USING CRITIQUE TECHNIQUES TO IMPROVE PROGRAMMING SKILL

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ABSTRACT

Certain teaching methods may be effective in dissemination of subject knowledge across students but at the same time, the same method may not be that useful when applied to other subjects. For creative subjects like visual arts, the use of a standard academic checklist to ascertain knowledge acquisition may not prove to be effective in tracking students' artistic developments. In such a case, a preferred teaching strategy would be the use of unbiased feedback and comments to review, discuss and reflect on how much the students have made meaningful connections of their own learning. Conducting critique sessions may accentuate success in attaining set learning outcomes. This technique was piloted and used in a First-Year programming module "Fundamentals of Programming" at Singapore Polytechnic. This was to provide students with an integrated learning experience that allows acquisition of the necessary competence in understanding and applying programming knowledge and concurrently developing personal and professional skills such as communication, giving / receiving feedback and computational thinking. A key outcome is that students will learn the importance of writing well-constructed efficient programming codes with ideas generated from alternative approaches. This is an essential disciplinary skill of an IT professional in the rapidly expanding technology industry. This paper also shares how adjustments are introduced in student engagement and the learning environment in response to the Covid-19 pandemic.

KEYWORDS

Critique techniques, Peer learning, Problem solving, Programming, Virtual workspaces, Standards: 1, 2, 6, 7, 11 and 12.

INTRODUCTION

Learning to write programming codes requires both problems solving skills and knowledge of the notation syntax of a programming language. Based on the problem statement, the programmer selects appropriate control structures to perform sequential processing, selection for decision making, and iteration for repetitive control to produce an algorithm to solve a problem. Often this process can result in coming up with many possible solutions. This is because the same problem regarding the control structures can be designed and put together in various ways. Upadhyay (2020) proposed that a good computer program is not just about running flawlessly without any errors. Good programmers should also look into the adoption of

best practices in writing efficient programs so that the codes are maintainable, extensible and easy to understand in the final design.

In the School of Computing, all First-Year students are required to take a common module ST0502 Fundamentals of Programming in semester 1 as a foundational IT module. The skills and knowledge learnt serve as building blocks for advanced programming modules in their studies, which eventually train them to be infocomm professionals in areas such as Software & Applications, Cybersecurity, AI and Data Science/Analytics to meet the demand of the IT industry.

Students taking programming for the first time often spend much time learning the programming concepts, language syntax and writing codes to solve a given problem. It has been observed during class exercises that some students struggle to develop the required basic algorithm. There were others who had completed the class exercises but may not have been aware of other better solutions that can run more efficiently than what they have derived. In a typical programming class, lecturers review the exercises of their students and will use one or two solutions to explain how concepts and programming constructs are applied. Students will then carry on completing the rest of the class exercises without going through any comparative evaluation for alternative solutions. The unfortunate thing is that the students will miss out valuable opportunities to explore possibly better solutions. This missed opportunity to deep-dive into a wider perspective to other solution offerings minimizes their chances to realise their weaknesses in programming techniques. This gap in the learning experience compelled the author to reflect critically on her own teaching practice, which led her to explore further on how group and peer critique techniques can be effectively employed as a form of formative assessment in CDIO context that can enhance students' learning on a technical module related to programming fundamentals. This can also assist to develop the students' attitude and skills in becoming competent and reliable IT professionals.

Due to the Covid-19 pandemic, all lessons adopted a fully Home-Based Learning (HBL) approach at the start of the 2020 new academic year and lessons were conducted synchronously using Microsoft Teams online platform. As such, instead of addressing the physical learning space of CDIO standard 6, the virtual online space was used as the platform for students' learning. It was also an opportune time to explore using a structured critique methodology by the author and students involved in this programming module.

LITERATURE REVIEW

Learning to program requires the understanding in the application of the various computer language syntax. But it has been observed that the competency required of a good programmer lies more towards having the effective knowledge of problem-solving skills (Sprinkle & Hubbard, 2012). Although the proper use of language syntax is still an important factor when teaching students about programming, their problem-solving skill will play a bigger role to ensure a higher success rate of writing efficient codes for the programs to run successfully and efficiently.

In any problem-solving scenario, the expected outcome is to attain a positive and workable end result. Programming is about writing the steps that follow a set of rules that is the algorithm (Miller & Ranum, 2013). Writing a good algorithm to a problem will determine the resource

efficiency in getting the final desired result. This would rely very much on the ability of the programmer to do the correct problem-solving process to derive an expected outcome.

There is a myriad of problem-solving tools that can be effectively used in group setting to productively brainstorm and come out with a solution to a stated problem. One of the most effective ways is to create a non-threatening environment to facilitate ideas generation that the students in the group can share (Smart, 2020). In this respect, a facilitator like the teacher can use action dialogue with the students in the form of constructive critique to draw out their learning to be shared. This is widely used in design studio education as it is an essential mode of assessment West (2015). This form of brainstorming will encourage active participation to understand and be exposed to the problem-solving process within teacher-students and peer-to-peer critique sessions. Utaberta et al. (2020) distinguished interim critiques as being educational in nature where students receive feedback to improve on their works as opposed to just using critique for the purpose of assessing performance / knowledge only. These interim critiques range from relaxed chats to more stressful forms such as individual, formative, peer, group, public, written, seminars to panel critiques, which if conducted properly will bring about meaningful learning.

In his expounding on Constructive Alignment (Figure 1), Biggs (2003) argued that students learn best when they are able to construct their own learning with the appropriate activities that are able to anchor their learning. In this respect, Biggs continued that educators would need to create learning environments that can support these learning activities in order to achieve the desired learning outcomes. Much of Biggs' work is founded on the belief of the much earlier works of Tyler (1945) who claimed that active learning behaviours are what will help students to learn. The introduction of critique sessions is an activity to facilitate this learning. The giving of good feedback is one way to significantly contribute towards Constructive Alignment (Gallagher, 2017).

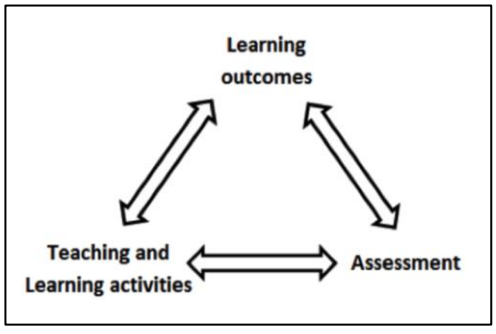

Figure 1. Constructive alignment

Chandrasekera (2015) recognized this and mentioned that "Design critiques, sometimes referred to as design juries or design reviews, are used both as an educational exercise as well as an evaluation tool and have been used in design education for more than a century." Our focus here is towards this evaluation purpose and so that critique techniques are used as a "knowledge building tool" for the students. In any conventional teaching and learning environments, the teachers will always have the control on the subject matters on how and what are to be taught. With critique as a learning tool, the offering of constructive feedback for students by the teacher or from fellow students may give greater meaning to what is needed to be better understood. This can offer an improved level of authentic learning for the students.

Friese (2015) described a range of critique methods that can be effectively employed in teaching and learning. Although Friese's area of expertise is in Art and Design, she proposed that critiques are a methodology that can be employed to achieve learning outcomes of most subjects when it is properly applied. This paper will select some of these critique methods that will be modified and managed accordingly to suit the HBL environment when conducting the module.

METHOD

The study consisted of three classes of First Year students from three different Diplomas. A total of 62 students were in the program participating in this study: 19 students from Diploma in Common Infocomm Technology Programme, 20 students from Diploma in Infocomm Security Management and 23 students from Diploma in Information Technology.

The module ST0502 Fundamentals of Programming was conducted twice a week synchronously online lasting three hours each. Students in each class are divided into smaller online groups consisting of four to five student members. Using the feature of Teams Channel, each of these groups were placed in an online "breakout room" within Microsoft Teams software.

As this was the commencement of the new academic year, most of the First-Year students were new to each other. It was observed that most were "shy and unfamiliar" to articulate during the online discussions. As compared, it will not be a very different scenario if the same session is to be conducted face-to-face. The other point to note which is also important is to prepare a safe non-threatening environment to conduct the critique sessions. To ensure the rationale and importance of each students' participation, the lecturer briefed the students on the purpose and the advantages of the critique sessions that would be incorporated during the lessons.

A typical lesson will involve the lecturer to teach the concepts and knowledge using online synchronous lecture lasting about 30~45 minutes. Students will use the remaining lesson time to complete the module exercises. These were mainly tutorials and practical exercises that included topical self-check quizzes to be done under the supervision of the lecturer.

Upon completion of the online synchronous lecture, the students will 'go' to their respective online "breakout rooms" to do their exercises. During this period, the lecturer will navigate from "room to room" virtually to assist and check on the students' progress. Once the group has completed almost half the exercises, the lecturer acting as the facilitator, will initiate the critique session.

Typically, two types of critiques were carried out: Peer and Group. Peer critiques were facilitated by students with minimal lecturer's supervision. For the group critiques, the lecturer was the facilitator. In both experimental techniques, the lecturer selected the tutorial and practical questions for critique. The students took turns to present their solutions by sharing their presentation screens using Microsoft Teams. The lecturer started off the group critique with easy questions and demonstrated how to give constructive feedback, and emphasized the importance of being open and confident in speaking in class. In addition, students who were still unfamiliar or uncomfortable to participate during the critique sessions were guided by the lecturer. Questions asked can range from approaches to the problem, reasons for constructing the programming codes, rationale for selecting a particular programming

technique or anything related to the solution presented by the student or others. The sessions then progressed to more difficult and complex scenarios as the students became more confident in articulating their answers according to their understanding. Once the group was observed to have traction to the critique process with the students able to facilitate each other to look at the programming problems and issues for that topic themselves, the lecturers will exit from the group. The students will continue on with their own peer-to-peer critique. The lecturer will move on to another group and repeat the same process until all the students in the class have participated in the critique within their groups.

At the end of the term, two online surveys were conducted concurrently to gather students' feedback on their learning experiences. One was at SP campus level for all modules comprising standard questions designed for all courses and the other was conducted by the lecturer for her three classes only. Customized questions were designed to gather feedback on the use of critique techniques for only these students taking Fundamentals of Programming module.

FINDINGS AND DISCUSSIONS

To determine the effectiveness of critique in learning programming, the students completed an online survey created using Microsoft Teams forms. 60 students responded to the survey. Key summary of findings and discussions of the results are as follows:

98.3% (Figure 2) agreed that critique sessions were useful for them to gather feedback on their solutions and to learn alternative solutions to solve the same problem. This indication suggested that the students learnt much from the feedback that they obtained from the lecturer and fellow classmates when they presented their solutions to the group. By having the Q&A activity, it helped to clarify their understanding and efficiency of the different programming constructs used by other students in comparison to their own solutions. The lecturer noticed that students with a programming background contributed and shared programming knowledge/contents beyond the module syllabus.

93.3% (Figure 3) agreed that they were more confident and seemed not afraid or shy to show their working solutions to others. The fact that they received constructive feedback that have helped improve their solution was encouraging. On the same note, if the critique was more of a criticism, it may have highly dampened the students' morale instead. Only 6.7% of the students did not feel confident. Thus, further investigation is needed to determine the reason for this. The lecturer observed that over a period of time, those students who perceived their works were being "confronted", slowly developed confidence and were more forthcoming in presenting their solutions to others. These confident and openness attitudes are important attributes of an IT professional.

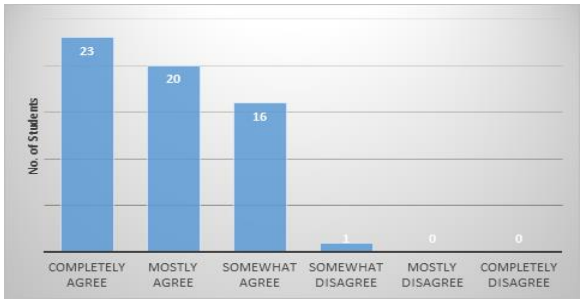

Figure 2. Responses question on usefulness of feedback

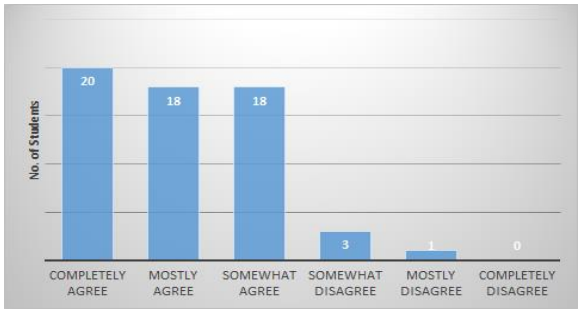

Figure 3. Responses to question on confidence in showcasing students' work

As First Year students are new to each other, the students may not be accustomed and comfortable to pose questions even during a face-to-face setting within a big class. For the sessions that were conducted online, 91.7% (Figure 4) of them agreed that they could learn positively from one another and to discuss problems in the smaller settings that have been organized for them. It was observed that students spoked and shared more openly in their breakout rooms. These small group online social spaces seemed to have offered greater opportunities for group members to interact and bond better. Only 8.3% did not find the small breakout groups useful. Further study can be conducted to investigate why they were not able to learn in smaller group settings and what can compel and motivate them to do so.

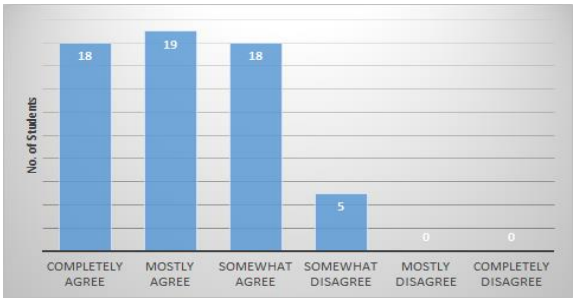

Figure 4. Responses to question on usefulness of breakout session

An open-ended question was asked regarding students' overall learning experiences in the module. Below were some of the comments collated on how the critique sessions have helped to motivate their learning:

"I was able to clarify my question with my classmates during breakout sessions and learn the way they used to code."

"I had a chance to experience different kinds of problem-solving methods and it was a good mental exercise."

"I like the breakout sessions because I can talk to my classmates and learn from them."

"When we break out into our groups, the classmates are actually very helpful in trying to help me with the codes."

"...the time was well spent on further reinforcing the concept through trying out the practical for myself and discussing methods of solving the question with my classmates."

In the separate campus wide HBL survey which was carried out concurrently at the end of the term, similar positive feedback was received on the usefulness of critique in learning programming:

"We are able to critique our classmates' work and observe different logical processes."

"I honestly felt like I learned alot when the lecturers interacted much with the students and showing our solutions to them during class allowed the whole class to give feedback."

"We have group discussions mostly for every lesson and I think it is a good way for learning as I can clarify my questions from my lecturer and peers."

"I like that the lecturer created breakout groups in this module so that the students can discuss and clarify feedback from the lecturer in a small group."

"It is fun doing the practical and figuring out how to use different codes to achieve different outputs."

For the Fundamentals of Programming module, a change on how students can be taught was taken into account since it has to be conducted home-based via online. To ensure that the students' understanding who have now to be taught online are still comparable to previously sessions engaged on-site, the critique model was used on selected batches of First Year students to survey their understanding. The initial survey has shown that conducting the facilitator-led critique followed by peer-to-peer among the class group are positive and have beneficial goodness for both the lecturer and the students. Technology has played a part to offer a conducive environment to be able to create "non-threatening rooms" for students to be placed into for the critique sessions. This offered a more comfortable smaller group space for them to participate in giving comments to each other's work. However, the downside was occasional internet connection problems may disrupt learning/discussion.

Both qualitative and quantitative feedback gathered did suggest that critique techniques have been mostly useful in assisting the students to learn this programming module, alongside developing their skills and attitudes of an infocomm student. The results also suggested that through the critique sessions with Q&A and offering constructive feedback, most students can learn more with understanding and meaning besides enjoying the interactions with fellow students. It also serves as a form of formative assessment for learning for both students and lecturer. The critiques contributed by students provide ongoing feedback to the lecturer on the students' progress and understanding. This way, the teaching can be appropriately adjusted to improve desired learning outcomes (Cambridge Assessment International Education, 2020).

The future of HBL may be more than just an option in the future for tertiary education. To cater to the use of this mode of learning, the critique model can be expanded further with emphasis on CDIO on its useful features:

1. To enhance the integrated learning experiences by inviting industry professionals for the critique sessions. Field trips or short attachments to infocomm companies provide great opportunities for students to learn about attitude, skills and technical knowhow within the industry.

2. To infuse critiques as a learning activity to align with the learning outcomes of the programming module and assessment for all Fundamentals of Programming classes that can encourage active participation from students to have deep engagement with the learning materials (Biggs & Tang, 2011).

3. To promote the usage of critiques as an effective learning activity that can be applied appropriately for the other modules in the School to enhance students' learning.

4. To design easy but more detailed evaluation tools that can measure and provide the effectiveness of critique sessions in enhancing students' learning quality.

To facilitate a non-biased adoption in using the critique methodology with the academics, lecturers have to be offered ample resources and assistance to prepare themselves if they are neither confident nor comfortable. For example, a meaningful critique session will certainly desire a higher ability to use questioning techniques and facilitation skills during the teacher-students interaction. Inevitably, there will be some other competencies that will be important to manage critique sessions smoothly. The development of these competencies can be raised with relevant training/sharing of activities:

1. Organize community of practice feedback/sharing sessions among teaching teams to sense and gather concerns of staff in using critiques for their lessons. The information gathered can be collated to develop the appropriate form of critique session to be introduced for specific classes.

2. Conduct short courses to equip teaching staff on the critique model and the techniques that can offer lecturers the ways to assess students' thinking processes and encourage articulation of their understanding / ideas / thoughts.

3. Build individual staff capability through peer observation among the teaching team, to learn from each other's teaching practice and provide constructive feedback for professional development and personal reflection (Department of Education and Training Melbourne, 2018).

4. Document reference guides for staff and students to be familiar with the attributes and cooperative actions required. This is to manage productive critique sessions for their respective teaching/learning e.g. teaching lesson guides with sample critique facilitation questions to avoid sporadic and unstructured critique sessions.

CONCLUSION

The current Covid-19 pandemic has initiated a time of serious reflection for business deliverables in both the public and private sectors on what's next for a New Normal. The education industry has also not been spared from re-looking at its delivery model for teaching and learning in a situation where alternate forms of educational interactions have to be introduced. Even with the advancement in educational technology over the past couple of decades, teaching and learning are still mainly conducted within an onsite face-to-face scenario between the teachers and students. No matter what the situation is, the challenge is always to ensure an effective content delivery system to provide interactive and meaningful individual learning seamlessly.

This paper examined the application of constructive critique in the teaching and learning of a programming module in providing an integrated online learning environment for students with respect to various CDIO standards. Students who were more self-directed and understood the lessons generally will have no problem participating productively during critique sessions. They are quite spontaneous in sharing and learning from one another. The peer-to-peer feedback also provided these students to generate greater ideas upon what they already know. In a way, the critique sessions have expanded their knowledge, not just through what was officially delivered but also by the engagement of ideas with one another. On the other hand, students struggling with the module may not be able to articulate as well during the critique sessions. But with appropriate prompting by the lecturer, they gained greater confidence and begin to engage with the rest of the class on the subject content. Although a longer period of time may be required and encouragement from the lecturer as the facilitator, these sessions will ultimately assist these students to develop their understanding further regarding what are required to be competent in the subject area. It will also greatly help to direct them in the right path through the participation in the students' feedback to clear their doubts. In both instances, the final learning outcome is achieved even though the learning journey taken to reach the final destination differs.

The next step is to expand the list of benefits in using critique sessions that have been developed for this current module to be implemented for the other modules in the same course. The final intention by the author will be to initiate further explorations that can effectively implement the critique techniques for other Diploma courses in Singapore Polytechnic.

REFERENCES

Biggs, J. (2003). Teaching for Quality Learning at University (2nd Edition). Maidenhead : Open University Press.

Biggs, J. & Tang, C. (2011). Teaching For Quality Learning At University. United Kingdom : McGraw-Hill Education.

Cambridge Assessment International Education (2020). *What is assessment for learning?* Retrieved https://cambridge-community.org.uk/professional-development/gswafl/index.html

Chandrasekera, T. (2015). Towards an online based design critique framework for design education. *International Journal of Education and Information Technology, 1*(3): 61–69.

Department of Education and Training Melbourne.(2018). *Peer Observation, Feedback and Reflection : A Practical Guide for Teachers.* Australia : State of Victoria.

Friese, N. (2015). *Using a Variety of Critique Formats for Successful Learning Outcomes*. Retrieved from https://risdcollegiateteaching.files.wordpress.com/2009/01/2015-types-and-variety-of-studio-critique-formats.pdf

Gallagher, G. (2017). *Aligning for Learning: Including Feedback in the Constructive Alignment Model*. Retrieved from https://www.researchgate.net/publication/319211051_Aligning_for_Learning_Including_Feedback_in_the_Constructive_Alignment_Model

Miller, B. & Ranum, D. (2013). *Problem Solving with Algorithms and Data Structures using Python*. Retrieved from https://runestone.academy/runestone/books/published/pythonds/index.html

Smart, J. (2020). *35 Problem Solving Techniques And Activities To Create Effective Solutions*. Retrieved from https://www.sessionlab.com/blog/problem-solving-techniques/#6-discovery-action-dialogue-dad

Sprinkle, M. and Hubbard, J. (2012). *Problem Solving & Programming Concepts*. New Jersey : Pearson Education, Inc.

Tyler, R.W. (1949). *Basic Principles of Curriculum and Instruction*. Chicago: University of Chicago Press

Upadhyay, A. (2020). *7 Common Programming Principles That Every Developer Must Follow.* Retrieved from https://www.geeksforgeeks.org/7-common-programming-principles-that-every-developer-must-follow/

Utaberta, N., Hassanpour, B., Zaharin, A. & Surat, M. (2010). *An Analytical Study Of Critique Session In Architecture Design Studio*. Retrieved from https://www.researchgate.net/publication/252014334_An_analytical_study_of_critique_session_in_architecture_design_studio

West, D. (2018). *4 Reasons Critiques Need to Be Part of Your Curriculum.* Retrieved from https://theartofeducation.edu/2018/01/08/creative-class-critiques/

BIOGRAPHICAL INFORMATION

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