Journal of Research and Curriculum Development, Vol.13, Issue.2, July – December, 2023
ISSN: 2730-387X (Online) https://so03.tci-thaijo.org/index.php/jrcd/index

# Effect of Reflection on Analytical and Critical Thinking Skills for Engineering and Technology Students: A Case Study in a General Education Class

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Received: September 30, 2023
Revised: November 5, 2023
Accepted: November 21, 2023

**Abstract:** This pilot study aimed to investigate the effect of student's learning-reflection skill as a mediator on the thinking skills of participants taking a subject, Learning and Problem-Solving Skills. The course covered analytical thinking skills and critical thinking skills. Throughout the 15-week semester, the practice of reflection using the 3-basket technique was implemented. Using the coaching competency, the instructor created an environment in which students could safely reflect on their learning as a group or individually. At the end of the semester, the perception of the students' thinking and learning abilities, i.e., analytical thinking and critical thinking, and reflection skills were evaluated and correlated with the predictors such as the class satisfaction in terms of the structure/activities, the instructor's behavior/in-class environment, and the students' behaviors. The results showed strong positive correlations of the predictors with the students' reflection and thinking skills. In addition, both instructor's behavior as coach/in-class environment and students' behaviors significantly effected students' thinking abilities via students' reflection skills as the mediator.

**Keywords:** Analytical thinking, Critical thinking, Reflection skill, Teacher as a coach, Three-basket technique

## Introduction

As the world situation changes due to Covid-19, education also changes in many aspects (Zhao & Watterston, 2021), and online-based classes become the most common means of teaching during this pandemic (Tang et al., 2020). Therefore, it is important to consider many aspects of online-based learning environments (Martin & Doris, 2018) including class setup created by lecturers, course structure, method of delivering, etc. This study aimed to investigate the student's learning experience in various aspects including student's satisfaction with the class structure/activities, the instructor's behavior/in-class environment, the students' own behaviors, and the perception of their thinking and reflecting skills. By focusing on the usage of reflection, it was expected that the study would provide a guideline for the usage of reflection to improve online learning with the support of the instructor and in-class environment.

The study investigated the relationships between 1) student's satisfaction with the course structure/activities and instructor's behavior/in-class environment, 2) students' behaviors and 3) their perceived thinking and reflection skills. The study intended to study the correlation of each factor for the improvement of teaching and learning. The main question was how the learning reflection embedded in the course would help improve the student's thinking skills. A pilot study was applied in the class of a general education, Learning and Problem-Solving Skills, at King Mongkut's University of Technology Thonburi (KMUTT), Thailand. The course description was "This course aims to equip students with the skills necessary for life-long learning. Students will learn how to generate positive thinking, manage knowledge and be familiar with learning processes through projects based on their interests. This includes setting up learning targets; defining the

problems; searching for information; distinguishing between data and fact; generating ideas, thinking creatively and laterally; modeling; evaluating; and presenting the project."

In the class, engineering and technology students were from the international program, KMUTT. This subject itself challenged the instructor to deliver such a profound thinking skills to the students. Each module in the class (covering analytical thinking, critical thinking, and learning skills i.e., learning reflection) was designed to train students to become social change agents according to the KMUTT Student Qualification Framework (KMUTT Student QF) (KMUTT Student QF, 2016). The class focused on the understanding of "thinking skills" and "learning skills" for the foundation to develop "problem-solving skills." The class applied learning reflection as a tool to develop student's experience into a body of "knowledge" and eventually become one's own "life skill." To know the effectiveness of the content-delivery method, the perception and satisfaction of students were important for enhancing student's performance. There were factors related to the student's achievement. For example, Yu et al. showed the effect of personal well-being on university students' learning achievement over time by mediating or moderating effects of internal and external university engagement. Internal university engagement such as academic challenges and learning with peers showed a significant mediation effect (Yu et al., 2018).

Teachers as coaches became increasingly common in this era. Even though teaching and coaching were in the different quadrants in the TAPS model (Rock, 2006). In a conventional classroom, teaching or coaching alone might not be able to fulfill the students' and/or class expectations due to the differences between students in many aspects, for example, students' learning styles (Cimermanová, 2018; İlçin et al., 2018). Coaching technique can improve students' abilities, for example, analytical thinking skills can be improved using a collaborative coaching method (Wongyai, 2018). Chaplin (2007) also showed that coaching methods can develop critical thinking skills in the introductory biology course (Chaplin, 2007). However, many coaching skills, for example, deep listening and power questioning, may not be performed well in a large classroom. To coach was to guide and to let the coachee (in this context, students) explore their own experience (to explore their lesson) with guidance for the students to acquire knowledge or solutions. The knowledge of learners then becomes important because they must have enough background to be able to make their own decisions or solutions. This is the reason why coaching and teaching are complementary. In this class, both teaching and coaching techniques were applied to help the students develop their learning and thinking skills using learning reflection.

Learning reflection as mentioned earlier was a starting point for oneself to develop their experiences into knowledge and eventually life skills. By asking a specific set of questions, in this study, the 3-basket reflecting technique (Jutarosaga, 2019) was used as a tool for the students to conclude or express their learning experience throughout the semester. Learning reflection was used in many learning models, for example, in Experiential Learning Theory (Kolb, 1984). Learning reflection, reflective observation, was part of this learning theory. Learners had to try to understand the topics from observation and reflections. Gibbs reflective cycle (Gibbs, 1988) was one of the subjects and a learning tool for the students to practice in class. Since there were 6 steps of Gibbs reflective cycle, students might hesitate to answer or might be confused about the steps. Three-basket reflection method (Jutarosaga, 2019) (How did you feel?, What did you learn?, How would you apply what you learned for the future?) was applied in this study. Peer coaching through self-reflection and feedback can help instructors and improve student learning (Becker, 1996). In this study, not only as an expert coach, but a teacher would also act as a peer coach to help the students by creating a safe environment for them to reflect on their learning throughout the semester.

At the end of the semester, a post-course survey, consisting of a set of questions, voluntarily answered by the students was used to reconfirm the instructor's observation. Besides the Likert-scale questionnaire, additional open-ended questions using the 3-basket reflection technique would be provided to identify student's perception and satisfaction with the instructor's delivery method. These reflection responses were qualitatively analyzed and used to support the quantitative analysis. It was important to know if the students could identify their in-class experience during the instructor's teaching or coaching. The study also aimed to relate the students' perception during the class (lecturer behavior/in-class environment) to the students' thinking skills, especially with the students' reflection skill as a mediator. Therefore, it was necessary to understand the relationship between 1) the students' satisfaction (with class structure/activities and instructor's behavior/in-class environment) and students' behaviors, 2) students' behaviors and students' perception of their thinking performance, and 3) students' satisfaction and students' perception on their learning performance? The objectives of this research were to (1) acquire a set of questionnaires to evaluate the student's perception of their performance including 1) analytical thinking, 2) critical thinking, and 3) reflecting skills as well as the student's satisfaction on 4) the class structure/activities, 5) the instructor's behavior as coach/in-class environment, 6) the student's behavior during the semester, in a general education class, Learning and Problem-Solving Skills. (2) to investigate the correlation between 1) the student's satisfaction with class structure/activities and instructor behavior as coach/environment and student's behavior, 2) student's behavior and student's perception on their performance, and 3) student's satisfaction and student's perception of their performance. (3) to confirm whether the learning reflection is a mediator for the satisfaction of the class structure/activities and the instructor's behavior as coach/environment as predictors on analytical and critical thinking skills as responses. Three entities mentioned in Moore's framework i.e., Learner, Content and Instructor and the interaction among the entities, Learner-Content, Instructor-Content and Learner-Instructor were keys for meaningful learning (Moore, 1989). Therefore, not only the characteristics of learners, instructors, and content but also the interaction among them (or within, for example, learner-learner interaction) was important, especially for the students to achieve the expected learning outcome. Martin & Doris (2018) showed that all interactions were important. In addition, students had a high perception of the importance of how the instructor interacts with them (Martin, & Doris, 2018). In our case, as shown in Figure. 1, we were interested in the effect of not only the instructor factors which were the instructor's behavior and the in-class environment (P5) but also the class structure and class activities (P4) on the perception of learning performance -- analytical thinking (P1), critical thinking (P2) and reflection skills (P3) -- via the student behaviors (student engagement) (P3) as a mediator. In addition, the correlation among the parameters would be investigated for observing the mediation effect of students' behaviors (P6) and the reflection skills (P3) later in the study.

## Research methodology

*Target group*

Participants were 27 volunteer engineering and technology students in the international program attending a general education class at King Mongkut's University of Technology Thonburi (KMUTT) in the semester 1/2022. The research was designed to be a typical classroom action research. The class was instructed so that the students would have

opportunities to practice self-reflection many times throughout the 15-week semester. In the final class, these volunteer students answered the designed questionnaire.

*Research variables*

According to the above framework, the student's learning performance, the analytical thinking skill (P1), critical thinking skill (P2) and reflection skill (P3), were treated as responses (dependent variables). The student's satisfaction with class structure/activities (P4) and instructor's behavior (teaching/coaching style) and class environment (P5) as the independent variables (predictors). In addition, student's in-class behavior (P6) was treated as the mediator. The instructor's behavior in our case was similar to the learner-instructor interaction in the previous research in some ways (Martin, & Doris, 2018). It described how the instructor behaved while teaching. In the case of class structure, the questions aimed to ask if the students felt each component in the class, such as a clear agenda, briefing section, group activities, etc., helped them understand the topics better or not. While the student's behavior was to identify what level of participation they committed during the semester. The responses were their perception of their reflection and thinking performance.

*Research Tools*

*Course planning:* The course was divided into 2 pathways to instruct the students 1) analytical thinking skill and 2) critical thinking skill. Learning reflection was designed for students to practice throughout the semester (in mostly every class). The expected learning outcome of the subject was the following. "Students are life-long learners. Students can design, assess, and improve their learning strategies, learn effectively, can search knowledge, and evaluate the reliability of the information resources. Students can solve problems systematically, develop analytical thinking, synthesis thinking, critical thinking, and creative thinking and realize their importance. In addition, students can learn, practice, and apply thinking tools in problem solving, logical and systematical thinking. Students can learn to respect difference and variety in opinions/ideas/attitudes. Students can organize their thoughts and convey them through writing." The learning outcome was shown in Table 1.

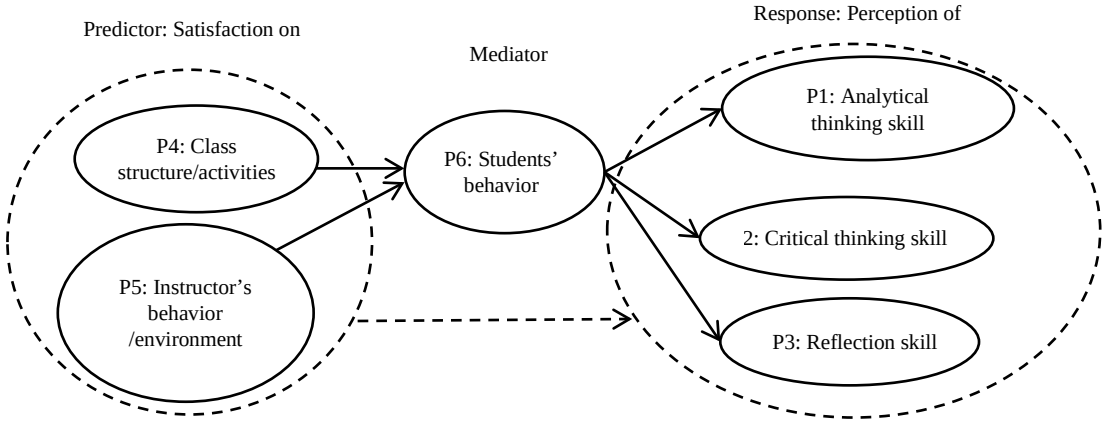


Figure 1. Concept model of this study. Responses: Student's P1) Analytical thinking skill, P2) Critical thinking skill and P3) Reflection skill, Predictors: P4) Class structure/activities and P5) Instructor's behavior and environment and Mediator: P6) Students' behavior

Table 1. Skill definition and learning outcome

| Skills | Definition | Learning Outcome |
|---|---|---|
| Analytical Thinking | The ability to distinguish concrete and abstract components using a variety of analytical criteria, rational, causing holistic understanding. | MLO1 - Ability to distinguish concrete and abstract components using different criteria/methods. |
| | | MLO2 - Be able to present a sequence of analytical thinking with logic, easy to understand, leading to a holistic idea and conveying the benefits of analysis. |
| Critical Thinking | The ability to think clearly and distinguish facts and opinions correctly. Based on reasons, make decisions, and be able to synthesize information into conclusions. | MLO3 - Be able to specify the function of the text (concept ideas) that make up the topics that need to be conveyed. |
| | | MLO4 - Be able to recognize and assess if the supporting premises are opinions or facts which produce a conclusion. |
| Reflective Thinking | The ability to honestly recognize one's own emotions, feelings, thoughts, and reasons. Analyze and synthesize their own learning styles and can be used in life. | MLO5 - Be able to explain, compare, and assess their own level of knowledge through various forms of reflection.<br>MLO6 - Be able to analyze and comment on their own learning style to be used as a basis for setting goals in life. |

Following the course outline, each class would be broken down into 4 or 5 sub-sessions consisting of 1) Briefing, 2) Group Activity, 3) Student Presentation, 4) Reflection and 5) Assignment. A briefing was done mostly at the first part of each 3-hour lecture, as the teacher explained what to do in the session. Group activities were done by breaking down students into small groups and letting them work together. The lecturer gave a visit to a group from time to time to provide an opportunity for students to ask questions and teacher for giving comments. Next, the presentation allowed students verbally shared their works and answered questions from friends and the instructor. The instructor encouraged the students to provide constructive comments for their friends. After that, the instructor would provide additional comments and wrap up the class. At the end of the class, the reflection was when lecturer asked, “How do you feel about the session including activities in the class?”, “What did you learn from today’s session?” and “How will you creatively use what you learned in the future?” before the class conclusion. The examples of the results of each individual reflection using Mentimeter were shown in Figure 2. To encourage the students to reflect, in some cases, a couple of random students were asked to reflect verbally using the same questions. In addition, assignments related to the class would usually be provided for the students to practice on their own and submitted later for the evaluation of their knowledge and learning skills and for the grading purpose.

*Assessment tools:* To gather research data, an instrument used in the experiment was a questionnaire for the collection of student’s thinking and reflecting skills, behavior, and satisfaction. The research was conducted by using a mixed method with a post-survey questionnaire consisting of 5-level Likert-scale questions and 3 open-ended questions. Likert-scale questionnaires were developed based on the learning outcome and some questions were adapted Tan (2001) to prove the thinking skills of the students (Tan, 2001).

The questionnaires from Tan (2001) had been previously used to evaluate the effectiveness of innovation project (Abdullah et al., 2012). The same set of questions were explored using the factor analysis (Hazlina, 2020). Also, the questions previously grouped as critical and creative thinking habits (Abdullah et al., 2012) were categorized as analytical thinking habits, critical thinking habits, meta-cognitive thinking, meta-cognitive behavior, and practical thinking (Hazlina, 2020). According to the analysis, we re-grouped the questions with additional newly designed questions to evaluate the students' perception according to our learning outcome. The questions not only measured perceived thinking and reflecting abilities of the students but also their satisfactions on the delivery method of the class and the instructor's behavior/environment. Answers to open-ended questions were used to support the finding from the qualitative results.

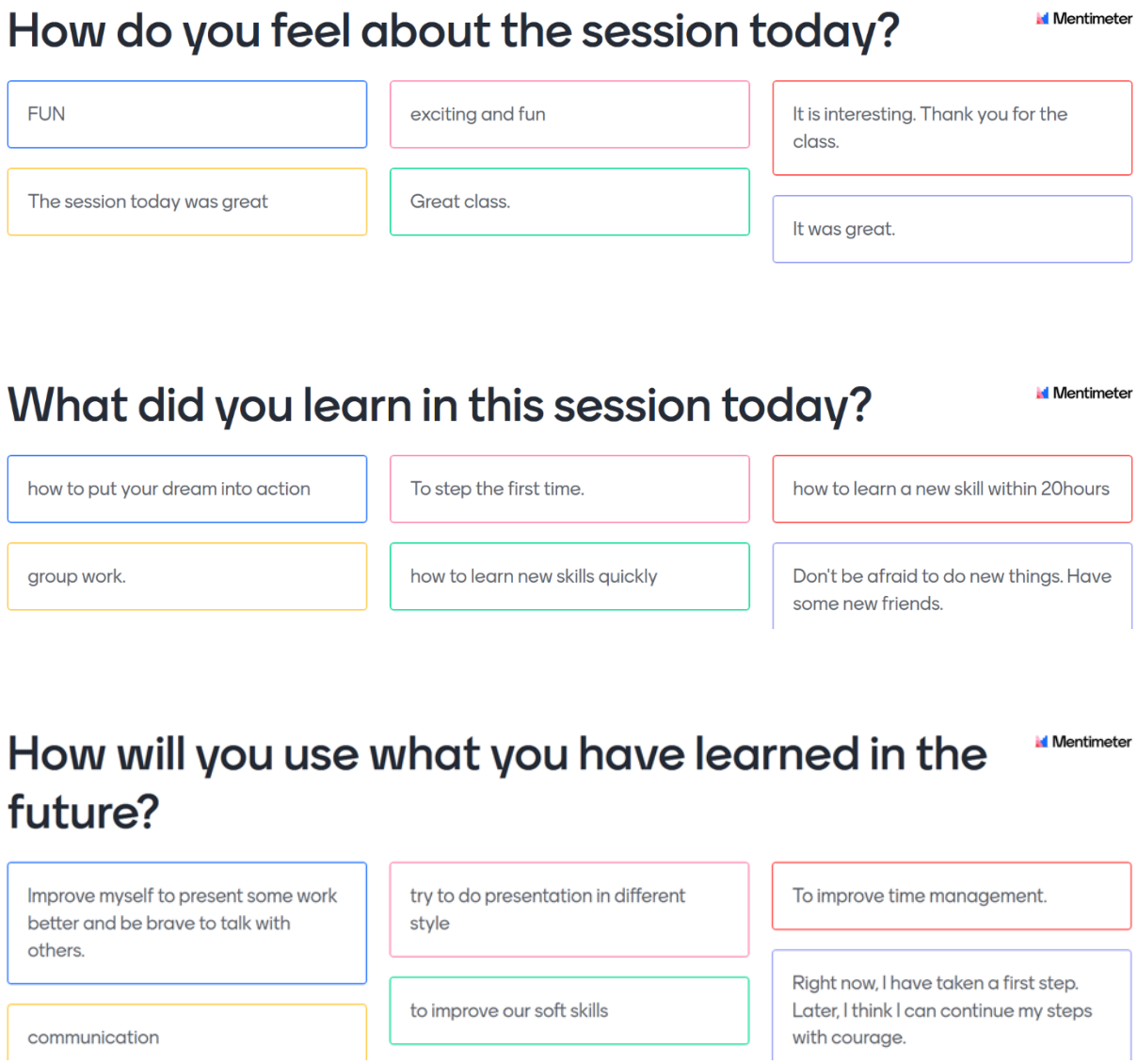


Figure 2. Examples of students' reflection at the end of the session

Table 2. Number of items and an example of items in each variable.

| Category | Variables | Number of items | An example of item |
|---|---|---|---|
| Responses: Student's perception of his/her learning and thinking skills. | Analytical Thinking | 10 | I am able to breakdown the situation into smaller components using different criteria. |
| | Critical Thinking | 10 | I am able to differentiate between fact and opinion. |
| | Reflection Skill | 11 | I am able to describe what I did in class in details. |
| Predictors: Student's satisfaction on the following topics. | Instructor's behavior/in-class environment | 7 | I like when the instructor encouraged me to participate in the discussion. |
| | Class structure/activities | 7 | "Class agenda" provided at the beginning of the class allow me to know I should expect in the class. |
| Mediator: | Student's behavior | 8 | I paid attention to the class during the briefing. |

*Data acquisition and analysis*

The questionnaire was conducted in the last session in a general class, Problem Solving and Thinking Skills, at KMUTT, semester 1/2022. The students were provided time for 30 minutes to reflect on the activities that took place in the whole semester and their learning and thinking experience. This post survey questionnaire was used to evaluate the students' perception and satisfaction of learning activities on the students' thinking habit. The post questionnaire consisted of 3 parts: part 1 background information, part 2 class satisfaction and students' behavior and the final part 3 open-ended self-reflecting questions.

The descriptive statistics, mean, standard deviation and correlation was used to analyze the quantitative data. Mean was for a central tendency; standard deviation provided us how much the data deviate from the central tendency and correlation allowed us to find the relationship among interested variables. The regression was also used to evaluate an assumed mediation factors in the study which was the students' behaviors during the class. In addition to the regression analysis, mediator test followed Baron & Kenny (1986) (Baron & Kenny, 1986). The Sobel test (Sobel, 1982) was used to verify if the assumption of mediation effect was significant or not (Preacher & Leonardelli, 2010).

## Research results

The survey results were collected from the 27 volunteer students. The internal consistency of the questions was evaluated using Cronbach's alpha. The questions were divided into 6 parts to evaluate the students' 1) analytical thinking (10 questions), 2) critical thinking (10 questions), 3) reflection skill (11 questions), 4) satisfaction on the class structure (7 questions), 5) satisfaction on the lecturer behaviors/environment (7 questions) and 6) students' behaviors (8 questions). The Cronbach's alphas of question part 1 to 6 were 0.85, 0.89, 0.88, 0.88, 0.85 and 0.86, respectively. Cronbach's alpha above 0.8 was considered that each set of the questionnaires had good internal consistency.

**The students' perception on their reflection and thinking skills**

Descriptive statistics such as mean and standard deviation were used to analyze each question. The agreement range was divided into 5 ranges, which 1.00-1.80 meant strongly disagree (SD), 1.81-2.60 meant disagree (D), 2.61-3.40 meant neutral (N), 3.41-4.20 meant agree (A) and 4.21-5.00 meant strongly agree (SA). All questions were rated above 3.40 indicating that students agree with the statement mentioned in each question. For the perceived analytical thinking skill part, question no. 5, "I am more aware of things around me and ask more questions so as to understand something better.", was rated at the highest of 4.30±0.67. For the critical thinking skill, question no. 1, "I am able to differentiate between fact and opinion", was rated at the highest of 4.41±0.69 which was targeted for one of the learning outcomes for the students in this subject. For the perceived reflection skills, question no. 8, "I learn to listen and respect alternate viewpoints.", was rated at the highest of 4.48±0.70.

Besides the thinking skills acquired by the students, some students confirmed that they had practice not only self-assessment but also noticed that they can evaluate their friends' work by giving positive and constructive comments. They learned to listen and respect other points of view.

> *"Throughout the course of the semester, I learned a lot about myself through a series of self-assessments and know what area I need to improve.* For example, concrete and abstract idea would be the content that I want to know better about it.

> "*From learning how to see things holistically to learning how to reflect on ourselves, there's no doubt that I have learned a lot from this class.* … I became proficient in organizing my ideas into facts and opinions and in expressing my thoughts with premises and conclusions. *I learned to reflect on myself such as what I have learned and in what areas I am still lacking in*. I acquired skills in working with other people and communicating with them effectively and efficiently...."

> "*… After every presentation, the professor also asked the other classmates to give positive comments and constructive comments about my presentation and also the professor himself gave us some comments on how we can improve and what are our good points and bad points. These things helped me a lot in improving and reflecting myself."*

**The student's satisfaction of the class structure/activities and instructor's behavior/environment and their behavior**

In the case of the students' satisfaction of the class structure/activities and instructor's behavior/environment and their own behaviors, the highest rating of 4.26±0.81 was the statement no. 3, "Briefing or lecturing" by the lecturer at the beginning of the class helps me understand the topic better. While the lowest ratio of 3.78±1.01 was the statement no. 4, "Group activities" in the break-out room helps me understand the topic better. This suggested that input from lecturers from briefing or lecturing was still an important part of learning from the students. Also, the larger variation on the opinion on "Group activities" showed the different opinions from the students. It might indirectly help them learn by creating an environment to communicate with other students and make friends, which would be mentioned later by the students' answers to the open-ended questions.

For the satisfaction of the students of the lecturers and environment, students agreed that the feedback and words of appreciation were important. Similar to the previous finding, the feedback from the instructor had a strong impact on the student engagement and less impact with the opportunity to reflect (Martin, & Doris 2018). In our case, the students agreed that the lecturer waited to listen and reflect. They felt that the class was safe to express their opinions and thoughts. For the students' behaviors in class, the students strongly agreed that they participated in the discussion in the breakout room, practiced reflection when requested, and helped team members finish the assignment.

Through qualitative data according to answers from the open-ended questions, we had further evidence to validate the above finding. According to the answers, students felt comfortable in class. Feedback, support, and encouragement from instructor were important to the students to enhance their satisfaction in class. In addition, students can also improve themselves while participating in the class activities.

> "*The class was really fun and the environment was really good.* Furthermore, this class helped me in developing myself in different ways. The memorable moments about this class was group works as we could make more friends."

> "*I feel comfortable with the teacher*; the teacher is very kind and nice. When I have a question outside class. He answers me clearly. In the part of teaching, I feel relaxed, but I understand what he teaches as well."

> "Feel good in this class, professor is s very kind guy. *When I do the present, I am never afraid to do it and not nervous because he always supports what we do, and always give some good advice."*

**The correlation analysis of student's satisfaction, behavior and learning performance**

To identify relationship among the parameters, the predictors were assumed to be the satisfaction of 1) class structure/activities and 2) instructor's behavior/environment. The mediator was assumed to be the students' behavior. The responses were student's perceived critical thinking, 2) analytical thinking and 3) reflection/practical thinking skills. Pearson correlation analysis was performed on the predictors, mediator, and the response. The Pearson correlation of 0.714, 0.839 and 0.801 ($p < 0.001$) corresponded to the relationship between predictor and mediator, predictor and response, and the mediator and the response, respectively.

The p-value of the regression coefficients between the response (students' perceived thinking and reflection skills) and the predictors (class structure and instructor behavior/environment) as well as the assumed mediator (students' behaviors) and the response was < 0.001. However, when conducting the regression analysis on the response versus assumed mediator and predictor found that Response = 0.954 + 0.333 Mediator + 0.440 Predictor. The regression coefficient of the predictor term was still large (with p-value < 0.001) compared to that of the assumed mediator term. Therefore, the assumption of both class structure and instructor behavior as the predictor, the assumption of student behavior as mediator and the perceived thinking/reflection skills as responses might not be corrected or only partial mediated.

Table 3. Means, SDs and Pearson correlation of predictors, mediator and responses.

| Variable | Description | M = 27 | SD | Correlation | |
|---|---|---|---|---|---|
| | | | | 2 | 3 |
| 1 Predictor | The satisfaction of 1) class structure/activities and 2) instructor's behavior/environment. | 4.14 | 0.84 | 0.714* | 0.839* |
| 2 Mediator | The student's behavior. | 4.02 | 0.82 | - | 0.801* |
| 3 Responses | The satisfaction of Instructor's behavior/environment. | 4.11 | 0.74 | - | - |

*p < 0.001

**Correlation and regression analysis of individual parameter**

For a better understanding, instead of grouping all questionnaires together for predictor, mediator and repsonse, each part of the questionnaires was separated and correlated using Pearson correlation. All positive correlations were observed among P1 - P6. The strong positive correlation (>0.82) was observed among the perceived learning outcomes of the students, analytical thinking (P1), critical thinking (P2) and reflection skills (P3). In addition, the satisfaction of class structure/activities (P4) and the instructor's behavior/environment (P5) were positively correlated (0.826) to the critical thinking skill (P2). The students' behavior (P6) and perceived reflection skills (P3) also had a strong positive correlation of 0.811.

Table 4. Means, SDs and Pearson correlation for each variable.

| Variable | M = 27 | SD | Correlation Metrix | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | 5 | 6 |
| 1 Analytical Thinking Skill | 4.10 | 0.67 | 0.837* | 0.823* | 0.737* | 0.681* | 0.772* |
| 2 Critical Thinking Skill | 4.15 | 0.74 | - | 0.848* | 0.826* | 0.826* | 0.681* |
| 3 Reflection Skill | 4.10 | 0.79 | - | - | 0.697* | 0.732* | 0.811* |
| 4 Class structure/ activities | 3.97 | 0.86 | - | - | - | 0.794* | 0.699* |
| 5 Instructor's behavior/in-class environment | 4.32 | 0.78 | - | - | - | - | 0.651* |
| 6 Student's behavior | 4.02 | 0.82 | - | - | - | - | - |

*p < 0.001

**Mediation analysis**

**- The effect of class structure/activities and instructor's behavior/environment on student's reflection skill via their behavior**

From Table 5, the regression analysis of P3 (reflecting skills) as a response, P6 (students' behavior) as a mediator and P5 (instructor behavior/environment) & P4 (class structure/activities) as predictors, the regression coefficients of both predictors became smaller while the p-value became larger. This indicated that the students' behavior was a partial mediator. For P5→P6→P3 and P4→P6→P3, P6 (students' behavior) was a partial mediator. To check the mediator, the method was suggested by Baron & Kenny (1986)

(Baron & Kenny, 1986). The Sobel test was used to verify if the mediation effect was significant or not (Preacher & Leonardelli, 2010). Assuming students' behaviors as mediator, path c' (Figure 3) called the direct effect would become less or not significant. Path c' was the indirect effect of the response to the predictor. Complete mediation was when predictor no longer effected the response after mediator had been controlled (path c' zero). Partial mediation was when the path from predictor to response was reduced in absolute value but was still not zero after introducing the mediator. c' was reduced (from c) in both cases of P4 and P5 as predictors (0.5566, $p<0.001$ to 0.2022, $p=0.124$ and 0.6685, $p<0.001$ to 0.3226, $p=0.018$, respectively) and was not zero. The students' behavior was a partial mediator. For P4→P6→P3, the p value of the regression coefficient of class structure/activities became not significant. The class setup had a positive effect on the ability of the students' reflection skill via students' behavior as mediator.

Table 5 Analysis for the predictors (class structure/activities and instructor's behavior/ environment) on response (the student's reflection skill) via student's behaviors as mediator.

**Class structure/activities (P4) → Students' behavior (P6) → Students' reflection skill (P3)**

**P3 = 1.89 + 0.557 P4**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 1.8922 | 0.4606 | 4.11 | 0.000 |
| P4 | 0.5566 | 0.1146 | 4.86 | 0.000 |

**P6 = 1.57 + 0.617 P4**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 1.5741 | 0.5072 | 3.10 | 0.005 |
| P4 | 0.6172 | 0.1262 | 4.89 | 0.000 |

**P3 = 0.988 + 0.202 P4 + 0.574 P6**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 0.9882 | 0.4286 | 2.31 | 0.030 |
| P4 | 0.2022 | 0.1268 | 1.60 | 0.124 |
| P6 | 0.5743 | 0.1436 | 4.00 | 0.001 |

**Instructor's behavior/environment(P5) → Students' behavior (P6) → Students' reflection skill (P3)**

**P3 = 1.21 + 0.669 P5**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 1.2146 | 0.5424 | 2.24 | 0.034 |
| P5 | 0.6685 | 0.1246 | 5.37 | 0.000 |

**P6 = 1.19 + 0.657 P5**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 1.1862 | 0.6673 | 1.78 | 0.088 |
| P5 | 0.6571 | 0.1533 | 4.29 | 0.000 |

**P3 = 0.590 + 0.323 P5 + 0.526 P6**

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 0.5901 | 0.4475 | 1.32 | 0.200 |
| P5 | 0.3226 | 0.1276 | 2.53 | 0.018 |
| P6 | 0.5265 | 0.1264 | 4.17 | 0.000 |

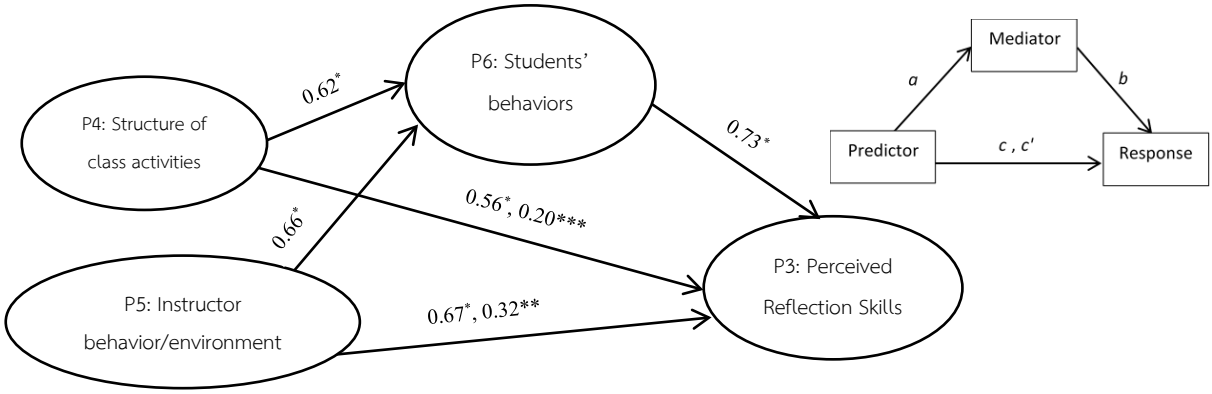


Figure 3. Mediated relationship between perceived reflection skills and (a) structure of the class, (b) instructor behavior/environment with students' behaviors as the mediator. (*$p < 0.001$, **$p < 0.05$, *** $p > 0.05$)

**- The effect of instructor's behavior/environment and student's behavior on their thinking skills via the reflection skill**

Since the assumption of instructor/environment was not a well predictor on the students' reflection performance for the students' behavior as a mediator, components were broken down to smaller components (P1 – P6). Consequently, the instructor's behavior and

the students' behavior were then treated as predictors separately for the students' thinking skills via the perceived students' refection skill as a mediator. First, we considered the instructor/environment as a predictor, the perceived reflection skill as the mediator and the perceived critical thinking skill as the responses according to this path, P6→P3→P2 and following by P6→P3→P1 for the analytical thinking skills. The casual-step approach and Sobel test were again performed. The indirect effect (c') was smaller with a larger p value than the total effect (c). The c' values were 0.2333, p = 0.116 and -0.0174, p = 0.918 in the case of students' behavior (P6) as predictor and the analytical thinking skill (P1) and critical thinking skill (P2), respectively, with reflection skill (P3) as a mediator. Since the p value of the c' became not significant, we can conclude that the students' behavior had a positive effect on their thinking skills which was fully mediated by the reflection skill. Also, the c' values were 0.1314, p = 0.314 and 0.4054, p = 0.002 in the case of instructor's behavior/environment (P5) as a predictor and the analytical thinking skill (P1) and critical thinking skill (P2), respectively, with students' reflection skill (P3) as a mediator. The effect of instructor's behavior/environment on the analytical thinking skill was fully mediated by the students' reflection skill, but only partially mediated in the case of the critical thinking as a response. Both instructor's behavior/environment and students' behavior showed a positive impact on the students' thinking skills through the reflection skill. This was consistent with the prior finding which showed the reflection had a positive impact on learning achievement (Martin & Ertzberger, 2016). The students who showed perceived reflection skill consequently showed both critical and analytical thinking. The instructor's behavior and in-class environment (perceived by the students) strongly support the students' perceived thinking skills through their perceived reflective thinking behavior.

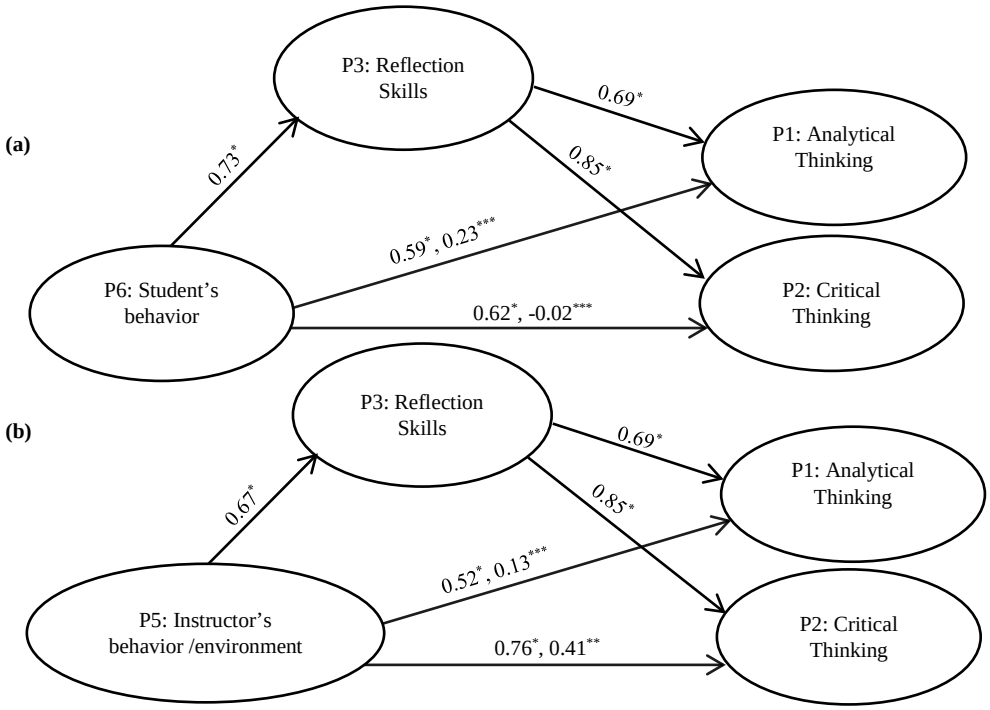


Figure 4. Mediated relationship between (a) students' behaviors and thinking skills with reflection skill as the mediator and (b) instructor behavior and environment and thinking skills with reflection skills as the mediator. (*p < 0.001, ** p < 0.05, *** p > 0.05)

From students' comments, instructor's and students' behaviors showed a support to their learning. The reflection, for example, showed that instructor/environment encouraged students to practice reflection, so they obtained the thinking skills. The comments showed their reflection ability that students realized that the instructor's method and ability benefited them. Also, the student mentioned their participation in group work and activities in class would help him/her to be able to use the thinking and learning skill in the future.

> "... I also learned how to make a conclusion based on facts, figures, opinions, and premises as well. *I learned is how to give constructive feedback to others.* It is important that you do not want to upset or give negative feelings to the person when you have to give feedback."

> "*… Through the group working and debate presentation, I am quite used to applying the knowledge I have stored in mind in my studies.*

> *"…So, I guess that's the very start for me to keep utilizing these skills and make good use of it in the future…"*

In addition to the perception of their thinking and reflection thinking which was obtained mainly from the perception of volunteer students, the scores of the 3 modules (analytical thinking, critical thinking and learning modules) according to the class rubric were simply normalized to 5 level. Then, 5-level scores of each module and the average 5-level Likert-scale of each perceived skill (analytical thinking, critical thinking and reflection skills) were tested using a Mann-Whitney U test to determine if the normalized score statistically different from the students' perception on their performance or not. The preliminary showed that the median value of each data was not significantly different. It preliminary confirmed that students well perceived their skills similar to how the instructor observed.

## Discussion

The class aimed to improve the student's thinking and learning skills using reflection as a tool and providing a safe environment. In current research, cognitive skills meant the ability to think and to learn. These skills consisted of 5 domains, perception, attention, memory, language and thinking (Wongyai, 2015). In this class, the thinking and learning skills were analytical thinking, critical thinking, and reflection skills. The instructor requirement was to open the learner's mind for learning. Coach should make learners see the values and the importance of the subject, create the feeling that the subject is not difficulty, build the learners' confidence, diminish stress or anxiety of the learners, and create the feeling that the learner is an important person (Wongyai, 2015).

GROW (Goal, Reality, Opportunity, and Way forward) model was a conventional model for coaching. Coaches should facilitate coachees to realize their own goal, reality (their current situation), opportunity (their possible available actions) and way forward (their actions after the sessions). As a cognitive coach (Wongyai, 2015), the responsibility was not solely for the student to obtain each item on their own. The GROW model must be applied to students and instructors. The coach has responsibility to set up the learning goal, checking the learners' situation, select appropriate methods to convey contents, have a practical

approach in action with clear goals and steps, and evaluate if learners have developed their cognitive skills or not. The subject learning outcome is the goal. The observation of learners by an instructor in many aspects is reality. Many teaching techniques including creating environments are options. Class action steps are ways forward. The teaching technique in the study was the reflection using a 3-basket technique in the safe environment created by the instructor.

The preliminary finding was that via the student's perceived reflection skills, the high order thinking skills such as analytical thinking and critical thinking can be improved by providing the environment created by the instructor and student's own behavior. As for the reflection as the mediator, 3-basket reflection technique and the power question showed the improvement of the systematic creative thinking skills, for examples, the participants of humanized health care development with a simulated family system (Jutarosaga, 2021), health care personnel of Chaiyaphum Hospital, Thailand (Luecha et al., 2022) and for evaluation of teaching and learning in the Bachelor of Public Health program Community Health Program Sirindhorn College of Public Health Khon Kaen Province (Thamsaeng, 2020). Not only the systematic creative thinking skills but also the analytical and critical thinking skills of the learners can be improved or developed. Besides health care sectors, reflection had been used in engineering and science education. The achievement goals of the students were significantly related to the reflection especially for the mastery approach – focuses on learning and understanding materials – in the achievement goal theory (Heo et al., 2018). The course reflection including content, organization, assignment, and conclusion were mostly related to the questions "What did you learn?" in our setup. Metacognitive awareness showed a positive relationship with the learning performance of the students (Ridley et al., 1992). Reflection on students' personal thoughts and feelings can provide valuable information to the instructor. Positive feelings such as enjoyment and relaxation can indicate that the student is engaged and learning, while negative feelings such as nervousness and difficulty can help the instructor identify areas for improvement.

As for the instructor's behavior/environment and student's behavior, this study showed that both factors had a significant effect on the student's thinking skills via reflection skills as mediator. The students strongly agreed that the instructor's safe space, active listening, reflection, feedback, and words of appreciation caused students to participate in the class. Research showed that characteristics of instructor, peer, self and physical environment caused the safe classroom (Holley & Steiner, 2005). The common instructor's characteristics were to provide safe classroom included being non-biased/nonjudgmental/open, developing ground rules, being respectful/supportive, encouraging class participation. According to Holley & Steiner (2005), a safe classroom help students learn about others' ideas, perspectives, thoughts and experiences. It also provided opportunities for students to expand their points of view. This supported our finding that the instructor's behavior/environment caused the safe classroom for the students to participate (i.e., reflection). Subsequently, the students not only learned about others' experiences but also learned their weakness/strength of themselves. In addition to the instructor's behavior/environment, the student's behaviors also led to the improvement of thinking performance. The students strongly agreed that participating in in-class group discussions, practicing reflection and helping teammates with assignments enhance their thinking skills. Both instructor's behavior/environment and student's participation in the well-designed class structure and activities could enhance their thinking skills via reflection skills.

## Conclusion

The overall student's satisfaction on class management (class structure/activities) and instructor's behavior as coach/in-class environment showed the positivity effects on the student's perceived thinking and reflecting performance which partially mediated by the students' behavior. When considering only the instructor behavior/environment or students' behavior as predictors, it was observed that the students' reflective thinking was a significant mediator to the students' critical and analytical thinking skills. This pilot study then suggested that instructor's behavior/class environment and students' behaviors were important in achieving the thinking skills according to the learning outcome. When both factors were available and used appropriately, students learned to reflect. By doing so, students could develop both analytical thinking and critical thinking via reflection skill as a mediator.

One of the limitations was the size of the population. To clarify for future study, the questionnaire shall be revised, simplified, and used again for a larger population to confirm the effect of instructor behavior/environment (predictors) on the reflection skill (mediator) and both critical and analytical skills. Criteria should be developed to evaluate the reflection quality. In addition, instead of the student's perception on the thinking abilities, the in-class performance using grading system (rubric) can be used to confirm and correlate with their perception. It was important for the students to recognize and acknowledge their abilities.

## Acknowledgement

Authors would like to thank Office of General Education, Faculty of Liberal Art, King Mongkut's University of Technology Thonburi (KMUTT), Thailand for the materials and class support. The thanks extended to Thailand Coaching Institute and Faculty of Industrial Education and Technology, KMUTT for providing the support and valuable information of coaching competency. Moreover, authors would like to express special appreciation to Assoc. Prof. Dr. Wichai Wongyai, Assoc. Prof. Dr. Marut Patphol and Dr. Makarapan Jutarosaga for the comments and suggestions. Last but not least, thanks go to the volunteers to answer the questionnaire without them to this study would not be possible.

## References

Abdullah, H., Mohd Nizah, M. A., & Baharun, H. (2012). Promoting thinking skills: An evaulation of effectiveness of invention project. *Elixir Social Studies*, *44*, p.7178-7187.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, p. 1173-1182. https://doi.org/10.1037/0022-3514.51.6.1173

Becker, J. M. (1996). *Peer coaching for improvement of teaching and learning.* Retrieved from http:// https://teachersnetwork.org/tnli/research/growth/becker.htm

Chaplin, S. (2007). A model of student success: Coaching students to develop critical thinking skills in introductory biology courses. *International Journal for the scholarship of teaching and learning*, *1*(2), p. 2.

Cimermanová, I. (2018). The effect of learning styles on academic achievement in different forms of teaching. *International Journal of Instruction*, *11*(3), p. 219-232. https://eric.ed.gov/?id=EJ1183439

Gibbs, G. (1988). *Learning by doing: A guide to teaching and learning methods.* Further Education Unit.

Hazlina, A. (2020). Exploring factor structures of a thinking questionnaire. *Ulum Islamiyyah*, *31*, p. 35-53. https://doi.org/10.33102/uij.vol31no.199

Heo, D., Anwar, S., & Menekse, M. (2018). The relationship between engineering students' achievement goals, reflection behaviors, and learning outcomes. *International Journal of Engineering Education*, *34*(5), p. 1634-1643.

Holley, L. C., & Steiner, S. (2005). Safe space: Student perspectives on classroom environment. *Journal of Social Work Education*, *41*(1), p. 49-64.

İlçin, N., Tomruk, M., Yeşilyaprak, S. S., Karadibak, D., & Savcı, S. (2018). The relationship between learning styles and academic performance in TURKISH physiotherapy students. *Bio Medical Center Education*, *18*(291), p.1-8. https://doi.org/10.1186/s12909-018-1400-2

Jutarosaga, M. (2019). Developing creative systems thinking processes: A refection of thinking through Three- Basket Technique. *Journal of Research and Curriculum Development*, *9*(2), p. 203-222. https://so03.tci-thaijo.org/index.php/jrcd/article/view/216950

Jutarosaga, M., Mahaprom, T., Somtua, N., Komaratat, S., Sansuk, J., Chanaboon, A., & Jutarosaga, A. (2021). Effect of the humanizes health care development with simulated family system on systematic creative thinking skills with three baskets technique among health care personnel. *Journal of Research and Curriculum Development*, *11*(1), p. 49-70.

KMUTT. (2016). *Student QF*. https://www.c4ed.kmutt.ac.th/qf-2

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.

Luecha, W., Pratumtin, A., Gomaratus, S., Pinprasong, N., Wannuruk, S., & Sunato, P. (2022). Effects of the humanized health care learning process development using a Simulated Family System on creative systematic thinking process through a Three-Basket Technique of caring team leaders in Chaiyaphum hospital. *Nursing Journal of The Ministry of Public Health*, *32*(3), p. 109-121.

Martin, F. B., & Doris U. (2018). Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. *Online Learning*, *22*(1), p.205-222. https://eric.ed.gov/?id=EJ1179659

Martin, F.B, & Ertzberger, J. (2016). Effects of reflection type in the here and now mobile learning environment. *British Journal of Educational Technology*, *47*(5), p. 932-944. https://doi.org/https://doi.org/10.1111/bjet.12327

Moore, M. G. (1989). Editorial: Three types of interaction. *American Journal of Distance Education*, *3*(2), p. 1-7. https://doi.org/10.1080/08923648909526659

Preacher, K. J., & Leonardelli, G. J. (2010). Calculation for the sobel test. Retrieved from https://quantpsy.org/sobel/sobel.htm

Ridley, D. S., Schutz, P. A., Glanz, R. S., & Weinstein, C. E. (1992). Self-regulated learning: The interactive influence of metacognitive awareness and goal-setting. *The journal of experimental education*, *60*(4), p. 293-306.

Rock, D. (2006). *Quiet leadership : Help people think better - don't tell them what to do: Six steps to transforming performance at work*. Collins.

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. *sociological methodology*, *13*, p. 290-312. https://doi.org/10.2307/270723

Tan, G. Y. H. (2001). *Analysis and evaluation of the Thinking Programme in developing critical and creative thinking among lower secondary students in The Chinese High School* AARE Annual Conference, Fremantile. https://www.aare.edu.au/publications/aare-conference-papers/show/3309/analysis-and-evaluation-of-the-thinking-programme-in-developing-critical-and-creative-thinking-among-lower-secondary-students-in-the-chinese-high-school

Tang, T., Abuhmaid, A. M., Olaimat, M., Oudat, D. M., Aldhaeebi, M., & Bamanger, E. (2020). Efficiency of flipped classroom with online-based teaching under COVID-19. *Interactive Learning Environments*, p. 1-12. https://doi.org/10.1080/10494820.2020.1817761

Thamsaeng, A. (2020). Evaluation of teaching and learning of communicable and non-communicable diseases course by using 3 basket techniques of students in the Bachelor of Public Health program Community Health Program Sirindhorn College of Public Health Khon Kaen Province. *Research and Development Health System Journal*, *13*(1), p. 287-291.

Wongyai, W., & Patphol, M. (2015). *Cognitive coaching*. Charansanitwong Printing Co., Ltd.

Wongyai, W., Patphol, M., & Intalapaporn, C. (2018). Developing the analytical thinking of teachers students by collaborative coaching approach. *Veridian E-Journal, Silpakorn University (Humanities, Social Sciences and arts)*, *11*(2). p. 232-239.

Yu, L., Shek, D. T. L., & Zhu, X. (2018). The influence of personal well-being on learning achievement in university students over time: Mediating or moderating effects of internal and external university engagement [Original Research]. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.02287

Zhao, Y., & Watterston, J. (2021). The changes we need: Education post COVID-19. *Journal of Educational Change*, *22*(1), p. 3-12. https://doi.org/10.1007/s10833-021-09417-3