

# An MDRE approach to promoting students' learning performances in the era of the pandemic: A quasi-experimental design

Gwo-Jen Hwang<sup>1</sup>  | Chin-Lan Yang<sup>2,3</sup>  | Kuei-Ru Chou<sup>4,5</sup>  |  
Ching-Yi Chang<sup>4,5</sup> 

<sup>1</sup>Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taipei, Taiwan

<sup>2</sup>Department of the Nursing, National Taipei University of Nursing and Health Sciences, Taipei, Taiwan

<sup>3</sup>Department of the Nursing, Hsin Sheng Junior College of Medical Care and Management, Taoyuan City, Taiwan

<sup>4</sup>School of Nursing, College of Nursing, Taipei Medical University, Taipei, Taiwan

<sup>5</sup>Department of Nursing, Shuang Ho Hospital, Taipei Medical University, New Taipei City, Taiwan

## Correspondence

Ching-Yi Chang, School of Nursing, College of Nursing, Taipei Medical University, 250 Wuxing Street, Taipei 11031, Taiwan.  
Email: frinng.cyc@gmail.com

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## Abstract

Educators have indicated the need to foster students' ability to solve problems by acquiring up-to-date knowledge as well as promoting their competences for making decisions from diverse perspectives based on the acquired knowledge. Traditional courses mainly use lecture-based instruction without providing sufficient opportunities for students to practice and interact with the teacher; therefore, it is difficult to deliver such up-to-date knowledge via traditional instruction, not to mention fostering students' critical thinking. In this study, the Mobile technology-supported Decision, Reflection and Exercise (MDRE) model is proposed to address this problem. Moreover, a learning system is developed based on the proposed approach. To evaluate the effectiveness of the proposed approach, a quasi-experiment was conducted in a university with a two-group pretest posttest design to assess participants' learning achievement, critical thinking and learning satisfaction. The participants were two classes of undergraduate students. One class with 37 students was the experimental group learning with the MDRE learning approach, whereas the other class with 37 students was the control group learning with the conventional technology-based learning

approach. Analysis of covariance was performed to evaluate the effect of the intervention on the target outcomes. It was found that the experimental group showed better learning achievement, critical thinking and learning satisfaction than the control group. This implies that the MDRE approach has good potential in helping learners think from diverse perspectives and promoting their learning performance and engagement, which is important in higher education aimed at fostering students' competence of acquiring up-to-date knowledge for solving problems.

#### KEYWORDS

critical thinking, decision making, mobile applications, mobile learning

### Practitioner notes

What is already known about this topic

- Fostering students' problem-solving competence is an important educational objective.
- The advancement of mobile and wireless communication technologies provides opportunities for students to acquire up-to-date information for solving problems.
- In the conventional technology-enhanced professional learning mode, instructors generally use computers to present learning content and exemplary cases. In such a learning mode, learners have few opportunities to think in depth.

What this paper adds

- A Mobile technology-supported Decision, Reflection and Exercise (MDRE) approach is proposed to guide students to make decisions and think from diverse perspectives via acquiring up-to-date information using a mobile application.
- An experiment was conducted to show the effectiveness of the proposed approach.
- The experimental results showed that the MDRE approach is able to boost students' creative thinking tendency and learning satisfaction as well as promoting their learning achievement.

Implications for practice and/or policy

- The MDRE approach has great potential for professional training aiming to foster students' learning achievement, critical thinking and learning satisfaction.
- It is suggested that researchers and school teachers can apply the MDRE approach to other professional courses, such as nursing training programs and business planning courses.

## INTRODUCTION

Fostering students' ability to solve problems by acquiring up-to-date knowledge as well as assessing the acquired content from diverse perspectives has been emphasized by educators as important competences in the 21st century (Albahlal, 2019; Sulisworo & Toifur, 2016). From the perspective of constructivism and connectivism, shifting the power in education away from individuals, such as learners and instructors, to a collective group is important (Bozkurt, 2017). It closely aligns to learning that harnesses technology to take learners beyond the walls of the classroom, such as handheld devices and VR (Thongkoo et al., 2019). Connectivism is positioned as a new philosophy of education for the digital age (Siemens & Conole, 2011). It makes Vygotsky's concept of the zone of proximal development (ZPD) more flexible as well as expanding it to include learning that lies outside the learner, in social networks and technological tools (Mattar, 2018). For example, Cavus and Uzunboylu (2009) pointed out the importance of fostering students' ability to acquire up-to-date knowledge in a mobile web learning environment. In traditional instruction for undergraduate students, teachers generally deliver the content of textbooks and some illustrative cases reported in research articles in a lecture-based mode. In such a learning mode, students have few opportunities to acquire knowledge on their own, not to mention learning to make judgments using the acquired knowledge (Lai & Wu, 2012). Scholars have, therefore, pointed out the need to shift the educational paradigm to the learner-centred mode, which encourages students to acquire up-to-date knowledge from diverse channels (Schutte et al., 2017). In the era of mobile and wireless communication, such a knowledge-acquiring mode is very important, in particular in the time of the COVID-19 pandemic (Onyema et al., 2020).

In the conventional technology-based learning (CTL) approach, teachers generally use a computer with network communications and a projector to present multimedia content. They also design activities to engage students in learning from supplementary content. In some technology-based learning activities, students could be asked to search for information to answer a list of questions on a worksheet provided by the teacher for investigating a specified issue (Craig & Petticrew, 2013). However, due to a lack of guidance, students might not think deeply, not to mention considering problems from diverse angles (Radulović & Stančić, 2017; Warsah et al., 2021). Scholars have pointed out the importance of providing suitable guiding scaffolding to help students compare and reflect in the process of trying to acquire knowledge (Ge & Chua, 2019; Røsvik & Haukedal, 2017).

To cope with this problem, we introduced the Mobile technology–supported Decision, Reflection and Exercise (MDRE) approach in an attempt to overcome the shortcomings of the conventional learning approach and ultimately to enhance students' learning achievements and critical thinking. To verify the efficacy of this model, we used a quasi-experiment to answer the following research questions:

1. How does the MDRE learning approach influence student learning achievements in comparison with the CTL approach?
2. How does the MDRE approach influence student critical thinking in comparison with the CTL approach?
3. How does the MDRE learning approach influence students' learning satisfaction with the CTL approach?

## LITERATURE REVIEW

### Mobile technology in educational settings

In professional training, such an ability of finding and using up-to-date information for problem solving has also been highlighted (Kinsella et al., 2018). Researchers have indicated that most students tend to rely on what they have learned from the textbooks and, hence, might not be able to find and use the up-to-date knowledge when dealing with practical cases (Leighton & Griffioen, 2021; Pavlidou et al., 2021). The popularity of mobile and communication technologies has significantly affected the way of teaching and learning (Linderman et al., 2020). Via mobile devices with computer networks, people are able to access the most up-to-date information at any time; therefore, scholars have emphasized the need to foster students' competence of searching for and applying the up-to-date knowledge to problem solving (Lopez & Cleary, 2019). This implies the importance of fostering their critical thinking ability for adopting proper information to make decisions when facing practical problems (Silwal & Panta, 2021). In the past decade, several researchers have attempted to use mobile applications in professional training programs (Bacca et al., 2015; Cattaneo et al., 2015). For example, Ruiz-Rube et al. (2019) conducted a mobile technology-based activity in a training program on the Internet of Things. Radosavljevic et al. (2020) implemented a mobile-based augmented reality system to improve students' problem-solving in a Postal Services Practicum program. Hester et al. (2021) also used a mobile application for training learners' skills of taking clinic patients' vital signs. Meanwhile, a mobile virtual reality application for patient training has been used in hospital education (Singleton et al., 2021).

On the other hand, Craig and Petticrew (2013) indicated that, without proper guidance or support, students generally answer the questions listed on worksheets based on what they have learned from the textbook. Some students even used their limited awareness regarding the questions rather than attempting to collect up-to-date information to make decisions. Several scholars have further pointed out the need to foster students' competence of extending what they have learned from the textbooks by acquiring additional knowledge from the Web (Márquez-Hernández et al., 2020; Reyhav & McHaney, 2017). This could enable them to perceive questions from diverse angles. For example, Chang et al. (2021) emphasized several advantages of engaging students in mobile-based decision-making activities, including promoting students' learning efficiency, critical thinking and problem solving. Tai and Ting (2020) reported that the use of mobile applications had good potential for fostering engineering students' learning performance and reflective thinking in cross-disciplinary learning. Furthermore, scholars have indicated the importance of providing more practice activities using mobile and wireless communication technologies to encourage students to acquire up-to-date knowledge for solving problems (Gharbi & Haddadi, 2020; Shadieff et al., 2018).

### Mobile technology-facilitated higher order thinking

From the perspective of Bloom's taxonomy of educational objectives, it is important to consider how to engage students in higher order thinking (eg, evaluating, analysing and making decisions) in educational settings (Behrenfeld & Boss, 2018). In traditional lecture-based instruction and assessment, the main foci of the class tend to be 'memorizing', 'comprehension' or 'skill mastering' (Hoellwarth et al., 2005). Scholars have suggested that the professional education curriculum learning model can be assisted by applying technology that helps improve students' critical thinking (Chang et al., 2020; Hwang & Chang, 2020; Kumar & Murali, 2020). Moreover, if students are constantly finding and looking at up-to-date

information, they are researching the change or paradigm shift of the specified issues, which is helpful for promoting their higher order thinking (Hu et al., 2007).

Parsazadeh et al. (2018) specified that using mobile applications to acquire up-to-date knowledge for decision making could not only improve students' learning engagement and peer interactions but also had the potential to facilitate their knowledge construction. Moreover, van Wyk and van Ryneveld (2018) validated that learners who were engaged in judging and interacting with others were generally more involved in the classroom activities and had better learning achievements than those learning with traditional lecture-based instruction. Bernardo and Santos (2021) further emphasized the importance of guiding students to acquire mobile technology–supported up-to-date knowledge for promoting students' learning outcomes. Additionally, Peng et al. (2020) pointed out the need to engage students in making reflections via interacting in social contexts during the exercising process, which echoes the social constructivism theory (Bozkurt, 2017).

In the era of the COVID-19 pandemic, it is even more crucial to foster students' ability to keep track of up-to-date information and making correct judgments, in particular, knowledge related to health and nutrition (Askeer et al., 2020). As a consequence, in this study, a MDRE model is proposed by referring to the literature to facilitate students' learning in professional training programs for nutritional assessment.

## MOBILE TECHNOLOGY–SUPPORTED DECISION, REFLECTION AND EXERCISE MODEL

Although several previous studies have attempted to guide learners to search for information on the Internet, the main foci of the studies were generally related to students' information-searching competences (Alving et al., 2018; Huertas-Bustos et al., 2018; Sanchiz et al., 2019). Some studies related to professional training have used practicing cases to guide learners to learn to make decisions; however, the acquisition of up-to-date information was not emphasized (Gale, 2021; Krishnan, 2018; Oh & Yang, 2019). To address this problem, a model for guiding students to make decisions and reflections via seeking up-to-date information is needed.

Figure 1 shows the MDRE model, which consists of a mobile application with three learning stages, that is, Decision, Reflection and Exercise. To enable students to access the most up-to-date information, a mobile application connected to a database with up-to-date content was adopted for implementing the MDRE mode. The mobile application was developed based on the data collected and analyzed by a group of domain experts in the Ministry of Health and Welfare (2021). It provides various practical cases as well as an inquiry interface to answer questions regarding the problems of health and welfare. More importantly, it is able to provide up-to-date information by connecting to the data released by institutes of health and welfare from around the world.

Figure 2 shows the interface of the mobile application. A worksheet with a series of situational cases is provided by the teacher to guide learners to complete learning tasks following the order of the three stages.

### Decision stage

In the 'Decision' stage, students are guided to make decisions after reading the information of a list of situational cases presented by the teacher. For example, the students are asked to analyse the status and make dietary recommendations for a practical case: 'A female patient with a height of 160 cm and weight of 53 kg drinks a glass of milk (about 240 ml), eats two

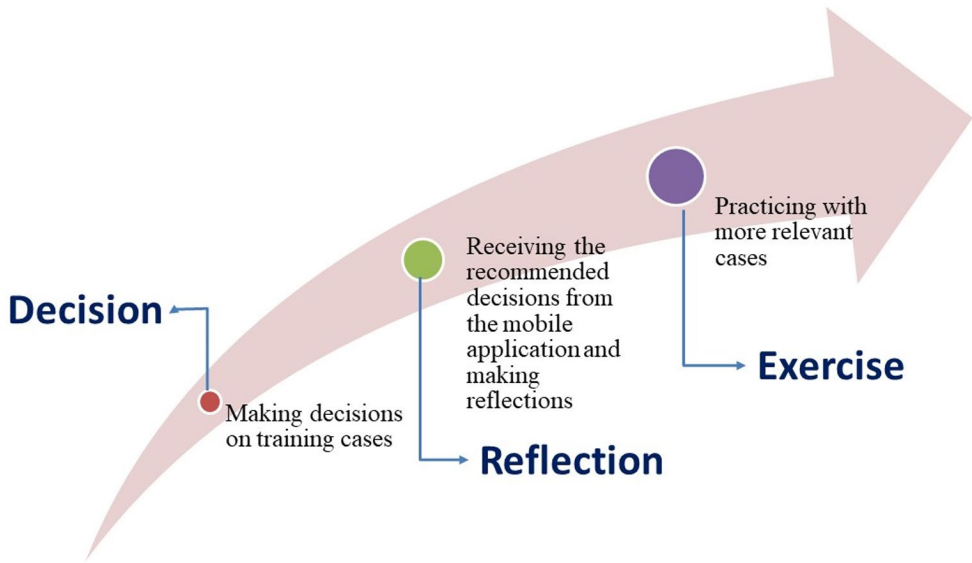


FIGURE 1 The MDRE learning model

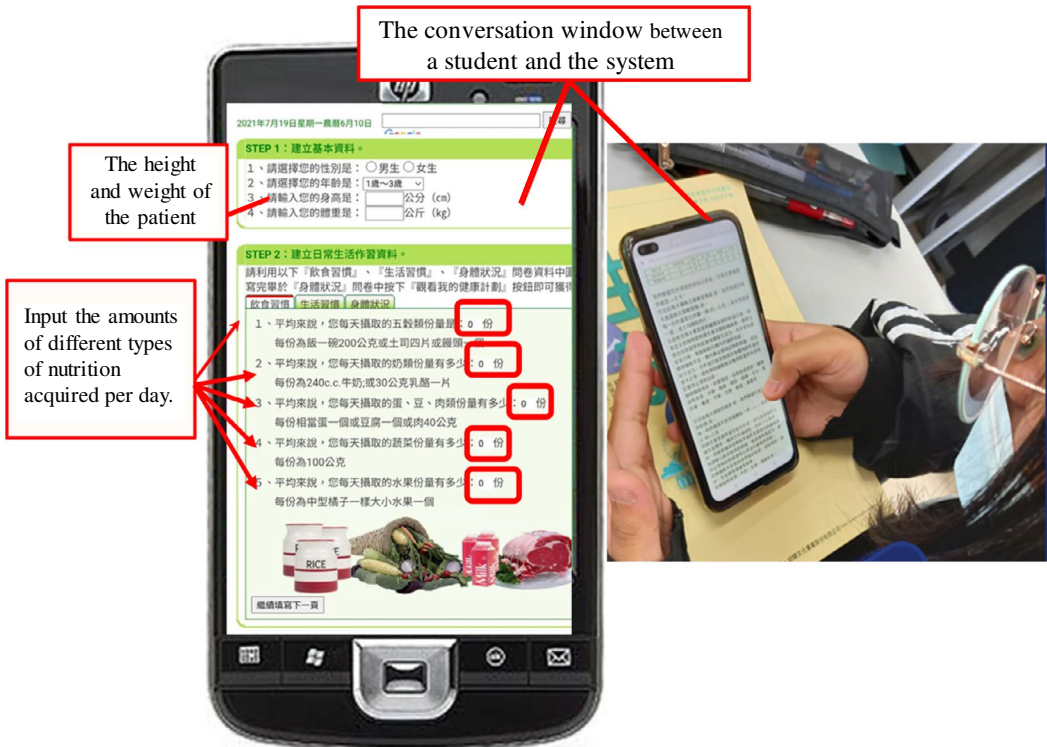


FIGURE 2 Students complete learning tasks through the use of the mobile application

slices of white toast with a poached egg and one slice of cheese for breakfast. Then, she eats half a bowl of white rice with one piece of braised pork ribs (about the size of a palm) and side dishes including one small serving of cabbage, one small serving of water spinach



FIGURE 3 Interface for interacting with the mobile application



FIGURE 4 Exercise with a worksheet via the mobile application

and one orange for lunch. Dinner then includes a bowl of dry noodles and preserved egg tofu. Supper includes a cup of milk with four spoons of milk powder soaked in 250 ml of drinking water’.

### Reflection stage

In the ‘Reflection’ stage, students are guided to seek advice from the mobile application by inputting the data of the case, as shown in Figure 3. The case to be dealt with is presented on the worksheet. Students are guided to input the gender, age, height and weight based on the patient’s information as well as the patient’s eating details and health details obtained from the worksheet. For the case presented in Figure 3, the system

recommends consuming three servings of five-grain rhizomes, one serving of milk, four servings of eggs, beans, fish or meat, three servings of vegetables, and three servings of fruit per day as well as the reasons for making the recommendations. The students can then compare their decisions with those provided by the mobile application and reflect on their decision-making process.

## Exercise stage

In the 'Exercise' stage, students are guided to make decisions on relevant situational cases provided by the teacher on a worksheet to practice making judgments, as shown in Figure 4. In this illustrative example, students are asked to provide dietary advice for several cases, including suggested amounts of whole grains, meat, fish and eggs, fruit and vegetables per day. The students need to provide their recommendations via the mobile application. The system then evaluates their answers and gives immediate feedback.

## QUASI-EXPERIMENTAL DESIGN

### Participants

The participants were two classes of undergraduate students taking a nutritional assessment course at a nursing school in Taiwan. The course is a compulsory basic nursing course in schools and hospitals and is a necessary part of nursing training. One of the classes with 37 students was assigned to be the experimental group using the MDRE approach, while the other class with 37 students was the control group learning with the CTL approach. Both classes were taught by the same instructor who had more than 10 years' experience of teaching nutritional assessment and nursing courses. The average age of the students was 21 years old. Pre- and posttest experiments were designed to compare the two groups of students' learning achievement, critical thinking and learning satisfaction.

### Learning content

In the present study, the adopted learning content was the nutritional assessment program of a university. Educators have indicated that, in learning nutritional assessment, in addition to the content from textbooks, it is also important to acquire the up-to-date information announced by the health or medical institutes from around the globe (Rabito et al., 2017). The American Dietetic Association outlines the nutrition care process, including nutrition assessment, diagnosis, intervention, monitoring and evaluation (Hanninen & Rashid, 2019; Swan et al., 2019). Students need to learn how to correctly apply nutritional assessment, diagnosis, and intervention methods, which is important for providing effective nutritional monitoring and evaluation suggestions to individual patients, before starting clinical practice in hospitals. Nowadays, owing to the Internet, innovative nutritional evaluation tools, automated diet records, and online diet evaluation tools are available via using mobile applications. This not only improves accuracy, but also reduces dietary data collection and processing costs (Eldridge et al., 2019). Classifying diet measurement technology helps users understand the information on diet replacement, improvement, or supplementation. In recent years, articles have been published on the selecting and reporting of technology applications related to dietary assessment. For example, scholars use smartphone food records and supporting information to improve the dietary behavior of young people



**TABLE 1** Illustrative example of categories of food (Taiwan food exchange lists)

Category	Protein (gm)	Fat (gm)	Carbohydrate (gm)	Calorie (kcal)
Dairy products				
Full fat	8	8	12	150
Low fat	8	4	12	120
Degreased	8	+	12	80
Beans, fish, eggs and meat				
Full fat	7	3	+	55
Low fat	7	5	+	75
Degreased	7	10	+	120
Grains and starchy vegetables				
Vegetables	1		5	25
Fruits	+		15	60
Fats, oil, nut and seeds		5		45

*Note:* +, indicates trace amounts.

(Kerr et al., 2016). In the nutritional assessment program of the present study, the categories of food as well as the corresponding nutritional information are listed in Table 1, showing the six major nutrients required by the human body, that is, carbohydrates, protein, fat, minerals, vitamins and water. This implies three main sources of energy: carbohydrates, fats and protein. Carbohydrates are the main source, providing four calories per gram; fat provides nine calories per gram and protein provides four calories per gram. The calories are calculated by multiplying the number of grams by the calories per gram. According to this table, if a full fat dairy product contains 8 g of protein, 8 g of fat and 12 g of carbohydrate, the calorie count is, therefore,  $8 \times 4 + 8 \times 9 + 12 \times 4 = 152$ , so one glass of full fat dairy product is around 150 calories.

## Experimental procedure

This quasi-experiment was conducted over a period of 4 weeks (two sessions with a total of 100 min each week), as shown in Figure 5. In the first week, the students received the pretest and pre-questionnaires after learning the basic knowledge of the course unit. In the second and third weeks, the lecturer first introduced the nutritional assessment course and explained the activity and case study instructions. Students were asked to provide nutritional assessments and suggestions based on each case, then took the pretest and critical thinking pre-questionnaire to understand the students' relevant prior knowledge and feelings. During this learning stage, the experimental group learned with the MDRE approach for the nutrition assessment course. Conversely, the control group learned through the CTL approach; that is, teachers used the Daily Diet Guide and PPT (PowerPoint) to explain the content and cases. The content learned by the two groups of students was the same. The worksheet included information about whole grains, beans, fish, eggs, meat, dairy products, vegetables, fruit, oils, nuts and seeds and to practice nutritional evaluation skills for providing dietary suggestions. During the practice and discussion stage, both groups of students could then ask and discuss any nutritional assessment questions with teachers or classmates. This enabled peers to practice with each other according to the worksheet.

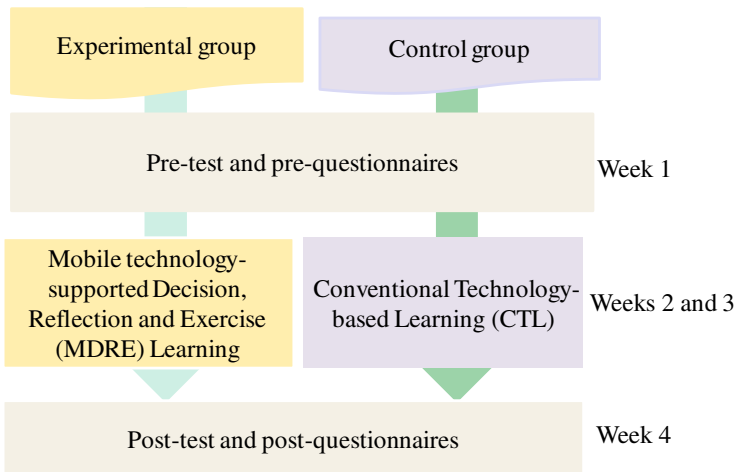


FIGURE 5 Procedure of the quasi-experiment design

After the class activities, the students completed the posttest and critical thinking questionnaire.

## Measuring tools

The pretest and posttest were designed by two experts with more than 10 years' experience of teaching the course as well as assessing students' learning performance in the course. The pretest aimed to assess the learners' basic knowledge of learning the course unit, while the posttest aimed to evaluate their learning achievement related to the use of the acquired knowledge to make correct judgments. For example, one of the posttest items is 'Consider a case that a male is losing weight with a balanced diet by controlling calories due to obesity. His lunch is limited to 550 calories. Which of the following food combinations is most suitable for him? (A) 2 medium-sized cabbage fried buns + 1 tea egg + 1 plantain. (B) 1 cup of low-fat fresh milk + 2 thick slices of toast + 1 poached egg + 1 slice of ham. (C) 1 bowl full of five-grain rice + 1 roasted chicken leg (2.5 taels of meat) + half a bowl of fried greens + cold cucumber 1 small plate (about 100 g) + 1 orange. (D) Convenience store tuna and rice balls 1 + lettuce salad 1 box'. Both tests consisted of 25 multiple-choice questions with a perfect score of 100. The KR20 of the pretest and posttest were 0.72 and 0.75 respectively.

The critical thinking measure was developed by Hwang and Chen (2017), and the learning satisfaction questionnaire was developed by Yien et al. (2011). Each measure consisted of five items and used a 5-point Likert rating scale. The Cronbach's  $\alpha$  coefficient values for the critical thinking and learning satisfaction questionnaires were 0.83 and 0.82 respectively.

## EXPERIMENTAL RESULTS

The collected data were analyzed by referring to the literature of educational statistics (Abbott, 2011; Ley & Verdebout, 2018; Ravid, 2011). Accordingly, analysis of covariance (ANCOVA) was adopted to compare the posttest scores of the two groups by excluding the impacts of the differences between their pretest scores.

## Learning achievement

This study used the prelearning test as the covariate for analysis and the postlearning test as the dependent variable. The Levene's test revealed that the homogeneity assumption was confirmed for learning achievement  $F(1, 70) = 0.04$  ( $p > 0.05$ ). In addition, after verifying that learning achievement scores  $F(1, 72) = 8.75$  ( $p > 0.05$ ) complied with the assumption of regression homogeneity, we used ANCOVA for post-hoc analysis of the scores of the two groups. Here, we used a visit method for ANCOVA analysis. As shown in Table 2, the learning achievement  $F(1, 71) = 22.87$  (95% confidence interval 17.86 to 32.51;  $p < 0.001$ ) results suggested that the intervention was effective. Students using the MDRE learning approach had better learning achievement results (mean = 88.66; SD = 10.84) compared with students learning with the CTL approach (mean = 63.47; SD = 19.55). For learning achievement, the experimental and control groups' adjusted averages were 85.81 and 66.32 respectively. This means that the MDRE learning approach can more effectively improve learning achievement compared with the CTL approach. In addition, the correlation coefficients for learning achievement ( $\eta^2 = 0.244$ ) were greater than 0.138, implying that the MDRE learning approach had a great influence on student achievement.

## Critical thinking

This study used the prelearning test as the covariate for analysis and the postlearning test as the dependent variable. The Levene's test revealed that the homogeneity assumption was confirmed for critical thinking  $F(1, 70) = 3.75$  ( $p > 0.05$ ). In addition, after verifying that critical thinking ratings  $F(1, 72) = 8.79$  ( $p > 0.05$ ) complied with the assumption of regression homogeneity, we used ANCOVA for post-hoc analysis of the scores of the two groups. Here, we used a visit method for ANCOVA analysis. As shown in Table 3, the critical thinking  $F(1, 71) = 44.57$  (95% confidence interval 0.87 to 1.38;  $p < 0.001$ ) results suggest that the intervention was effective. Students using the MDRE approach had better critical thinking results (mean = 4.56; SD = 0.52) compared to students learning with the CTL approach (mean = 3.43; SD = 0.58). For critical thinking, the experimental and control groups' adjusted averages were 4.41 and 3.58 respectively. This means that the

TABLE 2 Participant learning result of learning achievement

Variance	Group	N	Mean	SD	Adjusted mean	Std. error.	F	$\eta^2$
Learning achievement	Experimental group	37	88.66	10.84	85.81	2.69	22.87***	0.244
	Control group	37	63.47	19.55	66.32	2.69		

\*\*\* $p < 0.001$ .

TABLE 3 Participants' critical thinking learning result

Variance	Group	N	Mean	SD	Adjusted mean	Std. error.	F	$\eta^2$
Critical thinking	Experimental group	37	4.56	0.52	4.41	0.08	44.57***	0.386
	Control group	37	3.43	0.58	3.58	0.08		

\*\*\* $p < 0.001$ .

TABLE 4 Results of learning satisfaction for the MDRE learning approach

Variable	Groups	N	Mean	SD	t	d
Learning satisfaction	Experimental group	37	4.70	0.48	3.97*	0.82
	Control group	37	4.25	0.60		

\* $p < 0.05$ .

MDRE approach can more effectively improve critical thinking compared to the CTL approach. In addition, the correlation coefficients for critical thinking ( $\eta^2 = 0.386$ ) were both greater than 0.138, implying that the MDRE learning approach had a great influence on students' critical thinking.

## Learning satisfaction

Table 4 shows the *t*-test result for the MDRE learning approach ratings of the two groups' learning satisfaction. The means and standard deviations of the ratings were 4.70 and 0.48 for the experimental group and 4.25 and 0.60 for the control group. The ratings of the two groups were significantly different, with  $t = 3.97$  (95% confidence interval 0.22 to 0.68;  $p < 0.05$ ). There was a significant difference between the two groups with  $d = 0.82$ . This implies that there was a more positive effect on the learning satisfaction of the participants in the experimental group than on those in the control group.

## DISCUSSION

In this study, an MDRE model was proposed. Moreover, a quasi-experiment was conducted in a university to compare the learning performances of the students learning with the MDRE approach and those learning with the CTL approach.

### Research question (1)—Learning achievement

In terms of learning achievements, it was found that the students learning with the MDRE approach showed significantly higher test scores than those learning with the CTR approach. This could be due to the fact that the MDRE-based learning contexts not only enabled the students to connect their prior knowledge to the problems they were facing but also guided them to make reflections before conducting exercises or practice. As indicated by several scholars (Chmiel et al., 2017; Hwang & Chen, 2017), engaging students in facing practical problems could promote the effectiveness of their performance as well as reflective thinking. This implies that guiding students to attempt to make decisions before getting feedback could facilitate their reflective thinking, and hence improve their learning performance. The finding also echoes the research of Abubakar et al. (2019), who emphasized the need to design activities to engage students in practicing and reflecting as well as the constructivism and connectivism theories. Several scholars have also emphasized that harnessing technology enables learners to access up-to-date knowledge beyond the walls of the classroom, and hence makes Vygotsky's ZPD concept more flexible (Mattar, 2018; Siemens & Conole, 2011).

## Research question (2)—Critical thinking

From the experiment results, it was found that the experimental group students had significantly better critical thinking than the control group. In the MDRE approach, the students were guided to make decisions and then conduct self-assessments by acquiring up-to-date knowledge from the mobile application. That is, the MDRE facilitated the students' judgements and seeking of up-to-date information to verify the judgements they made. During this learning process, they were able to face the practical tasks in a deep thinking manner and to see the tasks from diverse perspectives, which could facilitate their critical thinking, as indicated by several scholars (Porter et al., 2020; Yien et al., 2011). As illuminated by Chang et al. (2020), situating students in decision-making contexts could generally encourage them to think critically as well as facilitating their learning engagement. Goksu (2016) also reported similar findings in a study using a knowledge-based system to support eighth-grade students to make judgments; they found that engaging students to compare their own decisions with those provided by the teacher enhanced their critical thinking and thus promoted their learning performance. Therefore, it is inferred that the effects of the MDRE on students' critical thinking is due to the process of guiding them to make decisions and acquiring up-to-date knowledge from the provided mobile application form making comparisons and reflections before conducting further practice.

## Research question (3)—Learning satisfaction

Moreover, it was found that the students in both the experimental and control groups showed high learning satisfaction with the learning activities with average ratings of 4.7 and 4.25 respectively. This implies that the instructor's teaching ability was highly recognized by the students. Furthermore, the students in the MDRE group had significantly higher learning satisfaction than those in the CTR group. This indicates that the students were generally in favour of the guidance provided by the MDRE approach, which allowed them to make decisions and acquire up-to-date knowledge on their own before practicing rather than watching the instructor's demonstration. This finding provides further evidence of Li's (2018) point that guiding students to learn via using mobile applications with proper learning strategies could improve their learning satisfaction as well as promoting their learning performances. Several scholars have also indicated that, with proper guidance and supports, students generally had a positive perspective on learning to solve problems on their own rather than following a specified list of operations to complete learning tasks (Al Mamun et al., 2020; Thongkoo et al., 2019; Zheng et al., 2018). This also echoes the theory of self-directed learning, which emphasizes the importance of allowing learners to make decisions or plans on their own, as indicated by several researchers (Shin et al., 2017; Yeoh et al., 2017; Zhoc et al., 2018).

## LIMITATIONS AND SUGGESTIONS

On the other hand, there are some limitations of the present study. First, the experimental time was not long, and hence it might be improper to infer that the same findings would be obtained for a long-term activity. Second, the quasi-experiment was conducted in a nursing training course, and hence some modifications (eg, adopting different mobile applications) could be needed to extend the findings to other professional training contexts. Third, the students' learning process was not recorded or analyzed; therefore, the discussion and conclusions were based on the quantitative data and the literature.

Based on these limitations, we recommend the following amendments for future studies:

1. Conducting long-term studies to further investigate the effects of the proposed approach on students' learning performances and perceptions.
2. Applying the approach to other professional training courses aiming to foster students' decision-making competences, such as other nursing courses or professional programs (eg, business courses).
3. Recording and analysing students' decision-making processes during the learning activities so that in-depth investigation and discussion can be conducted for providing valuable suggestions to teachers and researchers.

## CONCLUSIONS

To sum up, the contribution of the present study is to propose the MDRE learning approach and examine the effectiveness of guiding students to make decisions, acquire up-to-date knowledge via mobile applications and make reflections before doing exercises in professional training programs. By associating the statements in the literature review and the discussion, it was found that the MDRE approach can be fully supported by the literature and several educational theories. More importantly, the barriers to implementing the MDRE approach in professional training are low, and hence the findings of the present study could be a good reference for those who intend to conduct research and instruction in professional training programs in the future. In particular, in the time after the pandemic, the findings could be a good reference for helping students learn how to keep track of the pandemic and make suitable decisions to protect themselves and their families. As suggested by several scholars, educating students to learn up-to-date knowledge is very important in the pandemic and post-pandemic eras (Erduran, 2020; Murphy, 2020).

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## CONFLICT OF INTEREST

There is no potential conflict of interest in this study.

## ETHICS STATEMENT

The participants were protected by hiding their personal information during the research process. They knew that their participation was voluntary and that they could withdraw from the study at any time.

## DATA AVAILABILITY STATEMENT

The data can be obtained by sending a request e-mail to the corresponding author.

## ORCID

Gwo-Jen Hwang  <https://orcid.org/0000-0001-5155-276X>

Chin-Lan Yang  <https://orcid.org/0000-0002-3554-1697>

Kuei-Ru Chou  <https://orcid.org/0000-0002-4882-3503>

Ching-Yi Chang  <https://orcid.org/0000-0002-3146-2270>

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