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Portraying Students' Critical Thinking Skills through Research Skill Development (RSD) Framework: A Case of a Biology Course in an Indonesian University

Raissa MATANIARI[1], John WILLISON [2], M. H . Effendi HASIBUAN [3], Urip SULISTIYO[4], Fatria DEWI[5]

[1] M.Ed., Faculty of Education, Jambi University, Jambi-INDONESİA, ORCID ID: 0000-0002-3878-984X
[2] Dr., School of Education, The University of Adelaide, Adelaide-SOUTH AUSTRALİA, ORCID ID: 0000-0003-1892-1089
[3] Dr., Faculty of Education, Jambi University, Jambi-INDONESİA, ORCID ID: 0000-0001-7613-2526
[4] Dr., Faculty of Education, Jambi University, Jambi-INDONESİA, ORCID ID: 0000-0002-3270-1261
[5] M.Pd., Faculty of Education, Jambi University, Jambi-INDONESİA.

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ABSTRACT

Because critical thinking is essential for scientific learning, academics and casual staff struggle to effectively develop students' critical thinking. This study examined the integration of the Research Skill Development (RSD) framework into a Biology course in an Indonesian University and tested how it helped academics and casual staff develop students' critical thinking. Specifically, the study focused on the benefits attained by the students and how the use of the RSD framework structured their lab reports. This study employed instruments, i.e., questionnaires, student open-field questions, semi-structured interviews, and a rubric. The results indicated two benefits: self-perception on critical thinking and appropriate student lab reports for the RSD framework.

Keywords: Biology learning; Critical thinking skills; developing nation; lab report; research skill development.

INTRODUCTION

Researches in the Unites States, New Zealand, Tasmania, Australia and UK have noted that critical thinking is essential for learning. Teachers play a significant role in strengthening students' critical thinking skills by using critical instructions in order to students' learning (Helsdingen, Van Gog, & Van Merrie¨nboer, 2011) and developing

Correspondence author e-mail: raissamataniari@gmail.com

communication and reflection skills (Edens, 2000). Since critical thinking is commonly represented as a major goal to achieve the educational goals of developing countries (Azizah, 2015), teachers should not only acquire critical thinking skills themselves, but also enrich learning environments with critical thinking activities. These abilities are seen as the indicator of a good and effective teaching.

Having national educational standards for teachers (Hitz, 2008) is essential to address the 'student' context of each country. In light of the Regulation of Teacher Competence Standards at Republic of Indonesia (Azizah, 2015), teachers are required to master the content and teaching of their disciplines. Therefore, faculty of Education purposes to equip pre-service teachers with these competence standards by developing their content knowledge and critical thinking skills. Hence, it is expected that they will be able to foster students' critical thinking skills in their teaching careers.

To train pre-service teachers' critical thinking skills, a particular framework needs to be integrated on the curriculum of pre-service teacher education. For example, Research Skill Development (RSD) (Willison & O'Regan, 2007) outlines the facets of inquiry to involve critical thinking skills. RSD framework offers six facets (embark/clarify, find/generate, evaluate/reflect, organise/manage, synthesise/analyse, and communicate/apply) that range from closed inquiries (lecturer specified) to opened inquiries (student specified) (Willison & O'Regan, 2007). The RSD framework promotes students' learning autonomy, cooperative critical thinking and metacognition (Wilmore & Willison, 2016). Comprehensive features of RSD framework have attracted interests of researchers in Australia, US, Chile, Malaysia, South Pacific, Canada, UK, and Cambodia. In cultivating student critical thinking, the related literature has showed the effectiveness of the RSD framework on such research contexts as: information literacy (Klebansky & Fraser, 2013), doctoral education (Matas, 2012), literacy and research skills (Miller, 2014), postgraduate multidisciplinary research projects (Venning & Buisman-Pijlman, 2011) and law (Watson & Papas, 2009).

Since critical thinking could be effectively developed through engagement in research processes, research activities are central to critical thinking. Engaging students in a research-based subject such as science improves their critical thinking skills (Robinson & McDonald, 2015). In Indonesian universities, science subject provides lab activities, which require students to write their own lab reports as the learning outcomes. Science lab activities such as experiments and lab report writing are pathways to guide students to employ their critical thinking skills during science learning. Correspondingly, Wass, Harland and Mercer (2011) emphasize that students' writing activities are ways to develop critical thinking skills. The integration of the RSD framework into the research-based activities gives an opportunity for assessing students' lab reports in terms of critical thinking and writing skills (Wass, Harland, & Mercer, 2011, p.322).

In order to become professional biology teachers in the Republic of Indonesia, students are required to complete the 'Plant Physiology' course (Ministry of Research, Technology and Higher Education Republic of Indonesia, 2015). However, student academic records on the 'Plant Physiology' course showed that students possessed below 70 marks (73% in 2013, 58% in 2014, 65% in 2015, 64% in 2016 and 66% in 2017) meaning a poor academic achievement according to the Indonesian University standards. The low academic achievement might be due to the abstract concepts in the 'Plant Physiology' course. An abstract concept is difficult to transform due to its theoretical nature, relatively huge quantity of any novel and highly terminological engagement for biology-based higher-order reasoning skills (Basey, Maines, Francis, & Melbourne, 2014). Hasibuan, Harizon, Ngatijo, and Mukminin (2019), who investigated teachers' teaching strategies, found that they predominantly used traditional teaching strategy such as lecturing. Therefore, new strategies are needed to encourage students to pass the course with a better score.

In order to address the issue, a workshop was conducted with two lab tutors and 42 students to introduce the RSD framework to them. The workshop presented an assessment rubric for the RSD framework that guides students to prepare their reports based on six facets of the RSD framework after their laboratory activities (Willison, 2012). Later, the students were guided to structure their weekly lab reports according to the RSD rubric during a 13-week Plant Physiology lab activity. Hence, it was intended that such a learning process would improve their critical thinking skills.

Numerous researchers have discussed the roles of teachers on strengthening students' critical thinking skills, the use of critical instruction(s) to prompt students' learning (Helsdingen, Van Gog Van & Merrie¨nboer, 2011), communication and reflection skills (Edens, 2000). To develop critical thinking skills, the use of RSD has also became one priority in Fiji educational system (Janif, 2017) and other research contexts (Klebansky & Fraser, 2013; Matas, 2012; Miller, 2014; Venning & Buisman-Pijlman, 2011; Watson & Papas, 2009). However, little research has been implemented to illuminate how to integrate RSD into the Indonesian context. Thus, this study aimed to portray students' critical thinking skills via the RSD. By doing this, this study may promote the use of the RSD framework in other developing countries.

The Aim of the Study

This study used a rubric guideline to guide students to write their laboratory results based on six facets of the RSD framework that led them to critical thinking and writing skills (Willison, 2012) over the semester. This study was conducted at the 'Plant Physiology' course in the University of Jambi, Indonesia. The sample of the research consisted of 41 students and 2 Lab tutors.

This project aimed to portray the students' critical thinking skills by focusing the benefits attained by the students and how the use of the RSD framework structured their lab reports. The benefits involved students' self-perceptions of critical thinking and appropriate student lab reports for the RSD framework. Two research questions guided the current study:

- How does the use of the RSD framework develop the students' critical thinking skills based on their self-perceptions?
- What are the qualities of their lab reports after the RSD-based report structure?

METHODS

The Department of Biology Education at Jambi University consists of three classes each year. Each class has a different number of students. However, the students' final examination scores between 2013 and 2017 showed that all three classes obtained poor scores for the 'Plant Physiology' course. In other words, despite a difference in class size, all classes indicated very similar abilities in the course. However, a large class possesses a particular challenge to overcome learning difficulties and direct students towards active learning (Pollock, Hamann, & Wilson, 2011). Therefore, this project was conducted with one class that included more students than the other classes.

This study was conducted in 2018 in the 'Plant Physiology' course, Department of Biology Education, Jambi University, Indonesia. The participants consisted of forty-two junior (Year 3) university students and two lab tutors, who guided the students when doing their laboratory activities. The participants signed consent forms to comply with the ethical clearance protocols of Jambi University and the University of Adelaide. The participants were initially exposed to the RSD framework in a workshop. The workshop introduced the RSD rubric and rubric-related lab report format to the tutors and students. Later, the students were

asked to report their laboratory experimental results according to the six facets of the RSD framework. The students weekly wrote their reports based on their weekly laboratory activities.

This study sought how the use of the RSD framework provided the benefits for the students to structure their lab reports. The benefits involved their self perceptions on critical thinking and appropriate lab reports for the RSD framework. Therefore, this study employed instruments adapted from the RSD framework (Willison, 2007), e.g., questionnaires (see Table 2), student open-field questions, semi-structured interviews, and a rubric (see Table 1). The instruments were re-validated by piloting the questionnaire with 30 students in a parallel class in the current setting of the study. The results of the pilot-study showed that the questionnaire was valid (p-value < .05, alpha=.92). Reliability values of all instruments were also checked through a test-re-test method. The instruments were administered to the sample during the 12^{th} and 13^{th} week of the research implementation. Thus, the reliability of the collected data was examined.

a) Data Collection

1. Questionnaire and student open field questions

The Secretary of Department of Science gave the participants' time to answer the paper and pencil questionnaire in the final lab session. The questionnaire incorporated a participant information sheet, 13 Likert scale questions and 3 open field questions for their agreement with the study. The questionnaires anonymously surveyed their perceptions of the use of the RSD-integrated report. To ensure data security, only the researchers had access to the identified data. However, the data in the current study were de-identified to make student's individual information anonymous. The questionnaire required careful consideration on data collection: the format of the questionnaire, timing and place for administrating the questionnaire.

2. Interview

E-mails from the secretary of the Science Department provided participant information sheets to tutorsto get their agreement for interview sessions. The researchers scheduled the time and date for the interview. Despite the fact that the interviews were conducted with individually identifiable data, only the researchers had access to the identified data for the sake of data security. The semi-structured interviews with eight questions were intended to capture the tutors' perceptions of the use of the RSD-integrated lab report.

3. RSD rubric

The RSD rubric, as the guidelines for students in writing the lab report, purposed to reflect the objectives and goals of the RSD-integrated lab report. The rubric reflecting six RSD facets was adapted from an 8-indicator rubric used for a Human Biology laboratory report (Peirce et al., 2008):

(a) Students embark on inquiry and so determine a need for knowledge/understanding.
(b) Students find/generate needed information/data using appropriate methodology.
(c) Students critically evaluate information/data and the process to find/generate.
(d) Students organise information collected/generated.
(e) Students synthesise and analyse new knowledge.
(f) Students communicate knowledge, and understand and use the process to generate scientific knowledge.

Table 1. *The RSD rubric used to structure and assess student lab report*

		LEVEL 1 (0-25) Students research at the level of a closed inquiry and require a high degree of structure /guidance	LEVEL 2 (26-50) Students research at the level of a closed inquiry and require a moderate degree of structure/guidance	LEVEL 3 (51-75) Students research independently at the level of a closed inquiry	LEVEL 4 (76-100) Students engage in open inquiry, within structured guidelines
A.	Students embark on inquiry and so determine a need for knowledge/understanding	Aims/hypothesis are not made explicitly	Aims/hypothesis are not clearly stated or inappropriate	Aims/hypothesis are clear, but adhere closely to guidelines	Aims/hypothesis are clear, focused and innovative
B.	Students find/generate needed information/data using appropriate methodology	Source of data cited	Data sampling protocols are adequate	Data gathered are appropriate to aims/hypothesis	Data from a variety of sources are used or rigorous data are collected
C.	Students critically evaluate information/data and the process to find/generate	Self-evaluation of the completed project	Limitations or biases of the report are stated	Limitations and biases of the report are clearly stated	Evaluation of the whole study design is rigorous
D.	Students organise information collected/generated	Data are gathered without presenting in the report	Data are incorporated into a report but there is no clear link between the sections	Report writing conventions are generally followed by a coherent flow	Report writing conventions are followed completely
E.	Students synthesise and analyse new knowledge	Limited synthesis of data with literature Results are repeated with minor analysis	Data are compared or contrasted with literature Data analysis, but inappropriate on occasions	Data are compared and contrasted with literature Data analysis is appropriate	Synthesis of data with other studies is rigorous Data analysis is comprehensive
F.	Students communicate knowledge and understand and use the process to generate scientific knowledge	Title is presented References are used, but Harvard referencing style is not followed	Title portrays a general sense of the report References are used and sometimes Harvard referencing style is followed	Title succinctly portrays the full dimensions of the report Variedreferences are used and Harvard referencing style is usually followed	Title succinctly portrays the report from an “original” perspective Varied hypes are used and Harvard referencing style is followed consistently

(b) Data Analysis

The data were collected within four months and analysed using several procedures. Descriptive statistics (mean and standard deviation) were implemented to analyse the students’ questionnaires and lab report scores, while thematic codes were deployed to analyse the data from the tutors’ interviews and students’ answers to the open-field questions. The data from the lab reports were categorised into four levels according to the RSD rubric. The

four categories described the learning outcomes of the students' acquired critical thinking skills after using the RSD rubric in writing their lab reports. The interview data and student open-field responses were transcribed and coded into themes (Creswell, 2014). The interview responses from the tutors were coded into Tutor A and B (T#A, T#B). The students' comments were labeled as Student 1, Student 2 (S1, S2, and so forth).

FINDINGS

The findings portrayed two kinds of benefits attained by the students after using the RSD-integrated lab report. The benefits included their self-perceptions of critical thinking skills and appropriate lab report for the RSD framework.

The students attained appropriate skills in constructing their lab reports. Overall, the students indicated a high agreement level on the use of the RSD lab report for their critical thinking development (M: 5.32; SD: 1.05). As seen from Table 2, 13 items represented their agreements concerning their abilities in writing their lab reports, the importance of critical thinking for their future careers, and their general critical thinking skills.

Table 2. *The students' self-perceptions of the RSD-Integrated Lab Report for Critical Thinking skills*

Question	Mean	SD	Item (1-3= disagree, 4= neutral, 5-7= agree)	Description	Broad Agreement (%)
1	4.74	.85	I am good at critical thinking in general.	Neutral	20.50
2	4.49	.91	I am good at critical thinking in laboratory activities in plant biology.	Neutral	10.25
3	5.18	1.34	The lab reports for this course have helped me to specify clear hypotheses in biology lab reports.	Agree	43.60
4	5.74	1.02	The lab reports for this course have helped me to gather information and data in biology lab reports.	Agree	59.00
5	5.54	1.05	The lab reports for this course have helped me to generate alternative ideas in biology lab reports.	Agree	51.28
6	5.23	1.01	The lab reports for this course have helped me to evaluate the study design of my biology lab reports.	Agree	33.33
7	4.92	1.11	The lab reports for this course have helped me to manage resources and teams during the plant biology laboratory activities.	Neutral	25.64
8	5.44	.99	The lab reports for this course have helped me to analyse the information and data for biology lab reports.	Agree	46.15
9	5.49	.97	The lab reports for this course have helped me to synthesise the information and data for biology lab reports.	Agree	43.59
10	5.28	1.08	The lab reports for this course have helped me to communicate orally what I understand from biology laboratory activities.	Agree	41.02
11	5.49	1.12	The lab reports for this course have helped me to communicate in writing what I have understood from biology laboratory activities.	Agree	58.97

12	5.38	1.04	The lab reports for this course have helped me to communicate in tables what I have understood from biology laboratory activities.	Agree	43.59
13	6.18	1.10	The ability to think critically in learning biology will be important in my career.	Agree	74.36
TOTAL MEAN	5.32	1.05		Agree	20.50

Table 3. *A summary of the RSD-integrated Rubric level, Number of Students and Student Score Range*

Rubric Levels	Number of Students	Student Score Range
4 (76-100)	26	76-81
3 (51-75)	15	71-75
2 (26-50)	1	47
1 (0-25)	0	-

Table 3 shows the RSD-integrated Rubric level, Number of Students and Student Score Range according to the average scores of the lab reports marked by the lab tutors after a 13-week implementation.

As can be seen from Table 3, most of the students achieved the highest level of critical thinking skills according to the RSD rubric. In other words, most of the students succeeded to structure their lab reports based on the RSD rubric that aimed to drive the students' biology learning to critical thinking.

DISCUSSION and CONCLUSION

a) Students' Perceptions of Critical Thinking Skills According to Six RSD Facets

This section presents findings from students' perceptions of critical thinking skills and their lab report scores in regard to the RSD rubric.

1. Embark and clarify

The students' embarking/clarifying skills used the initiatives to specify clear hypotheses in biology lab reports (M: 5.18; SD: 1.34; Broad agreement: 20.05%). Hypotheses for every lab activity were written in the lab guidebook. However, the guidebook only contained one short statement for each hypothesis. This may hinder students to improve the statement(s) themselves. Given these points, students then reasonably agreed that the lab reports for this course had helped them to specify clear hypotheses since they were required to formulate more focused and innovative hypotheses for every lab report. Only eight of 39 students stated that embarking/clarifying skills had helped them to develop their critical thinking skills. A previous study suggested that student formulation of their own hypotheses in biology lab activities resulted in a movement of students from "receivers of fact" to "investigators of idea" (Luckie, Maleszewski, Loznak & Krha, 2004).

2. Find and generate

Their responses to the Likert-type scale displayed their positive attitudes to the use of the initiative to develop their 'find and generate' skills (M: 5.54; SD: 1.05; Broad agreement: 51.28%). The 'find and generate' skills for critical thinking included the ability to characterise what the research involved. However, only six of 42 students considered a find/generate skill (e.g., determination to learn) important to develop critical thinking skills:

S12: Determination to learn has helped me to develop my critical thinking skills…

3. Evaluate and reflect

Table 2 displays the students' agreement levels regarding to the use of the reports to design and evaluate their biology lab activities (M: 5.23; SD: 1.01; Broad agreement: 33.33%). In marking the students' lab reports, the researchers noticed that the students did not engage in the 'evaluate and reflect' facet in the RSD rubric. Hence, this difficulty may stem from their unfamiliarity with the rubric. That is, this may result from a lack of a training session after the workshop. Further should be undertaken to make the rubric familiar for the students.

Accordingly, students seem to have underestimated the importance of 'evaluate and reflect' facet on critical thinking skills, as seen from their answers on the open-field question. Only 3 students in the open-field answers agreed that the aspects categorised into 'evaluate and reflect' facet helped them to develop their critical thinking skills:

S11: Evaluating on a basis of experiences has helped me to develop my critical thinking skills…

Correspondingly, a previous study, which used reflective writing to enhance reasoning skills, reported the effectiveness of the 'evaluate and reflect' facet in professional development (Khine, 2015). The integration of the 'evaluate and reflect' facet in learning could enrich learning engagement(Nettleback, 2005).

4. Organise and manage

The students moderately perceived the 'organise/manage' facet due to the organisational and management issues occurring in their learning processes (M: 4.92, SD: 1.11; Broad agreement: 25.64%). 17 out of 39 students wrote some comments about organisational and management issues during the initiative implementation. One student wrote the following quotation for the open-field questions:

S18: Lack of facilities, such as reading sources, information and laboratory equipments, technology, peer learning, innovative learning and time management, has been barriers for me to develop my critical thinking skills and support my learning.

For the organisational and management issues, the students expressed their hesitation about the item asking the use of initiatives to manage resources and teams during the plant biology laboratory activities. Hence, lack of facilities supporting learning as stated by Student 18, might be a reason of their hesitation. In fact, the initiative implementation did not sufficiently address these facilities (e.g., technology, innovation and time management) as key features of the 'manage and organise' facet. The failure to address these needs might reduce and restrict their learning experiences and achievements (Carnwell, Moreland, & Helm, 2001). Hasibuan, Ngatijo, and Sulistiyo (2019), who conducted a research on the implementation of learning strategy, suggested organizational- and management-related issues to create a supportive learning environment.

5. Analyse and synthesise

For the quality of the lab reports, the researchers and the tutors noted that the students had still been struggling with analysing and synthesising information and data for their lab reports. Analyzing and synthesising, which are high autonomy skills, are indicators of students' critical thinking skills. Hence, this means that students need more structured guidance for writing their lab reports (Willison, 2007). Indeed, the students gave broad agreement on the use of the lab report to analyse (M: 5.44; SD: .99; Broad agreement: 46.15%) and synthesise (M: 5.49; SD: .97; Broad agreement: 43.59%) information and data.

Their limited measured skills of the facet 'communicate and apply' might have influenced their lap reports. According to the tutors, some reports were marked below Level 3 due to their inabilities to synthesise, analyse evaluate and reflect related skills/knowledge/data:

Tutor#A : Some students have not still been ready to change the structures/scaffolds of their lab reports.

The students' responses to the open-field questions pointed that most of them did not consider the skills 'synthesising and analysing' as part of their critical thinking skills. In fact, a previous study, who carried out an inquiry-based practices for undergraduate laboratory, agreed that engaging students in analysing their own data and drawing their own conclusions were the most important process for a research activity as a critical reflection (Burgacic, Zimbardi, Macaranas, & Thorn, 2012).

6. Communicate and apply

The number of the students, who viewed the use of the lab report as a written communication (M: 5.49; SD: 1.12; Broad agreement: 58.97%), was higher than those, who saw it as an oral communication (M: 5.28; SD: 1.08; Broad agreement: 41.02%). This case on the oral communication may result from their perceived differences between written and oral communication (Willison, Schapper & Teo, 2009). That is, they may have seen a written communication as an easy way to express their knowledge, as compared with an oral one. In other words, the fact that they generally felt themselves more confident in written communication than oral communication may have motivated them to use the initiatives within a written communication instead of an oral one. Previous research by Hasibuan, Harizon, Ngatijo, Fuldiaratman, and Sulistiyo (2018) suggests that learning strategy encouraging students to perform intense debate highly promote their communication skills.

In using the report for communication, the students showed a high agreement on the use of the lab report to communicate what they had understoodd from the Biology laboratory activities (M: 5.38; SD: 1.04; Broad agreement: 43.59%). Even though the use of tables for communication skills may be beneficial to indicate students' deep learning, this study did not give the students an opportunity for presenting most of the reports in the form of tables. The number of the students, who agreed with the use of the lab report to communicate in tables, was notably higher than other items (see Table 2). This may come from the communication skills embedded within this item. That is, the students may have valued the communication skills as compared with other skills.

As noted in the open-field response, the students significantly valued the skills of the 'communicate and apply' facet to feature strongly Biological critical thinking and develop their own critical thinking skills.

S7: Doing a lab activity, writing a lab report and working on an assignment have helped me to develop my critical thinking skills.

Their perceived values of the 'communicate and apply' facet may result from the intelligible features of the facet. As a matter of fact, their skills of communication and application were the most common skills in their lab activities. Among all measured skills, most of the students perceived the skills of the 'communicate and apply' facet as the most important indicators for their critical thinking skills. Indeed, the skills of the 'communicate and apply' facet are seen as the higher-order learning domain of students' autonomy (Willison, 2012) to demonstrate their critical thinking skills. However, the students' responses to the open-field questions revealed that they seem to have presumed the skills of the 'communication and application' facet as the most required skills to develop their critical

thinking skills. Hence, they may have underestimated the necessity of other skills in the higher-order learning domain: analyse, synthesise, evaluate and reflect.

The fact that the students limitedly emphasised on the measured skills of the 'communicate and apply' facet might have influenced their lab reports. According to the tutors, some reports were marked below Level 3 due to the lack of skills on synthesising, analysing, evaluating and reflecting:

Tutor#A : Some students have not still been ready to change the structures/scaffolds of their lab reports.

The students' perceptions of the questionnaire and open-field questions indicated that the RSD-Integrated lab reports were adequately significant for enhancing their critical thinking skills. Some internal and external factors (e.g., certain internal limitations and biases of the current implementation such as the nature of methodology and the instrument; external aspects such as students' preferences of the use of particular skills for critical thinking) may also have affected their perceptions.

After the use of the RSD in their lab reports, the students' confidence levels about their critical thinking seem to have affected their perceptions of general critical thinking skills. Even though the students did not express a high agreement on Items 1 and 2, they were sufficiently confident about their general critical thinking skills. They also highly agreed on how critical thinking skills would be important for their future careers.

b) Appropriate Lab Reports for the RSD Framework

Most of the students attained the highest lab report levels according to the 4-level RSD rubric (see Table 1), which was used to categorise and mark their lab reports. The lab report at Level 4 obtained 90 scores, because it contained rich literature with communicative synchronization and stated conclusions based on the literature. The lab report at Level 3obtained 70 scores by delivering sufficiently rich discussions and opinions. However, it did not adequately link its own statements with the relevant literature. lab report at Level 2 obtained 50 scores because of a lack of discussion. Further, it did not have any link between the literature and their experiment results.

As seen from Table 3, despite various lab report levels appeared, almost all of the students got higher scores than 70. Majority of the students at Levels 3-4 of the RSD rubric might imply that their lab reports improved their self perceptions of critical thinking skills after the use of the RSD-integrated lab report. Most of the lab reports were qualified according to the RSD framework.

Two tutors also supported an improvement in their lab reports after integrating the RSD into the lab report. Two tutors examined the strengths of the initiatives: efficiency of the RSD-integrated lab report, effectiveness of the RSD-integrated lab reportand the RSD rubric. Both of the tutors concurred that the rubric contributed significantly to their marking procedure. For instance, the rubric helped to produce more valid scores. One tutor stated:

Tutor#B: The rubric made the marking system to be more explicit. It helped the marking system to produce more objective scores.

Two tutors, who were in charge of the 'Plant Physiology' lab activities, also revealed how they perceived the RSD-integrated report to develop the students' critical thinking skills. Tutors generally approved the effectiveness of the RSD-integrated report on the quality of the lab reports. An excerpt from Tutor A is shown as follows:

Tutor#A: The quality of lab report was improved as compared to the previous one… The RSD-integrated lab report helped students scaffold their writing skills/styles, apply their knowledge according to the rubric, and comprehend the lab activity more…

The tutors perceived improvements in the lab reports and their contents as compared with those of previous years. Because the students were asked to structure their lab reports according to the RSD rubric, their contents became more systematic, informative and concise. In writing their lab reports based on the RSD rubric, the students needed to analyse their lab activities/findings and synthesise new knowledge by simultaneously reflecting their scientific experiences on their lab activities and daily lives. Thus, the RSD-integrated lab reports seem to have encouraged the students to go beyond low cognitive levels, and employ the 'application, analysis, and synthesis' skills that may lead to critical thinking skills.

Further, two tutors discussed the opportunities for the initiatives to implement the Plant Biology learning. They agreed that the implementation of the initiatives would be more effective at articulating and scaffolding explicitly the indicators of the students' critical thinking skills (Kirschner, Sweller, & Clark, 2010). In this instance, clear articulation and scaffolding for better initiative implementation could be done by training the lab tutors and students about the use of the RSD-integrated report and RSD rubric. The tutors also regarded guidebooks as an important instructional tool to explain how to use the initiative and rubric in the 'Plant Physiology' lab activities. For example, the present study exploited a guided approach to achieve inquiry based learning. This study showed that critical thinking development could be enhanced by guiding and addressing the skills needed for critical thinking (Chaplin, 2003). Ultimately, the tutors were confident that the RSD-integrated report would be suitable for any lab-based course after the implementation of the initiatives was well prepared.

The findings of the interviews suggested that the tutors approved the use of the RSD-integrated report and attributed itspositive impacts to the critical thinking skills. Despite of some pitfalls at the implementation of the initiatives, the tutors recommended that the initiative(s) should have been improved for other lab-based courses.

Suggestions

The RSD-integrated lab reports of the 'Plant Physiology' course emerged two benefits for the students: Self-perception on Critical Thinking and an improvement in the Lab Report. The results indicated that the students actively approved the use of the RSD-integrated lab report as a facilitator of critical thinking skills. Correspondingly, their lab report scores showed that most of them achieved the highest level of the RSD rubric. In other words, it can be deduced that the RSD-integrated lab report plays a significant role in guiding and evolving students' critical thinking skills.

Given the aforementioned issues, the present study recommends that future researches should deliberately consider the organisational and management issues during the implementation of the initiative(s) that may influence their research outcomes. Because this study denoted the significant benefits of the RSD framework, further studies are needed to test its applicability and feasibility in different context(s) or countries.

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