Evidence-Based Reflective Practice to Help Engineering At-Risk Students in Supplementary Lesson Context

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Abstract
This paper documents the author's application of reflective practice to enhance quality teaching, in a supplementary lesson context at Singapore Polytechnic (SP). Conceive-Design-Implement-Operate educational framework standards were implemented in active teaching and learning methods as well as enhancement of faculty teaching competence, via evidence-based reflective practice (EBRP). To help engineering at-risk students to pass their module and avoid repeating/expulsion, the author utilized an EBRP checklist that he customized to suit engineering schools. The ten core principles of learning embedded in the EBRP checklist enhanced the at-risk students' learning experience of their module, via the author's supplementary lessons. Coupled with its evidence-based approach, the EBRP checklist is a concise and structured template to quantify quality teaching. For data collection and analysis, an original "crosshairs" methodology was employed. A "vertical line" was formed by two EBRP data points (qualitative), while a "horizontal line" was formed by two assessment data points (quantitative). These lines intersect to form the crosshairs, offering a widespread and balanced coverage for data collection and analysis. The EBRP checklist used together with the crosshairs methodology yielded significant positive assessment results. Eventually, majority of the engineering at-risk students (above 80% for five semesters, based on post-intervention results) benefited from the consequential enhanced quality teaching to pass their module, avoid repeating/expulsion and hence progress to their next academic phase of the SP education system.

Keywords: Evidence-Based, Reflective Practice, EBRP Checklist, Engineering, At-Risk Students, Crosshairs, Supplementary Lesson

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Introduction

Reflective Practice

Reflective practice has long been applicable in various professional disciplines, especially in the field of pedagogy. According to Schön (1983), it is regarded as an individual's competency to reflect on/in one's actions, in order to be in an iterative process of continuous improvement through practice. Hence, it is a common habit among lecturers to maintain a teaching journal/portfolio that they update frequently, akin to an engineer's logbook.

In educational literature, one well-known model of reflective practice by Gibbs (1988) is a closed-loop of six steps: description, feelings, evaluation, analysis, conclusions and action plan. Another educational model by Larrivee (2000) highlights the difficulty of good reflective practice, because a lecturer's response to a situation is filtered through five screens: past experiences, beliefs, assumptions and expectations, feelings and mood, personal agendas and aspirations. Generally, these popular educational models of reflective practice are inherently subjective as they involve content such as feelings and mood, as shown in Figure 1 below. They may not suit lecturers of science, technology, engineering and mathematics schools, who are more accustomed to objective content like formulas and laws.

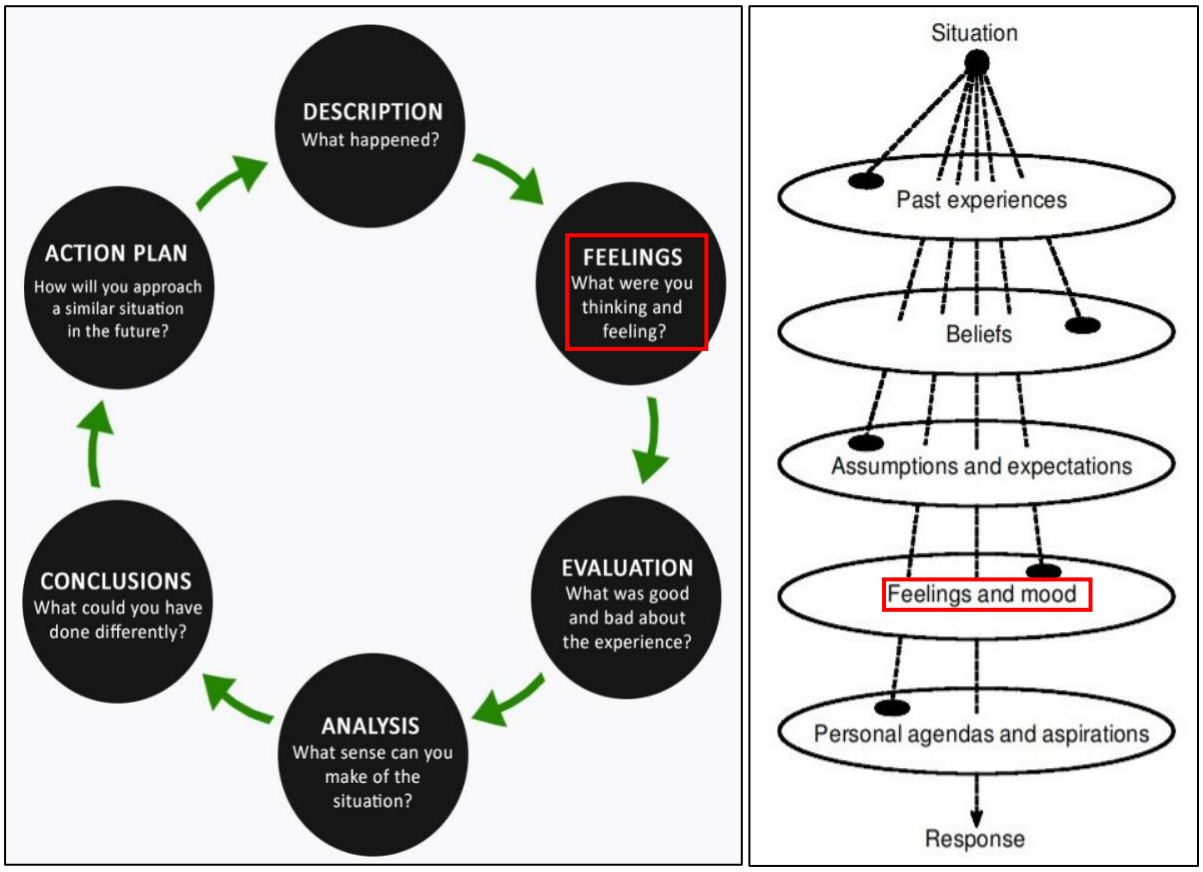

Figure 1: Reflective practice models by Gibbs (1988) & Larrivee (2000)

Evidence-Based Reflective Practice Tool

One method to somewhat "measure" subjective reflective practice is by the inclusion of objective evidence.

In educational literature, it is highly recommended by researchers for good reflective practice used in education to be evidence-based (Hattie, 2008 & Sale, 2015). This evidence-based approach is similarly applicable to engineering students in flipped learning (Sale et al., 2017 & Cheah et al., 2019), as studied by the author too (Leong, 2021). For nurses, evidence-based practice to improve patient outcomes via concrete evidence has been applicable since the 1800s by Florence Nightingale (Mackey et al., 2017). For lawyers, the strict compliance of the law of evidence is vital in all legal proceedings (Chen et al., 2018). Similarly for lecturers, such as of engineering schools, the utilization of an evidence-based reflective practice (EBRP) tool should be beneficial for pedagogy (Sale, 2020). To provide lecturers with some prediction of learning effectiveness before lesson and also diagnosis after lesson. EBRP aims to shed some light on how to enhance and quantify quality teaching.

To illuminate quality teaching, ten core principles of learning (Conceive-Design-Implement-Operate CDIO educational framework standard 8 in active teaching and learning methods) are embedded in the EBRP tool by Sale (2015 & 2020) to quantify quality teaching:

(1) Learning goals, objectives & proficiency expectations are clearly visible to students.
(2) Students' prior knowledge is activated & connected to new learning.
(3) Content is organized around key concepts & principles that are fundamental to understanding the structure of a subject.
(4) Good thinking promotes the building of understanding.
(5) Learning is enhanced through multiple methods & presentation modes that engage the range of senses.
(6) Learning design utilizes the working of memory systems.
(7) Assessment is integrated into the learning design to provide quality feedback.
(8) The development of expertise requires deliberate practice.
(9) A psychological climate is created which is success orientated and fun.
(10) Motivational strategies are incorporated into the design of learning experiences.

These core principles are all mutually inclusive and when used together with evidence of effectiveness to quantify quality teaching, they enhance quality teaching (CDIO standard 10 in enhancement of faculty teaching competence). Singapore Polytechnic (SP) implemented reflective practice as an annual performance goal for all academic staff since 2018/2019. The inception of this SP policy is to encourage lecturers to conduct reflective practice and even go further as action research (Toh et al., 2020), like this pedagogical study by the author. The EBRP tool by Sale (2020) was shared with Teaching and Learning (T&L) Mentors and Specialists of all the schools in SP, including the author, when he was Senior Education Advisor at the Educational Development department. Refer to Figure 2 below for this EBRP tool.

In the learning experience (e.g., lesson/session plan) was there:	**Evidence of Effectiveness** What specific Strategies - Methods/Activities and/Resources were employed to enhance this aspect of the learning process, and how effective were they? (Based on your observation and any other feedback if available (e.g., peer observation, student feedback)
Clear communication of the Learning Outcomes to the students? o What specifically is to be learned o The purpose of this learning o How this learning connects to the wider learning goals (topic areas, skills) for this module	
Activation of students Prior Learning and connections to new knowledge presented? o Identifying what students already know/don't know about the topic before the start of a session o Helping students to fill important knowledge gaps/clear up misconceptions o Making connections between what is to be learned now (e.g., new knowledge/skills) to what has already been learned	
Instruction focusing on the Key Concepts and Principles for understanding this topic or skill area? o Identifying and illustrating the most fundamental concepts/principles to be learned o Explaining how these connect to the learning outcomes	
o Methods and activities to help students to understand these concepts/principles in real work/life contexts	
Use of activities that involve Good Thinking to facilitate understanding? o Enabling students to engage in the types of thinking necessary (e.g., analysis, comparison & contrast, inference & interpretation, evaluation) to connect new knowledge to what they already know o Building the necessary mental models in long-term memory	
Appropriate variety in the methods, activities, media used o Focused on the learning outcomes and the student profile o Encouraging engagement and interest o Maintaining good attention levels	

Figure 2: Evidence-based reflective practice tool by Sale (2020), part 1 of 2

Utilizing Core Principles of Learning ***In the learning experience, was there:***	**Evidence of Effectiveness** What specific Strategies, Methods and/or Resources were employed to enhance this aspect of learning, and how effective were they? (Based on your observation and any other feedback if available (e.g., peer observation, student feedback)
Application of practices consistent with Human Memory processes? o Chunking of content to minimize cognitive overload o Periodic recap and review of key concepts and principles o Doing *Whole-Part=Whole* analysis – showing how new parts of the learning connect to the wider topic or skill area	
Formative Assessment of the student learning and provision of quality two-way feedback? o Monitoring student learning through testing key concepts and skills o Providing clear and specific feedback (e.g., task, process, self-management) o Encouraging two-way and peer feedback where possible and useful	
Opportunities for Practice to enhance understanding and/or skill acquisition? o Spaced-practice across sessions to build understanding and competence o Deliberate-practice focused on specific skill development tailored to student's skill levels	
Interactions/activities that foster a climate conducive for building rapport, encouraging Success and a sense of Fun? o Use of growth mindset strategies (e.g., showing how effort impacts learning; sticking with students when they need help; mastery learning) o Use of expressive language and supporting body language in communication (e.g. expressive tone, smile, eye contact) o Allowing/facilitating humour and fun to occur in the lesson	
Aspects of the lesson (not identified above) that seemed to enhance interest and supported the learning experience: o Use of a story, analogy, example o A specific method/activity type o An aspect of communication style	

Figure 2: Evidence-based reflective practice tool by Sale (2020), part 2 of 2

Background

Supplementary Lesson Context

Diploma in Mechanical Engineering (DME) is the first such course in Singapore, with a history of 66 years to date and is the flagship diploma with the largest student cohort in SP School of Mechanical & Aeronautical Engineering (MAE). The author is MAE's T&L Mentor as well as the module coordinator of DME core module Thermofluids 1, which is taken by engineering students from five different SP courses.

Since 2020/2021 semester 2, MAE formally implemented supplementary lessons for engineering at-risk students to manage the failure rates of its four targeted core modules, namely Thermofluids 1 & 2 and Mechanics 1 & 2. At-risk students consisted of students who

performed the worst for their Mid-Semester Tests (MST) in the current semester, and repeat students who failed their modules in the previous semester. Supplementary lessons implemented were extra face-to-face tutorials delivered in classrooms by the respective module coordinators (including the author), beyond the at-risk students' regular timetables for 1 hour weekly.

Customized Evidence-Based Reflective Practice Checklist

In 2020/2021 semester 2, two classes of Thermofluids 1 engineering at-risk students were assigned to the module coordinator (the author) for supplementary lessons. These classes consisted of 33 Thermofluids 1 MST worst performing students and 12 repeat students, assembled from five different SP courses. If they fail their module, they will have to repeat the module in the following semester or will be expelled from the school respectively. The author decided to utilize the EBRP tool by Sale (2020) to help his two classes of at-risk students to pass their module and avoid repeating/expulsion.

The author customized the tool into a more concise EBRP checklist, such as by minimizing pedagogical jargons and adding numbered checkboxes for the ten core principles of learning (CDIO standard 8). Due to its inherent evidence-based approach, the concise EBRP checklist also acts like a structured template for a lecturer to quantify quality teaching (CDIO standard 10). As a result, the EBRP checklist is suited for engineering schools who are more accustomed to objective content, especially tweaked for MAE.

This customized EBRP checklist was shared with all MAE academic staff and lecturers generally found it easy to digest and use for reflective practice. MAE management also requested the author to conduct sharings for academic staff, to help lecturers with poor student feedback scores/comments and to facilitate reporting officers in grading reflective practice for annual performance goals. Refer to Figure 3 below for the author's customized EBRP checklist (Leong, 2021).

10 Core Principles of Learning In your lesson:	Evidence of Effectiveness What was done for this core principle and how effective was it? (Based on your observation or any other feedback).
(1) Learning objectives made known to students? ☐ • The purpose of this lesson & what specific topics to be learned.	•
(2) Review students' prior knowledge & connect to new knowledge? ☐ • Identify what students already know/don't know at the start of lesson. • Link back to what is to be learned now.	•
(3) Focus on key concepts & fundamental principles? ☐ • Deliver the most basic concepts & principles, without excessive details & repetitions.	•
(4) Promote good thinking? ☐ • Students are stimulated to think (analyse/compare/interpret/evaluate) about the content to improve their understanding.	•
(5) Variety in delivery methods & media? ☐ • Variety promotes interest & student engagement, to improve their attention.	•
(6) Enhance students' memory? ☐ • Bite-sized content to avoid mental overload. • Periodic recap & review of key concepts.	•
(7) In-class assessment & two-way feedback? ☐ • Monitor student's learning progress by testing key concepts. • Encourage feedback between students & staff.	•
(8) Chances to practice? ☐ • Periodic practice for students to improve competence. • Deliberate-practice focused on specific weaknesses of students.	•
(9) Fun & positive atmosphere? ☐ • Positive verbal & body languages to bond with students. • Humour in class to enhance learning.	•
(10) Spark students' interest & improved the learning experience? ☐ • Motivate & inspire students to learn. • Use of a story, analogy, case-study.	•

Figure 3: Customized evidence-based reflective practice checklist by author (Leong, 2021)

Methodology

In 2020/2021 semester 2, two classes of 45 Thermofluids 1 engineering at-risk students were assigned to the module coordinator (the author) for supplementary lessons. These classes consisted of 33 Thermofluids 1 MST worst performing students and 12 repeat students, assembled from five different SP courses. If they fail their module, they will have to repeat the module in the following semester or will be expelled from the school respectively. The

author decided to utilize his customized EBRP checklist to help his two classes of at-risk students to pass their module and avoid repeating/expulsion. These at-risk students were not taught by the author in the previous semester. Therefore, the key intervention process of this study was the author's supplementary lessons via his customized EBRP checklist throughout the following semester. This study's objective is to ascertain the effects of EBRP on the engineering at-risk students. The focus group in this study's scope is the 12 repeat students among the two classes of 45 at-risk students, due to the availability of their pre-intervention data.

Crosshairs Data Collection & Analysis

For data collection and analysis, the author composed and employed an original "crosshairs" methodology, which is similar to the conventional "triangulation" (O'Donoghue et al., 2003). The data input was by means of both qualitative and quantitative research paradigms. A "vertical line" was formed by two EBRP data points (qualitative), while a "horizontal line" was formed by two assessment data points (quantitative). Eventually, these lines intersect to form the crosshairs. The two EBRP data points were from both lecturer and student, whereas the two assessment data points consist of both formative and summative. Overall, the crosshairs methodology "aims" to a widespread and balanced coverage for data collection and analysis. So as to obtain insightful information on the intervention from multiple perspectives. Refer to Figure 4 below for the author's original crosshairs methodology (Leong, 2021).

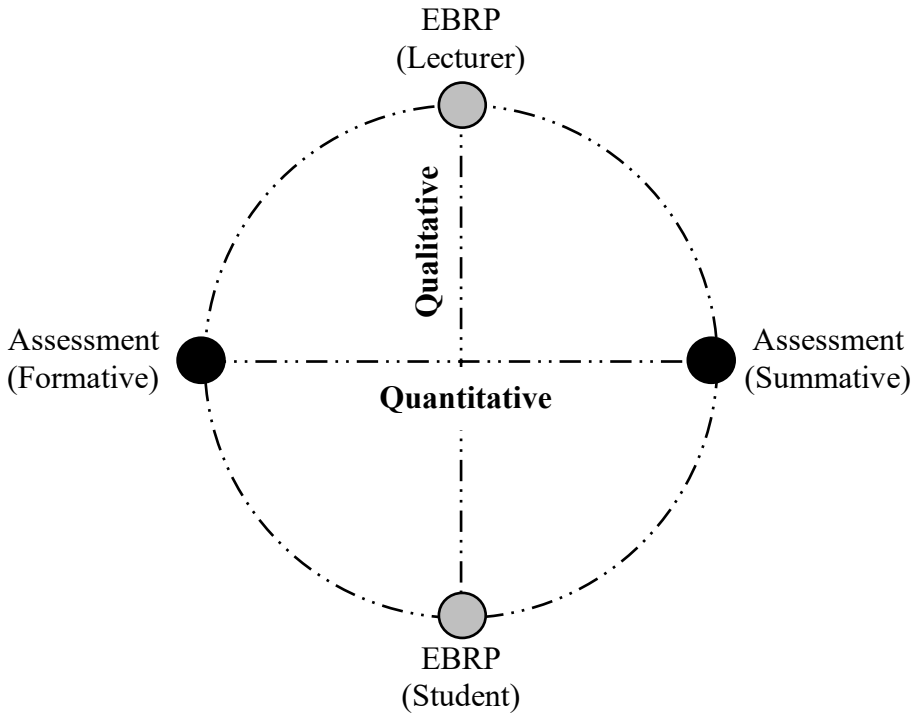

Figure 4: Crosshairs methodology for data collection & analysis by author (Leong, 2021)

For EBRP data points, the lecturer can be the teaching lecturer and/or another observer lecturer, while the student can be the learning student and/or another observer student. For assessment data points, the formative part can be the Mid-Semester Test (MST) and/or In-Course Assessment (ICA), while the summative part can be the Exam or End-Semester Test.

Qualitative Data Collection & Analysis

For the qualitative aspects of this study, EBRP was done by the teaching lecturer (the author) and another MAE observer lecturer, in addition to an observer student. The observer student was a DME Year 3 graduating student invited to sit-in the lesson and use EBRP for student feedback. Being a graduating top student with an excellent Grade Point Average (GPA) of 3.96, it would be insightful to note this student's opinions. Considering that this student also attended countless lessons by various lecturers from different schools in SP for the past 3 years.

Quantitative Data Collection & Analysis

For the quantitative aspects of this study, the formative assessment was the MST, while the summative assessment was the Exam. These at-risk students were not taught by the author in the previous semester. Therefore, the key intervention process of this study was the author's supplementary lessons via his customized EBRP checklist throughout the following semester. Their Thermofluids 1 MST and Exam scores were compared for 2020/2021 semester 1 (pre-intervention) and 2020/2021 semester 2 (post-intervention), to obtain insightful information on students' achievement of learning outcomes.

According to the well-known educational research by Hattie (2008), formative evaluation to lecturers has a high effect size of 0.9, considering that the medium is only 0.4. Refer to Figure 5 below. This method is where lecturers take action to get formative feedback on their teaching and then act on it, which is similar to the author's intervention process and this study. There was ongoing evaluation of the author's supplementary lessons via his customized EBRP checklist throughout the semester, as EBRP can predict learning effectiveness before every lesson and diagnose after every lesson. This study also commenced during the first term of the semester, such that it is possible to tweak if necessary in the second term based on the MST scores' comparison.

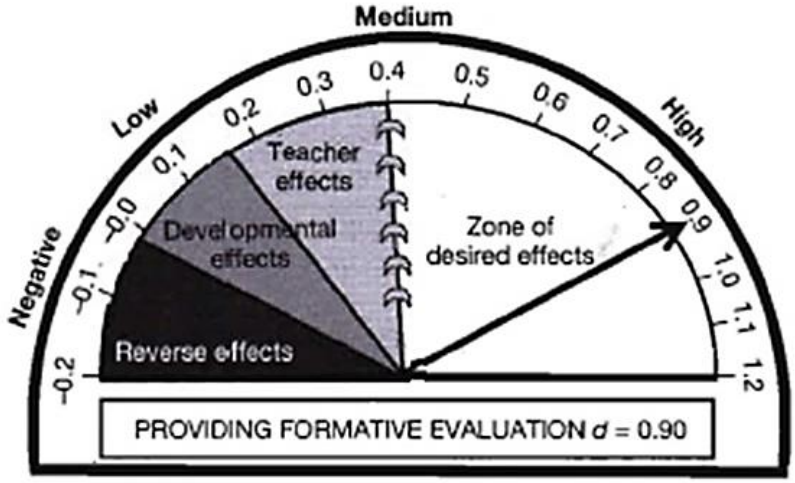

Figure 5: Formative evaluation to lecturers with high effect size of 0.9 by Hattie (2008)

Results & Discussion

Qualitative Data

For the qualitative aspects of this study, EBRP data were from the teaching lecturer (the author) and another MAE observer lecturer, in addition to an observer student (DME graduating top student with excellent GPA). The customized EBRP checklist was used by the author for his supplementary lessons throughout the semester, as prediction of learning effectiveness before every lesson and/or diagnosis after every lesson. Refer to Figure 6 below, for the author's EBRP data for one of his pivotal supplementary lessons in the Thermofluids 1 syllabus.

10 Core Principles of Learning **In your lesson:**	**Evidence of Effectiveness** **What was done for this core principle and how effective was it?** **(Based on your observation or any other feedback).**
(1) Learning objectives made known to students? ✓ • The purpose of this lesson & what specific topics to be learned.	• *Topic & learning outcome (Viscosity) communicated to students at start of 1hr weekly supplementary.* • *Announced: 1 MST topic per wk, to solve 3 past MST qns per lesson (total of 4 topics to prepare repeat students for upcoming MST).* • *Students were aware & some already turned to the corresponding pages on notes without prompting.*
(2) Review students' prior knowledge & connect to new knowledge? ✓ • Identify what students already know/don't know at the start of lesson. • Link back to what is to be learned now.	• *Prior week's past MST qns corrected in-class & given back to students to refer.* • *Students were aware of their own mistakes & current level of knowledge & what gaps can be bridged in today's lesson.*
(3) Focus on key concepts & fundamental principles? ✓ • Deliver the most basic concepts & principles, without excessive details & repetitions.	• *Summary of the few key formulas required for Viscosity, written on whiteboard.* • *Students copied down the summary & we periodically referred back to it throughout lesson.* • *Hardcopy printout of definitions & SI units of symbols used in MST formulas, given out to students.*
(4) Promote good thinking? ✓ • Students are stimulated to think (analyse/compare/interpret/evaluate) about the content to improve their understanding.	• *Students were given time to think & then share some examples of Newtonian & Non-Newtonian fluids, after my brief explanation of these fluids' characteristics.* • *Students expressed enlightenment & noted that these are commonly tested in past MST qns.*
(5) Variety in delivery methods & media? ✓ • Variety promotes interest & student engagement, to improve their attention.	• *Uplifting video clip of MythBusters was showed & students watched keenly. "Failure is an option, if we learn from it" message to motivate repeat students.* • *Visualiser to project notes & whiteboard for drawing & writing were used too.*
(6) Enhance students' memory? ✓ • Bite-sized content to avoid mental overload. • Periodic recap & review of key concepts.	• *Summary of the few key formulas required for Viscosity, written on whiteboard.* • *Students copied down the summary & we periodically referred back to it throughout lesson.* • *Students often recapped the hardcopy printout of definitions & SI units of symbols used in MST formulas, when solving the past MST qns.*
(7) In-class assessment & two-way feedback? ✓ • Monitor student's learning progress by testing key concepts. • Encourage feedback between students & staff.	• *Solving of the past MST qns was initially/partially done as in-class Q&As between me & students. Parts answered wrongly will be mitigated by my correction or facilitation by another student. Parts answered correctly will be reinforced to enhance memory retention. Impromptu questions from students were also addressed.* • *Students participated in Q&As & doubts were sorted out before proceeding to the next qn.*
(8) Chances to practice? ✓ • Periodic practice for students to improve competence. • Deliberate-practice focused on specific weaknesses of students.	• *Main focus of 1hr supplementary lesson was for repeat students to deliberate-practise the past MST qns, to prepare for upcoming MST.* • *Towards end of lesson, most students often can independently solve the past MST qns without my help.* • *Students also had access to hardcopy notes & online material to practise other lecture & tutorial qns.*
(9) Fun & positive atmosphere? ✓ • Positive verbal & body languages to bond with students. • Humour in class to enhance learning.	• *Light-hearted pedagogy infused in lessons, with the presence of positive comments & occasional jokes.* • *Students were recognised & addressed by their names to foster bonding.*
(10) Spark students' interest & improved the learning experience? ✓ • Motivate & inspire students to learn. • Use of a story, analogy, case-study.	• *Uplifting video clip of MythBusters was showed & students watched keenly. "Failure is an option, if we learn from it" message to motivate repeat students.* • *Video clip also served as a wake-up-call, as this was the late 5pm final lesson of the day.*

Figure 6. EBRP data by the author, via customized EBRP checklist

The ten core principles of learning by Sale (2015 & 2020) embedded in the author's customized EBRP checklist enhanced the at-risk students' learning experience of their module, via his supplementary lessons throughout the semester. Several noteworthy similar evidence of learning effectiveness were found in the EBRP data by the author, the observer lecturer and the observer student:

- ✓ *All core principles of learning were attained.*
  After all, these ten core principles are all mutually inclusive and when used together with evidence of effectiveness to quantify quality teaching, they enhance quality teaching.
- ✓ *Opening summary of key formulas with corresponding symbols & SI units to enhance memory of both prior & new knowledge.*
  (This corresponds to core principles 1, 2, 3 & 6)
- ✓ *Real-life examples (like common Newtonian & Non-Newtonian fluids) to reinforce key principles & stimulate good thinking.*
  (This corresponds to core principles 3, 4 & 6)
- ✓ *Interesting variety in delivery methods (like motivational video) to maintain students' attention.*
  (This corresponds to core principles 5, 9 & 10)
- ✓ *In-class questions-&-answers to ensure clear understanding before proceeding to next question.*
  (This corresponds to core principles 4, 7 & 8)
- ✓ *Deliberate-practice of three past MST questions on one key MST topic in-class every week, to progressively build students' independence.*
  (This corresponds to core principles 3, 7 & 8)
- ✓ *Humour & analogy to popular show (like motivational video) to engage students in a fun setting.*
  (This corresponds to core principles 9 & 10)

On top of the focus group in this study's scope (2020/2021 semester 2), the author also taught these Thermofluids 1 supplementary lessons to other at-risk students for the next four semesters (2021/2022 semester 1 to 2022/2023 semester 2). Totalling to 157 engineering at-risk students (including 51 repeat students) assembled from five different SP courses for five semesters, who benefited from the consequential enhanced quality teaching of EBRP.

Quantitative Data

For the quantitative aspects of this study, assessment data were from the formative MST and the summative Exam. The Thermofluids 1 at-risk students were not taught by the author in the previous semester. Therefore, the key intervention process of this study was the author's supplementary lessons via his customized EBRP checklist throughout the following semester. Their Thermofluids 1 MST and Exam scores were compared for 2020/2021 semester 1 (pre-intervention) and 2020/2021 semester 2 (post-intervention), to obtain insightful information on students' achievement of learning outcomes. This study commenced during the first term of the semester, such that it is possible to tweak if necessary in the second term based on the MST scores' comparison. Refer to Table 1 below for the Thermofluids 1 MST scores' comparison of the 12 repeat students (anonymous), among the two classes of 45 at-risk students.

Student	Pre-Intervention MST (2020/2021 Sem1)	Post-Intervention MST (2020/2021 Sem2)
1	12/100	98/100
2	20/100	69/100
3	48/100	89/100
4	0/100	71/100
5	12/100	70/100
6	16/100	62/100
7	14/100	88/100
8	54/100	95/100
9	36/100	36/100
10	16/100	34/100
11	24/100	76/100
12	18/100	*deferred*

Table 1: Thermofluids 1 MST scores for pre & post interventions

The formative MST scores' comparison showed a significant positive trend after intervention. The average score improved by 49%, from 23/100 to 72/100 marks (rounded off to nearest whole number). Pre-intervention showed only one pass, but post-intervention showed nine passes (including four grades of A). Based on the positive outcome of the formative MST, the author decided to continue delivering supplementary lessons via his customized EBRP checklist in the second term. This approach is akin to the high effect size method of formative evaluation to lecturers by Hattie (2008). In a hopeful attempt to prepare the 12 repeat students for the summative Exam, and also to help as many of the at-risk students as possible to pass at the end of the semester.

Refer to Table 2 below for the Thermofluids 1 Exam scores' comparison of the 12 repeat students (anonymous) among the two classes of 45 at-risk students, as well as their overall final grades after factoring in MST and ICA too.

Student	Pre-Intervention Exam (2020/2021 Sem1)	Post-Intervention Exam (2020/2021 Sem2)	Post-Intervention Final Grade (2020/2021 Sem2)
1	9/100	55/100	**B+**
2	12/100	45/100	**D+**
3	25/100	53/100	**C+**
4	14/100	72/100	**B**
5	10/100	58/100	**B**
6	29/100	53/100	**C**
7	11/100	80/100	**A**
8	29/100	84/100	**A**
9	41/100	56/100	**C**
10	*absent*	37/100	**F**
11	*absent*	77/100	**A**
12	*absent*	*deferred*	

Table 2: Thermofluids 1 Exam scores for pre & post interventions, & final grades

The summative Exam scores' comparison also showed a significant positive trend after intervention. All repeat students who sat for the post-intervention Exam improved in their scores. Their average score improved by 41%, from 20/100 to 61/100 marks (rounded off to nearest whole number). For pre-intervention in the previous semester, all 12 of them failed based on overall final grades and hence repeated Thermofluids 1. Eventually for post-intervention in the following semester, only one repeat student among the two classes of 45 at-risk students failed the module and faced expulsion.

At-risk students require lecturers' monitoring and intervention. The monitoring of engineering at-risk students to predict their performance in flipped learning was studied by other SP academic staff (Kok-Mak et al., 2019). However, such intervention lack studies that are backed by quantitative assessment data collected and analyzed accurately. Ideally, an accurate study should keep all variables constant, except the variable in the study's objective. National Aeronautics and Space Administration (NASA) compared the data of genetically identical twin astronauts (one was in space, while the other remained on Earth) over a year to accurately study the effects of space on humans (Garrett-Bakelman et al., 2019). Likewise, the author was given the unique opportunity to accurately study the effects of EBRP on the same 12 repeat students learning the same module, via comparing their pre and post interventions' quantitative assessment data over 2 consecutive semesters.

Based on post-intervention final grades in Table 2 above, 90% of the at-risk students passed their module in 2020/2021 semester 2. On top of the focus group in this study's scope (2020/2021 semester 2), the author also taught these Thermofluids 1 supplementary lessons to other at-risk students for the next four semesters (2021/2022 semester 1 to 2022/2023 semester 2). Based on post-intervention final grades, 82%, 88%, 85%, 85% of the at-risk students passed their module from 2021/2022 semester 1 to 2022/2023 semester 2 respectively. Eventually, majority of the engineering at-risk students (above 80% for five semesters) passed their module and avoided repeating/expulsion.

Reflections & Conclusion

The EBRP checklist is a versatile educational instrument that can be utilized both as an intervention and also for data collection and analysis. A lecturer can use the EBRP checklist as prediction of learning effectiveness before lesson and as diagnosis after lesson. To shed light on how to enhance and quantify quality teaching. Resembling survey and observation forms, the EBRP checklist can also be used by a lecturer for qualitative data collection and analysis.

It was challenging for the author to help his engineering at-risk students with only 1 hour weekly for supplementary lessons. Moreover, in order not to clash with students' regular timetables, supplementary lessons were scheduled beyond office hours (after 5pm) which was unconducive for both teaching and learning. Hence, in-class questions-&-answers and deliberate-practice on key topics (core principles 3, 7 & 8) were particularly important for supplementary lessons to be fruitful. Follow-up work in the near future shall involve utilizing EBRP as intervention for differentiated instruction and data-enabled flipped learning via cloud-based learning management system. To collect data for learning analytics outside the classrooms, to continue helping more engineering students in their learning.

The tenet of every lecturer's pedagogical technique is to ensure their students achieve the learning outcomes and progress academically. The author's customized EBRP checklist used

together with his original crosshairs methodology yielded significant positive assessment results. Eventually, majority of the engineering at-risk students (above 80% for five semesters, based on post-intervention final grades) benefited from the consequential enhanced quality teaching to pass their module, avoid repeating/expulsion and hence progress to their next academic phase of the SP education system.

The author received many feedback emails and messages from his at-risk students, over the five semesters. The author hereby concludes this paper by sharing one such memorable message below, demonstrating the fruitful implementation of evidence-based reflective practice (EBRP).

From: Student 6 (anonymous)

Hey Mr Leong,
I want to thank you for the semester I had with you. To be honest, I had a really rough time in SP, no lecturers that was able to help me too. It might sound like an exaggeration but its not, you were the first lecturer that made me interested and actually follow the class.

I was comfortable with you too! Your remedial was the highlight of my week in school. I always looked forward to it.

Once again, thank you for being an amazing lecturer. It might not be much to you, but it means a lot to me to be able to talk to one lecturer and having one to check on me. I hope we can keep in contact with each other, so that if we ever cross paths or meet again in the future, I can meet you as a better person AND being in a better position.

Sent: 11 March 2021 10:16 pm

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