

Application of Research Skill Development (RSD) in Sustainable Engineering Teaching and Learning

Poovarasi Balan^a, Hien Tran Minh^b, and Sossamma George^b.

School of Engineering, Monash University Malaysia^a

Library and Learning Commons, Monash University Malaysia^b,

Corresponding Author Email: poovarasi.balan@monash.edu

SESSION

C3: Integration of teaching and research in the engineering training process

CONTEXT In the offering of CHE3163 Sustainable Processing 1 for 3rd year Chemical Engineering students in Monash University Malaysia, an LCA software, GaBi was introduced for the first-time in 2017. It was part of the effort to introduce research-led approaches and up-to-date knowledge using technology-enhanced engagement. As part of the assignment question, GaBi software for advanced LCA analysis was introduced to study electricity generation using renewable and nonrenewable options. Through collaborative efforts with librarians, the research skills development (RSD) workshops have been integrated to assist the students with self-directed learning of new software for their LCA assignments.

PURPOSE How to embed the research skills amongst the students when dealing with their assignment?

APPROACH The RSDf workshop with a few activities were conducted. During the workshop, students were introduced to the RSD framework as well as linking it to the LCA assignment given. Students' feedback on the RSDf workshops collected and analysed. Both quantitative and qualitative questions were provided to participants.

RESULTS The closed ended survey results 75% stating the workshop was good or excellent, they enjoyed the opportunity to work with classmates, and the workshop developed their understanding of how they could apply the RSD to self-directed learning when conducting the LCA assignment.

CONCLUSIONS RSDf has enhanced students' research skills when conducting assignments, i.e. learning of new software in this context.

KEYWORDS Sustainability, engineering education, Research Skill Development (RSD), teaching research linkages, undergraduate research.

Introduction

Assignments are integral part of many undergraduate courses and often used as summative assessments to gauge the student's performance. The assignments are carefully designed by the educators to enhance specific set of skills required by the students as per the course syllabus. The required skills vary from problem-solving to public-speaking, depending on the nature of the courses and degrees offered. However, most of the assignments will require the students to begin the task by 'researching' about the problem at hand. Interestingly, the ability to carry out the required research on the task assigned can be further enhanced by exposing the students on the framework known as 'research skills development' (RSD).

The RSD framework is a conceptual model that provides an explicit scaffold and precise building blocks for the student to develop their research skills (e.g., information literacy, academic writing, critical thinking; Willison & O'Regan, 2007). The RSD framework was developed by researchers at the University of Adelaide (Willison & O'Regan, 2007) and represents a conceptual framework that assists academics and staff to develop academic curricula that explicitly develop research skills for their students.

Research and communication skills need to be fostered over several years and students will benefit most from this if the RSD framework is clearly defined through their assignments and they are made aware of the progression they will encounter from the first stages of the degree through to graduation (Burkill, 2009).

The RSD delineates the skills associated with research into six facets: embark on research and clarify understandings needed; find information and generate data; evaluate information and data, and reflect on processes used; organise information and manage processes; analyse trends and synthesise new understandings; and communicate and apply understandings and processes ethically. These six facets are elaborated into five levels of student autonomy, with Level 1 being Prescribed Research and Level 5 being Open Research (Willison & O'Regan, 2007). The student autonomy is determined based on the degree of input provided by the instructor when assigning the task, either through step-by-step approach, restricted degree of guidance or fully open-ended.

The RSD can also be used to introducing students to necessary aspects of research processes; and for analysing teaching, learning and assessments elements in curricula. (Willison & Buisman-Pijlman, 2016). A multi-institution study showed that use of the RSD framework could effectively help individual educators and small teams to design semester-length courses that developed students' discipline-specific research skills in many disciplines and year levels (Willison, 2012). The RSD framework is also useful in assisting staff to develop assessment rubrics that explicitly state the skills required to succeed in an assessment task.

The importance of research skills is established as mentioned above and can be taught through RSD framework to students. In the offering of CHE3163, students were required to use a new life cycle assessment (LCA) software known as GaBi. This is a free educational software with user-friendly features. Students needed to carry out their assignment with the software and compare their experience without the LCA software. In learning the software, students needed to apply self-directed learning through various research skills. The scope of work in this paper focuses on students experience in learning research skills through 'research skills development' (RSD) framework workshops.

Approach

The 2-hours RSD workshops were designed and conducted. It has been previously shown that collaborative learning environments help improve students' critical thinking and reasoning skills (Collier, 1980; Dunne & Bennett, 1990), particularly if peer learning is directly

associated with an assignment (Boud, Cohen, & Sampson, 2001). Consequently, the workshops were designed as an interactive class where group discussion was used to analyze the assessment task and decide how to best approach the LCA assignment. Small workshops are usually better for problem based learning, as they promote discussion and higher order cognitive reasoning skills (Boud et al., 2001; Collier, 1980; Dunne & Bennett, 1990).

The classes were conducted in two workshops of 42 students and 15 students, respectively with five staff members present: two academic staff, two librarians, and one research assistant. Two librarians facilitated the workshops, providing students with activities for discussions on RSD and the academic staff facilitated the discussion on linking LCA assignment with RSD skills. The activities included: (1) students to discuss and draw their interpretation of a ‘research savvy’ student; (2) students to read a press release about ‘Facebook is closing down’ and explain why they trusted or distrusted the press release’; (3) students were given a set of six colourful cards, which each card assigned to one of the six RSD facets, and students to match the cards to the skills that they identified in other activities and (4) students to have discussions around the RSD placemat and how it can be used to support their assignments. Students were encouraged to work in groups during the activities and they were then asked to present their ideas to the workshop. All activities used in the workshops were designed to help students to derive the six facets of the RSD and were given to students in a logical sequence to help them in understanding the RSD. After attending the workshop, students were expected to be able to correlate the RSD with their research process and apply the RSD to improve their assignment.

During the workshop, students were introduced to the RSD framework as well as linking it to the LCA assignment given. The students were given the LCA assignment to evaluate the environmental indicators such as global warming potential, acidification and nutrification, associated with electricity generation options using renewable and nonrenewable options. Students needed to map the research skills that they learnt in the workshop by listing down the type of skills they needed to accomplish the LCA assignment and map them with 6 facets of RSD. Completion of LCA assignment primarily involved self-learning of a new software, known as GaBi. Students needed to apply the fundamentals learnt under LCA topic using the software to calculate the environmental indicators that were mentioned above. They were asked to brainstorm and present their findings during the workshop.

At the end of the workshop, the feedback from the RSD workshops were gathered through both close and open-ended survey questions. The close-ended surveys were run as a Monash Audience Response Survey (MARS) session and open-ended survey feedback was gathered through printed feedback forms.

Results and Discussion

Both quantitative and qualitative questions as shown in Table 1 were provided to participants. Fifty-seven students completed the feedback form after the workshops.

Table 1: Close-ended questions for RSD workshop

No	Question
1	The overall the workshop was
2	The content of the workshop was at the right level for me

3	The workshop was thought provoking
4	The content of the workshop is relevant to my learning
5	The workshop achieved the stated learning objectives
6	I enjoyed the opportunity to work with classmates/ in groups
7	There were sufficient opportunities to participate in this workshop
8	The workshop developed my understanding of how I could apply the RSD to LCA assignments
9	The workshop developed my understanding of how I could apply the RSD to self-directed learning when I conduct LCA assignments
10	The RSD workshop nudged me into learning ‘how to think’ rather than ‘what to think’ and to unpack thinking processes
11	The workshop brought home the importance of my role in student autonomy / academic independence when I conduct the LCA assignments
12	The workshop provided me with a framework and space to strengthen career and lifelong skills in terms of sustainability in engineering

The feedback form comprised of 12 Likert-scale statements (i.e. quantitative questions) about the effectiveness of the RSD workshop activities included: “The workshop was thought provoking”, “I enjoyed the opportunity to work with colleagues from other areas across the university” and “The workshop developed my understanding of how I could apply the RSD to LCA assignments”. The Likert scale questions numbered 2-12 from ranged from (5) being strongly agree, (4) agree, (3) neutral, (2) disagree (1) strongly disagree; whereas question number 1 had a scale of 5(Excellent), 4(Good), 3(Fair), 2(Could be better) and 1(Poor). The quantitative survey containing the Likert-scale questions feedback form was run as a Monash Audience Response Survey (MARS) to increase engagement and the number of responses.

Table 2: Open-ended questions

No	Questions
1	Something new I discovered was
2	Something I would like to know more about is

3	Would you recommend this workshop to friends?
4	Any other comments?

Students were also given open-ended questions through printed feedback forms as listed in Table 2. The open-ended survey questions were further evaluated along themes of responses and its significance.

The Likert-scale questions survey (Table 1) results approximately 75% stating the workshop was good or excellent (Q1), they enjoyed the opportunity to work with their classmates (Q6), and the workshop developed their understanding of how they could apply the RSD to self-directed learning when conducting the LCA assignment (Q9); results depicted in Figures 1, 2 and 3.



Figure 1 : Response to question on 'overall experience of the workshop'

The workshop comprising of various fun activities such as building a pyramid and drawing a 'research-savvy' student provided the engineering students to break-free from traditional class setting lectures and tutorials. Observations and informal feedback received from the students were positive, which contributed to 75% of class agreeing that the workshop was good or excellent. More than 60% of the participants also agreed to the statement 'The RSD workshop nudged me into learning "how to think" rather than "what to think" and to unpack thinking processes.

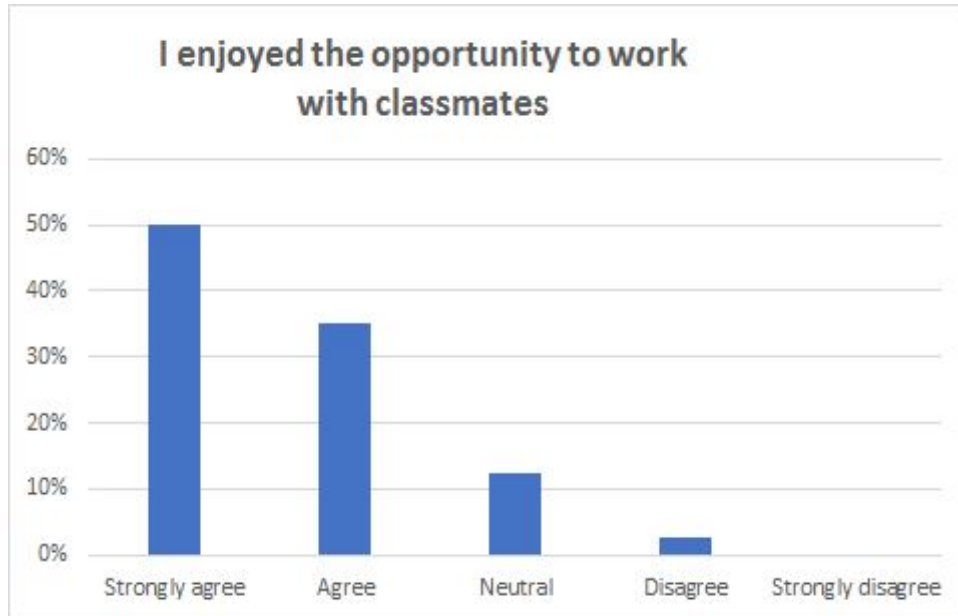


Figure 2 : Response to question on 'working with classmates'

Some of them were introduced to new friends during the workshop and enjoyed the experience. Most importantly, the RSD framework unpacked important skills needed in planning the LCA assignment task. They brain-storm the LCA assignment and discussed on how to carry out the task using a new software. This also resulted in 75% of the class agreeing that the workshop helped them to apply RSD to self-directed learning of new software, GaBi. This free educational software is being introduced for the first time in offering of unit CHE3163 and posed students with new challenge of learning the software with minimal help from the tutorials conducted. Students are aware of traditional manual LCA calculations and required to apply the fundamentals when using the software.

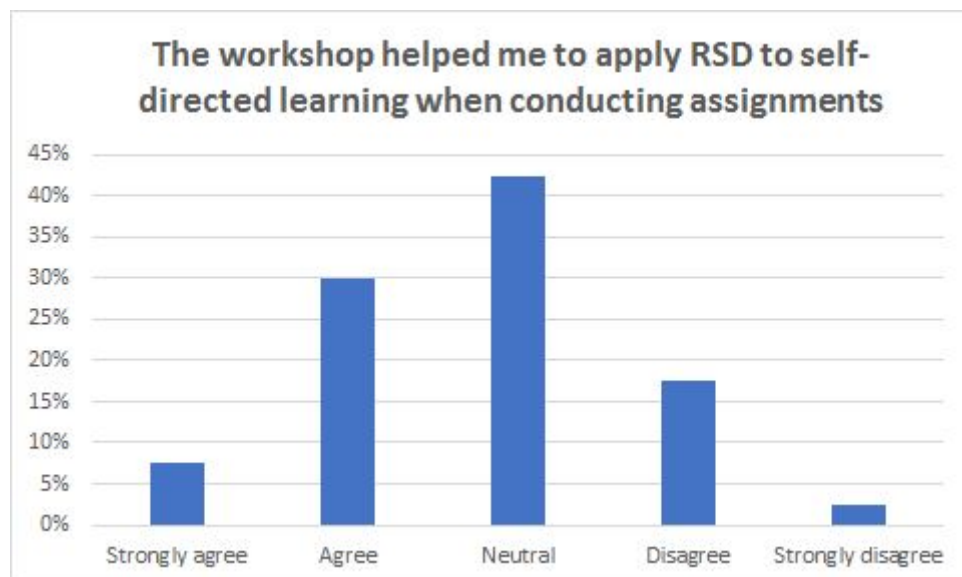


Figure 3 : Response to question on 'self-directed learning'

The results of open-ended feedback (Table 2) is illustrated in the Pareto Charts and depicted as Figures 4, 5 and 6. The responses to the open ended questions were categorized according to main themes and Pareto Charts was generated based on the 80/20 principle.

The significant themes from “Q1: something new I discovered” were “awareness and applications of RSD, exposure and awareness, importance of self-autonomy”. Other feedback received included “enjoyed the activities of the day, gained more knowledge and skills, importance of communication and importance of teamwork”. Some of the interesting comments include : “*I have not researched well for my past assignments and I learned that there are many ways to research, evaluate and compose question*”; “*on how to apply RSD to my LCA assignment and student role in doing LCA assignment*” and “*the detail in which a project should be handled and the layers of depth in research for me to handle assignments through RSD*”.

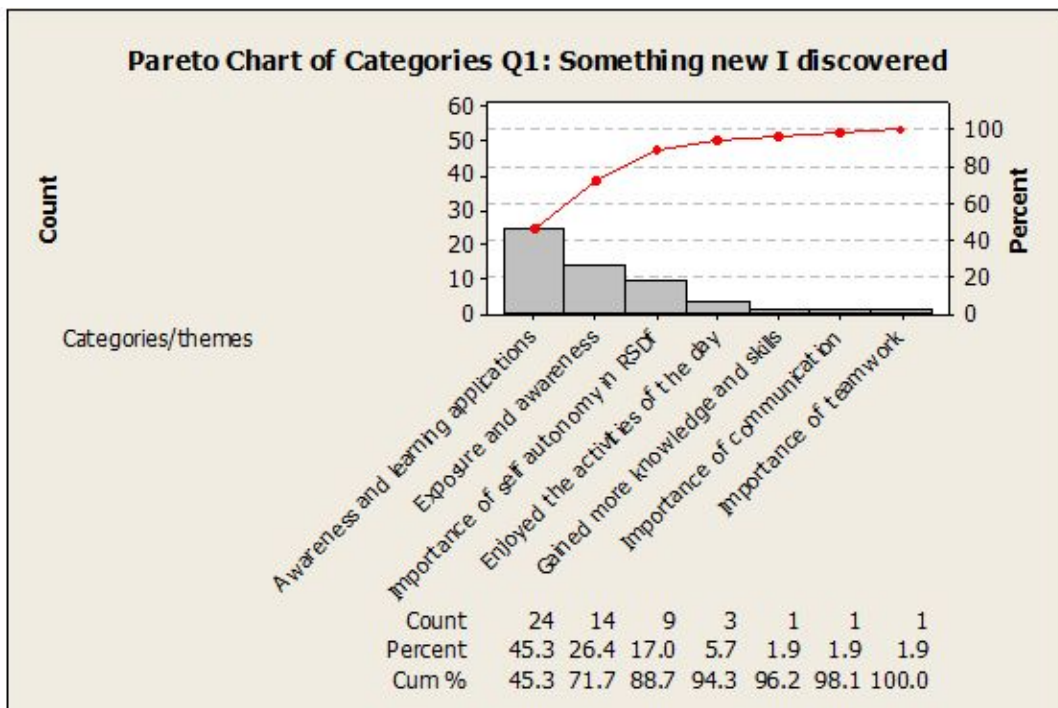


Figure 4: Response to Q1 according to themes and categories

As for question 2 ‘Something I would like to know more about is’ the significant themes that came through at 80% were “more on RSDf and applications”, “awareness and applications” and less significant were the feedback on “other aspects” as can be seen on Figure 5. Some of the interesting comments are “how to do research in an efficient way” and ‘the way to research the software’. The second comment in the former sentence shows the gap in the workshop conducted in which there was no activity on linking RSD with the use of learning a new software. This is mainly due to the limitation of time for the workshop as well as no discussions were designed to discuss about the special features of the software. Such students’ feedback is an important aspect to further improve the design of activities to brainstorm specifically on the software and RSD framework. However, discussions on how to carry out the overall LCA assignment after learning about RSD was carried out effectively. Students were also exposed to the marking rubrics designed specifically for the LCA assignment. The rubrics provided them with clear expectations on each grade requirement on different aspects of assignment such as LCA methodology, LCA indicator calculations, report presentation, and critical review of the environmental burdens calculated.

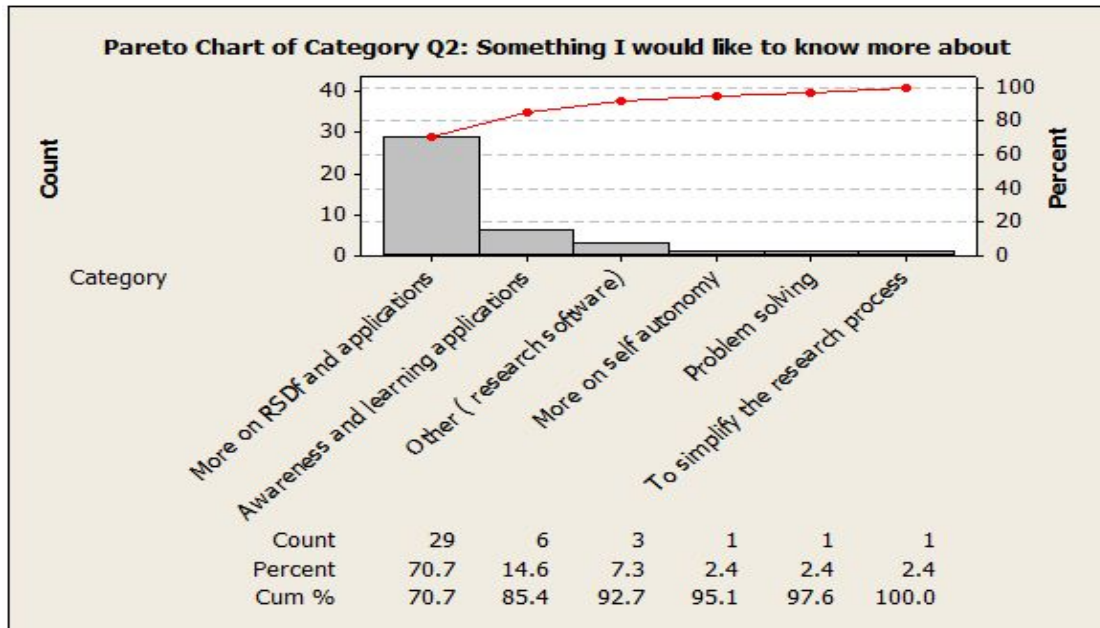


Figure 5: Response to Q2 according to themes and categories

As for the third question “Would you recommend this workshop” 84% said “yes”. 13.7% were neutral and 2% said “No” as illustrated in the Figure 6 below. Most of them also added that it would be helpful if they recommended to their friends who are keen on research. This shows the significance of the RSD.

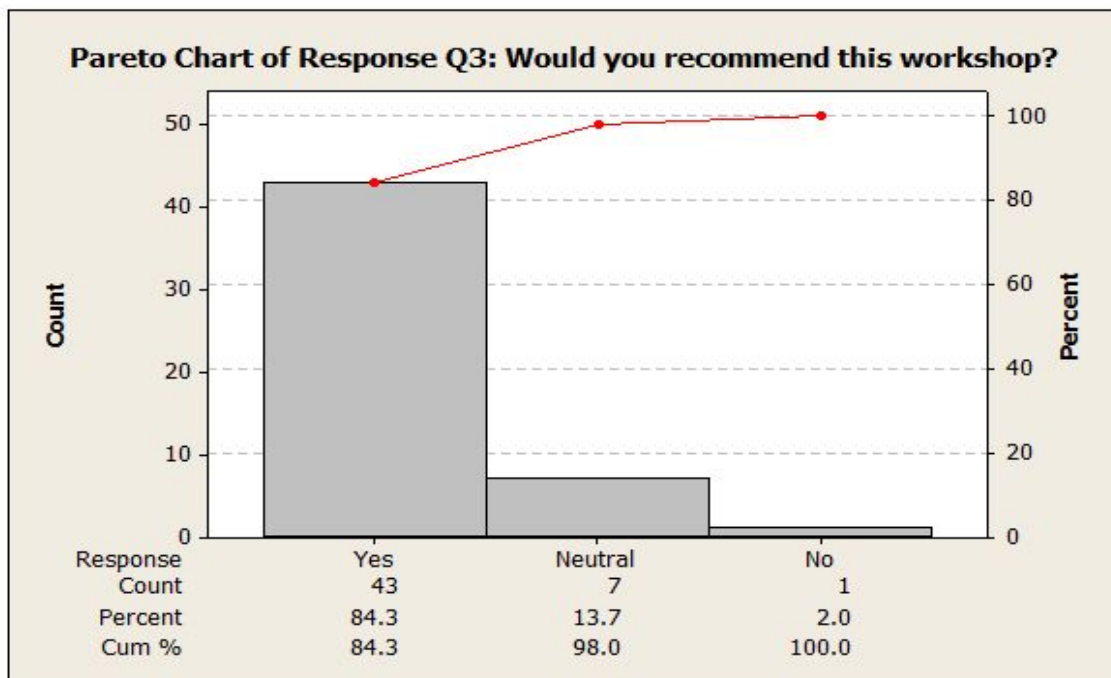


Figure 6: Response to Q3 on ‘recommendation of the workshop’

Conclusions

It is evident from the quantitative and qualitative analysis that the RSD framework has enhanced students’ research skills before conducting LCA assignments. Students benefited from learning six facets of RSD framework and clear about autonomy they have on their LCA assignment. However, the RSD framework can be applied in all assignments and research

work. The development of the marking rubrics and discussion revolving around it during workshop has helped students to get clear directions on the expectation of LCA assignment.

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