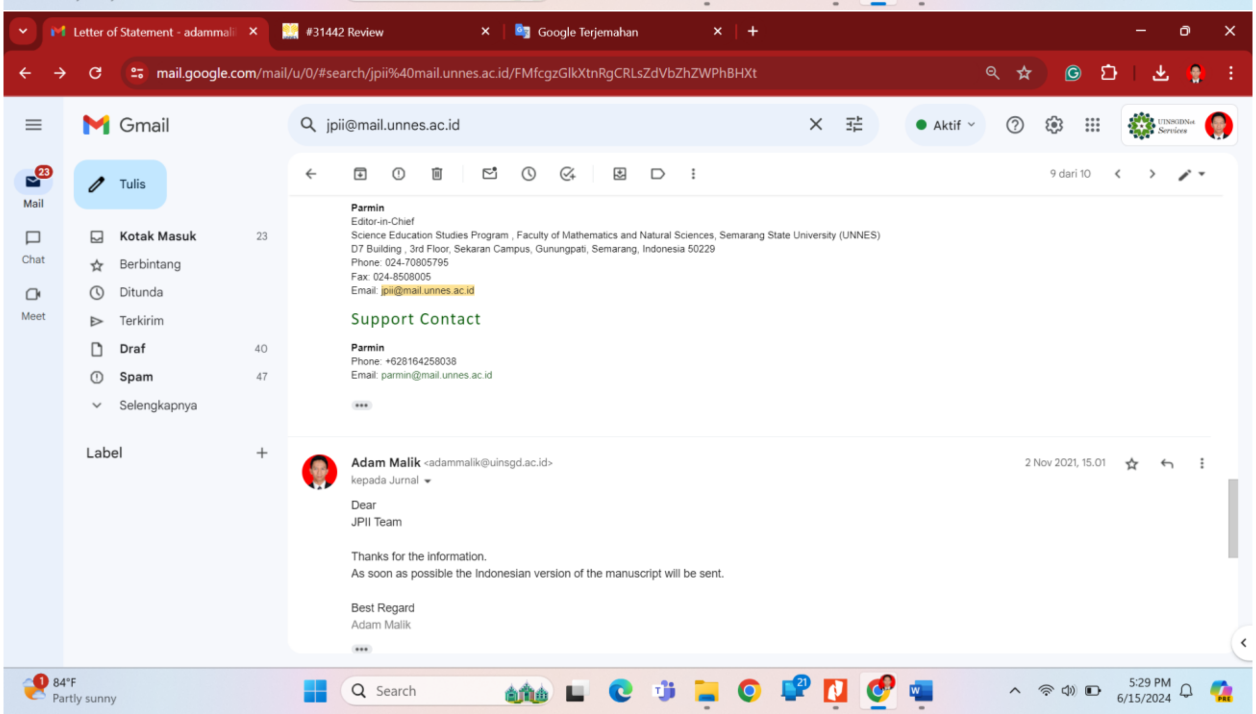

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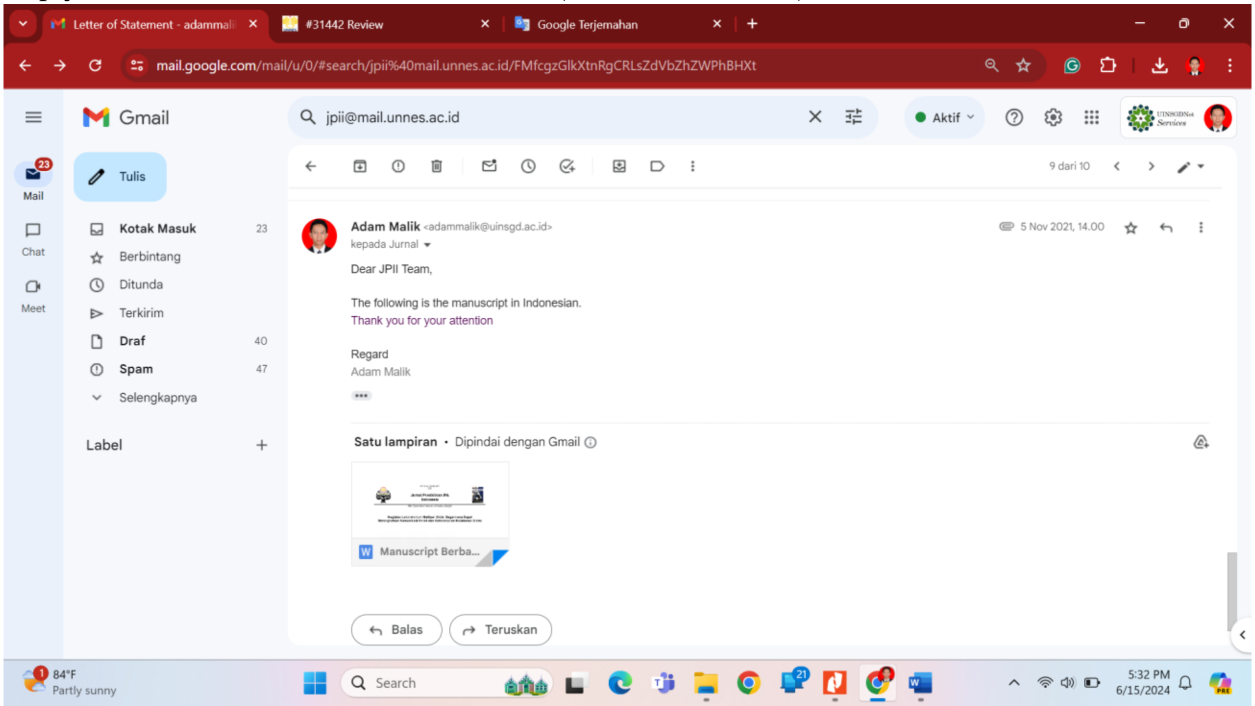

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ABSTRACT

Penelitian ini bertujuan untuk menganalisis pengaruh model eksperimen dan gender terhadap keterampilan komunikasi dan kolaborasi ilmiah. Penelitian ini menggunakan kuasi-eksperimen desain yang terdiri dari lima kelompok sebagai kelas kontrol dan lima kelompok sebagai kelas eksperimen. Subjek penelitian ini adalah 327 siswa (168 siswa menggunakan HOT Lab dan 159 menggunakan *Multiple Skill*; 69 Laki-laki dan 258 Perempuan berusia 18 sampai 22 tahun) dengan kemampuan dan kebiasaan belajar yang heterogen yang berasal dari lima universitas berbeda yang mewakili empat wilayah: Sumatera , Jawa, Kalimantan, dan Sulawesi. Kelas kontrol melakukan kegiatan berdasarkan model *Higher Order Thinking Laboratory*, sedangkan kelas eksperimen melakukan kegiatan berdasarkan Model Aktivitas Laboratorium *Multiple Skill*. Data penelitian ini dikumpulkan dengan menggunakan instrumen yang telah divalidasi dan dianalisis dengan menggunakan uji Multivariat. Penelitian ini menunjukkan bahwa model eksperimen memiliki pengaruh yang lebih signifikan berpengaruh pada peningkatan keterampilan siswa daripada jenis kelamin. Secara khusus, Model Kegiatan Laboratorium *Multiple Skill* meningkatkan keterampilan kolaborasi siswa daripada keterampilan komunikasi. Selain itu, penelitian ini mengungkapkan bahwa model eksperimen dan gender tidak cocok untuk analisis bersamaan. Penelitian ini diharapkan dapat memberikan metode bagi peneliti selanjutnya untuk mengoptimalkan kemampuan komunikasi dan kolaborasi ilmiah mahasiswa. Selanjutnya, penelitian ini memberikan gambaran bagi guru untuk melatih beberapa keterampilan berpikir dalam satu waktu.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

Penyebaran informasi yang cepat dan kemudahan akses informasi dari berbagai sumber telah menjadi ciri abad 21, termasuk pendidikan di abad 21. Saat ini, siswa dapat dengan mudah mengakses berbagai sumber belajar yang mungkin tidak dapat diakses oleh guru. Selain itu, siswa dan guru dapat dengan mudah membagikan temuannya melalui berbagai platform, baik platform gratis maupun berbayar. Selain itu, diperlukan keterampilan tambahan agar siswa dan guru dapat menyampaikan temuannya dengan tepat. Kemampuan seperti itu disebut *Scientific Communication Skills* (SCS), yang menjadi salah satu kompetensi penting di abad 21(Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017). SCS memberikan kontribusi ilmiah sehingga dapat diterima di masyarakat. SCS mendorong siswa untuk menyampaikan fakta dan argumen serta penjelasan berbasis data (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Selain itu, SCS diperlukan untuk menjelaskan berbagai konsep fisika dan menyederhanakan penjelasan hasil penelitian yang kompleks (Dannels et al., 2003; Saleh et al., 2017. Selain itu, saat ini mahasiswa berada di era globalisasi yang menuntut untuk menyampaikan gagasan kepada masyarakat. Namun, keterampilan komunikasi belum banyak mendapat perhatian terutama di lingkungan pembelajaran laboratorium.

Sebuah studi menunjukkan bahwa keterampilan komunikasi secara konsisten gagal ditunjukkan oleh siswa sains dari pada keterampilan analitis, teknis, dan pemecahan masalah (Gray et al., 2005). Lulusan tidak secara konsisten menampilkan keterampilan komunikasi saat perekrutan kerja (McInnis et al., 2000). Tempat kerja modern mengeluh bahwa lulusan sains tidak dapat memenuhi persyaratan komunikasi yang baik (Herok et al., 2013). Mempelajari cara berkolaborasi jarang dianggap sebagai capaian hasil pendidikan (Liebech-Lien & Sjølie, 2021). Studi lain menunjukkan bahwa mempraktikkan keterampilan komunikasi sains pada calon sarjana bermanfaat bagi individu dan masyarakat (Besley & Tanner, 2011). Siswa perlu berlatih komunikasi ilmiah untuk memecahkan masalah ilmiah dan sosial (Bray et al., 2012), keterampilan kolaborasi meningkatkan efikasi diri, dan kesempatan untuk bekerja dengan mitra luar negeri untuk calon guru (Hur et al., 2020).

Penelitian-penelitian sebelumnya umumnya masih menginvestigasi permasalahan tersebut dan belum mengoptimalkan pembelajaran eksperimental. Penelitian difokuskan pada pengembangan strategi, metode, dan pendekatan pembelajaran untuk meningkatkan HOT (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). Selain itu, peneliti juga fokus pada perbaikan model pembelajaran (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) dan media pembelajaran (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) atau evaluasi (Calhoun et al., 2010 ; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

Sementara itu, SCS dan keterampilan berpikir lainnya terbukti lebih efektif dipraktikkan dengan menggunakan pembelajaran berbasis eksperimen (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), pembelajaran berbasis eksperimen dan model eksperimen lainnya melibatkan siswa untuk mengamati fenomena, menelusuri penyebab, menguji hipotesis, menafsirkan, menganalisis, dan menjelaskan temuan.

Model eksperimen memungkinkan siswa untuk mempraktekkan SCS dan keterampilan kolaborasi (CS) secara bersamaan yang ditunjukkan oleh aktivitas eksperimental yang memungkinkan siswa untuk bekerja dalam kelompok (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson , 1992; Silvia et al., 2009; Wang et al., 2015). Seperti SCS, CS juga diperlukan untuk abad ke-21 (García, 2016) untuk memfasilitasi siswa untuk berkolaborasi bahkan dengan orang asing.

CS, dalam kondisi yang sama dengan SCS, masih kurang mendapat perhatian dalam proses pembelajaran . Sebagian besar sekolah masih mengutamakan persaingan antar siswa sebagai upaya untuk meningkatkan hasil belajarnya. Akibatnya, sering terjadi perbedaan yang signifikan dalam kemampuan siswa. Namun, beberapa upaya untuk mempraktikkan CS secara efektif sudah mulai berkembang. Setidaknya ada empat ruang lingkup yang signifikan sebagai fokus pengembangan CS yaitu strategi pembelajaran (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), model pembelajaran (Erika & Prahani, 2017;. Liu et al, 2011), media pembelajaran (Ardhyani & Khoiri, 2017; Ayd ı n, 2016; Rosidah & Rosdiana, 2019;. Rubini et al, 2018) dan evaluasi pembelajaran (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Penelitian tentang CS sering menggabungkan perlakuan dengan keterampilan lain: dengan keterampilan berpikir kritis (Hughes et al.,

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• contain urgency (importance) to research
• contain a carrying capacity in the form of supporting data and facts
• contain a preliminary study as a basis for the importance of the research conducted
• contain a GAP ANALYSIS Departing from the preliminary study, analysis of published articles formulated in the Gap analysis
GAP ANALYSIS refers to articles published in various internationally reputable journals to emphasize the novelty of research.
• clear limitation of research objectives

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2.We provide previous research results in the text and highlighted in green
3.We provide previous research results in the text and highlighted in green
4.research that constructs the combination of communication and collaboration skills is still rarely conducted., Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women

2018), dengan pemikiran kreatif (JW Chang et al., 2016) dengan hasil belajar (García, 2016), dan dengan keterampilan argumentasi dan efikasi diri (Erika & Prahani, 2017). Namun, penelitian yang mengkonstruksi kombinasi keterampilan komunikasi dan kolaborasi masih jarang dilakukan. Oleh karena itu, penelitian ini bertujuan untuk menyelidiki pembelajaran berbasis eksperimen yang melatih dan mengembangkan SCS dan CS secara bersamaan.

Masalah lain yang telah ditemui, terutama dalam pembelajaran berbasis eksperimen, adalah konsekuensi gender. Stereotip yang mengakar dalam masyarakat mempercayai bahwa siswa laki-laki memiliki kemampuan lebih baik dari siswa perempuan. Berdasarkan penenlitian sebelumnya menunjukkan laki-laki lebih baik dalam bekerja dengan teknologi daripada wanita (Crymble, 2016). Selanjutnya, keberadaan gender tidak selalu memberikan perbedaan yang signifikan dalam meningkatkan hasil belajar. Menurut Brodahl (2011), jenis kelamin tidak signifikan mempengaruhi menulis praktek. Namun, kemampuan siswa yang berbeda didominasi oleh adaptasi mereka untuk teknologi yang diterapkan. Bekerja sama, perbedaan gender sering digunakan untuk menentukan divisi tugas kelompok, terutama karya-karya kelompok yang membutuhkan keterampilan fisik (Adolphus & Omeodu, 2016). Siswa cenderung menjadi penonton dan penulis data (seperti sekretaris) ketika metode ini diterapkan selama kegiatan eksperimental. Hasil ini secara tidak langsung akan mempengaruhi kesiapan siswa untuk menjadi calon guru. Oleh karena itu, penelitian ini menggunakan gender sebagai faktor untuk mengevaluasi efek gender pada kemampuan siswa.

Penelitian ini berfokus pada penentuan peningkatan simultan SCS dan CS yang dipraktikkan dengan mengimplementasikan dua model eksperimen, HOT Lab dan MSLAM. Penelitian ini bertujuan untuk mengetahui kesiapan setiap model eksperimen untuk melatih dua atau lebih keterampilan berpikir secara bersamaan. Kajian ini diharapkan dapat memberikan gambaran model kesiapan dan mungkin memberikan refleksi untuk perbaikan model di masa yang akan datang. Dengan demikian, proses pembelajaran menjadi lebih efisien dan berhasil menyiapkan output atau profil lulusan dengan keterampilan yang menonjol. Peneliti berhipotesis bahwa siswa yang melakukan eksperimen dengan mengadopsi model MSLAM akan memiliki SCS dan CS yang lebih baik daripada mereka yang menggunakan model HOT Lab.

Selain itu, penelitian ini berfokus untuk mengidentifikasi pengaruh gender terhadap pembelajaran berbasis eksperimen. Asumsi bahwa siswa laki-laki lebih baik daripada siswa perempuan dalam hal kegiatan eksperimen secara psikologis mempengaruhi sudut pandang siswa dan guru. Oleh karena itu, penelitian ini diharapkan dapat mendeskripsikan efek dari perbedaan gender. Para peneliti berhipotesis bahwa tidak ada perbedaan yang signifikan antara siswa laki-laki dan siswa perempuan. Rumusan masalah penelitian ini adalah 1) Bagaimana pengaruh Model HOT Lab dan MSLAM secara simultan terhadap peningkatan SCS dan CS? 2) Apakah gender mempengaruhi praktik SCS dan CS secara simultan?

METHODS

Penelitian ini menggunakan metode penelitian *quasi-experimental* yang membahas tentang pengaruh model eksperimen HOT Lab dan MSLAM dalam mempraktikkan SCS dan CS secara bersamaan (Ary et al., 2018). Selanjutnya, gender digunakan sebagai faktor tinjauan untuk menentukan pengaruhnya terhadap pembelajaran eksperimental, terutama pada berlatih SCS dan CS pada satu waktu.

Penelitian ini melibatkan 327 siswa (168 siswa menggunakan HOT Lab dan 159 menggunakan *Multiple Skill*; 69 Laki-laki dan 258 Perempuan berusia 18 sampai 22 tahun), dan mereka dibagi menjadi sepuluh kelompok: lima kelompok menerapkan MSLAM sebagai kelas eksperimen, dan lima kelompok kelompok menerapkan HOT Lab sebagai kelas kontrol. Semua kelompok melakukan percobaan terkait konten rangkaian seri-paralel pada kelistrikan dan elastisitas.

Penelitian ini dilaksanakan pada bulan Mei 2019 hingga Juli 2020 dengan mempraktikkan HOT Lab dan MSLAM kepada mahasiswa pendidikan fisika dari lima universitas yang mewakili empat wilayah di Indonesia. Mereka adalah Jawa (UIN Sunan Gunung Dajti Bandung dan IAIN Syekh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), dan Sulawesi (UIN Alauddin Makassar). Para siswa memiliki keterampilan akademik dan pengalaman laboratorium yang heterogen. Di setiap universitas, mahasiswa dibagi menjadi dua kelompok: satu kelompok bereksperimen dengan menggunakan model HOT Lab sebagai kelas kontrol, dan kelompok lainnya bereksperimen dengan menggunakan model MSLAM sebagai kelas eksperimen.

Dalam penelitian ini, peserta melakukan kegiatan percobaan sesuai petunjuk praktikum masing-masing. Selama pelaksanaan, dilakukan observasi untuk memperoleh informasi tentang kemampuan kolaborasi dan komunikasi ilmiah.

Lembar penilaian yang digunakan untuk mengumpulkan data terdiri dari penilaian SCS dan CS. Rubrik penilaian yang digunakan dikembangkan mengikuti pembelajaran modern. SCS instrumen terdiri dari tiga aspek: penulisan ilmiah, perwakilan informasi, dan presentasi pengetahuan. Sementara itu, instrumen CS terdiri dari tujuh indikator: kontribusi, kerja kelompok, tanggung jawab, pemecahan masalah, keterbukaan pikiran, rasa hormat, dan

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• contain detailed research stages
• Each stage is explained and analyzed by what method
• Data analysis must be with clear references
• The research instruments used were elaborated to the data analysis technique
• It is hoped that there will be a modification in the stages of research from sources referred by the researcher

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1. Research stage in provided in 4th paragraph
2. We focused on analysis of students result, while the data is taken by observation of student competences
3. Data analysis is provided in the las paragraph.
4. We apologies that we not modified any stage of research model. This research adopt all of stage in quasi-experiment, while the learning module used modified form previous research

kemampuan investigasi kelompok. Lima pengamat di masing-masing universitas mengisi instrumen didasarkan pada rubrik dengan berbagai 1-3 atau 1-4 untuk beberapa indikator. Semua instrumen divalidasi oleh penilaian ahli dan direkomendasikan digunakan untuk mengukur kemampuan siswa.

Siswa kelas kontrol bereksperimen dengan 11 tahap HOT Lab, sedangkan siswa di kelas eksperimen bereksperimen dengan 15 tahap MSLAM. Tahapan HOT Lab terdiri dari masalah dunia nyata, pertanyaan eksperimental, solusi alternatif, pertanyaan konseptual, prediksi, alat dan bahan, eksplorasi, pengukuran, analisis data, menjawab prediksi, dan presentasi. Sedangkan tahapan MSLAM terdiri dari orientasi masalah, brainstorming, alternatif ide, diskusi, pertanyaan konseptual, prediksi, peralatan, eksplorasi, pengukuran, pengolahan data, analisis, kesimpulan, presentasi, dan evaluasi.

Analisis MANOVA digunakan untuk menentukan kontribusi dua jenis kegiatan eksperimen terhadap SCS dan CS siswa. MANOVA dipilih karena sesuai dengan desain penelitian dimana terdapat dua variabel dependen yang saling berkaitan, yaitu model praktikum dan jenis kelamin (Warne, 2014). Selain itu, perbedaan gender digunakan sebagai faktor review dalam kemampuan siswa. Signifikansi statistik penelitian ini adalah tingkat 0,05 dalam uji hipotesis dua sisi.

RESULTS AND DISCUSSION

Experimental Model

Analisis pertama membahas efek dari model eksperimental pada peningkatan SCS dan CS yang ditunjukkan pada Tabel 1.

Tabel 1. Uji multivariat dengan metode lambda Wilks

	Nilai	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Tabel 1 menunjukkan bahwa model eksperimen berpengaruh signifikan terhadap SCS dan CS, ditunjukkan dengan nilai signifikansi yang lebih kecil dari 0,05. Analisis selanjutnya menggunakan data *Test of Between-Subject Effects* pada masing-masing kelompok keterampilan seperti yang disajikan pada Tabel 2. Analisis ini dilakukan dengan mengacu pada nilai intersep dan signifikansi.

Tabel 2. Uji efek antara subjek – model eksperimental

Kelompok Siswa	Topik	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Rangkaian Listrik	0.00	0.058	0.000	0.068
	Elastisitas	0.00	0.013	0.000	0.042
UIN Imam Bonjol Padang	Rangkaian Listrik	0.00	0.184	0.000	0.000
	Elastisitas	0.00	0.446	0.000	0.000
UIN Alauddin Makasar	Rangkaian Listrik	0.00	0.851	0.000	0.000
	Elastisitas	0.00	0.946	0.000	0.000
IAIN Palangka Raya	Rangkaian Listrik	0.00	0.637	0.000	0.006
	Elastisitas	0.00	0.003	0.000	0.000
IAIN Syekh Nurjati Cirebon	Rangkaian Listrik	0.00	0.112	0.000	0.000
	Elastisitas	0.00	0.060	0.000	0.000

Tabel 2 menunjukkan bahwa nilai intersep setiap kelompok mata pelajaran lebih kecil dari 0,05 dan diinterpretasikan signifikan. Hasil ini menunjukkan bahwa ada peningkatan SCS dengan mengabaikan pengaruh eksperimen. Hasil ini belum final karena wajib dikonfirmasi dengan nilai signifikan. Data menunjukkan bahwa hanya dua kelompok mata pelajaran yang memiliki nilai lebih rendah dari 0,05 pada SK, dan hanya tiga kelompok mata pelajaran yang memiliki nilai lebih tinggi dari 0,05 pada PK. Oleh karena itu, hanya dua kelompok subjek pada SCS dan tujuh kelompok pada CS yang menunjukkan pengaruh yang signifikan.

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- Tables or graphs (one selected) must represent different results
- The results of data analysis must be strong in answering the analysis gap
- Display of results other than those narrated in table-graph-image-modeling
- The research novelty has not been clear enough
- It is recommended not to repeat the references in the introduction, using previous research findings.
- References used should be taken from reputable journals.
- It is necessary to explain the specifications of the findings in this study that show

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1.The data in table has been explained after the table or figures, and the discussion of our finding explained in discussion section
2.we have explained that our finding is significant to improve the CS better than SCS
3.The result is focused in Table, while description and discussion focused in natarive
4.The finding of our study is the learning process using MSLAM or HOT Lab could not be practiced more than one competences simultaneously
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2. The pictures/tables must not be consecutive.

Gender Effect

Gender digunakan sebagai faktor analisis. Gender diasumsikan sebagai variabel yang dapat membedakan SCS dan CS siswa saat melakukan eksperimen. Dengan demikian, analisis gender dilakukan serupa dengan analisis model eksperimen.

Tabel 3. Uji multivariat dengan metode lambda Wilks

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

Pada Tabel 3, analisis statistik membuktikan bahwa jenis kelamin tidak memberikan kontribusi yang signifikan terhadap peningkatan SK dan SK karena nilai signifikansi keempat kelompok mata pelajaran lebih dari 0,05 . Sedangkan perhitungan lebih lanjut dibuktikan pada Tabel 4.

Table 4. Uji efek antar-subjek–gender

Subject Groups	Topik	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Rangkaian Listrik	0.00	0.926	0.000	0.793
	Elastisitas	0.00	0.395	0.000	0.173
UIN Imam Bonjol Padang	Rangkaian Listrik	0.00	0.182	0.000	0.533
	Elastisitas	0.00	0.611	0.000	0.412
UIN Alauddin Makasar	Rangkaian Listrik	0.00	0.706	0.000	0.038
	Elastisitas	0.00	0.214	0.000	0.757
IAIN Palangka Raya	Rangkaian Listrik	0.00	0.064	0.000	0.540
	Elastisitas	0.00	0.164	0.000	0.550
IAIN Syekh Nurjati Cirebon	Rangkaian Listrik	0.00	0.422	0.000	0.003
	Elastisitas	0.00	0.167	0.000	0.668

Tabel 6 menunjukkan bahwa nilai intersep pada SCS dan CS lebih kecil dari 0,05. Oleh karena itu, dapat disimpulkan bahwa terjadi peningkatan SCS dan CS dengan mengabaikan kontribusi gender. Sementara itu, kolom sig. untuk SCS menunjukkan bahwa gender tidak berpengaruh signifikan terhadap SCS. Namun, nilai sig. untuk CS menunjukkan bahwa sig. nilai dua kelompok mata pelajaran lebih rendah dari 0,05, dan ini menunjukkan bahwa gender mempengaruhi peningkatan CS.

The integrated analysis of the experimental model and gender

Tabel 6 menunjukkan bahwa nilai intersep pada SCS dan CS lebih kecil dari 0,05. Oleh karena itu, dapat disimpulkan bahwa terjadi peningkatan SCS dan CS dengan mengabaikan kontribusi jenis kelamin. Sementara itu, kolom sig. untuk SCS menunjukkan bahwa gender tidak berpengaruh signifikan terhadap SCS. Namun, nilai sig. untuk CS menunjukkan bahwa sig. nilai dua kelompok mata pelajaran lebih rendah dari 0,05, dan ini menunjukkan bahwa gender mempengaruhi peningkatan CS.

Tabel 5. Uji multivariat dengan metode lambda Wilks

		Nilai	F	sig.
UIN Sunan Gunung Djati	Model Ekpseirmen	0.005	3201.903	0.000
	Jenis Kelamin	0.943	0.958	0.437
UIN Imam Bonjol	Model Ekpseirmen	0.381	21.952	0.000
	Jenis Kelamin	0.904	1.433	0.236

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2. The pictures/tables must not be consecutive.

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		Nilai	F	sig.
UIN Alauddin	Model Ekpseirmen	0.895	1.679	0.167
	Jenis Kelamin	0.358	25.519	0.000
IAIN Palangka Raya	Model Ekpseirmen	0.460	15.876	0.000
	Jenis Kelamin	0.915	1.257	0.298
IAIN Syekh Nurjati	Model Ekpseirmen	0.555	13.853	0.000
	Jenis Kelamin	0.854	2.940	0.026

Hasil pengujian efek antar mata pelajaran pada Tabel 8 menunjukkan bahwa secara keseluruhan SK dan PK siswa meningkat tanpa mempertimbangkan pengaruh model eksperimen. Selanjutnya hasil penelitian menunjukkan bahwa gender memiliki nilai intersep yang kecil yaitu 0,05. Mengingat kontribusi model eksperimen dan jenis kelamin, SCS dan CS meningkat secara tidak signifikan yang ditunjukkan oleh skor rata-rata nilai signifikansi pada exp.: 0,24 untuk SCS dan 0,08 untuk CS Sementara itu, jenis kelamin mempengaruhi SCS sebesar 0,39 dan CS sebesar 0,29. Namun, dinyatakan bahwa dalam SCS, model eksperimen lebih berpengaruh daripada gender .

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2. The pictures/tables must not be consecutive.

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Table 6. Uji efek antar-mata pelajaran –analisis terintegrasi

Kelompok Siswa	Content	SCS Intercept	SCS Exp.	SCS Gender	CS Intercept	CS Exp.	CS Gender
UIN Sunan Gunung Djati Bandung	Rangkaian Listrik	0.00	0.000	0.303	0.000	0.063	0.632
	Elastisitas	0.00	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Rangkaian Listrik	0.00	0.172	0.169	0.000	0.000	0.503
	Elastisitas	0.00	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Rangkaian Listrik	0.00	0.723	0.886	0.000	0.051	0.000
	Elastisitas	0.00	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Rangkaian Listrik	0.00	0.599	0.064	0.000	0.006	0.473
	Elastisitas	0.00	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Rangkaian Listrik	0.00	0.124	0.469	0.000	0.000	0.003
	Elastisitas	0.00	0.069	0.192	0.000	0.000	0.420

Discussion

Hasil penelitian menunjukkan bahwa model eksperimen berpengaruh signifikan terhadap peningkatan kemampuan kolaborasi dan kemampuan komunikasi ilmiah siswa secara simultan. Menurut Liu (2011) dan Warne (2014), nilai signifikansi yang lebih kecil dari 0,05 menunjukkan bahwa variabel independen (model eksperimen) memberikan pengaruh yang signifikan terhadap variabel dependen (SCS dan CS) dengan tingkat kepercayaan 95%. Selanjutnya, hasil ini didukung oleh penelitian sebelumnya yang menunjukkan efek dari model eksperimental pada SCS (Aydın, 2016; Malik et al, 2018;. Sapriadil et al, 2018;. Walker & Sampson, 2013) dan CS (Sinex & Chambers, 2013; Zakwandi et al., 2020) Oleh karena itu, hasil ini menunjukkan bahwa SCS dan CS dapat ditingkatkan secara bersamaan melalui satu kegiatan laboratorium, *Multiple Skill Laboratory Activity Model* (MSLAM).

Tabel 1 menunjukkan keterbatasan model MSLAM dan HOT Lab, dan menunjukkan bahwa hanya 20% dari kelompok mata pelajaran yang mencapai target. Namun masih dapat dinyatakan adanya perbedaan nilai SCS dan CS dengan mengabaikan jenis kegiatan laboratorium. Banyak faktor yang menyebabkan kondisi ini, dan salah satunya adalah kegiatan belajar sebagaimana Rubini et al. (2018) membuktikan bahwa kegiatan pembelajaran yang monoton sulit untuk meningkatkan keterampilan siswa . Oleh karena itu, solusinya adalah menghadirkan berbagai kegiatan dan memberikan tantangan kepada siswa. Apalagi sebagian besar laboratorium sekolah di Indonesia belum optimal. Kondisi tersebut membawa beberapa dampak yang merugikan karena kegiatan eksperimen selalu membutuhkan pembiasaan. Selain itu, temuan lain mengungkapkan bahwa siswa memiliki kemampuan yang berbeda untuk melakukan topik eksperimen yang berbeda. Rata-rata signifikansi isi rangkaian listrik adalah 0,3684, dan tidak ada kelompok mata pelajaran yang berpengaruh signifikan.

Sedangkan signifikansi rata-rata topik elastisitas adalah 0,2936, ditunjukkan oleh dua kelompok mata pelajaran yang berpengaruh. Perbedaan ini mengusulkan gagasan bahwa siswa memiliki beberapa kendala dalam melakukan eksperimen pada rangkaian listrik. Rosidah & Rosdiana (2019) menyatakan bahwa siswa di sekolah tradisional di Indonesia menganggap topik kelistrikan kurang diminati dan menantang untuk dipelajari. Namun, siswa menganggap topik elastisitas lebih mudah dipelajari. Selanjutnya, hasil penelitian menunjukkan bahwa CS memiliki peningkatan yang lebih signifikan daripada SCS. Temuan ini serupa dengan penelitian Nurafiah et al. (2018), yang membuktikan bahwa CS siswa meningkat lebih tinggi daripada kemampuan berpikir kritis, kreativitas, dan komunikasi mereka. Uji korelasi dengan menggunakan nilai R^2 menunjukkan adanya hubungan antara variabel terikat dan variabel bebas. Tes menunjukkan bahwa SCS pada topik rangkaian listrik memiliki R^2 nilai 0,0316, nilai SCS pada topik elastisitas 0,1512, nilai CS pada topik sirkuit listrik adalah 0,2512, dan nilai CS pada topik elastisitas 0,3542. Dengan demikian, dapat disimpulkan bahwa korelasinya relatif rendah (Howarth, 2017).

Data dari perbedaan gender dari penelitian ini menunjukkan bahwa perbedaan gender tidak berpengaruh secara signifikan terhadap peningkatan SCS siswa dan CS. Hal ini menunjukkan bahwa siswa laki-laki dan perempuan memiliki kesempatan yang sama untuk mencapai kompetensi dalam pembelajaran berbasis eksperimen-. Hasil ini menegaskan orang-orang dari penelitian sebelumnya mengerahkan bahwa gender tidak signifikan menghasilkan perbedaan. Meski begitu, wanita memiliki nilai yang lebih baik daripada laki-laki (Shi et al., 2015). Namun demikian, Shi et al. (2015) berpendapat bahwa siswa masih dapat bekerja sama dalam melakukan eksperimen melalui disposisi terbaik. Namun, ada beberapa pertimbangan. Sebagai contoh, siswa perempuan cenderung bekerja sama dalam kelompok minoritas sedangkan siswa laki-laki yang banyak bicara ketika mereka bekerja secara independen. Shi et al. (2015) menambahkan siswa perempuan lebih mungkin untuk memainkan peran pendukung sementara siswa laki-laki memainkan peran penting ketika berkolaborasi dalam kegiatan eksperimental. Selanjutnya, hasil R2 menunjukkan korelasi yang sangat lemah antara gender dan SCS pada topik sirkuit listrik sebesar 0,02, gender dan SCS pada topik elastisitas sebesar 0,13, antara gender dan CS pada topik arus listrik sebesar 0,04, dan antara gender dan CS pada topik elastisitas sebesar 0,01.

Analisis terpadu dilakukan dengan menggunakan dua variabel bebas dimana satu faktor berpengaruh signifikan dan faktor lainnya tidak. Kondisi ini menunjukkan bahwa analisis faktor ini tidak sesuai karena mengarah pada nilai signifikansi yang tidak konsisten yang mungkin disebabkan oleh beberapa variabel. Model eksperimen merupakan faktor eksternal yang dapat dikelola dengan cara-cara tertentu, sedangkan gender merupakan faktor internal yang tidak dapat dikendalikan. Namun, indikator yang kemungkinan dipengaruhi oleh jenis kelamin, seperti motivasi dan perspektif, dapat dikelola. Oleh karena itu, dengan menggunakan MSLAM, kita dapat meningkatkan CS siswa lebih baik daripada SCS secara bersamaan. Sedangkan hasil juga menunjukkan bahwa SCS siswa belum dapat ditingkatkan secara optimal.

Keterbatasan penelitian ini adalah melakukan pengambilan sampel subjek dengan tingkat heterogenitas yang tinggi dan cakupan yang luas. Selain itu, kendala penelitian ini berkaitan dengan tingkat keterampilan dan perilaku awal pada masing-masing kelompok mata pelajaran. Instrumen penelitian ini adalah lembar observasi untuk mengukur SCS dan CS, sedangkan proses penilaiannya lebih kompleks. Oleh karena itu, penelitian lebih lanjut dapat menyelidiki pengembangan instrumen evaluasi yang secara tepat mengukur efek dari melakukan kegiatan laboratorium untuk meningkatkan lebih banyak keterampilan pada satu waktu. Oleh karena itu, diharapkan penelitian selanjutnya akan memberikan hasil pengukuran yang lebih spesifik.

CONCLUSION

Belajar berbasis eksperimen dengan menggunakan MSLAM dapat berdampak positif HOT Lab. Secara keseluruhan, komunikasi dan kolaborasi keterampilan membaik setelah melakukan model eksperimental. Hasil analisis menunjukkan bahwa aspek pertunjukan eksperimental dampak yang lebih signifikan pada peningkatan komunikasi dan kolaborasi keterampilan ilmiah dari pada gender. Selain itu, kemampuan berkolaborasi ditingkatkan lebih baik dari kemampuan komunikasi ilmiah. Oleh karena itu, MSLAM dan HOT Lab yang lebih baik untuk meningkatkan kemampuan berkolaborasi. Keterbatasan penelitian ini mencakup sampling heterogenitas kelompok subjek, kebiasaan model eksperimental yang dilakukan oleh masing-masing subjek, dan instrumen penilaian yang digunakan untuk mengukur keterampilan komunikasi ilmiah dan kolaborasi. keterbatasan ini mengusulkan bahwa pelaksanaan eksperimental berbasis model pembelajaran membutuhkan pemberdayaan. Para siswa memiliki pengalaman belajar yang lebih adaptif dan kompatibel dengan kondisi saat ini. Selain itu, penelitian lebih lanjut mengembangkan instrumen penilaian yang tepat membutuhkan untuk dipertimbangkan.

ACKNOWLEDGEMENTS

Penelitian ini mendapat dukungan dana dari Kementerian Agama Republik Indonesia melalui Direktorat Jenderal Pendidikan Islam dengan Nomor Kontrak 19102000027424 melalui Hibah Nomor 1967 Tahun 2019 Tentang Penerima Bantuan Penelitian Terapan Global/Internasional Tahun Anggaran 2019 untuk memfasilitasi pendanaan penelitian ini.

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For the number of references, we have add 68 reference, that combine the primary source and secondary source. We apologies that some reference more than 10 years, but that is our reference used and some of our previous research published nationally and internationally.

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Paper title: ***Multiple Skills*** **Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills**

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				Thank You
	• Does the title clearly and sufficiently reflect its contents?	√				Thank You
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?		√			
	• Is research question of the study clear and understandable?		√			
	• Does the rationale of the study clearly explained using relevant literature?		√			
	• Is the "aim" of the manuscript clear and understandable?		√			
Methods	• Is the methodology chosen suitable to the nature of the topic studied?		√			
	• Is the methodology of the research described clearly?(including study design, location, subjects, data collection, data analysis)		√			
	• Is there adequate information about the data collection tools used? (only for empirical studies)		√			
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Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?		√			
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	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
Conclusion	• Is the conclusion clear and in the form of a narration instead of pointers?		√			
	• Isn't the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√		Please provide at least **30 references** which 80% of them are taken from **the last 10 years (>2011)** articles of no-predatory journals	

	• Are the writing of references correct?		√			
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?		√			
	• The quality of the language is satisfactory		√			
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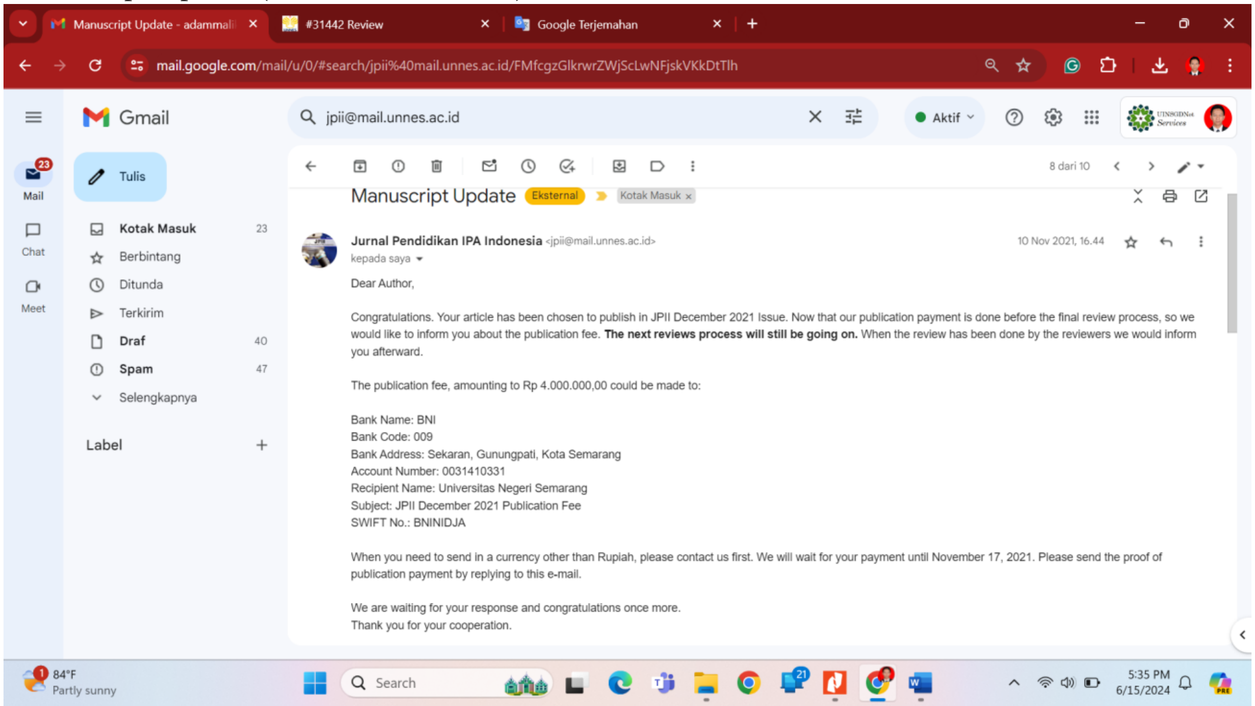
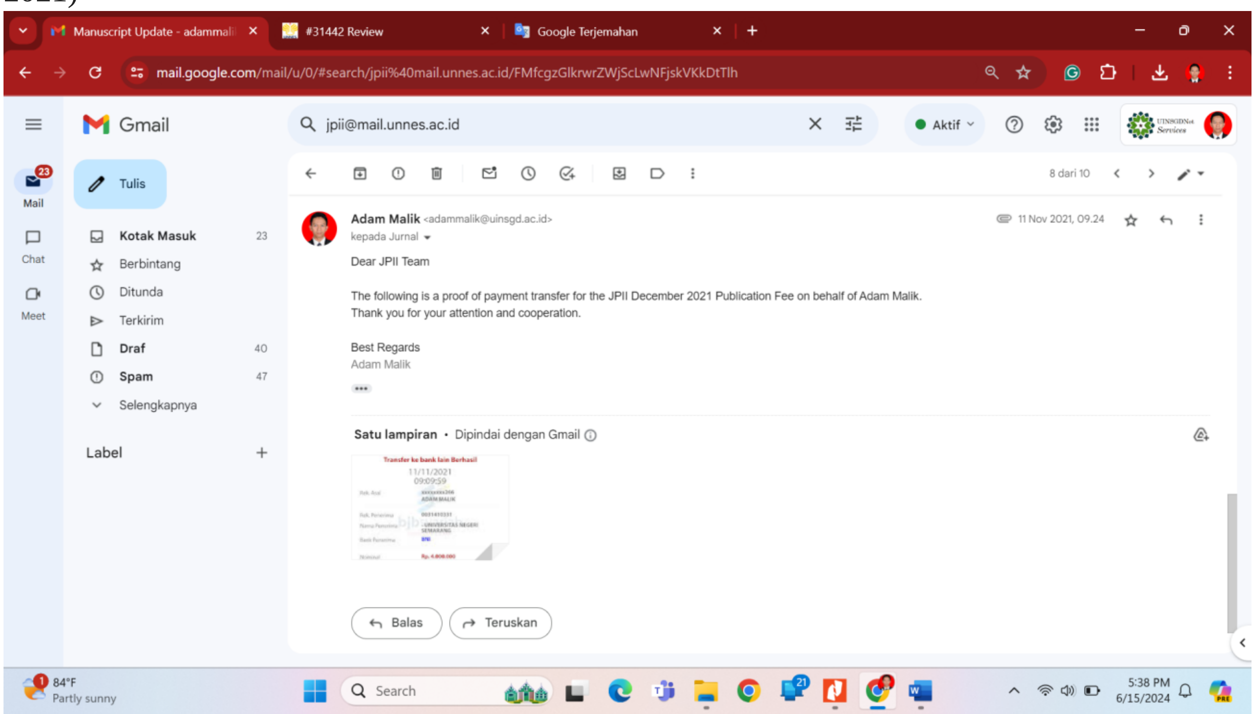
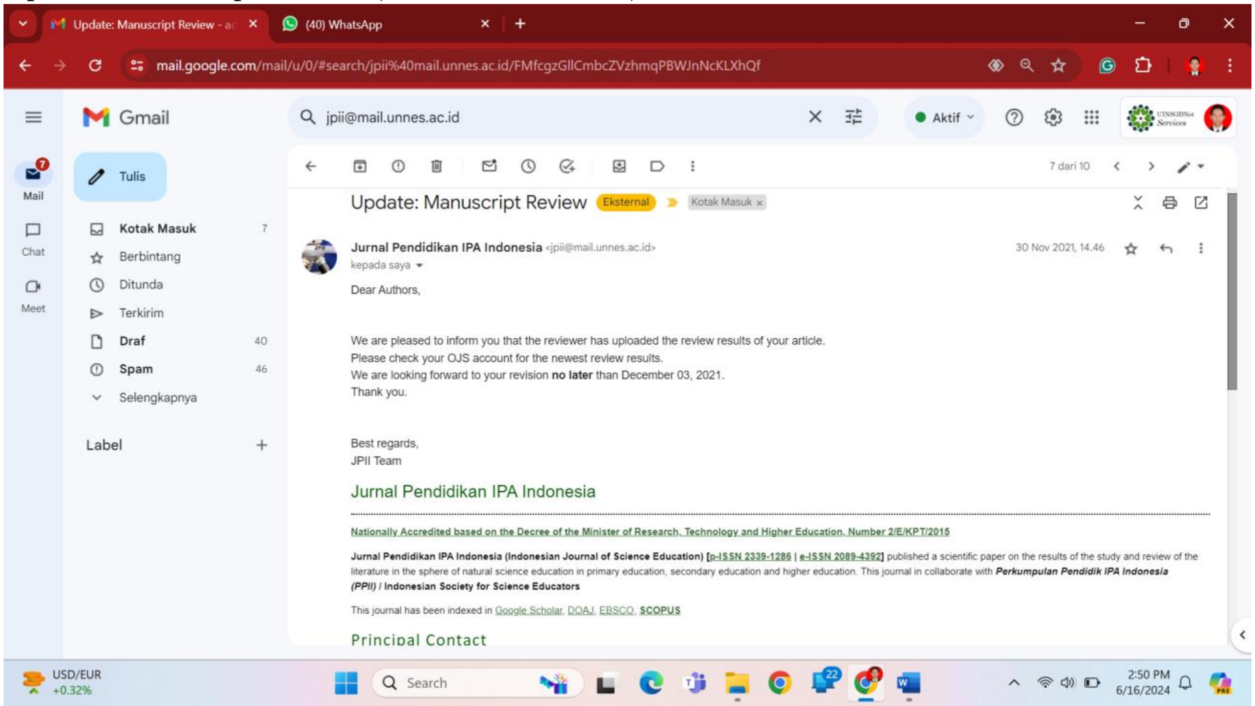
7. Manuscript Update (10 November 2021)



8. Proof of payment transfer for the JPII December 2021 Publication Fee (11 November 2021)



9. Update: Manuscript Review (30 November 2021)



JPII 5 (2) (2021) 247-
255

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

Multiple Skills Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills

DOI:

Accepted:... .Approved: ... . Published: ...

ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous skills and learning habits from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher-order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skills Laboratory Activity Model. The data were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model improves students' collaboration skills than communication skills. This study also reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The rapid distribution of information and easy access to information from various sources are characteristics of the 21st century, including 21st-century education. Nowadays, students can easily access various learning resources that may not be accessible to teachers. In addition, students and teachers can easily share their findings through various platforms, both free and paid. Therefore, additional skills are needed so that students and teachers can deliver their findings appropriately. Such skills are called Scientific Communication Skills (SCS), one of the crucial competencies in the 21st century (Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017), and it contributes scientifically to be accepted in society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the complex research results (Dannels et al., 2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study showed that communication skills consistently fail to be demonstrated by science students than analytical, technical, and problem-solving skills (Gray et al., 2005). Graduates do not consistently display communication skills when hiring (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study showed that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems (Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020)

Previous studies still generally investigate the issues and have not optimized the experimental learning. Researches focused on developing learning strategies, methods, and approaches to improve HOTs (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). In addition, the researchers also focused on improving the model of teaching (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) and learning media (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) or evaluation (Calhoun et al., 2010; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

While SCS and other thinking skills are proved more effectively practiced by employing experimental-based learning (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia et al., 2009; Wang et al., 2015). Like SCS, CS is also necessary for the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' skills. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategies (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), teaching model (Erika & Prahani, 2017; Liu et al., 2011), learning media (Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018) and learning evaluation (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to

investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the students' different skills are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with superior skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model.

In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Sheikh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as a control class, and the other group experimented by employing the MSLAM model as an experimental class.

In this study, participants carried out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the skills of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final skills of the participants.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open-mindedness, respect, and group investigation skills. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring students' skills.

The students in the control class experimented with 11 stages of the HOT Lab, while the students in the experiment class experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation. MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables: the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the students' skills. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

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Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provided in Table 3.

Table 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 3 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Table 4. This analysis was conducted by referring to intercept and signification values.

Table 4. The test of between-subject effects – an experimental model

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.058	0.000	0.068
	Elasticity	0.00	0.013	0.000	0.042
UIN Imam Bonjol Padang	Electric Circuit	0.00	0.184	0.000	0.000
	Elasticity	0.00	0.446	0.000	0.000
UIN Alauddin Makasar	Electric Circuit	0.00	0.851	0.000	0.000
	Elasticity	0.00	0.946	0.000	0.000
IAIN Palangka Raya	Electric Circuit	0.00	0.637	0.000	0.006
	Elasticity	0.00	0.003	0.000	0.000
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.112	0.000	0.000
	Elasticity	0.00	0.060	0.000	0.000

Table 4 indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender Effect

Gender is employed as a factor of analysis. Gender is assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 5. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317

	Value	F	sig.
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 5, statistics analysis proves that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Table 6.

Table 6. The test of between-subject effects–gender

Subject Groups	Content	SCS		CS	
		Intercept	Sig.	Intercept	Sig.
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.926	0.000	0.793
	Elasticity	0.00	0.395	0.000	0.173
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.182	0.000	0.533
	Elasticity	0.00	0.611	0.000	0.412
UIN Alauddin Makasar	Electric Circuit	0.00	0.706	0.000	0.038
	Elasticity	0.00	0.214	0.000	0.757
IAIN Palangka Raya	Elelctric Circuit	0.00	0.064	0.000	0.540
	Elasticity	0.00	0.164	0.000	0.550
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.422	0.000	0.003
	Elasticity	0.00	0.167	0.000	0.668

Table 6 shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the increase of CS.

The integrated analysis of the experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS, and CS. Table 7 shows that the p-values of most experimental models are less than 0.05. It indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

Table 7. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

The test results of between-subject effects in Table 8 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.:

0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 8. The test of between-subject effects –integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.00	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.00	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.00	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.00	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.00	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.00	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.00	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.00	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.00	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.00	0.069	0.192	0.000	0.000	0.420

Discussion

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different skills to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah and Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For

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● Communication and collaboration are very relevant to Vygotsky's learning Theory

example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve students' CS better than SCS simultaneously. While the result also shows that students' SCS cannot be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each subject group. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improve after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research developing an appropriate assessment instrument requires to consider.

ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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Paper title: Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
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References	• Do the references and citations match?		√		Please add references of relevant learning theory to complete the discussion.	
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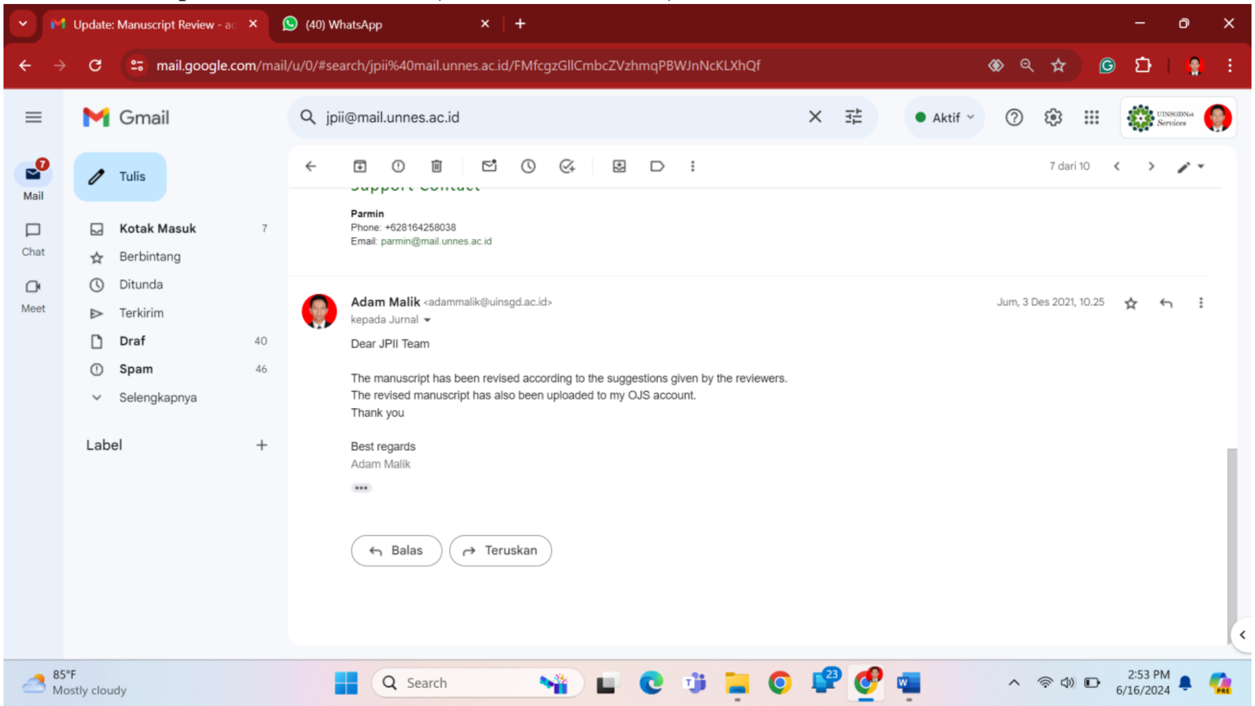
10. The manuscript has been revised (3 Desember 2021)



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255

Jurnal Pendidikan IPA Indonesia

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Multiple Skills Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills

DOI:

Accepted:... .Approved: ... . Published: ...

ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous skills and learning habits from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher-order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skills Laboratory Activity Model. The data were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model improves students' collaboration skills than communication skills. This study also reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The rapid distribution of information and easy access to information from various sources are characteristics of the 21st century, including 21st-century education. Nowadays, students can easily access various learning resources that may not be accessible to teachers. In addition, students and teachers can easily share their findings through various platforms, both free and paid. Therefore, additional skills are needed so that students and teachers can deliver their findings appropriately. Such skills are called Scientific Communication Skills (SCS), one of the crucial competencies in the 21st century (Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017), and it contributes scientifically to be accepted in society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the complex research results (Dannels et al., 2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study showed that communication skills consistently fail to be demonstrated by science students than analytical, technical, and problem-solving skills (Gray et al., 2005). Graduates do not consistently display communication skills when hiring (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study showed that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems (Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020)

Previous studies still generally investigate the issues and have not optimized the experimental learning. Researches focused on developing learning strategies, methods, and approaches to improve HOTs (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). In addition, the researchers also focused on improving the model of teaching (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) and learning media (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) or evaluation (Calhoun et al., 2010; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

While SCS and other thinking skills are proved more effectively practiced by employing experimental-based learning (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia et al., 2009; Wang et al., 2015). Like SCS, CS is also necessary for the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' skills. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategies (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), teaching model (Erika & Prahani, 2017; Liu et al., 2011), learning media (Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018) and learning evaluation (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to

investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the students' different skills are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with superior skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model.

In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Sheikh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as a control class, and the other group experimented by employing the MSLAM model as an experimental class.

In this study, participants carried out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the skills of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final skills of the participants.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open-mindedness, respect, and group investigation skills. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring students' skills.

The students in the control class experimented with 11 stages of the HOT Lab, while the students in the experiment class experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation. MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables: the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the students' skills. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

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Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provided in Table 3.

Table 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 3 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Figure 1. This analysis was conducted by referring to intercept and signification values.

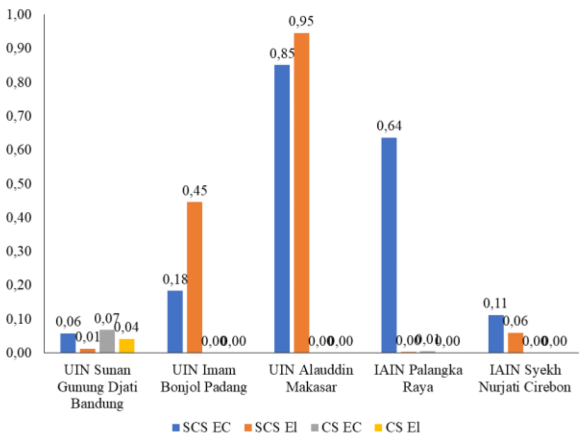

Figure 1. The test of between-subject effects – an experimental model (Intercept: 0.00)

Figure 1. indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender Effect

Gender is employed as a factor of analysis. Gender is assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 4. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 4, statistics analysis proves that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Figure 2.

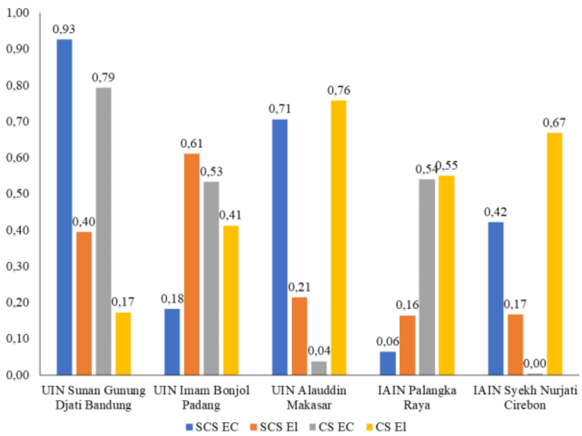

Figure 2. The test of between-subject effects–gender (intercept: 0.00)

Figure 2. shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the increase of CS.

The integrated analysis of the experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS, and CS. Table 5 shows that the p-values of most experimental models are less than 0.05. It indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

Table 5. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000

	Value	F	sig.
Gender	0.854	2.940	0.026

The test results of between-subject effects in Table 6 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 6. The test of between-subject effects –integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.000	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.000	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.000	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.000	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.000	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.000	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.000	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.000	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.000	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.000	0.069	0.192	0.000	0.000	0.420

Discussion

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different skills to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah and Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation

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● Communication and collaboration are very relevant to Vygotsky's learning Theory

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between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

Learning design in MSLAM builds students' knowledge through social interaction. This is in accordance with the learning characteristics proposed by Vygotsky that in a learning process student must actively build knowledge. Collaborative activities and scientific communication that emphasize high social interaction are expected to optimize students' thinking skills. Contextual physics phenomena allow students to learn from new things that are close to life. In addition, the design of learning activities that emphasize the completion of certain tasks is in accordance with the main principles of the learning model developed by Vygotsky, which is Scaffolding. (Shvarts & Bakker, 2019; Smagorinsky, 2018).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve students' CS better than SCS simultaneously. While the result also shows that students' SCS cannot be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each subject group. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improve after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research developing an appropriate assessment instrument requires to consider.

ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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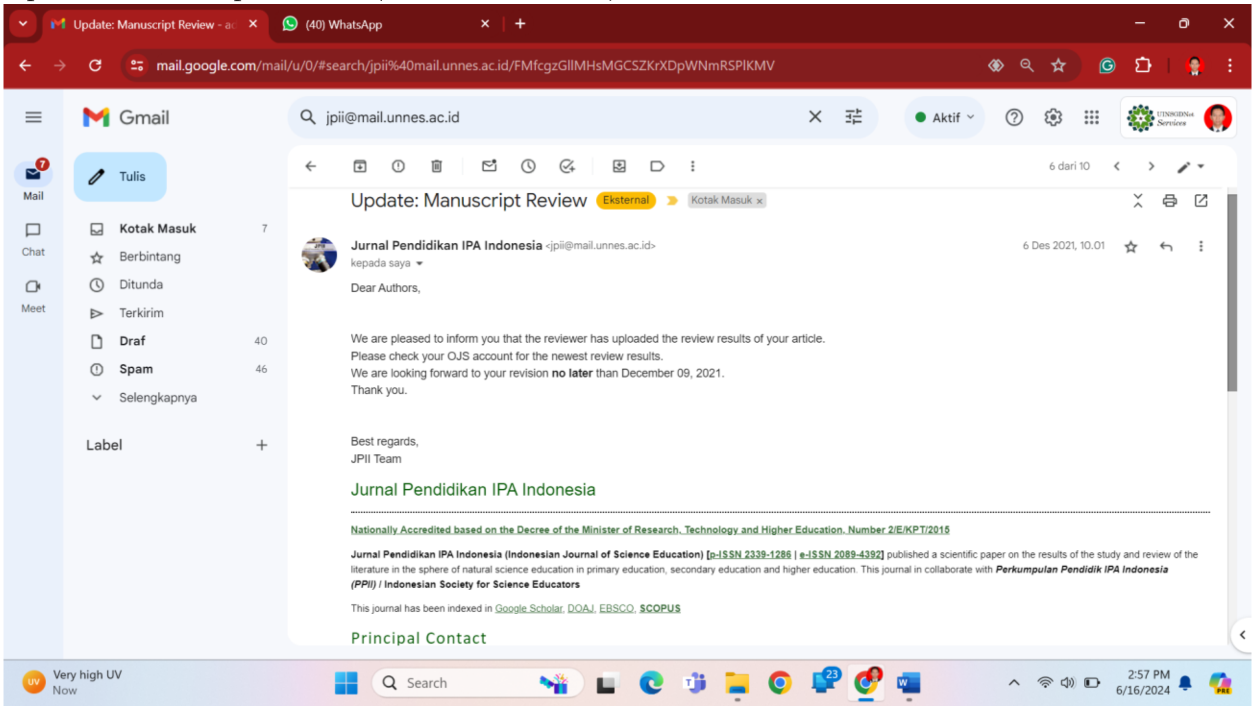
Paper title: **Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills**

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?	√				
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?	√				
	• Is research question of the study clear and understandable?	√				
	• Does the rationale of the study clearly explained using relevant literature?		√			
	• Is the "aim" of the manuscript clear and understandable?	√				
Methods	• Is the methodology chosen suitable to the nature of the topic studied?	√				
	• Is the methodology of the research described clearly?(including study design, location, subjects, data collection, data analysis)		√			
	• Is there adequate information about the data collection tools used? (only for empirical studies)		√			
	• Are the validity and reliability of data collection tools established? (only for empirical studies)		√			
	• Are the data collection tools suitable for the methodology of the study? (only for empirical studies)		√			
Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?		√		The presentation of numerical data can be presented in a table or graphic to make more interesting	Has been revised
	• Do the data analysis and the interpretation appropriate to the problem and answer the objectives?		√			
	• Does the "discussion" section of the manuscript adequately relate to the current and relevant litarature?		√		Discussion should be linked to relevant learning theory as characteristics of educational research, because communication and collaboration are very relevant to Vygotsky's learning Theory	Have been done
	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
	• Is the conclusion clear and in the form of a		√			

Conclusion	narration instead of pointers?					
	• Isn't the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√		Please add references of relevant learning theory to complete the discussion.	Have been done
	• Are the writing of references correct?	√				
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?	√				
	• The quality of the language is satisfactory		√			
	• The work relevant and novel		√			
	• Are there strong consistencies among the parts of the manuscript? (introduction, methods, results and discussion, and conclusion)		√			

11. Update: Manuscript Review (6 Desember 2021)



JPII 5 (2) (2021) 247-255

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

Multiple Skills Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills

DOI:

Accepted:... .Approved: ... . Published: ...

ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous skills and learning habits from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher-order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skills Laboratory Activity Model. The data were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model improves students' collaboration skills than communication skills. This study also reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

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Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The rapid distribution of information and easy access to information from various sources are characteristics of the 21st century, including 21st-century education. Nowadays, students can easily access various learning resources that may not be accessible to teachers. In addition, students and teachers can easily share their findings through various platforms, both free and paid. Therefore, additional skills are needed so that students and teachers can deliver their findings appropriately. Such skills are called Scientific Communication Skills (SCS), one of the crucial competencies in the 21st century (Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017), and it contributes scientifically to be accepted in society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the complex research results (Dannels et al., 2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study showed that communication skills consistently fail to be demonstrated by science students than analytical, technical, and problem-solving skills (Gray et al., 2005). Graduates do not consistently display communication skills when hiring (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study showed that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems (Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020)

Previous studies still generally investigate the issues and have not optimized the experimental learning. Researches focused on developing learning strategies, methods, and approaches to improve HOTs (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). In addition, the researchers also focused on improving the model of teaching (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) and learning media (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) or evaluation (Calhoun et al., 2010; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

While SCS and other thinking skills are proved more effectively practiced by employing experimental-based learning (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia et al., 2009; Wang et al., 2015). Like SCS, CS is also necessary for the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' skills. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategies (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), teaching model (Erika & Prahani, 2017; Liu et al., 2011), learning media (Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018) and learning evaluation (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to

investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the students' different skills are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with superior skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model.

In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Sheikh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as a control class, and the other group experimented by employing the MSLAM model as an experimental class.

In this study, participants carried out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the skills of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final skills of the participants.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open-mindedness, respect, and group investigation skills. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring students' skills.

The students in the control class experimented with 11 stages of the HOT Lab, while the students in the experiment class experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues,

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brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation. MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables: the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the students' skills. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provided in Table 3.

Table 3. The multivariate test by Wilks' lambda method

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	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 3 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Figure 1. This analysis was conducted by referring to intercept and signification values.

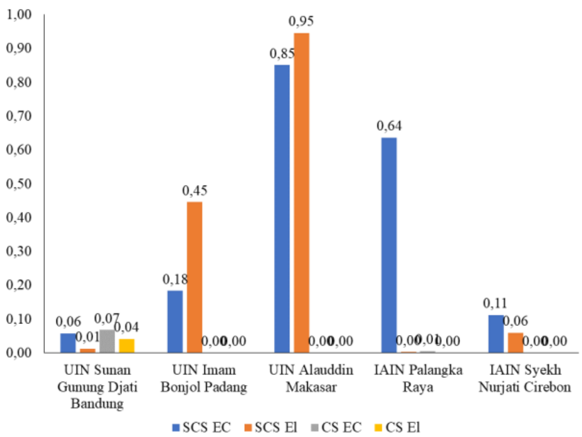

Figure 1. The test of between-subject effects – an experimental model (Intercept: 0.00)

Figure 1. indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender Effect

Gender is employed as a factor of analysis. Gender is assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 4. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 4, statistics analysis proves that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Figure 2.

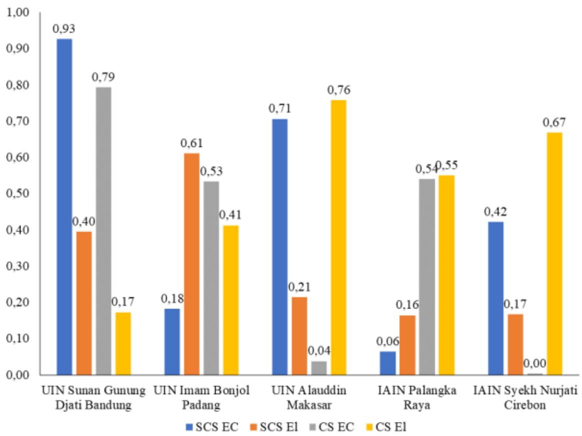

Figure 2. The test of between-subject effects–gender (intercept: 0.00)

Figure 2. shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the increase of CS.

The integrated analysis of the experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS, and CS. Table 5 shows that the p-values of most experimental models are less than 0.05. It indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

Table 5. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298

		Value	F	sig.
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

The test results of between-subject effects in Table 6 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 6. The test of between-subject effects –integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.000	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.000	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.000	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.000	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.000	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.000	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.000	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.000	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.000	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.000	0.069	0.192	0.000	0.000	0.420

Discussion

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different skills to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah and Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

Learning design in MSLAM builds students' knowledge through social interaction. This is in accordance with the learning characteristics proposed by Vygotsky that in a learning process student must actively build knowledge. Collaborative activities and scientific communication that emphasize high social interaction are expected to optimize students' thinking skills. Contextual physics phenomena allow students to learn from new things that are close to life. In addition, the design of learning activities that emphasize the completion of certain tasks is in accordance with the main principles of the learning model developed by Vygotsky, which is Scaffolding. (Shvarts & Bakker, 2019; Smagorinsky, 2018).

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The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve students' CS better than SCS simultaneously. While the result also shows that students' SCS cannot be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each subject group. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improve after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research developing an appropriate assessment instrument requires to consider.

ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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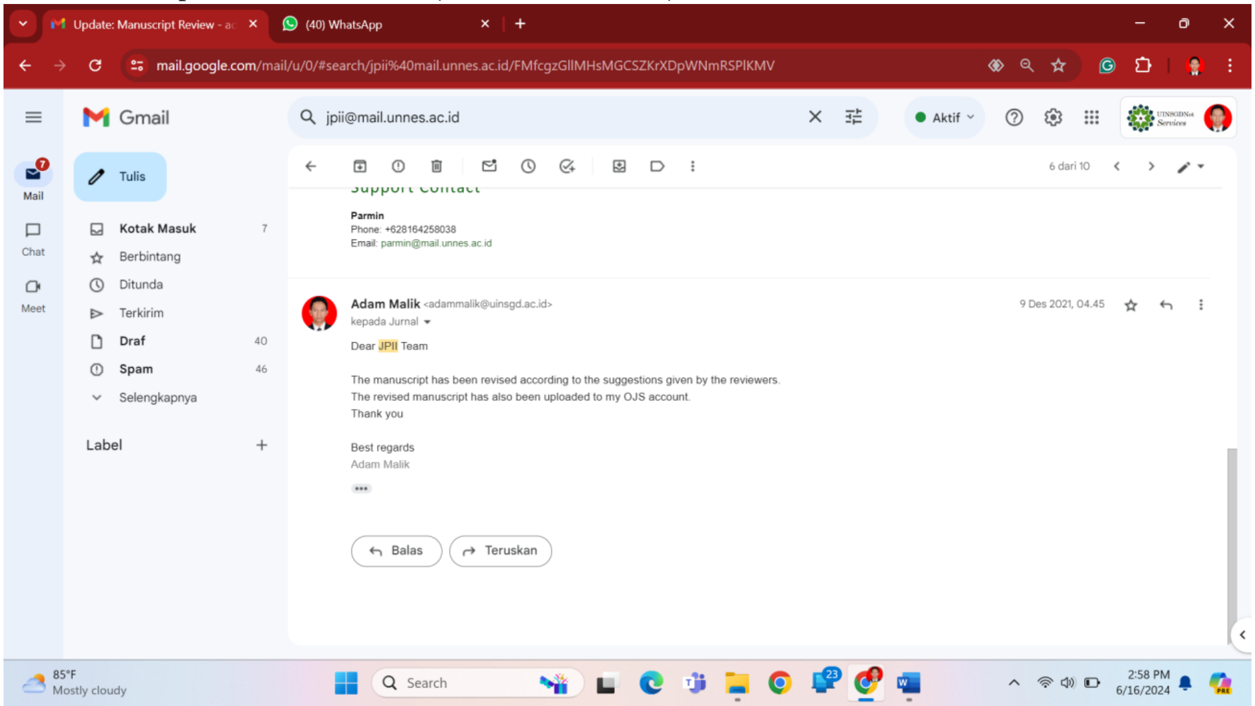
Paper title: **Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills**

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?	√				
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?	√				
	• Is research question of the study clear and understandable?	√				
	• Does the rationale of the study clearly explained using relevant literature?		√			
	• Is the "aim" of the manuscript clear and understandable?	√				
Methods	• Is the methodology chosen suitable to the nature of the topic studied?	√				
	• Is the methodology of the research described clearly?(including study design, location, subjects, data collection, data analysis)		√			
	• Is there adequate information about the data collection tools used? (only for empirical studies)		√			
	• Are the validity and reliability of data collection tools established? (only for empirical studies)		√			
	• Are the data collection tools suitable for the methodology of the study? (only for empirical studies)		√			
Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?		√		The presentation of numerical data can be presented in a table or graphic to make more interesting	Has been revised
	• Do the data analysis and the interpretation appropriate to the problem and answer the objectives?		√			
	• Does the "discussion" section of the manuscript adequately relate to the current and relevant litarature?		√		Discussion should be linked to relevant learning theory as characteristics of educational research, because communication and collaboration are very relevant to Vygotsky's learning Theory	Have been done
	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
	• Is the conclusion clear and in the form of a		√			

Conclusion	narration instead of pointers?					
	• Isn't the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√		Please add references of relevant learning theory to complete the discussion.	Have been done
	• Are the writing of references correct?	√				
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?	√				
	• The quality of the language is satisfactory		√			
	• The work relevant and novel		√			
	• Are there strong consistencies among the parts of the manuscript? (introduction, methods, results and discussion, and conclusion)		√			

12. The manuscript has been revised (9 Desember 2021)



JPII 5 (2) (2021) 247-255

Jurnal Pendidikan IPA Indonesia

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Multiple Skills Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills

DOI:

Accepted:... .Approved: ... . Published: ...

ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous skills and learning habits from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher-order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skills Laboratory Activity Model. The data were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model (MSLAM) improves students' collaboration skills **better than** communication skills. In MSLAM, the more activities to practice colaboration skills, e.g., brainstorming, exploration, and measurement, while the activities for practicing communication skills is depended on analysis and presentation only. This study also reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

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INTRODUCTION

The rapid distribution of information and easy access to information from various sources are characteristics of the 21st century, including 21st-century education. Nowadays, students can easily access various learning resources that may not be accessible to teachers. In addition, students and teachers can easily share their findings through various platforms, both free and paid. Therefore, additional skills are needed so that students and teachers can deliver their findings appropriately. Such skills are called Scientific Communication Skills (SCS), one of the crucial competencies in the 21st century (Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017), and it contributes scientifically to be accepted in society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the complex research results (Dannels et al., 2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study showed that communication skills consistently fail to be demonstrated by science students than analytical, technical, and problem-solving skills (Gray et al., 2005). Graduates do not consistently display communication skills when hiring (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study showed that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems (Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020)

Previous studies still generally investigate the issues and have not optimized the experimental learning. Researches focused on developing learning strategies, methods, and approaches to improve HOTs (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). In addition, the researchers also focused on improving the model of teaching (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) and learning media (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) or evaluation (Calhoun et al., 2010; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

While SCS and other thinking skills are proved more effectively practiced by employing experimental-based learning (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia et al., 2009; Wang et al., 2015). Like SCS, CS is also necessary for the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' skills. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategies (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), teaching model (Erika & Prahani, 2017; Liu et al., 2011), learning media (Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018) and learning evaluation (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to

investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the students' different skills are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with superior skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model.

In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). The experimental design is provided in Table 1 Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

Table 1. Experimental Design

Class	SCS		CS	
	Ctrl.	**Exp.**	**Ctrl.**	**Exp.**
A	A-C_1	A-X_1	A-C_2	A-X_2
B	A-C_1	A-X_1	A-C_2	A-X_2
C	A-C_1	A-X_1	A-C_2	A-X_2
D	A-C_1	A-X_1	A-C_2	A-X_2
E	A-C_1	A-X_1	A-C_2	A-X_2

Explanation: A: UIN Sunan Gunung Djati, B: UIN Imam Bonjol, C: UIN Alauddin, D: IAIN Palangkaraya, D: IAIN Syekh Nurjati

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as a control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Syekh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as a control class, and the other group experimented by employing the MSLAM model as an experimental class.

In this study, participants carried out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the skills of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final skills of the participants.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The rubric was feasible used according to five expert judgments. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-

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solving, open-mindedness, respect, and group investigation skills. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring students' skills.

The students in the control class experimented with 11 stages of the HOT Lab, while the students in the experiment class experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation.

MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables: the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the students' skills. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

Experimental Model

The first analysis discussed the effects of an experimental model on the improvement of SCS and CS provided in Table 2.

Table 2. The multivariate test by Wilks' lambda method

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	Value	**F**	**sig.**
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 2 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Figure 1. This analysis was conducted by referring to intercept and signification values.

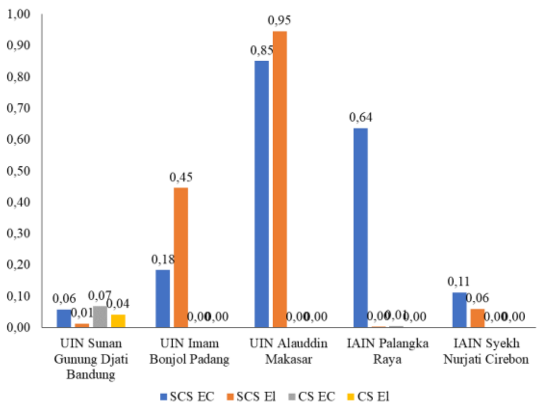

Figure 1. The test of between-subject effects – an experimental model (Intercept: 0.00)

Figure 1. indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender Effect

Gender is employed as a factor of analysis. Gender is assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 3, statistics analysis proves that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Figure 2.

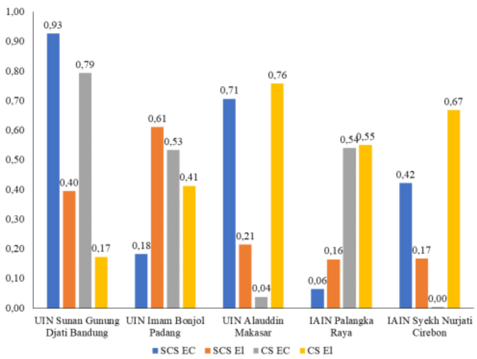

Figure 2. The test of between-subject effects–gender (intercept: 0.00)

Figure 2. shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of two subject groups are lower than 0.05, and it indicates that gender influences the increase of CS.

The integrated analysis of the experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS, and CS. Table 4 shows that the p-values of most experimental models are less than 0.05. It indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

Table 4. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

The test results of between-subject effects in Table 5 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 5. The test of between-subject effects–integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.000	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.000	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.000	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.000	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.000	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.000	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.000	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.000	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.000	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.000	0.069	0.192	0.000	0.000	0.420

Discussion

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different skills to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah and Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding was similar to that of the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

Learning design in MSLAM builds students' knowledge through social interaction. This is in accordance with the learning characteristics proposed by Vygotsky that in a learning process student must actively build knowledge. Collaborative activities and scientific communication that emphasize high social interaction are expected to optimize students' thinking skills. Contextual physics phenomena allow students to learn from new things that are close to life. In addition, the design of learning activities that emphasize the completion of certain tasks is in accordance with the main principles of the learning model developed by Vygotsky, which is Scaffolding. (Shvarts & Bakker, 2019; Smagorinsky, 2018).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve students' CS better than SCS simultaneously. While the result also shows that students' SCS cannot be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each subject group. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improve after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research

developing an appropriate assessment instrument requires to consider.

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ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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Paper title: Multiple Skills Laboratory Activities: How They Can Improve Student's Scientific Communication and Collaboration Skills

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?	√				
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?	√				
	• Is research question of the study clear and understandable?	√				
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Methods	• Is the methodology chosen suitable to the nature of the topic studied?	√				
	• Is the methodology of the research described clearly?(including study design, location, subjects, data collection, data analysis)		√			
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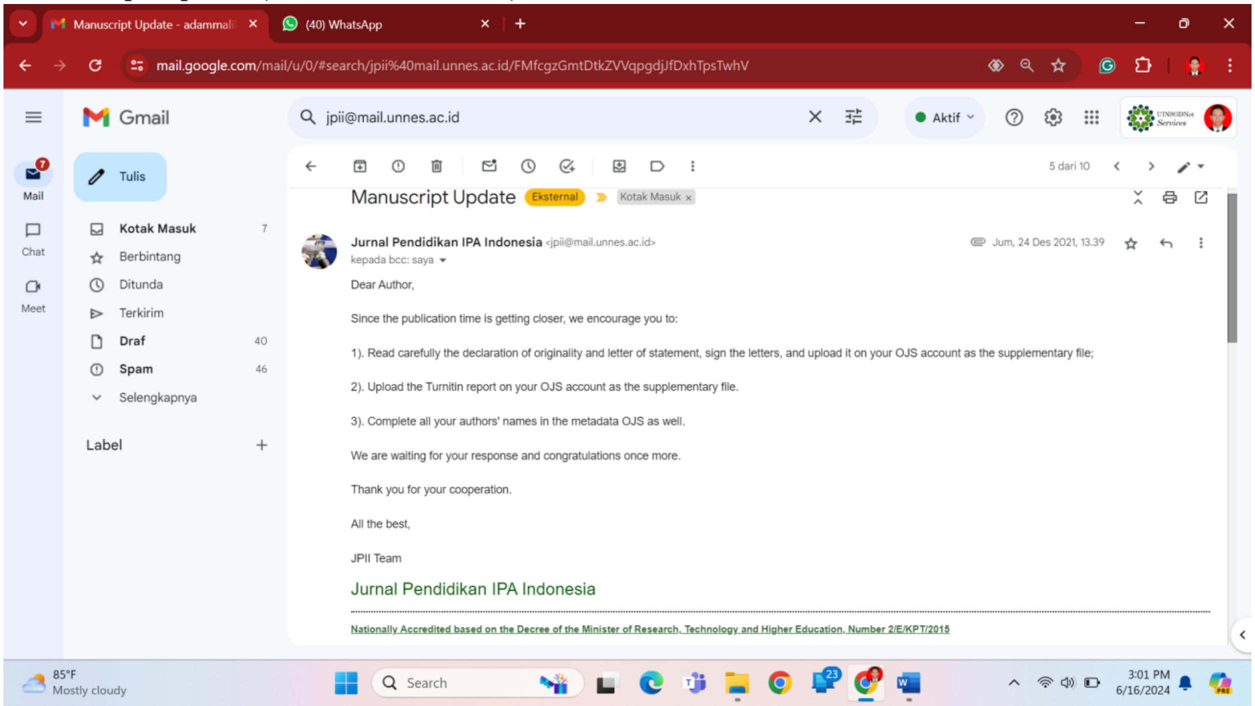
	• Are the validity and reliability of data collection tools established? (only for empirical studies)		√			
	• Are the data collection tools suitable for the methodology of the study? (only for empirical studies)		√			
Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?		√		The presentation of numerical data can be presented in a table or graphic to make more interesting	Has been revised
	• Do the data analysis and the interpretation appropriate to the problem and answer the objectives?		√			
	• Does the "discussion" section of the manuscript adequately relate to the current and relevant litarature?		√		Discussion should be linked to relevant learning theory as characteristics of educational research, because communication and collaboration are very relevant to Vygotsky's learning Theory	Have been done
	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
	• Is the conclusion clear and in the form of a		√			

Conclusion	narration instead of pointers?					
	• Isn't the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√		Please add references of relevant learning theory to complete the discussion.	Have been done
	• Are the writing of references correct?	√				
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?	√				
	• The quality of the language is satisfactory		√			
	• The work relevant and novel		√			
	• Are there strong consistencies among the parts of the manuscript? (introduction, methods, results and discussion, and conclusion)		√			

13. Manuscript Update (24 Desember 2021)



Manuscript Update

Jurnal Pendidikan IPA Indonesia <jpii@mail.unnes.ac.id>

Jum, 24 Des 2021, 13.39

kepada bcc: saya

Dear Author,

Since the publication time is getting closer, we encourage you to:

1). Read carefully the declaration of originality and letter of statement, sign the letters, and upload it on your OJS account as the supplementary file;

2). Upload the Turnitin report on your OJS account as the supplementary file.

3). Complete all your authors' names in the metadata OJS as well.

We are waiting for your response and congratulations once more.

Thank you for your cooperation.

All the best,

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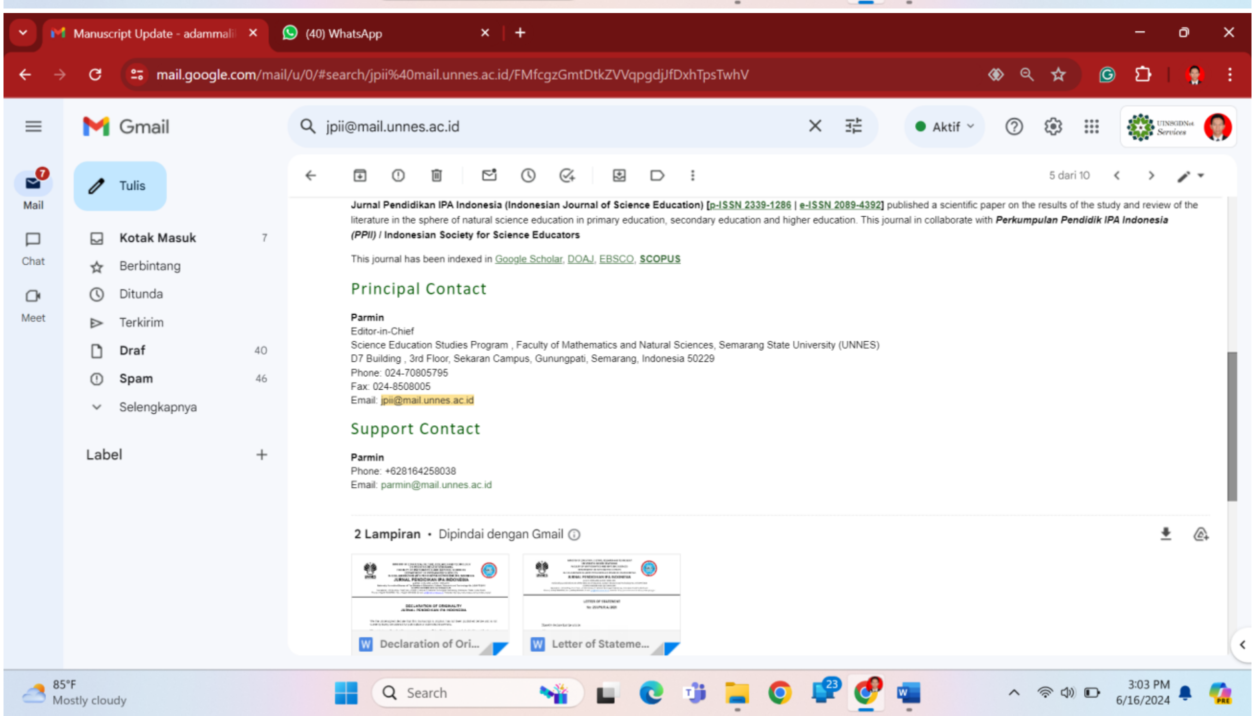

Jurnal Pendidikan IPA Indonesia (Indonesian Journal of Science Education) [p-ISSN 2339-1286 | e-ISSN 2089-4392] published a scientific paper on the results of the study and review of the literature in the sphere of natural science education in primary education, secondary education and higher education. This journal in collaborate with *Perkumpulan Pendidik IPA Indonesia (PPII) / Indonesian Society for Science Educators*

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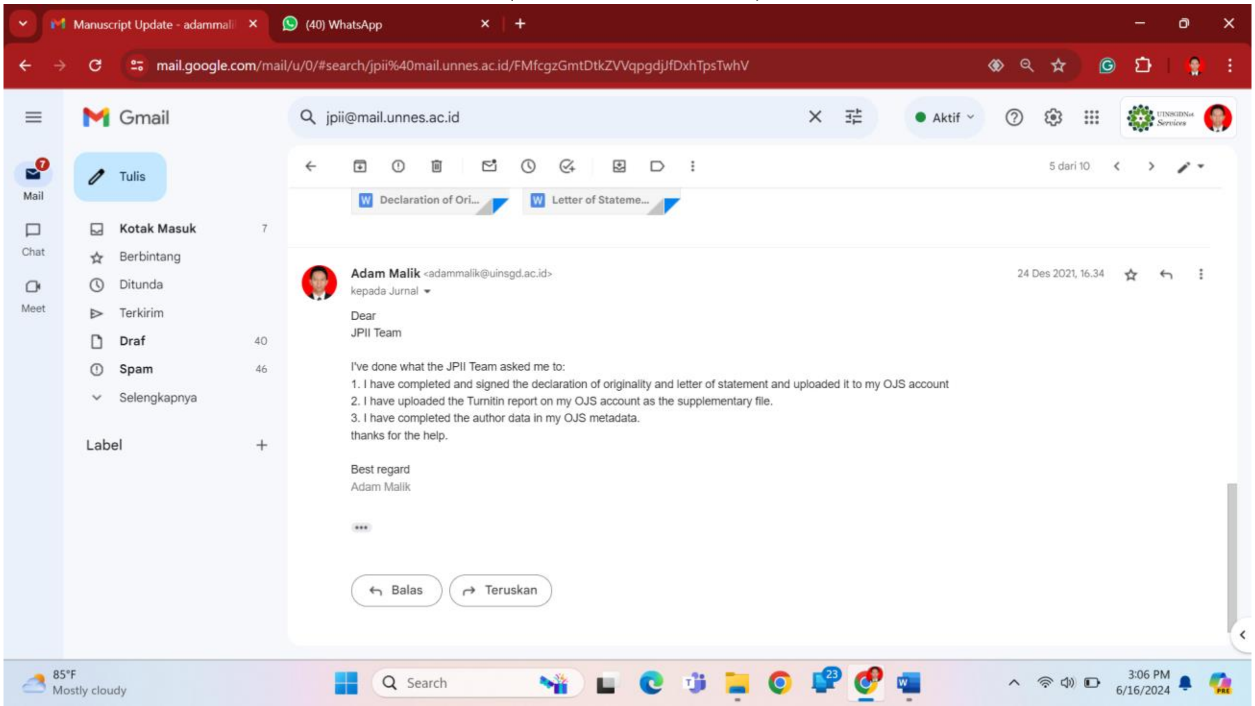
14. I've done what the JPII team asked me (24 Desember 2021)



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DECLARATION OF ORIGINALITY
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We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication or submitted elsewhere.

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

The first author,

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LETTER OF STATEMENT

No: 25/JPII/R.A./2021

I hereby declare that the article:

title : **Multiple Skill Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills**

authors : 1. Adam Malik
2. Mujib Ubaidillah

is **APPROVED** to be published in JPII for December 2021 Issue.

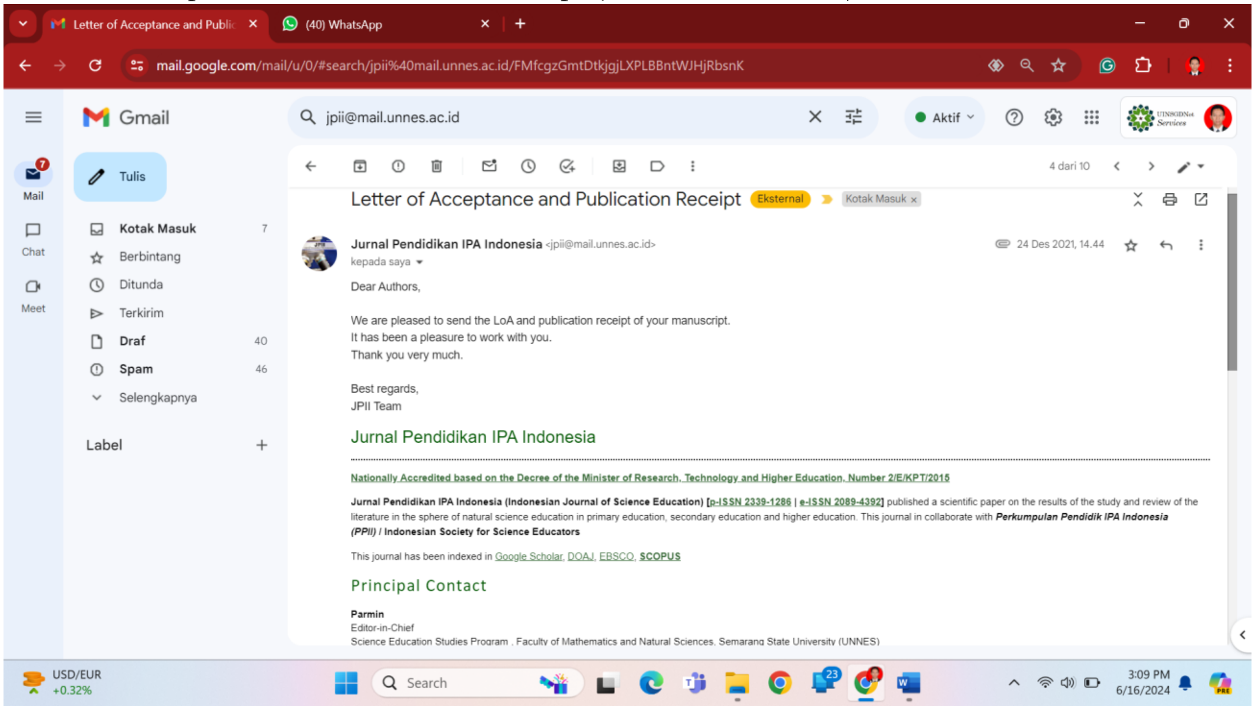
Hereby this statement is made truthfully and to be used accordingly.

Semarang, December 24, 2021

First Author,

Adam Malik

15. Letter of Acceptance and Publication Receipt (24 Desember 2021)



Letter of Acceptance and Publication Receipt

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Dear Authors,

We are pleased to send the LoA and publication receipt of your manuscript.
It has been a pleasure to work with you.
Thank you very much.

Best regards,
JPII Team

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Jurnal Pendidikan IPA Indonesia (Indonesian Journal of Science Education) [p-ISSN 2339-1286 | e-ISSN 2089-4392] published a scientific paper on the results of the study and review of the literature in the sphere of natural science education in primary education, secondary education and higher education. This journal in collaborate with ***Perkumpulan Pendidik IPA Indonesia (PPII) / Indonesian Society for Science Educators***

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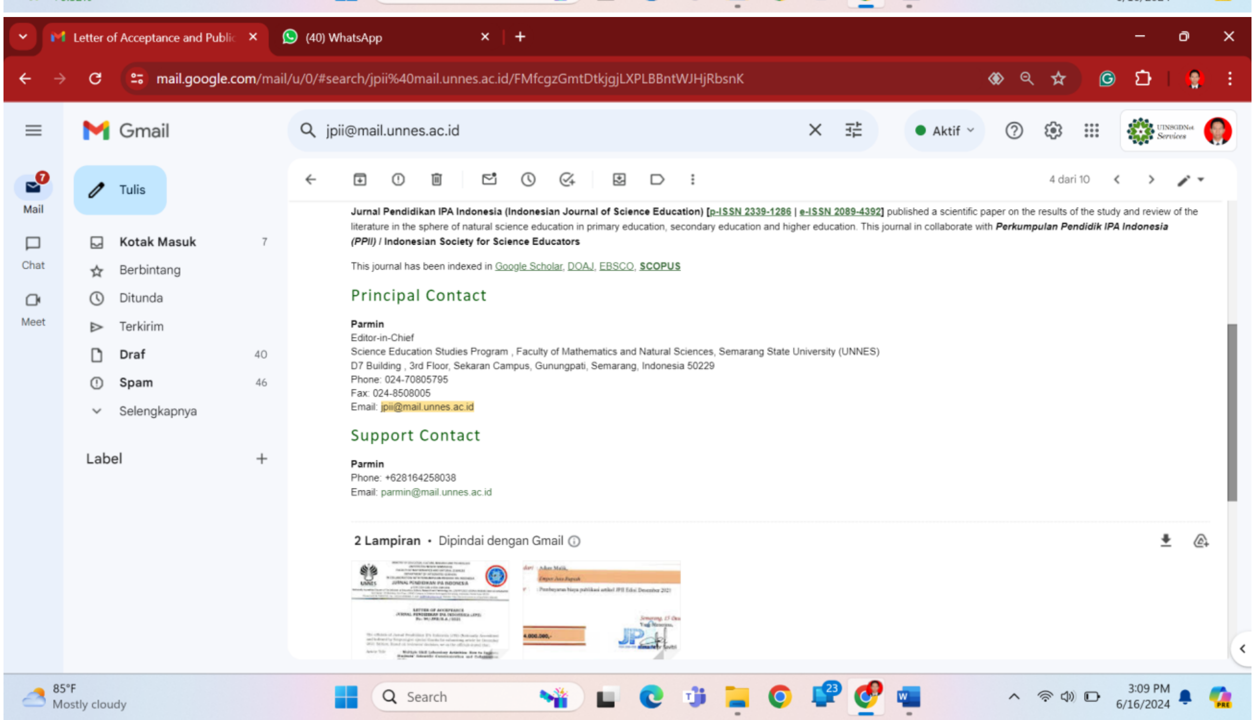

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LETTER OF ACCEPTANCE
JURNAL PENDIDIKAN IPA INDONESIA (JPII)
No: 94/JPII/R.A./2021

The officials of Jurnal Pendidikan IPA Indonesia (JPII) (Nationally Accreditted and Indexed by Scopus) give special thanks for submitting article for December 2021 Edition. Based on reviewers' decision, we as the officials stated that:

Article Title : **Multiple Skill Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills**

Authors : Adam Malik, Mujib Ubaidillah

is **accepted** and is going to be published in JPII December 2021 Edition.

The admision letter is made for appropriate use only. Thank you for the cooperation.

Semarang, 15th December, 2021
Editor-in-Chief of JPII,

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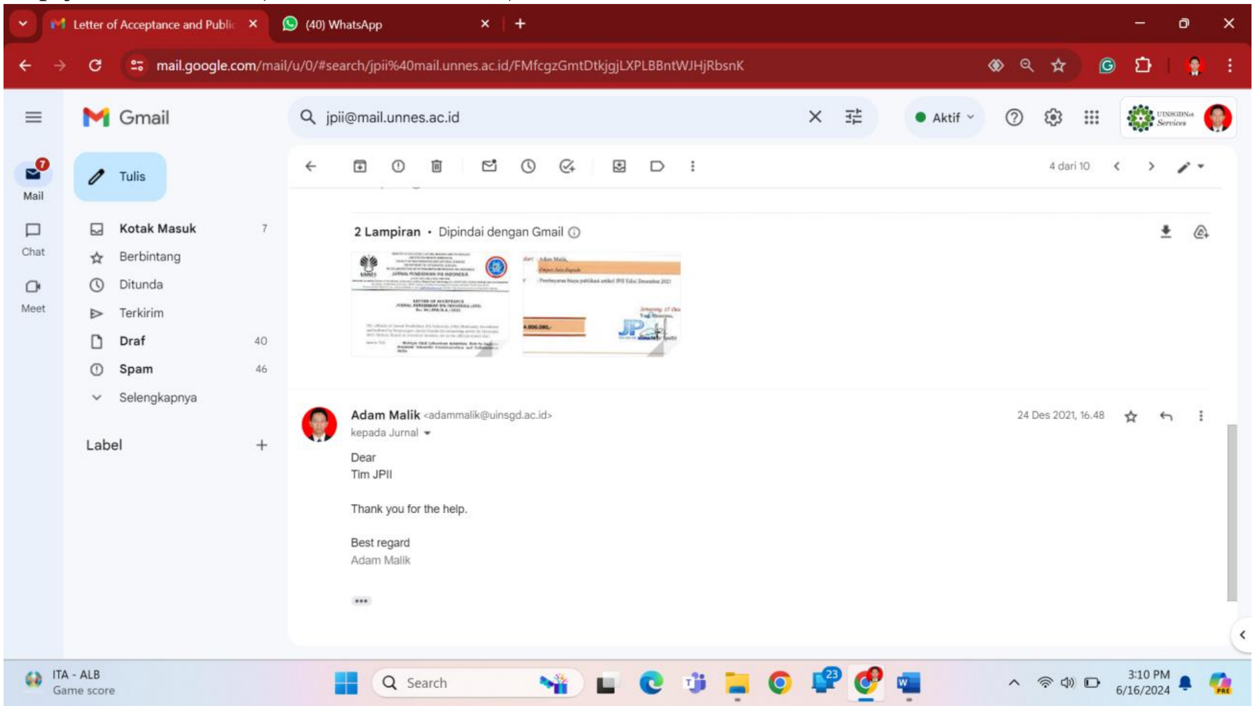
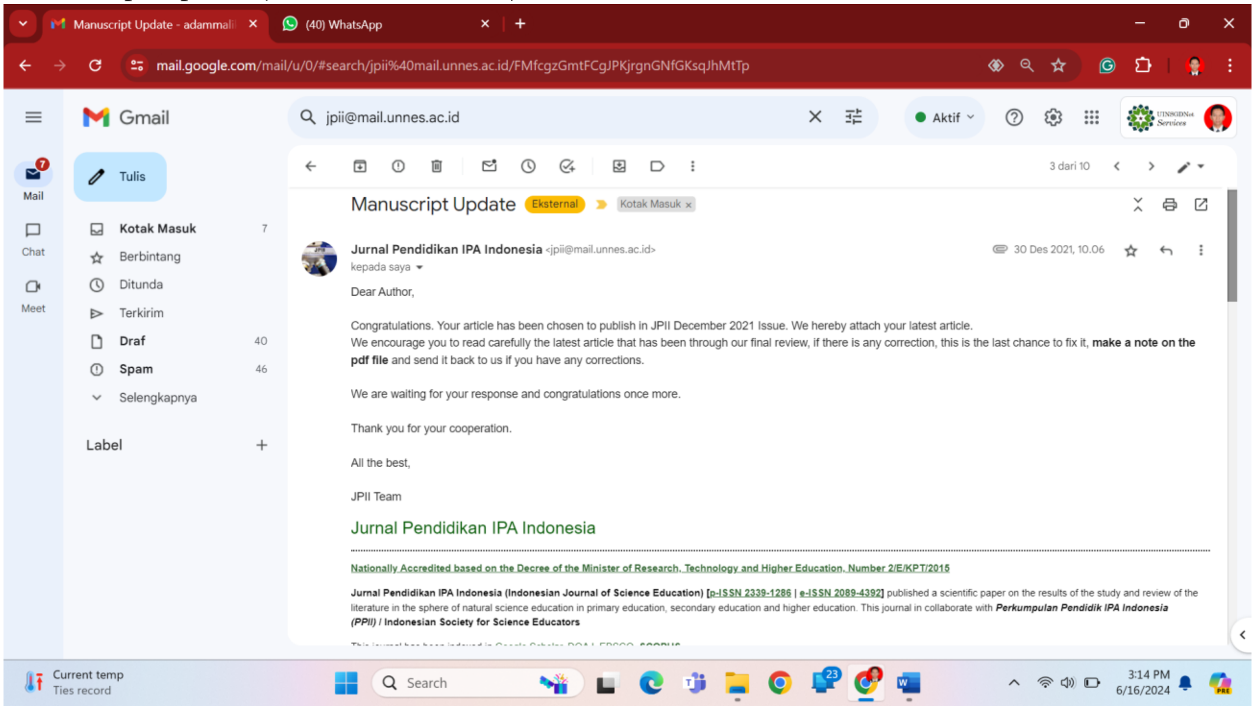
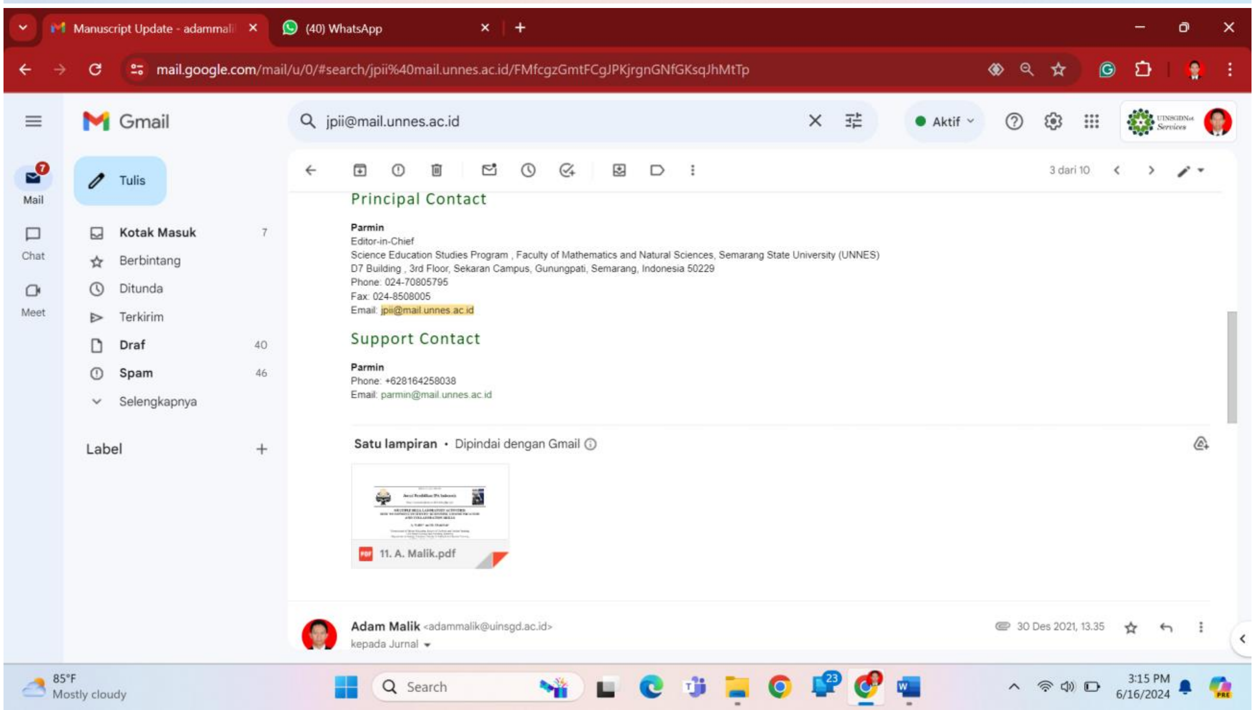
Dr. Parmin, M.Pd.
NIP 197901232006041003

16. Reply the Tim JPII (24 Desember 2021)



17. Manuscript Update (30 Desember 2021)





JPII 5 (2) (2021) 247-
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Multiple Skill Laboratory Activities: How to Improve Students' Scientific Communication and Collaboration Skills

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DOI:

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ABSTRACT

This study **aims** to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a **quasi-experimental** design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous skills and learning habits from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher-order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skill Laboratory Activity Model. The data were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more **significant** influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model (MSLAM) improves students' collaboration skills **better than** communication skills. MSLAM explores more activities to practice collaboration skills, e.g., brainstorming, exploration, and measurement, while the activities for practicing communication skills is depended on analysis and presentation only. This study also reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: scientific communication skills; collaboration skills; multivariate analysis

INTRODUCTION

The rapid distribution of information and easy access to information from various sources are characteristics of the 21st century, including 21st-century education. Nowadays, students can easily access various learning resources that may not be accessible to teachers. In addition, students and teachers can easily share their findings through various platforms, both free and paid. Therefore, additional skills are needed so that students and teachers can deliver their findings appropriately. Such skills are called Scientific Communication Skills (SCS), one of the crucial competencies in the 21st century (Alpusari et al., 2019; Chung et al., 2016; Gordon & Martin, 2019; Siddiq et al., 2016; van Laar et al., 2017), and it contributes scientifically to be accepted in society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Grainger et al., 2019; Hansen et al., 2018; Pehrson et al., 2016). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the complex research results (Dannels et al., 2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study shows that communication skills consistently fail to be demonstrated by science students than analytical, technical, and problem-solving skills (Gray et al., 2005). Graduates do not consistently display communication skills when hiring (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study shows that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems (Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020).

Previous studies still generally investigate the issues and have not optimized the experimental learning. There have been several studies focused on developing learning strategies, methods, and approaches to improve HOTs (Atasoy, 2013; Chen et al., 2013; Corder, 1995; Hošková-Mayerová, 2014; Klochkova et al., 2016; Kusumawati et al., 2015; Novita, 2010; Patriot et al., 2018; Prahani et al., 2016; Rickles et al., 2009; Triana et al., 2019; Woods et al., 2004). In addition, the researchers also focused on improving the model of teaching (Alpusari et al., 2019; Lubis et al., 2018; Spektor-Levy et al., 2008; Yuliardi, 2017) and learning media (Elmas et al., 2013; Pehrson et al., 2016; Triana et al., 2019; Van Nuland et al., 2012; Wang et al., 2015; Yang & Heh, 2007; Yuliardi, 2017) or evaluation (Calhoun et al., 2010; Dunbar et al., 2006; Harasym et al., 2008; Hobgood et al., 2002; Ladyshewsky & Gotjamanos, 1997; Pehrson et al., 2016; Susie et al., 1999).

While SCS and other thinking skills are proved more effectively by employing experimental-based learning (Nuryantini et al., 2020; Rahayu, 2020; Zhou et al., 2013), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Ardhyani & Khoiri, 2017; Y.-F. Chang & Schallert, 2005; Li & Adamson, 1992; Silvia et al., 2009; Wang et al., 2015). Like SCS, CS is also necessary for the 21st century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' skills. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategies (Khan, 2008; Luo, 2014; McCandliss et al., 2003; Sinex & Chambers, 2013; Sundari, 2008; Walker & Sampson, 2013; Warne, 2014), teaching model (Erika & Prahani, 2017; Liu et al., 2011), learning media (Ardhyani & Khoiri, 2017; Aydın, 2016; Rosidah & Rosdiana, 2019; Rubini et al., 2018), and learning evaluation (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the students' different skills are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with superior skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model.

In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS? 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). The experimental design is provided in Table 1. Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

Table 1. Experimental Design

Class	SCS		CS	
	Ctrl.	**Exp.**	**Ctrl.**	**Exp.**
A	A-C_1	A-X_1	A-C_2	A-X_2
B	A-C_1	A-X_1	A-C_2	A-X_2
C	A-C_1	A-X_1	A-C_2	A-X_2
D	A-C_1	A-X_1	A-C_2	A-X_2
E	A-C_1	A-X_1	A-C_2	A-X_2

Explanation: A: UIN Sunan Gunung Djati, B: UIN Imam Bonjol, C: UIN Alauddin, D: IAIN Palangkaraya, D: IAIN Syekh Nurjati

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as the control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity.

This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Syekh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as the control class, and the other group experimented by employing the MSLAM model as the experimental class.

In this study, participants carried out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the skills of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final skills of the participants.

The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The rubric was feasible used according to five expert judgments. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open-mindedness, respect, and group investigation skills. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring students' skills.

The students in the control class were experimented with 11 stages of the HOT Lab, while the students in the experiment class were experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation.

MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables: the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the students' skills. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

Experimental Model

The first analysis discusses the effects of an experimental model on the improvement of SCS and CS provided in Table 2.

Table 2. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 2 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Figure 1. This analysis was conducted by referring to intercept and signification values.

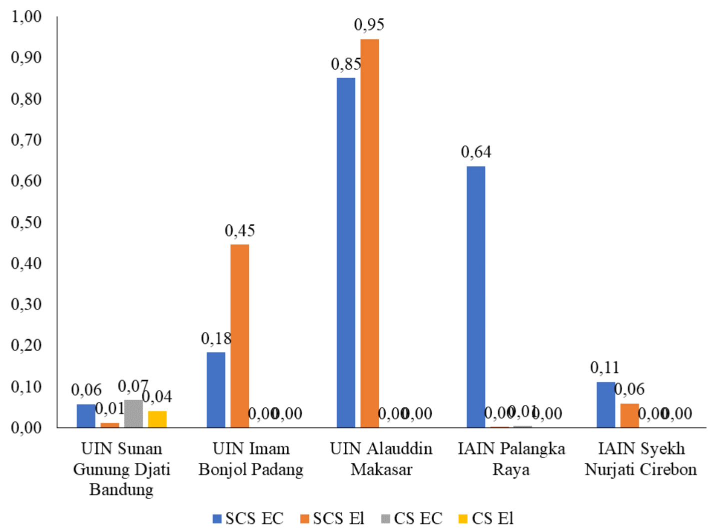

Figure 1. The test of between-subject effects – an experimental model (Intercept: 0.00)

Figure 1 indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender Effect

Gender is employed as a factor of analysis. Gender is assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 3. The multivariate test by Wilks' lambda method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 3, statistics analysis proves that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Figure 2.

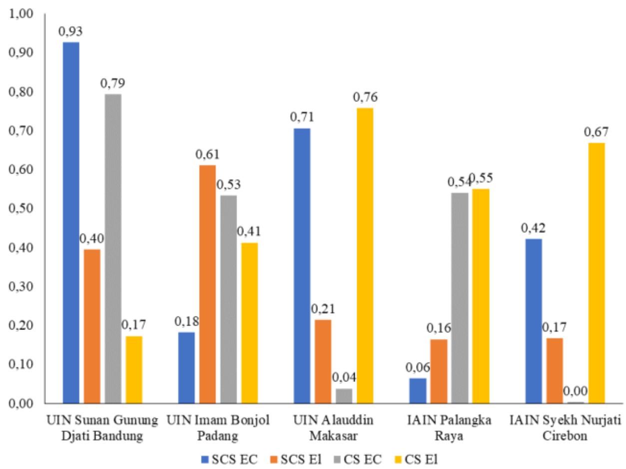

Figure 2. The test of between-subject effects–gender (intercept: 0.00)

Figure 2 shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of the two subject groups are lower than 0.05, and it indicates that gender influences the increase of CS.

The integrated analysis of the experimental model and gender

The last analysis discusses the contribution of laboratory activities and gender to achieve SCS and CS. Table 4 shows that the p-values of most experimental models are less than 0.05. It indicates that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

Table 4. The multivariate test by Wilks' lambda method

		Value	F	sig.
UIN Sunan Gunung Djati	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

The test results of between-subject effects in Table 5 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 5. The test of between-subject effects–integrated analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.000	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.000	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.000	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.000	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.000	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.000	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.000	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.000	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.000	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.000	0.069	0.192	0.000	0.000	0.420

Discussion

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018; Walker & Sampson, 2013) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different skills to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah and Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding is similar to the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

Learning design in MSLAM builds students' knowledge through social interaction. This is following the learning characteristics proposed by Vygotsky that in a learning process students must actively build knowledge. Collaborative activities and scientific communication that emphasize high social interaction are expected to optimize students' thinking skills. Contextual physics phenomena allow students to learn from new things that are close to life. In addition, the design of learning activities that emphasize the completion of certain tasks is following the main principles of the learning model developed by Vygotsky, which is Scaffolding. (Shvarts & Bakker, 2019; Smagorinsky, 2018).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve students' CS better than SCS simultaneously. While the result also shows that students' SCS cannot be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each subject group. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improve after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research on developing an appropriate assessment instrument needs to consider.

ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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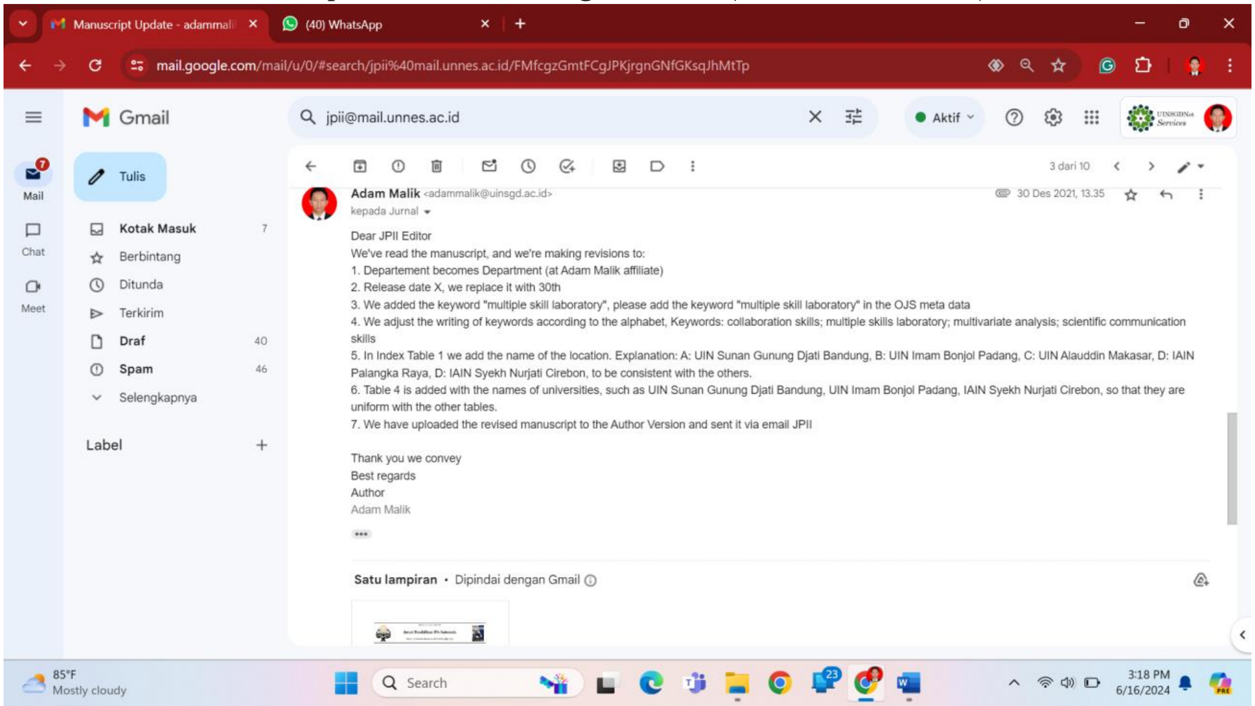

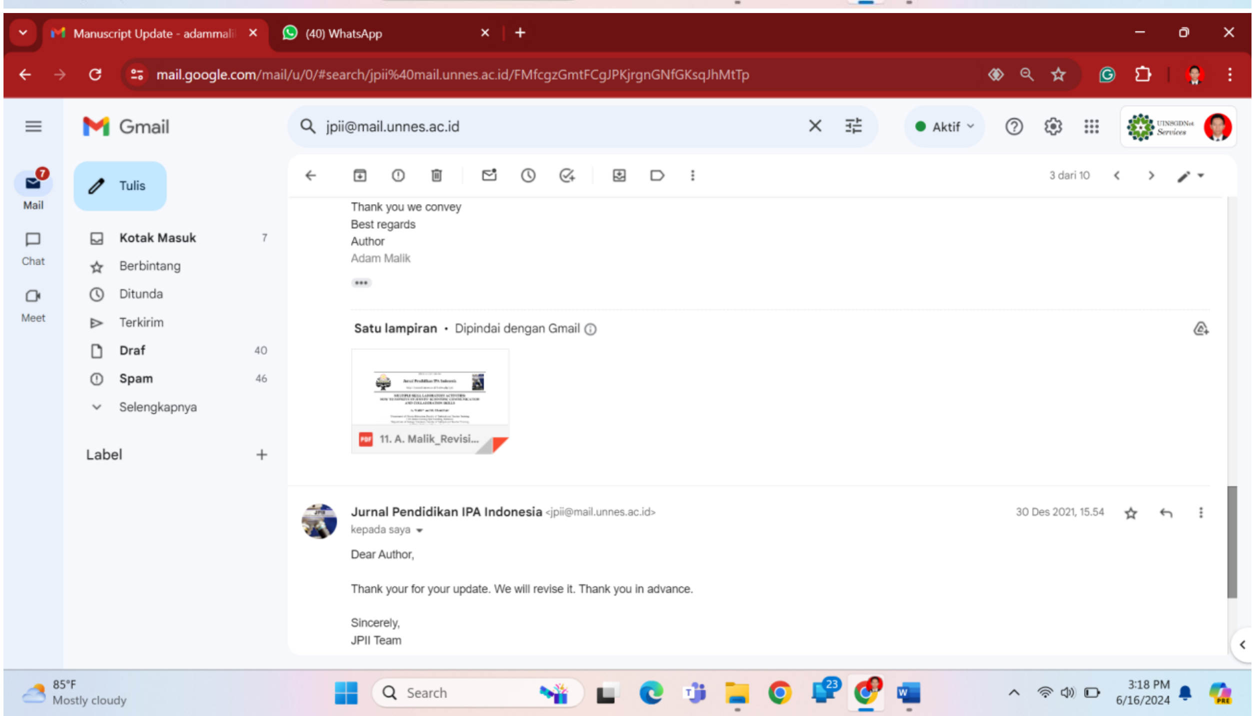

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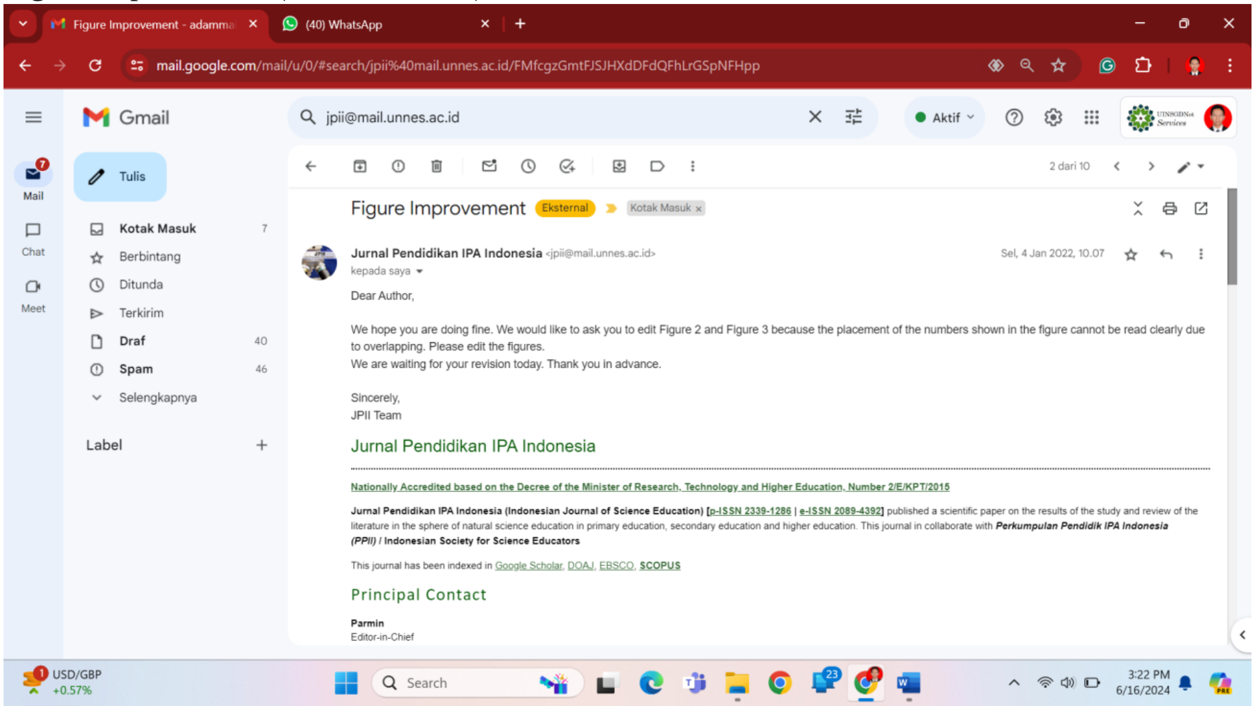

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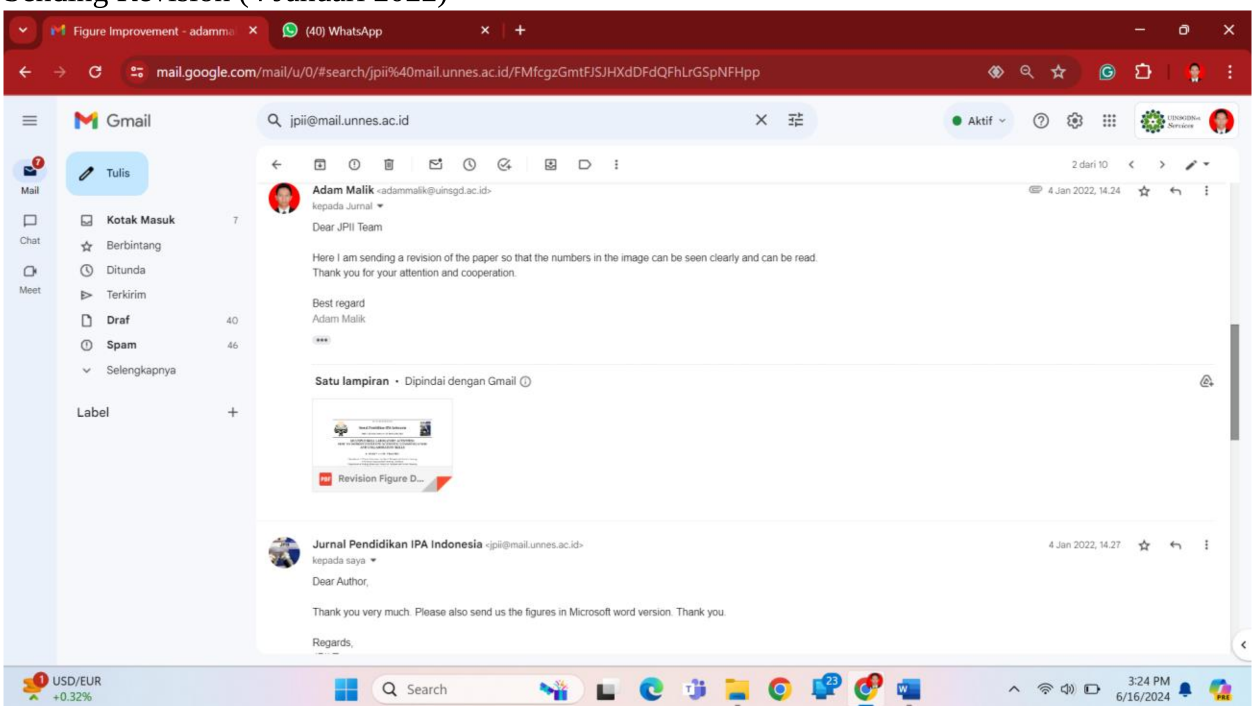

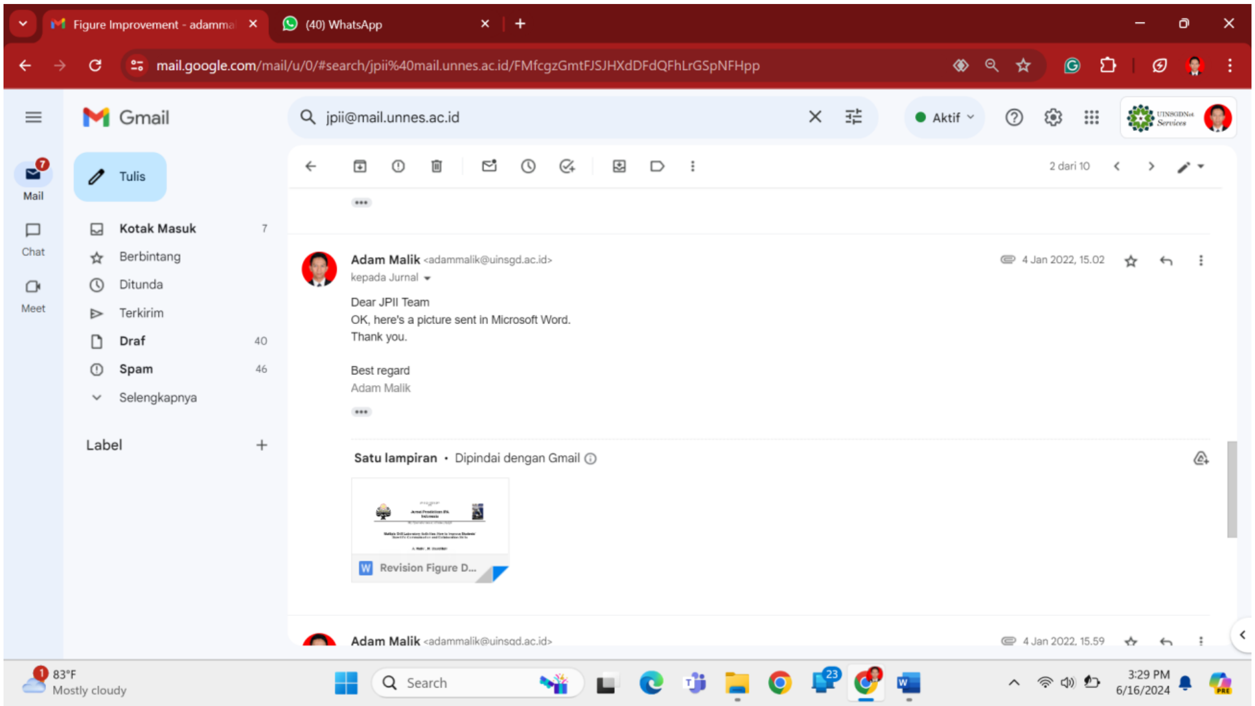
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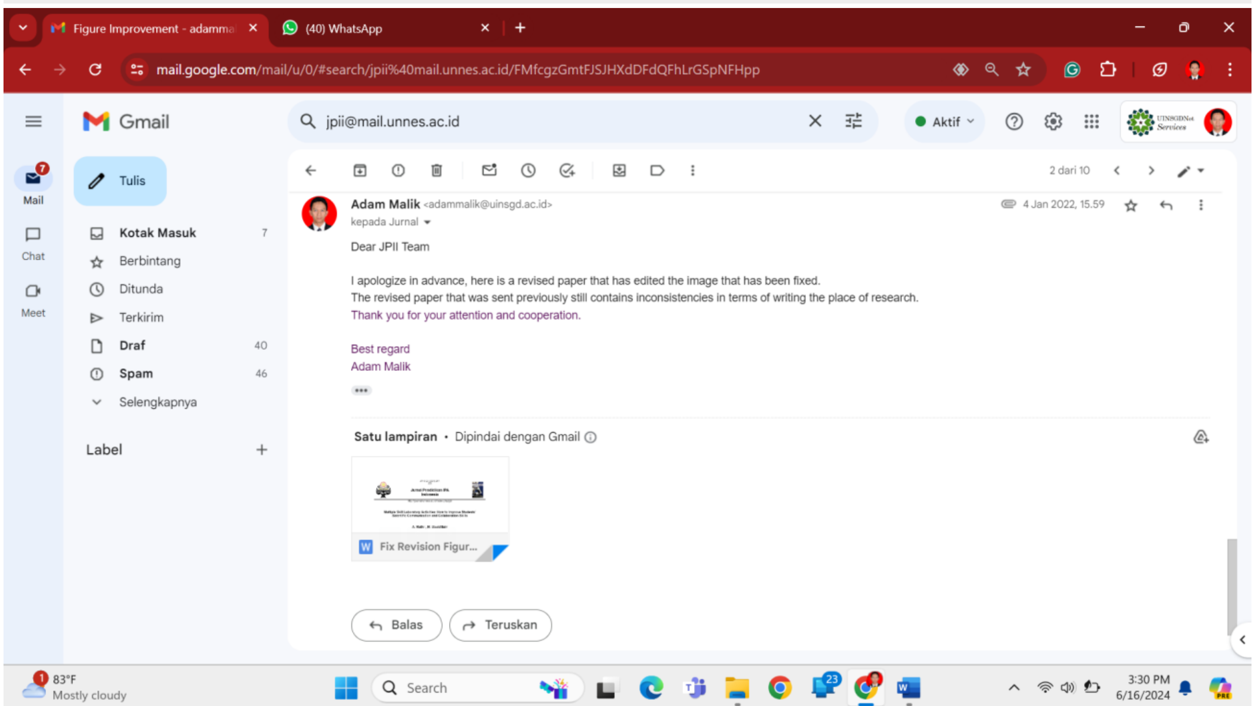
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MULTIPLE SKILL LABORATORY ACTIVITIES: HOW TO IMPROVE STUDENTS' SCIENTIFIC COMMUNICATION AND COLLABORATION SKILLS

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DOI: 10.15294/jpii.v10i4.31442

Accepted: August 1st 2021. Approved: December 27th 2021. Published: December 31st 2021

ABSTRACT

This study aims to analyze the effects of experiment models and gender on scientific communication and collaboration skills. This study employed a quasi-experimental design consisting of five groups as control classes and five groups as experimental classes. The subject of this study was 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old) with heterogeneous skills and learning habits from five different universities representing four regions: Sumatra, Java, Kalimantan, and Sulawesi. The control class conducted activities based on the Higher-order Thinking Laboratory model, while the experimental class conducted activities based on the Multiple Skill Laboratory Activity Model. The data were collected by employing a validated instrument and were analyzed by employing a Multivariate test. This study shows that the experimental model has more significant influences on improving students' skills than gender. Specifically, the Multiple Skill Laboratory Activity Model (MSLAM) improves students' collaboration skills better than communication skills. MSLAM explores more activities to practice collaboration skills, e.g., brainstorming, exploration, and measurement, while the activities for practicing communication skills is depended on analysis and presentation only. This study also reveals that the experiment model and gender are not suitable for concurrent analysis. This study is expected to provide methods for further researchers to optimize students' scientific communication and collaboration skills. Furthermore, this study provides an overview for teachers to practice several thinking skills at one time.

Keywords: collaboration skills; multiple skills laboratory; multivariate analysis; scientific communication skills

INTRODUCTION

The rapid distribution of information and easy access to information from various sources are characteristics of the 21st-century, including 21st-century education. Nowadays, students can easily access various learning resources that may not be accessible to teachers. In addition, students and teachers can easily share their findings through various platforms, both free and paid. Therefore, additional skills are needed so that students and teachers can deliver their findings appropriately. Such skills are called Scientific Communication Skills (SCS), one of the crucial competencies in the 21st-century (Chung et al., 2016; Siddiq et al., 2016; Shin, 2018; Alpusari et al., 2019; Gordon & Martin, 2019), and it contributes scientifically to be accepted in society. The SCS encourages students to deliver their facts and data-based arguments and explanations (Pehrson et al., 2016; Hansen et al., 2018; Grainger et al., 2019). Besides, SCS is necessary to explain various physics concepts and simplify the explanation of the complex research results (Dannels et al.,

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2003; Saleh et al., 2017). In addition, nowadays, students are in the globalization era that demands to convey ideas to the public. However, communication skills have not received much attention, especially in the laboratory learning environment.

A study shows that communication skills consistently fail to be demonstrated by science students than analytical, technical, and problem-solving skills (Gray, 2005; Sari & El Islami, 2020; Stieff & DeSutter, 2021). Graduates do not consistently display communication skills when hiring (McInnis et al., 2000). Modern workplaces complain that science graduates cannot meet the requirements of good communication (Herok et al., 2013). Learning how to collaborate is rarely considered an educational outcome (Liebech-Lien & Sjølie, 2021). Another study shows that practicing science communication skills in undergraduate candidates is beneficial to individuals and society (Besley & Tanner, 2011). Students need to practice scientific communication to solve scientific and social problems (Bray et al., 2012), collaboration skills increase self-efficacy, and opportunities to work with overseas partners for preservice teachers (Hur et al., 2020).

Previous studies still generally investigate the issues and have not optimized the experimental learning. There have been several studies focused on developing learning strategies, methods, and approaches to improve HOTs (Corder, 1995; Woods et al., 2004; Rickles et al., 2009; Novita, 2010; Atasoy, 2013; Chen et al., 2013; Hošková-Mayerová, 2014; Kusumawati et al., 2015; Klochkova et al., 2016; Prahani et al., 2016; Patriot et al., 2018; Triana et al., 2019). In addition, the researchers also focused on improving the model of teaching (Spektor-Levy et al., 2008; Yuliardi, 2017; Lubis et al., 2018; Alpusari et al., 2019) and learning media (Yang & Heh, 2007; Van Nuland et al., 2012; Elmas et al., 2013; Wang et al., 2015; Pehrson et al., 2016; Yuliardi, 2017; Triana et al., 2019) or evaluation (Ladyshewsky & Gotjamanos, 1997; Susie et al., 1999; Hobgood et al., 2002; Dunbar et al., 2006; Harasym et al., 2008; Calhoun et al., 2010; Pehrson et al., 2016).

While SCS and other thinking skills are proved more effectively by employing experimental-based learning (Zhou et al., 2013; Ibnu & Rahayu, 2020; Nuryantini et al., 2020), experiment-based learning and other experimental models involve students to observe phenomena, trace the causes, test hypotheses, interpret, analyze, and explain findings.

The experimental models enable students to practice SCS and the Collaborative Skills (CS) simultaneously demonstrated by an experimental activity that allows students to work in a group (Li & Adamson, 1992; Di Marco et al., 2009; Wang et al., 2015; Ardhyani & Khoiri, 2017). Like SCS, CS is also necessary for the 21st-century (García, 2016) to facilitate students to collaborate even with strangers.

CS, in the same condition as SCS, still receives less attention in the learning process. Most schools still prioritize competition among students as an effort to improve their learning outcomes. As a result, there are often significant differences in the students' skills. However, several efforts to effectively practice CS have started to develop. At least, there are four significant scopes as the focus of CS development that are learning strategies (McCandliss et al., 2003; Khan, 2008; Sundari, 2008; Sinex & Chambers, 2013; Walker & Sampson, 2013; Luo, 2014; Warne, 2014), teaching model (Liu et al., 2011; Erika & Prahani, 2017), learning media (Aydın, 2016; Ardhyani & Khoiri, 2017; Rubini et al., 2018; Rosidah & Rosdiana, 2019), and learning evaluation (Khan & Saleh, 1997; McCandliss et al., 2003; Walker & Sampson, 2013).

Research on CS frequently combines treatment for other skills: with critical thinking skills (Hughes et al., 2018), with creative thinking (Chang et al., 2016), with learning outcomes (García, 2016), and with argumentation skills and self-efficacy (Erika & Prahani, 2017). However, research that constructs the combination of communication and collaboration skills is still rarely conducted. Therefore, this study aims to investigate experimental-based learning that trains and develops SCS and CS simultaneously.

Another problem that has been encountered, especially in experimental-based learning, is gender consequence. Stereotypes rooted in society believe that male students have better skills than female students as an extended assumption that men are better at working with technology than women (Crymble, 2016). Furthermore, the existence of gender does not always provide a significant difference in improving the learning outcome. According to Brodahl (2011), gender does not significantly affect writing practices. However, the students' different skills are dominated by their adaptability to the technology applied. In collaboration, gender differences are frequently employed to determine a group's task divisions, especially group works that require physical skills (Adolphus & Omeodu, 2016). Students tend to be spectators and data writers (like a secretary) when this method is implemented during the experimental activities. This result will indirectly affect the students' readiness to be prospective teachers. Therefore, this study employs gender as a factor to evaluate the effects of gender on students' skills.

This study focuses on determining the simultaneous improvement of SCS and CS practiced by implementing two experimental models, HOT Lab and MSLAM. The study aims to investigate the readiness of each experimental model to practice two or more thinking skills simultaneously. The study is expected to propose a description of the readiness model and possibly provide a reflection to improve the model in the future. Thus, the learning process becomes more efficient and successfully prepares output or graduate profiles with superior skills. The researchers hypothesize that students who conduct experiments by adopting the MSLAM model will have better SCS and CS than those who employ the HOT Lab model. In addition, this study focuses on identifying the influences of gender on experiment-based learning. The assumption that male students are better than female students in terms of experimental activities psychologically influences students' and the teacher's point of view. Therefore, this study is expected to describe the effects of gender differences. The researchers hypothesize that there are no significant differences between male students and female students. The research questions of this study are 1) How do the HOT Lab Model and the MSLAM simultaneously affect the increase of SCS and CS?; 2) Does gender affect the simultaneous practices of SCS and CS?

METHODS

This study employed a quasi-experimental method that discussed the effects of the experimental model HOT Lab and MSLAM in simultaneously practicing SCS and CS (Ary et al., 2018). The experimental design is provided in Table 1. Furthermore, gender was employed as a review factor to determine their effects on experimental learning, especially on practicing SCS and CS at one time.

Table 1. Experimental Design

Class	SCS		CS	
	Ctrl.	Exp.	Ctrl.	Exp.
A	A-C_1	A-X_1	A-C_2	A-X_2
B	A-C_1	A-X_1	A-C_2	A-X_2
C	A-C_1	A-X_1	A-C_2	A-X_2
D	A-C_1	A-X_1	A-C_2	A-X_2
E	A-C_1	A-X_1	A-C_2	A-X_2

Explanation: A: UIN Sunan Gunung Djati Bandung, B: UIN Imam Bonjol Padang, C: UIN Alauddin Makasar, D: IAIN Palangka Raya, E: IAIN Syekh Nurjati Cirebon

This study involved 327 students (168 students used HOT Lab and 159 used Multiple Skill; 69 Male and 258 Female from 18 to 22 years old), and they were divided into ten groups: five groups applied the MSLAM as the experimental class, and five groups applied the HOT Lab as the control class. All of the groups conducted experiments on the series-parallel circuit on electrical and elasticity. This research was conducted from May 2019 to July 2020 by practicing the HOT Lab and the MSLAM to physics education students from five universities representing four regions in Indonesia. They were Java (UIN Sunan Gunung Dajti Bandung and IAIN Syekh Nurjati Cirebon), Sumatera (UIN Imam Bonjol Padang), Kalimantan (IAIN Palangka Raya), and Sulawesi (UIN Alauddin Makasar). The students had heterogeneous-academic skills and laboratory experience. In each university, the students were divided into two groups: one group experimented by employing the HOT Lab model as the control class, and the other group experimented by employing the MSLAM model as the experimental class.

In this study, participants carried out experimental activities according to their respective practicum instructions. During the implementation, observations were made to obtain information about the skills of scientific collaboration and communication. In the end, participants were given a post-test to get information about the final skills of the participants. The assessment sheets were employed to collect data consisting of assessment of SCS and CS. The assessment rubric used was developed following modern learning. The rubric was feasible used according to five expert judgments. The SCS instruments consisted of three aspects: scientific writing, information representative, and knowledge presentation. Meanwhile, the CS instruments consisted of seven indicators: contribution, group work, responsibility, problem-solving, open-mindedness, respect, and group investigation skills. Five observers in each university filled the instruments based on a rubric with a range of 1-3 or 1-4 for several indicators. All of the instrument was validated by expert judgment and recommended used for measuring students' skills.

The students in the control class were experimented with 11 stages of the HOT Lab, while the students in the experiment class were experimented with 15 stages of MSLAM. HOT Lab stages consisted of real-world problems, experimental questions, alternative solutions, conceptual questions, prediction, tools and materials, exploration, measurement, data analysis, answering predictions, and presentation. On the other side, MSLAM stages consisted of orientation issues, brainstorming, alternative ideas, discussion, conceptual questions, predictions, equipment, exploration, measurement, processing data, analysis, conclusion, presentation, and evaluation.

MANOVA analysis was employed to determine the contribution of two types of experiments on the students' SCS and CS toward experimental activities as their course. MANOVA was chosen because it fits the research design in which there are two interrelated dependent variables: the practicum model and gender (Warne, 2014). Moreover, gender differences were employed as a review factor in the students' skills. The statistical significance of this research was 0.05 level in two-tailed hypothesis tests.

RESULTS AND DISCUSSION

The first analysis discusses the effects of an experimental model on the improvement of SCS and CS provided in Table 2.

Table 2. The Multivariate Test by Wilks' Lambda Method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.472	1.867	0.00
UIN Imam Bonjol Padang	0.387	21.769	0.00
UIN Alauddin Makasar	0.353	26.529	0.00
IAIN Palangka Raya	0.460	16.171	0.00
IAIN Syekh Nurjati Cirebon	0.557	13.893	0.00

Table 2 shows that the experimental model significantly influences SCS and CS, shown by a significant value of less than 0.05. The subsequent analysis employed the Test of Between-Subject Effects data in each skill group as presented in Figure 1. This analysis was conducted by referring to intercept and signification values.

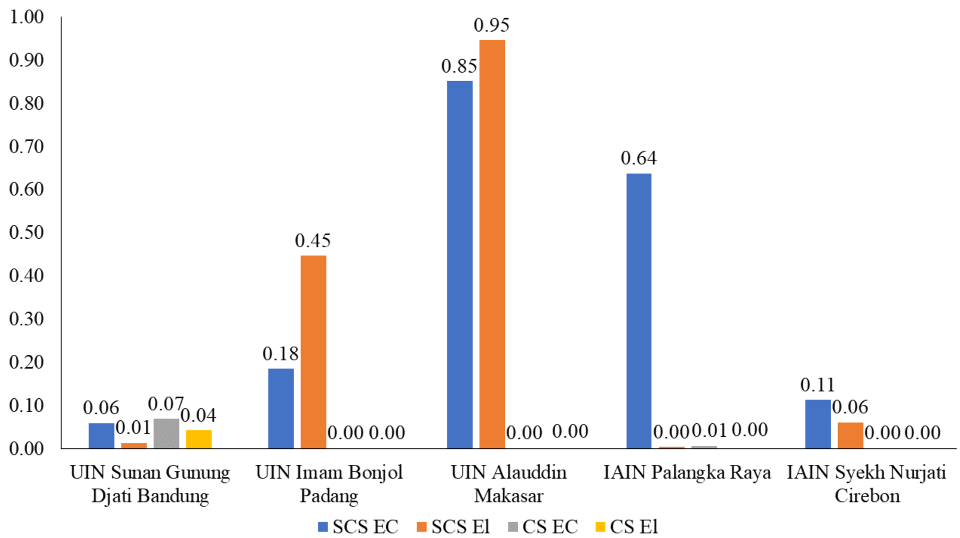

Figure 1. The Test of Between-Subject Effects – An Experimental Model (Intercept: 0.00)

Figure 1 indicates that the intercept value of every subject group is smaller than 0.05, and it is interpreted as significant. This result indicates that there is an increase in SCS by ignoring the experiment influence. This result has not been finalized because it is compulsorily confirmed with significant values. The data reveal that only two subject groups have a lower value than 0.05 in SCS, and only three subject groups have a higher score than 0.05 in CS. Therefore, only two subject groups on SCS and seven groups on CS show a significant effect.

Gender is employed as a factor of analysis. Gender is assumed as a variable that can differentiate students' SCS and CS when conducting the experiments. Thus, the gender analysis is conducted similarly to the experimental model analysis.

Table 3. The Multivariate Test by Wilks' Lambda Method

	Value	F	sig.
UIN Sunan Gunung Djati Bandung	0.008	2078.854	0.000
UIN Imam Bonjol Padang	0.919	1.211	0.317
UIN Alauddin Makasar	0.882	1.934	0.117
IAIN Palangka Raya	0.915	1.281	0.289
IAIN Syekh Nurjati Cirebon	0.859	2.879	0.029

In Table 3, statistics analysis proves that gender does not significantly contribute to the improvement of SCS and CS because the significance values of the four subject groups are more than 0.05. Meanwhile, more calculation is proved in Figure 2.

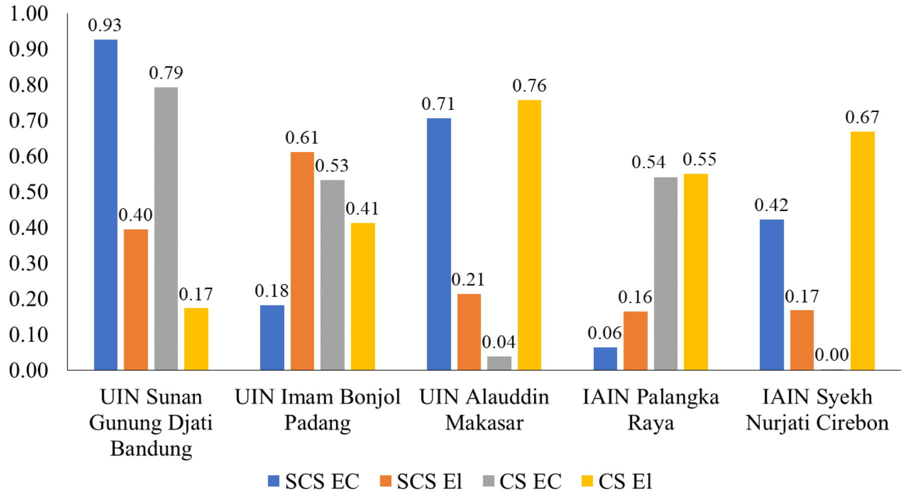

Figure 2. The Test of Between-Subject Effects–Gender (Intercept: 0.00)

Figure 2 shows that intercept values in both SCS and CS are smaller than 0.05. Therefore, it can be concluded that there is an increase in SCS and CS by ignoring the contribution of gender. Meanwhile, the column of sig. for SCS shows that gender does not significantly impact SCS. However, the value of sig. for CS shows that the sig. values of the two subject groups are lower than 0.05, and it indicates that gender influences the increase of CS. The last analysis discusses the contribution of laboratory activities and gender to achieve SCS and CS. Table 4 shows that the p-values of most experimental models are less than 0.05.

Table 4. The Multivariate Test by Wilks' Lambda Method

		Value	F	sig.
UIN Sunan Gunung Djati Bandung	Experimental model	0.005	3201.903	0.000
	Gender	0.943	0.958	0.437
UIN Imam Bonjol Padang	Experimental model	0.381	21.952	0.000
	Gender	0.904	1.433	0.236
UIN Alauddin Makasar	Experimental model	0.895	1.679	0.167
	Gender	0.358	25.519	0.000
IAIN Palangka Raya	Experimental model	0.460	15.876	0.000
	Gender	0.915	1.257	0.298
IAIN Syekh Nurjati Cirebon	Experimental model	0.555	13.853	0.000
	Gender	0.854	2.940	0.026

It shows that the experimental models can significantly affect the SCS and CS. Meanwhile, the significance values of the gender aspect are mostly greater than 0.05, and it indicates that gender does not significantly influence the increase of SCS and CS.

The test results of between-subject effects in Table 5 show that, overall, the students' SCS and CS increase without considering the influence of the experimental model. Furthermore, the results show that gender has a small intercept value of 0.05. Considering the contribution of the experimental model and gender, the SCS and CS insignificantly increase as indicated by the average scores of significance values in exp.: 0.24 for SCS and 0.08 for CS. Meanwhile, gender influences SCS by 0.39 and CS by 0.29. However, it is stated that in SCS, the experimental model is more influential than gender.

Table 5. The Test of Between-Subject Effects–Integrated Analysis

Subject Groups	Content	SCS			CS		
		Intercept	Exp.	Gender	Intercept	Exp.	Gender
UIN Sunan Gunung Djati Bandung	Electric Circuit	0.000	0.000	0.303	0.000	0.063	0.632
	Elasticity	0.000	0.016	0.548	0.000	0.057	0.243
UIN Imam Bonjol Padang	Elelctric Circuit	0.000	0.172	0.169	0.000	0.000	0.503
	Elasticity	0.000	0.442	0.278	0.000	0.000	0.190
UIN Alauddin Makasar	Electric Circuit	0.000	0.723	0.886	0.000	0.051	0.000
	Elasticity	0.000	0.211	0.826	0.000	0.614	0.000
IAIN Palangka Raya	Elelctric Circuit	0.000	0.599	0.064	0.000	0.006	0.473
	Elasticity	0.000	0.002	0.117	0.000	0.000	0.528
IAIN Syekh Nurjati Cirebon	Electric Circuit	0.000	0.124	0.469	0.000	0.000	0.003
	Elasticity	0.000	0.069	0.192	0.000	0.000	0.420

The study results indicate that the experimental model has significant effects on improving students' SCS and CS simultaneously. According to Liu (2011) and Warne (2014), a significance-value less than 0.05 indicates that the independent variables (the experimental model) bring significant impacts on the dependent variables (SCS and CS) with the level of confidence is 95%. Furthermore, these results are supported by previous studies that show the effects of the experimental model on SCS (Walker & Sampson, 2013; Aydın, 2016; Malik et al., 2018; Sapriadil et al., 2018) and CS (Sinex & Chambers, 2013; Zakwandi et al., 2020). Therefore, these results show that the SCS and CS can be simultaneously improved through one laboratory activity, the Multiple Skill Laboratory Activity Model (MSLAM).

Table 3 shows the limitation of MSLAM and HOT Lab models, and it reveals that only 20% of the subject group reach the target. However, it can still be stated that there is a difference in the value of SCS and CS by ignoring the type of laboratory activity. Many factors cause this condition, and one of them is learning activities as Rubini et al. (2018) prove that monotonous learning activities are difficult to increase the students' skills. Thus, the solution is presenting a variety of activities and providing the students with a challenge. Furthermore, most Indonesian school laboratories have not been optimized. The condition brings several harmful impacts because the experimental activities always require habituation. In addition, another finding reveals that the students have different skills to conduct different topics of an experiment. The significant average of electrical circuit content is 0.3684, and no subject group has a significant effect.

Meanwhile, the average significance of the elasticity topic is 0.2936, shown by two influential subject groups. This difference proposes the idea that students have some constraints on conducting experiments on electrical circuits. Rosidah & Rosdiana (2019) state that students in traditional schools in Indonesia consider the electricity topic less desirable and challenging to learn. However, the students consider elasticity topics easier to learn. Furthermore, the study result shows that CS has a more significant increase than SCS. This finding is similar to the study by Nurafiah et al. (2018), who prove that students' CS increases more highly than their critical thinking, creativity, and communication skills. The correlation test by employing the R^2 value indicates the correlation between dependent and independent variables. The test shows that SCS on the electrical circuit topic has an R^2 value of 0.0316, the value of SCS on elasticity topic is 0.1512, the value of CS on electrical circuit topic is 0.2512, and the value of CS on elasticity topic is 0.3542. Thus, it can be inferred that the correlation is relatively low (Howarth, 2017).

Learning design in MSLAM builds students' knowledge through social interaction. This is following the learning characteristics proposed by Vygotsky that in a learning process students must actively build knowledge. Collaborative activities and scientific communication that emphasize high social interaction are expected to optimize students' thinking skills. Contextual physics phenomena allow students to learn from new things that are close to life. In addition, the design of learning activities that emphasize the completion of certain tasks is following the main principles of the learning model developed by Vygotsky, which is Scaffolding. (Smagorinsky, 2018; Shvarts & Bakker, 2019).

The data of gender differences of this study show that gender differences do not significantly influence the improvement of students' SCS and CS. It indicates that male and female students have an equal opportunity to achieve competence in experiment-based learning. This result confirms those of previous research deploying that gender does not significantly result in differences. Even so, women have better grades than men (Shi et al., 2015). Nevertheless, Shi et al. (2015) argue that students can still work together in conducting experiments through the best possible disposition. However, there are several considerations. For example, female students tend to garrulously work in a minority group while male students are talkative when they work independently. Shi et al. (2015) add those female students are more likely to play a supporting role while male students play a prominent role when collaborating in experimental activities. Furthermore, the results of R2 show very weak correlations between gender and SCS on electrical circuits topic by 0.02, gender and SCS on elasticity topic by 0.13, between gender and CS on the electrical current topic by 0.04, and between gender and CS on elasticity topic by 0.01.

The integrated analysis is conducted by employing two independent variables in which one factor significantly influences and the other factor does not. This condition indicates that this factor analysis is unsuitable because it leads to inconsistent significance values possibly caused by several variables. The experimental model is an external factor that can be managed in specific ways, while gender is an internal factor that cannot be controlled. However, indicators that are likely influenced by genders, such as motivation and perspective, can be managed. Hence, by using MSLAM, we can improve students' CS better than SCS simultaneously. While the result also shows that students' SCS cannot be improved optimally.

The limitations of this research are conducting subject sampling with high levels of heterogeneity and broad scope. Besides, the constraints of this study relate to the level of preliminary skills and behavior in each subject group. The instrument of this study is the performance appraisal to measure SCS and CS, while the assessment process is more complex. Therefore, further research can investigate the development of evaluation instruments that precisely measure the effects of conducting laboratory activities to improve more skills at one time. Therefore, it is expected that further research will provide more specific measurement results.

CONCLUSION

Learning based-experiment by employing the Multiple Skill Laboratory Activity Model (MSLAM) can positively impact the HOT Lab. Overall, the communication and collaboration skills improve after conducting the experimental model. The analysis results reveal that the experimental aspect shows more significant impacts on improving scientific communication and collaboration skills than gender. Furthermore, the improved collaboration skills are better than scientific communication skills. Therefore, MSLAM and HOT Lab are better at improving collaboration skills. The limitations of this study include a sampling of heterogeneity of subject groups, the habits of the experimental model performed by each subject, and assessment instruments employed to measure skills of scientific communication and collaboration. These limitations propose that the implementation of experimental model-based learning requires empowerment. The students have a more adaptive learning experience and are compatible with the current conditions. Moreover, further research on developing an appropriate assessment instrument needs to consider.

ACKNOWLEDGEMENTS

This research received financial support from the Ministry of Religion of the Republic of Indonesia through the Directorate General of Islamic Education Contract Number 191020000027424 through the 1967 Grant of 2019 concerning Recipients of Global/International Applied Research Assistance for Fiscal Year 2019 to facilitate the funding of this research.

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21. Article Checking (10 Januari 2022)