Facilitating Students' Critical Thinking and Decision Making Performances: A Flipped Classroom for Neonatal Health Care Training

Ching-Yi Chang[1], Chien-Huei Kao[1] and Gwo-Jen Hwang[2*]

[1]Department of Midwifery and Women Health Care, National Taipei University of Nursing and Health Sciences, Taiwan // [2]Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan // frinng.cyc@gmail.com // chenhuei@ntunhs.edu.tw // gjhwang.academic@gmail.com

[*]Corresponding author

(Submitted April 5, 2020; Revised May 15, 2020; Accepted June 16, 2020)

ABSTRACT: In various case-based training courses, such as engineering, science and medical courses, students need to learn not only the skills to deal with problems, but also the knowledge to identify problems and make correct decisions. Such educational objectives have been recognized by educators as being important but challenging. In this study, an RSI (Recognize, Summarize, Inquire)-based flipped classroom is proposed to achieve this aim. Moreover, an explorative study was designed to probe the effectiveness of the proposed approach in a nursing case-based training course. The case-handling performances of the students trained with the RSI-based flipped classroom and those trained with the conventional flipped classroom were compared. The findings reveal that the RSI-based flipped classroom promoted the students' learning achievement, self-efficacy, critical thinking, and satisfaction more than the conventional case-based training did.

Keywords: Flipped classroom, Flipped learning, RSI, Critical thinking, Decision making

1. Introduction

In training courses aiming to foster students' competences of handling cases, such as engineering, science and medical courses, students need to learn not only the skills to deal with problems, but also the knowledge to identify problems and make correct decisions. A classical application of such courses is the training of nursing skills. For example, in the program of newborn health care, neonatal assessment is an important skill to ensure that nursing staff can provide proper treatments during the delivery of newborns (Fuloria & Kreiter, 2002; Heymann, 1993). In physical examination assessment, neonatal assessment can reduce potential disease of neonatal and enable early detection of neurological or developmental problems. It is used as the standard for first-line medical staff to assess whether a newborn needs follow-up intensive care or follow-up assessment (Sullivan, Miller, Fontaine, & Lester, 2012). It also involves evaluating Apgar scores, basic vital signs, the nervous system and fetal developmental maturity. Each step needs to be monitored to determine whether there are abnormal signs (Fuloria & Kreiter, 2002; Georgieff, 1995). When assessing the musculoskeletal and nervous system functions of newborns, medical staff must have sufficient expertise and skills to judge and deal with the changes in newborns' physical signs (Alexander & Kuo, 1997; Brodish, 1981). Therefore, improving medical staff's assessment ability is particularly important to help maintain the safety of newborns (Rüdiger & Aguar, 2012).

In the traditional neonatal assessment training course, simulation aids are used to give students opportunities to practice assessment skills (Kola & Bijapur, 2019; Solà-Pola et al., 2020; Yigzaw et al., 2019). Researchers have indicated that the difficulties and challenges in traditional neonatal assessment are mainly due to the insufficient time for teachers to explain the signs of rare diseases as well as to guide students to practice neonatal assessments (Blake, 2012; Tappero & Honeyfield, 2018). Although some scholars have applied flipped classrooms in nursing education by shifting the lectures to the pre-class time to enable teachers to have more time to guide students to practice in the class, it still remains a challenge to foster students' decision-making competence (Chang, Chang, Hwang, & Kuo, 2019). Scholars believe that one of the problems is the lack of effective learning guidance strategies to facilitate students' deep thinking in learning with the instructional videos in the before-class learning stage (Chang, Kao, Hwang, & Lin, 2019; Kirch, 2016). Abeysekera and Dawson (2015) further pointed out that the degree of students' involvement in pre-class learning has a great impact on their performance in the class. Thus, this study proposes a flipped classroom learning approach based on RSI.

To verify the usefulness of the RSI approach, this study implemented this model on an e-learning platform and conducted an experiment in a nursing school neonatal health care training course.

2. Literature review

2.1. Flipped classrooms

The flipped classroom is a blended learning mode in which students generally learn with instructional materials in an individual space before the class, so that teachers can guide them to practice, discuss, or apply knowledge in the group space (Bergmann & Sams, 2012; Bhagat, Chang, & Chang, 2016; Lo, Lie, & Hew, 2018). Scholars have reported that the flipped classroom enables teachers to schedule more time to engage students in applying knowledge, which can promote their high-order thinking and communication competences owing to more interactions with teachers and peers for sharing knowledge and ideas (Chang, Chang, Hwang, & Kuo, 2019; Hwang & Lai, 2017). In recent years, the popularization of mobile systems with wireless networks has facilitated students' reading of the instructional materials in the pre-class stage, as well as assisting teachers in conducting in-class activities to promote interactions and knowledge sharing among students (Hsia & Sung, 2020). In addition, scholars have incorporated a large number of learning strategies or tools into flipped classrooms to improve students' learning achievements (Awidi & Paynter, 2019; Chang, Chang, Hwang, & Kuo, 2019). Several scholars have confirmed the effectiveness of flipped classrooms from various perspectives, such as allowing students to learn in an interactive and autonomous manner (Liou, Bhagat, & Chang, 2016; McLaughlin & Rhoney, 2015; Mirriahi, Alonzo, McIntyre, Kligyte, & Fox, 2015; Miles, Lee, Foggett, & Nair, 2017), improving students' learning performances (Dehghanzadeh & Jafaraghaee, 2018; Hwang, Lai, & Wang, 2015; Peterson, 2016; Wang, 2017), and promoting their self-efficacy (Tawfik & Lilly, 2015).

In the past decade, flipped classrooms have gradually been adopted in medical and nursing education with promising outcomes (Critz & Knight, 2013), such as improving students' learning achievements and learning smartification in emergency training courses for newborns (Rose, Claudius, Tabatabai, Kearl, Behar, & Jhun, 2016), promoting a sense of responsibility and problem-solving skills in a psychiatric nursing practicum course (Lee, Chang, & Jang, 2017), and improving critical thinking in a musculoskeletal medical-surgical nursing theoretical training course (Dehghanzadeh & Jafaraghaee, 2018). In addition, researchers have stated the potential of flipped classrooms in promoting learners' higher order thinking (Alsowat, 2016; Hussein et al., 2019). For example, Lee (2018) reported that students had better critical thinking performance in flipped scientific reading activities than those in traditional classrooms; Ding, Li, and Chen (2019) reported that flipped classrooms could promote students' critical thinking by employing a proper learning design in an ophthalmology course. Lin (2019) conducted an experiment in a software engineering course and indicated that the provision of proper supports in flipped classrooms could facilitate their problem-solving performance.

Despite a number of successful examples, scholars have pointed out several issues to be addressed when implementing flipped classrooms. For example, students tend to watch instructional videos without deep thinking in the pre-class stage, which is likely to lead to shallow discussion or poor performance in class (Lei, Yau, Lui, Tam, Yuen, & Lam, 2019; Luo, Kushnazarov, & Hew, 2019; Parsons & Beauchamp, 2012). Basal (2015) pointed out that, to implement a successful flipped classroom, it is necessary to adopt appropriate strategies to facilitate students' deep thinking when learning with the instructional videos in the pre-class stage. This is particularly crucial in case-based training courses, which not only aim to have learners memorize and comprehend the learning content, but also fosters their competences of making decisions and solving problems (Danielson & Berntsson, 2007; Phillips, 2000). Therefore, incorporating effective strategies into the individual space of flipped classrooms to improve students' learning performance and higher order thinking is a crucial issue (Kirch, 2016; Shannon, 2008; Yilmaz & Baydas, 2017). Several scholars have also reported similar concerns in flipped classrooms (Lin & Hsia, 2019; Lin, Hwang, & Hsu, 2019; Zhang, Fan, Xia, Guo, Jiang, & Yan, 2017).

2.2. Strategies and pedagogical theories of flipped classrooms

The literature has shown the importance of the pre-class stage in flipped classrooms. Several researchers have indicated that students' pre-class learning status could affect their in-class learning outcomes, including the learning tasks related to problem solving and critical thinking (Huong, Huy, & Ha, 2018; Li, 2019). Kirch (2012) further emphasized the need to guide students to learn in the pre-class stage, including guiding them to take notes, summarizing the learning content and raising questions. Several flipped classroom studies have also focused on improving students' pre-class performances in different courses, such as nursing skills training (Lin, Hwang, & Hsu, 2019; Mudd & Silbert-Flagg, 2016; Zhu, Lian, & Engström, 2020).

On the other hand, scholars have stated the need to further guide students to think in depth and to make reflections in addition to taking notes, summarizing learning content and raising questions (Lin & Hsia, 2019). From the perspective of identifying and solving problems, such as case handling in nursing education, it is important to guide students to have in-depth thinking and make reflections, so that they can correctly make clinical judgments as well as mastering clinical skills (Asselin, Schwartz-Barcott, & Osterman, 2013; Hicks-Moore & Pastirik, 2006). By referring to the experiential learning theory by Kolb (1976), it is important to facilitate students' learning through concrete experience, reflective observation, abstract conceptualization and active experimentation. In nursing training courses, those case studies generally provide a form of concrete experience to learners, while taking notes, answering questions and completing learning sheets could be treated as a form of abstract conceptualization. This indicates that additional guidance is needed to help learners reflect and explore based on what they have learned.

Thus, the study emphasized the significance of guiding students to think in-depth in a step-by-step manner when learning with instructional videos in the pre-class stage through recognizing key concepts (i.e., "Recognize"), organizing what they have learned (i.e., "Summary"), thinking in depth to inquire about the potential problems (i.e., "Inquire"). To verify the usefulness of the RSI-based flipped classroom approach, an experiment was conducted in a neonatal health care training course to answer the following research questions:

- Can the RSI-based flipped approach better improve the nursing students' learning achievement in neonatal assessment than the conventional flipped approach?
- Can the RSI-based flipped approach better improve the nursing students' self-efficacy in neonatal assessment than the conventional flipped approach?
- Can the RSI-based flipped approach better enhance the nursing students' critical thinking in neonatal assessment than the conventional flipped approach?
- Can the RSI-based flipped approach better enhance the nursing students' problem solving ability in neonatal assessment than the conventional flipped approach?
- Can the RSI-based flipped approach better enhance the nursing students' learning satisfaction in neonatal assessment than the conventional flipped approach?

3. Developing the RSI-based flipped learning environment

3.1. System structure

The RSI-based flipped learning environment was implemented on the Tronclass platform. Figure 1 shows the system structure. The teacher interface enables teachers to maintain student profiles or learning portfolios, edit test items, and design instructional videos and learning sheets. Students can use smartphones or tablets to view the learning materials and learning sheets, take notes, and complete learning tasks.

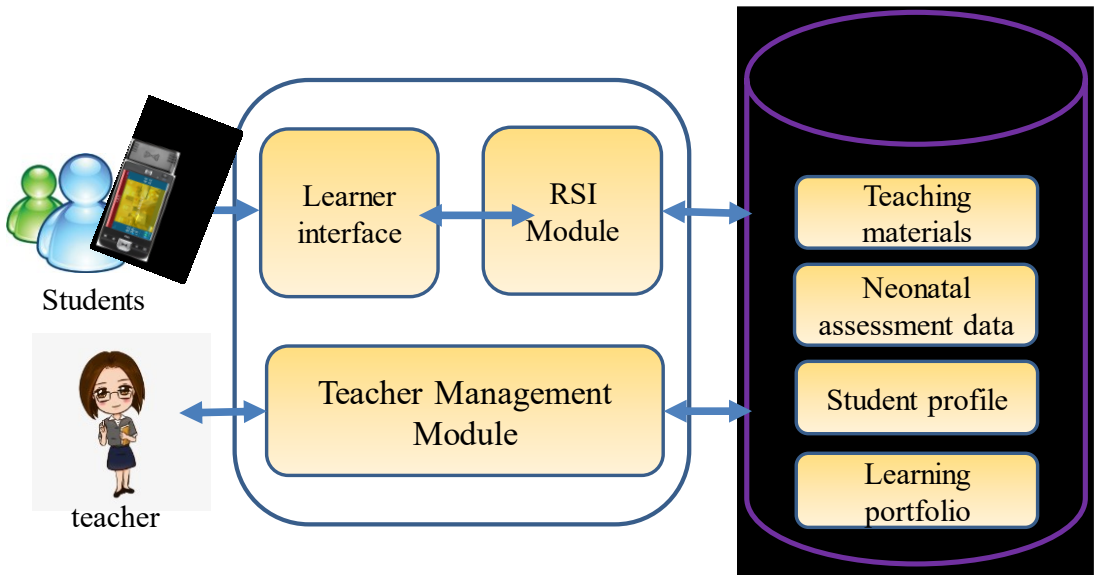

Figure 1. System structure

Figure 2. Interface for browsing the neonatal assessment instructional videos

Figure 3. Interface for annotating and summarizing the learning content

Students can use smartphones to access the learning system to watch the instructional videos and complete the learning tasks. The RSI-based learning mode consists of three stages. In the first stage, students recognize the key problems and take notes by watching instructional videos. Figure 2 shows the learner interface for a nursing training program: the instructional videos of neonatal assessment.

In the second stage, students are guided to summarize what they have learned and identified, as presented in Figure 3.

In the third stage, students are guided to inquire based on what they have summarized and identified. In this stage, they are encouraged to make reflections on the learning process, think diversely, and find potential problems regarding what they have learned. Figure 4 shows the interface of guiding students to reflect, think, and raise questions.

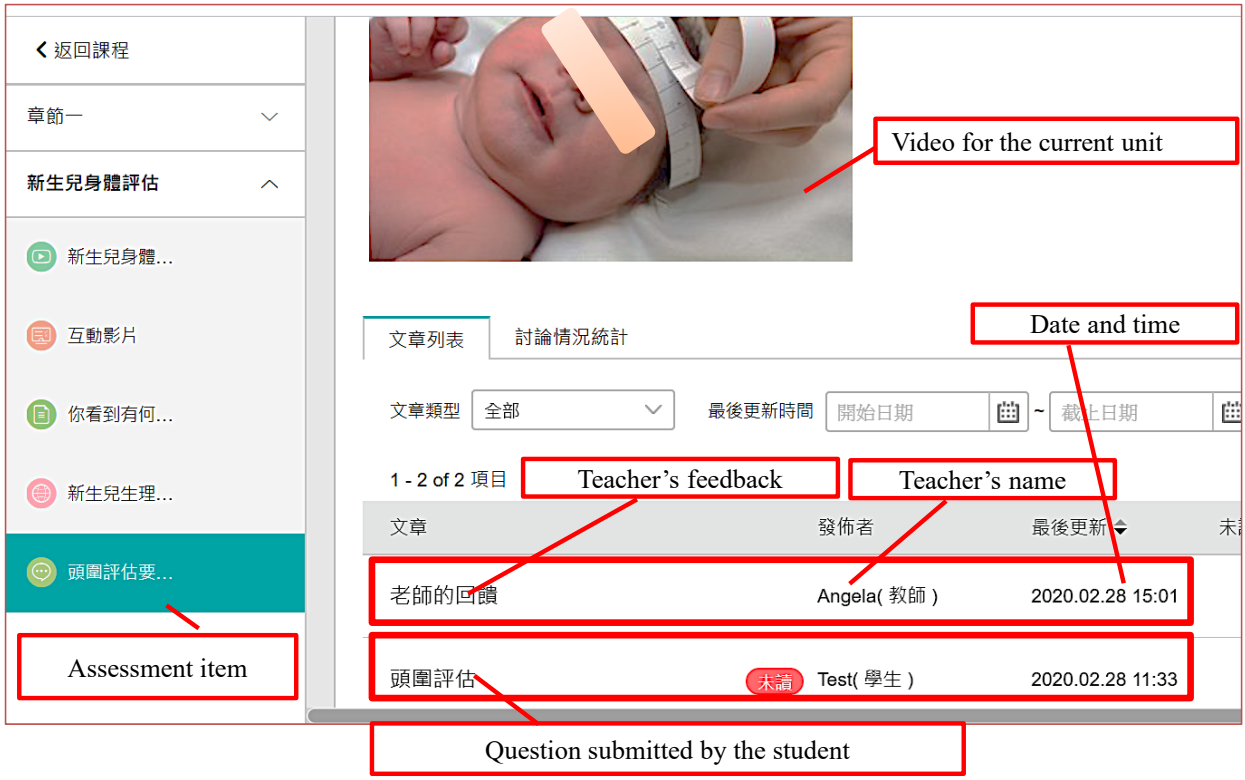

Figure 4. Interface for guiding students to reflect, think and question

4. Method

The experiment was conducted at a teaching hospital in Taiwan for a neonatal assessment training program.

4.1. Subjects

The subjects were 36 nursing students from two classes of a nursing university in northern Taiwan. Their average age was 21. One class with 18 students was chosen as the experimental group learning with the RSI-based flipped classroom. Another class with 18 students was the control group learning with the conventional flipped approach. The two classes received the same learning content and were instructed by the same teacher.

4.2. Experimental design

The schedule of the experiment is shown in Figure 5. Before the activity, the two groups were administered a pre-test and pre-questionnaires. During the experiment, the two groups learned through the online instructional videos in the pre-class time. In this stage, the experimental group learned with the RSI-based flipped approach via the online learning system to complete the learning task. That is, in the pre-class stage, the students were guided by the RSI procedure to recognize the key concepts in the instructional videos, summarize what they had learned, propose questions, and inquire by in-depth thinking or seeking evidence. On the other hand, the control group learned with the conventional flipped classroom. In the conventional mode, the students were asked to watch videos and take notes, do some exercises, and complete a learning sheet prepared by the teacher by answering a set of questions based on what they had learned from the learning content. After the activity, the students were administered a post-test and post-questionnaires.

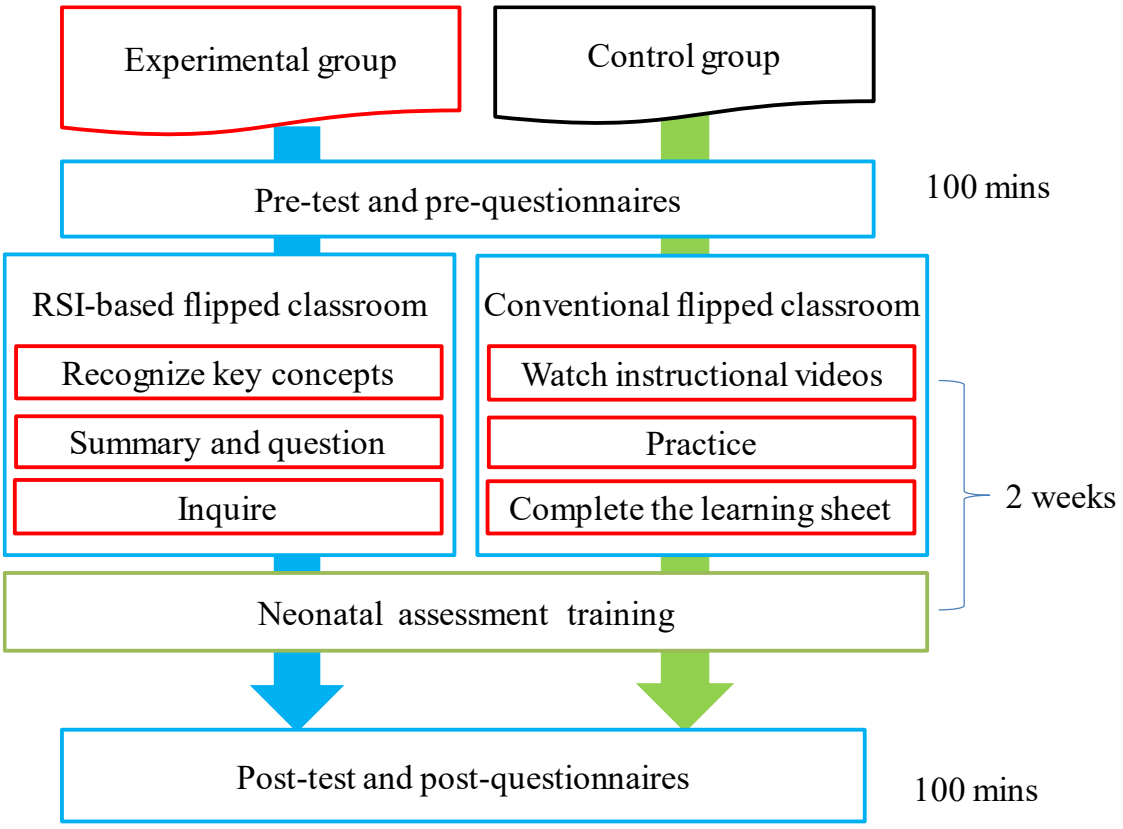

Figure 5. Procedure of the experimental design

In the class, the students were guided by the teacher to make decisions on several medical cases as well as practice relevant nursing skills. An example is shown in Figure 6, in which the students were asked to deal with a newborn case and to verbally explain the assessment information, such as swallowing reflex, gag reflex, rooting reflex, sucking reflex, Moro reflex, startle reflex, tonic neck reflex, Babinski's reflex, grasping reflex, stepping reflex, and crawling reflex.

Figure 6. In-class learning activity: students practice the nursing skills and make decisions during the OSCE process

4.3. Measuring tools

The pre-test was designed by two nursing teachers who had taught the course for more than 12 years. It was composed of 20 multiple-choice questions for evaluating learners' knowledge of clinical neonatal assessment. The perfect score was 100.

Table 1. Rubrics for the neonatal assessment skills test

Dimension	Items to observe
Vital Signs	heart rate, PR, BT
Distress	Facial expression, respiratory effort, activity, tone
Color	Tongue, mucous membranes (centrally pink vs. cyanotic), nail beds
Nutrition status	Subcutaneous fat, breast nodule
Hydration status	Skin turgor, anterior fontanel
Gestational age	Skin (smooth vs. peeling), ear cartilage, areola and nipple formation, breast nodule, sole creases, descent of tests, rugage, labia
Neurologic status	Posture, tone, activity, response to stimuli, cry, state, nipples (number and position), skin color
Respiratory/chest status	Respiratory rate and effort, retractions, nasal flaring, grunting, audible stridor or wheezing, chest shape, nipples (number and position), skin color
Cardiovascular status	Precordial activity, visible point of maximal intensity, skin perfusion and color
Abdomen	Size (full, distended, taut, shiny), shape (round, concave), distention (generalized or localized), visible peristaltic waves, visible bowel loops, muscular development/tone
Head	Size, shape, fontanels, suture lines, swelling, hair distribution, condition of hair
Eyes	shape, size, position, pupils, blink, extraocular movements, color of sclera, discharge, ability to fix and follow
Ears	shape, position, external auditory canal, response to sound
Nose	shape, nares, flaring, nasal bridge
Mouth	shape, symmetry, movement, philtrum, tongue
Neck	shape, range of motion, webbing, masses
Genitalia (male)	Scrotum, descent of testes, rugae, inguinal canals, foreskin, penile size, urine stream, meatus, perineum, anus
Genitalia (female)	Labia majora, labia minora, clitoris, vagina, perineum, inguinal canals, anus
skin	Color, texture, firmness, vernix caseosa, masses, lanugo, lesions (pigmentary, vascular, trauma-related, infectious)
Extremities	Posture, range of motion

The Rubrics for neonatal assessment skills tests originate from the physical assessment of neonatal postnatal performance proposed by Tappero and Honeyfield (2018). It consists of 20 dimensions, as shown in Table 1. Each dimension is scored with a 3-point rating scheme for evaluating learners' OSCE skills: 3 means completely meeting the standard, 2 means partially meeting the standard, and 1 means that the operation is incorrectly performed. Two experienced teachers were recruited to evaluate students' case-handling performances using the rubrics.

The self-learning efficacy scale was modified based on the scale developed by Pintrich et al. (1991). It consists of eight items, such as "I am confident that I can understand the most complex parts taught by teacher" and "I am confident that I can learn the key concepts taught by teachers." A 5-point Likert scoring scale was adopted in this measure, and the Cronbach's α value was .93.

The learning satisfaction scale was proposed by Chu et al. (2010). It is composed of nine items, such as "Using this way to learn, I can make some new discoveries or new knowledge" and "Using this way can help me learn to distinguish things." A 5-point Likert scoring scale was adopted in the measure. Its Cronbach's α value was .91.

The problem-solving questionnaire was proposed by Hwang and Chen (2017). A total of five items are included, such as "When solving a problem, I try to identify the problem type first" and "Before solving a problem, I think I need to understand the cause of the problem." A 5-point Likert scoring scale was adopted and its Cronbach's α value was .78.

The critical thinking scale was proposed by Hwang and Chen (2017). It consists of five items, such as "I ask myself periodically if I am meeting my goals" and "I periodically review to help me understand important relationships." A 5-point Likert scoring scale was adopted and its Cronbach's α value was .83.

4.4. Data analysis

To analyze the neonatal assessment OSCE scores as well as their self-efficacy, critical thinking, problem-solving, and learning satisfaction of the students learning with different approaches (i.e., the RSI-based flipped classroom and conventional flipped classroom), ANCOVA (Analysis of Covariance) was adopted. The Shapiro-Wilk test results of the ratings for individual measures are between 0.88 and 0.90 ($p > .05$). This reveals that data for individual scales have a normal distribution.

5. Results

5.1. Neonatal assessment OSCE result

To evaluate the students' neonatal assessment skills, ANCOVA was utilized to compare the neonatal assessment skills test scores of the two groups. The neonatal assessment skills test was the dependent variable and the pre-test was the covariate. The Levene's test of variance showed that the homogeneity assumption was confirmed with $F(1, 34) = .66$ ($p > .05$). In addition, the homogeneity of regression slopes was $F(1, 32) = .59$ ($p > .05$). Therefore, the ANCOVA could be conducted.

The ANCOVA result is shown in Table 2. The adjusted means and *SD* values were 96.67 and 1.59 for the experimental group, and 83.81 and 1.59 for the control group. The post-test scores of the two groups were significantly different with $F(1, 33) = 25.31$ ($p < .001$). The experimental group had significantly higher scores than the control group. Furthermore, the effect size (η^2) of learning approach was .434, which indicated a 1arge to medium effect size.

Table 2. ANCOVA results on students' neonatal assessment OSCE

Groups	*N*	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	η^2
Experimental group	18	95.63	7.67	96.67	1.59	25.31^{***}	.434
Control group	18	82.78	5.75	83.81	1.59		

Note. $^{***}p < .001$.

5.2. Self-efficacy

ANCOVA was utilized to compare the self-efficacy survey of the two groups. The self-efficacy post-test was the dependent variable and the pre-test was the covariate. The Levene's test showed that the homogeneity assumption was confirmed with $F(1, 34) = .38$ ($p > .05$). In addition, the homogeneity of regression slopes was $F(1, 32) = 1.46$ ($p > .05$). Therefore, the ANCOVA could be conducted.

The ANCOVA result is shown in Table 3. The adjusted means and *SD* values were 3.83 and 0.11 for the experimental group, and 3.28 and 0.11 for the control group. The post-test scores of the two groups were significantly different with $F(1, 33) = 5.05$ ($p < .05$). The experimental group had significantly higher scores than the control group. Furthermore, the effect size (η^2) of learning approach was .133, which indicated a medium effect size.

Table 3. ANCOVA results on students' self-efficacy

Groups	*N*	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	η^2
Experimental group	18	3.68	.62	3.83	.11	5.05^{*}	.133
Control group	18	3.13	.34	3.28	.11		

Note. $^{*}p < .05$.

5.3. Critical thinking

To evaluate the students' critical thinking, ANCOVA was used to analyze the critical thinking survey of the two groups. The critical thinking post-test was the dependent variable and the pre-test was the covariate. The

Levene's test revealed that the homogeneity assumption was confirmed with $F(1, 34) = .47$ ($p > .05$). In addition, the homogeneity of regression slopes was $F(1, 32) = 3.74$ ($p > .05$). Therefore, ANCOVA could be conducted.

The analysis result is shown in Table 4. The adjusted means and *SD* values were 4.55 and 0.13 for the experimental group, and 2.74 and 0.13 for the control group. The post-test scores of the two groups were significantly different with $F(1, 33) = 62.45$ ($p < .001$). The experimental group had significantly higher scores than the control group. Furthermore, the effect size (η^2) was .753, revealing a large to medium effect size.

Table 4. ANCOVA Results on students' critical thinking

Groups	*N*	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	η^2
Experimental group	18	4.53	.50	4.55	.13	62.45^{***}	.753
Control group	18	2.75	.60	2.74	.13		

Note. $^{***}p < .001$.

5.4. Problem-solving

ANCOVA was used to analyze the problem-solving survey of the two groups. The problem-solving post-test was the dependent variable and the pre-test was the covariate. The Levene's test showed that the homogeneity assumption was confirmed with $F(1, 34) = .17$ ($p > .05$). In addition, the homogeneity of regression slopes was $F(1, 32) = 1.57$ ($p > .05$). Therefore, ANCOVA could be applied.

The ANCOVA result is shown in Table 5. The adjusted means and *SD* values were 4.49 and 0.13 for the experimental group, and 2.77 and 0.13 for the control group. The post-test scores of the two groups were significantly different with $F(1, 33) = 86.80$ ($p < .001$). The experimental group had significantly higher scores than the control group. Furthermore, the effect size (η^2) was .725, revealing a large to medium effect size.

Table 5. ANCOVA results on students' problem-solving ability

Groups	*N*	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	η^2
Experimental group	18	4.47	.50	4.49	.13	86.80^{***}	.725
Control group	18	2.77	.60	2.77	.13		

Note. $^{***}p < .001$.

5.5. Learning satisfaction

To evaluate the students' learning satisfaction, ANCOVA was employed. The learning satisfaction post-test was the dependent variable and the pre-test was the covariate. The Levene's test showed that the homogeneity assumption was confirmed with $F(1, 34) = .16$ ($p > .05$). In addition, the homogeneity of regression slopes was $F(1, 32) = 2.99$ ($p > .05$). Therefore, ANCOVA could be applied.

The ANCOVA result is shown in Table 6. The adjusted means and *SD* values were 4.60 and 0.14 for the experimental group, and 2.80 and 0.14 for the control group. The post-test scores of the two groups were significantly different with $F(1, 33) = 87.25$ ($p < .001$). The experimental group had significantly higher scores than the control group. Furthermore, the effect size (η^2) was .726, revealing a 1arge to medium effect size.

Table 6. ANCOVA results on students' learning satisfaction

Groups	*N*	Mean	*SD*	Adjusted mean	Adjusted *SD*	*F*	η^2
Experimental group	18	4.59	.49	4.60	.14	87.25^{***}	.726
Control group	18	2.81	.67	2.80	.14		

Note. $^{***}p < .001$.

6. Conclusions and implications

In this study, an RSI-based flipped approach was proposed and implemented in a case-handling nursing course, Neonatal Assessment. The findings in the experiment reveal that the proposed approach has great potential for

improving students' neonatal assessment performance, self-efficacy, critical thinking, problem-solving ability and learning satisfaction.

6.1. Research question 1: Can the RSI-based flipped approach better improve the nursing students' learning achievement in neonatal assessment than the conventional flipped approach?

In terms of learning performance, it is inferred that the RSI-based approach facilitated the subjects' in-depth thinking in the pre-class time of the flipped classroom, which can further affect their performance in the corresponding in-class stage. As indicated by several flipped learning studies, acquiring knowledge in an effective and in-depth manner is the foundation for better involving students in the follow-up activities in flipped classrooms (Helgevold & Moen, 2015; Post, Deal, & Hermanns, 2015).

From the perspective of constructivism, engaging students in raising rather than answering questions raised by the teachers after browsing and summarizing the learning content enables them to reexamine the content from different aspects and to attempt to connect the new knowledge with their prior knowledge or past experience (Chien, Chen, & Liao, 2019; Jong, Chen, Tam, & Chai, 2019). This reveals that RSI not only facilitated the students' in-depth thinking, but also their attempt to extend their learning scope and to reorganize what they had learned, and therefore it helped the students make correct decisions to complete their learning goals by gaining and organizing knowledge in an effective manner. The findings are in line with those reported by several past studies regarding the use of question-proposing strategies, such as Lin and Hsia (2019) and Lin, Hwang, and Hsu (2019).

6.2. Research question 2: Can the RSI-based flipped approach better improve the nursing students' self-efficacy in neonatal assessment than the conventional flipped approach?

The experimental results also show that the RSA-based approach promoted the students' self-efficacy, which refers to a person's belief that he/she can successfully complete certain tasks or achieve certain desired goals (Bandura, 1988). Using the RSI mechanism, the students were guided not only to watch the instructional videos, but also to organize and reexamine what they had learned. It is inferred that students' self-efficacy was promoted owing to the fact that they had the opportunity to know the whole picture regarding the learning content and to think in depth by exploring relevant information. This echoes the findings of Hsia and Hwang (2020), that is, effective teaching strategies stimulate students' potential and improve their self-efficacy.

6.3. Research question 3: Can the RSI-based flipped approach better enhance the nursing students' critical thinking in neonatal assessment than the conventional flipped approach?

In terms of high-order thinking, which has been indicated as a potential objective of flipped classrooms by several scholars (Chang, Chang, Hwang, & Kuo, 2019; Ha, O'Reilly, Ng, Zhang, & Serpa, 2019), it is deduced that the RSI-approach encouraged the students to think from diverse perspectives when they were guided to raise questions in the pre-class time. Several previous studies regarding question-proposing also reported that, when trying to raise questions, students generally search for more relevant information and try to view the learning content from different perspectives; moreover, they are more willing to discuss with peers regarding the learning topics to gain more opinions from different perspectives (He, Holton, & Farkas, 2018; Ziegelmeier & Topaz, 2015). This implies that the students not only viewed the learning content in diverse ways, but also had more opportunities to resolve cognitive conflicts, which could contribute to the result that their critical thinking was promoted.

6.4. Research question 4: Can the RSI-based flipped approach better enhance the nursing students' problem solving ability in neonatal assessment than the conventional flipped approach?

The experimental results show that the participants who learned with the mechanism of the RSI-based flipped approach outperformed those who learned via the conventional flipped approach in terms of problem solving. In the application of the present study, through the RSI procedure, students can evaluate new born babies' status, taking into account diverse perspectives, such as Vital Signs, Distress, Color, etc. This allows them to interpret and organize the information, raise questions and think in depth based on the whole picture they have. This

finding is consistent with the research of Lin, Hwang, and Hsu (2019); that is, through the provision of stepwise guidance in flipped classrooms, students' problem solving ability could be improved.

6.5. Research question 5: Can the RSI-based flipped approach better enhance the nursing students' learning satisfaction in neonatal assessment than the conventional flipped approach?

The learning satisfaction results show that the participants who learned with the mechanism of the RSI-based flipped approach outperformed those who learned via the normal flipped approach. This indicates that the integration of the RSI-based flipped approach strategy into neonatal assessment activities can effectively improve students' learning satisfaction. In the meantime, from the post-test results, it was found that the experimental groups showed significantly better learning satisfaction than the control group, implying that the challenges of the learning tasks and the increased complexity of the learning materials were at an appropriate level within the zone of proximal development proposed by Vygotsky (1978). This finding complies with what has been reported by Lin and Hsia (2019) and Lin, Hwang, and Hsu (2019) that step-by-step guiding can inspire students to learn as it also increases their deep learning in the meantime.

6.6. Limitations and suggestions

It should be noted however that there are some limitations in the present study. First, its results were mainly derived from quantitative analysis; to further investigate the factors affecting students' learning performances and perceptions, it would be better to conduct in-depth interviews in the future. Second, owing to the low birth rate in Taiwan in the past decades, the sample size was not large, implying the need to perceive the findings in a conservative manner. Third, the application of the present study is neonatal assessment, and hence the research results can only be applied to those nursing or medical training programs with similar aims and features.

From the findings and discussion in this study, several suggestions for future research are given as follows:

(1) Examining the impacts of personal factors when using the RSI-based flipped approach. The factors could be students' learning performance, personal characteristics or perceptions. By taking the factors into consideration, more precise suggestions can be provided to help teachers and researchers use the RSI approach in better ways.
(2) Probing the effectiveness of the RSI-based flipped classroom from different angles. It is recommended that researchers should combine the convenience of science and technology and focus on analyzing more key factors that affect students' learning effects, such as applied technology learning resources, the content of course activities, multimedia formats, etc.
(3) Providing instant feedback to individual studies during the case-handling process in training programs. It is suggested that researchers can consider implementing a more customized and convenient online learning system using artificial intelligence or other new technologies to support RSI-based flipped classrooms in a more effective way.
(4) Probing the factors affecting students' learning outcomes through the RSI-based flipped classroom approach. It would be valuable to find the factors that stimulate students to think more deeply, improve their critical thinking ability, and promote their high-level reflection performance in the pre-class stage to promote their decision-making performances in dealing with the training cases in the class.
(5) Applying the RSI-based flipped approach to other training programs aiming at fostering students' decision-making and problem-solving competences. Engineering courses and scientific inquiries as well as other nursing or medical courses could be potential applications.

In summary, learning design plays a crucial role in education research and learner-centered learning. In case-handling training courses, such as nursing skills training, the RSI-based flipped classroom learning could be promising for those courses aiming at training students' competences of dealing with cases. As a consequence, it could be crucial to apply the approach to other courses and collect more data to further evaluate its usefulness in the future. It is also crucial to probe whether using the RSI approaches in other learning modes, such as inquiry-based mobile learning or contextual learning will have similar results.

Acknowledgement

This study was funded by the Ministry of Science and Technology of Taiwan. The project ID was MOST-108-2511-H-011-005-MY3. It was also funded by the National Taipei University of Nursing and Health Sciences under contract number 109ntunhs-NT-05 and the 109 Teacher Growth Community Program Subsidy.

References

Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: Definition, rationale and a call for research. *Higher Education Research & Development*, *34*(1), 1-14.

Alexander, M., & Kuo, K. N. (1997). Musculoskeletal assessment of the newborn. *Orthopedic nursing*, *16*(1), 21-31.

Alsowat, H. (2016). An EFL flipped classroom teaching model: Effects on English language higher-order thinking skills, student engagement and satisfaction. *Journal of Education and Practice, 7*(9), 108-121.

Asselin, M. E., Schwartz-Barcott, D., & Osterman, P. A. (2013). Exploring reflection as a process embedded in experienced nurses' practice: A Qualitative study. *Journal of Advanced Nursing*, *69*(4), 905-914.

Awidi, I. T., & Paynter, M. (2019). The Impact of a flipped classroom approach on student learning experience. *Computers & Education*, *128*, 269-283.

Bandura, A. (1988). Organizational application of social cognitive theory. *Australian Journal of Management, 13*(2), 275–302.

Basal, A. (2015). The Implementation of a flipped classroom in foreign language teaching. *Turkish Online Journal of Distance Education*, *16*(4), 28-37.

Bergmann, J., & Sams, A. (2012). Before you flip, consider this. *Phi Delta Kappan*, *94*(2), 25-25.

Bhagat, K. K., Chang, C. N., & Chang, C. Y. (2016). The Impact of the flipped classroom on mathematics concept learning in high school. *Educational Technology & Society*, *19*(3), 134-142.

Blake, D. (2012). Newborn examination: The Student's role? *British Journal of Midwifery*, *20*(12), 892-896.

Brodish, M. S. (1981). Perinatal assessment. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*, *10*(1), 42-46.

Chang, B. Y., Chang, C. Y., Hwang, G. H., & Kuo, F. R. (2019). A Situation-based flipped classroom to improving nursing staff performance in advanced cardiac life support training course. *Interactive Learning Environments*, *27*(8), 1062-1074.

Chang, C. Y., Kao, C. H., Hwang, G. J., & Lin, F. H. (2019). From experiencing to critical thinking: a contextual game-based learning approach to improving nursing students' performance in Electrocardiogram training. *Educational Technology Research and Development*, 1-21.

Chien, C. F., Chen, G. Y. H., & Liao, C. J. (2019). Designing a connectivist flipped classroom platform using unified modeling language. *International Journal of Online Pedagogy and Course Design*, *9*(1), 1-18.

Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. (2010). A Two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education*, *55*(4), 1618-1627.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Critz, C. M., & Knight, D. (2013). Using the flipped classroom in graduate nursing education. *Nurse Educator*, *38*(5), 210-213.

Danielson, E., & Berntsson, L. (2007). Registered nurses' perceptions of educational preparation for professional work and development in their profession. *Nurse education today*, *27*(8), 900-908.

Dehghanzadeh, S., & Jafaraghaee, F. (2018). Comparing the effects of traditional lecture and flipped classroom on nursing students' critical thinking disposition: A Quasi-experimental study. *Nurse Education Today*, *71*, 151-156.

Ding, C., Li, S., & Chen, B. (2019). Effectiveness of flipped classroom combined with team-, case-, lecture-and evidence-based learning on ophthalmology teaching for eight-year program students. *BMC Medical Education*, *19*(1), 419-428.

Fuloria, M., & Kreiter, S. (2002). The Newborn examination: Part I. Emergencies and common abnormalities involving the skin, head, neck, chest, and respiratory and cardiovascular systems. *American Family Physician*, *65*(1), 61-68.

Georgieff, M. K. (1995). Assessment of large and small for gestational age newborn infants using growth curves. *Pediatric Annals*, *24*(11), 599-607.

Ha, A. S., O'Reilly, J., Ng, J. Y., Zhang, J. H., & Serpa, S. (2019). Evaluating the flipped classroom approach in Asian higher education: Perspectives from students and teachers. *Cogent Education*, *6*(1), 1638147.

He, W., Holton, A. J., & Farkas, G. (2018). Impact of partially flipped instruction on immediate and subsequent course performance in a large undergraduate chemistry course. *Computers & Education*, *125*, 120-131.

Helgevold, N., & Moen, V. (2015). The Use of flipped classrooms to stimulate students' participation in an academic course in initial teacher education. *Nordic Journal of Digital Literacy*, *10*(01), 29-42.

Heymann, M. (1993). Early postnatal assessment of the newborn in the developing country: Malawi. *The ABNF Journal*, *4*(4), 90-94.

Hicks-Moore, S. L., & Pastirik, P. J. (2006). Evaluating critical thinking in clinical concept maps: A Pilot study. *International Journal of Nursing Education Scholarship*, *3*(1). doi:10.2202/1548-923X.1314

Hsia, L. H., & Hwang, G. J. (2020). From reflective thinking to learning engagement awareness: A Reflective thinking promoting approach to improve students' dance performance, self-efficacy and task load in flipped learning. *British Journal of Educational Technology*. doi:10.1111/bjet.12911

Hsia, L. H., & Sung, H. Y. (2020). Effects of a mobile technology-supported peer assessment approach on students' learning motivation and perceptions in a college flipped dance class. *International Journal of Mobile Learning and Organisation*, *14*(1), 99-113.

Huong, H. T. L., Huy, N. H. D., & Ha, N. N. (2018). The Flipped classroom: Using thematic teaching to develop critical thinking for high school students. *American Journal of Educational Research*, *6*(6), 828-835.

Hussein, M. H., Ow, S. H., Cheong, L. S., & Thong, M. K. (2019). A Digital game-based learning method to improve students' critical thinking skills in elementary science. *IEEE Access*, *7*, 96309-96318.

Hwang, G. J., & Chen, C. H. (2017). Influences of an inquiry-based ubiquitous gaming design on students' learning achievements, motivation, behavioral patterns, and tendency towards critical thinking and problem solving. *British Journal of Educational Technology*, *48*(4), 950-971.

Hwang, G. J., & Lai, C. L. (2017). Facilitating and bridging out-of-class and in-class learning: An Interactive E-book-based flipped learning approach for math courses. *Educational Technology & Society, 20*(1), 184-197.

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2015). Seamless flipped learning: A Mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education*, *2*(4), 449-473.

Jong, M. S. Y., Chen, G., Tam, V., & Chai, C. S. (2019). Adoption of flipped learning in social humanities education: The FIBER experience in secondary schools. *Interactive Learning Environments*, *27*(8), 1222-1238.

Kirch, C. (2016). *Flipping with Kirch: The ups and downs from inside my flipped classroom*. New Berlin: The Bretzmann Group.

Kola, D. A., & Bijapur, M. S. (2019). A Study to evaluate the effectiveness of simulation on newborn care among III year B. Sc. Nursing students of SDM Institute of Nursing Sciences, Sattur, Dharwad, Karnataka. *International Journal of Nursing Science Practice and Research*, *5*(1), 64-69.

Lee, Y. H. (2018). Scripting to enhance university students' critical thinking in flipped learning: Implications of the delayed effect on science reading literacy. *Interactive Learning Environments*, *26*(5), 569-582.

Lee, M. K., Chang, S. J., & Jang, S. J. (2017). Effects of the flipped classroom approach on the psychiatric nursing practicum course. *Journal of Korean Academy of Psychiatric and Mental Health Nursing*, *26*(2), 196-203.

Lei, C. U., Yau, C. W., Lui, K. S., Tam, V., Yuen, A. H., & Lam, E. Y. (2019). Designing instructional videos and classwork activities: Teaching internet of things via flipped classroom. *International Journal of Mobile Learning and Organisation*, *13*(4), 392-411.

Li, L. (2019). An Action research of O2O blended learning in the integrated English class under the context of a Chinese private language university. *The Online Journal of Distance Education and e-Learning*, *7*(4), 261-268.

Lin, H. C., Hwang, G. J., & Hsu, Y. D. (2019). Effects of ASQ-based flipped learning on nurse practitioner learners' nursing skills, learning achievement and learning perceptions. *Computers & Education*, *139*, 207-221.

Lin, Y. N., & Hsia, L. H. (2019). From social interactions to strategy and skills promotion. *Educational Technology & Society*, *22*(2), 71-85.

Lin, Y. T. (2019). Impacts of a flipped classroom with a smart learning diagnosis system on students' learning performance, perception, and problem solving ability in a software engineering course. *Computers in Human Behavior, 95*, 187-196.

Liou, W. K., Bhagat, K. K., & Chang, C. Y. (2016). Beyond the flipped classroom: A Highly interactive cloud-classroom (HIC) embedded into basic materials science courses. *Journal of Science Education and Technology*, *25*(3), 460-473.

Lo, C. K., Lie, C. W., & Hew, K. F. (2018). Applying "First Principles of Instruction" as a design theory of the flipped classroom: Findings from a collective study of four secondary school subjects. *Computers & Education*, *118*, 150-165.

Luo, J., Kushnazarov, M., & Hew, K. F. (2019). An Analysis of undergraduate level flipped courses based on the seven principles: A Case study. *International Journal of Mobile Learning and Organisation*, *13*(4), 412-451.

McLaughlin, J. E., & Rhoney, D. H. (2015). Comparison of an interactive e-learning preparatory tool and a conventional downloadable handout used within a flipped neurologic pharmacotherapy lecture. *Currents in Pharmacy Teaching and Learning*, *7*(1), 12-19.

Miles, C. A., Lee, A. C., Foggett, K. A., & Nair, B. K. (2017). Reinventing medical teaching and learning for the 21st century: Blended and flipped strategies. *Archives of Medicine and Health Sciences*, *5*(1), 97-102.

Mirriahi, N., Alonzo, D., McIntyre, S., Kligyte, G., & Fox, B. (2015). Blended learning innovations: Leadership and change in one Australian institution. *International Journal of Education and Development using ICT*, *11*(1), 4-16.

Mudd, S. S., & Silbert-Flagg, J. (2016). Implementing the flipped classroom to enhance nurse practitioner clinical decision-making in the care of the pediatric asthma patient. *Nursing Education Perspectives*, *37*(6), 352-353.

Parsons, J., & Beauchamp, L. (2012). *From knowledge to action: Shaping the future of curriculum development in Alberta*. Edmonton, AB, Canada: Alberta Education.

Peterson, D. J. (2016). The Flipped classroom improves student achievement and course satisfaction in a statistics course: A Quasi-experimental study. *Teaching of Psychology*, *43*(1), 10-15.

Phillips, J. R. (2000). Rogerian nursing science and research: A Healing process for nursing. *Nursing science quarterly*, *13*(3), 196-201.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor, MI: The University of Michigan.Post, J. L., Deal, B., & Hermanns, M. (2015). Implementation of a flipped classroom: Nursing students' perspectives. *Journal of Nursing Education and Practice*, *5*(6), 25-30.

Rose, E., Claudius, I., Tabatabai, R., Kearl, L., Behar, S., & Jhun, P. (2016). The Flipped classroom in emergency medicine using online videos with interpolated questions. *The Journal of Emergency Medicine*, *51*(3), 284-291.

Rüdiger, M., & Aguar, M. (2012). Newborn assessment in the delivery room. *Neoreviews*, *13*(6), e336-e342.

Shannon, S. V. (2008). Using metacognitive strategies and learning styles to create self-directed learners. *Institute for Learning Styles Journal*, *1*(1), 14-28.

Solà-Pola, M., Morin-Fraile, V., Fabrellas-Padrés, N., Raurell-Torreda, M., Guanter-Peris, L., Guix-Comellas, E., & Pulpón-Segura, A. M. (2020). The Usefulness and acceptance of the OSCE in nursing schools. *Nurse Education in Practice*, *43*, 102736. doi:10.1016/j.nepr.2020.102736

Sullivan, M. C., Miller, R. J., Fontaine, L. A., & Lester, B. (2012). Refining neurobehavioral assessment of the high-risk infant using the NICU network neurobehavioral scale. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, *41*(1), 17-23.

Tappero, E. P., & Honeyfield, M. E. (2018). *Physical assessment of the newborn: A Comprehensive approach to the art of physical examination*. New York, NY: Springer Publishing Company.

Tawfik, A. A., & Lilly, C. (2015). Using a flipped classroom approach to support problem-based learning. *Technology, Knowledge and Learning*, *20*(3), 299-315.

Vygotsky, L. (1978). *Mind in society: The Development of higher psychological process.* Cambridge, MA: Harvard University Press.

Wang, F. H. (2017). An Exploration of online behaviour engagement and achievement in flipped classroom supported by learning management system. *Computers & Education*, *114*, 79-91.

Yigzaw, M., Tebekaw, Y., Kim, Y. M., Kols, A., Ayalew, F., & Eyassu, G. (2019). Comparing the effectiveness of a blended learning approach with a conventional learning approach for basic emergency obstetric and newborn care training in Ethiopia. *Midwifery*, *78*, 42-49.

Yilmaz, R. M., & Baydas, O. (2017). An Examination of undergraduates' metacognitive strategies in pre-class asynchronous activity in a flipped classroom. *Educational Technology Research and Development*, *65*(6), 1547-1567.

Zhang, C., Fan, H., Xia, J., Guo, H., Jiang, X., & Yan, Y. (2017). The Effects of reflective training on the disposition of critical thinking for nursing students in China: A Controlled trial. *Asian Nursing Research*, *11*(3), 194-200.

Zhu, L., Lian, Z., & Engström, M. (2020). Use of a flipped classroom in ophthalmology courses for nursing, dental and medical students: A Quasi-experimental study using a mixed-methods approach. *Nurse Education Today*, *85,* 104262. doi:10.1016/j.nedt.2019.104262

Ziegelmeier, L. B., & Topaz, C. M. (2015). Flipped calculus: A Study of student performance and perceptions. *Primus*, *25*(9-10), 847-860.