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A Systematic Review of Self-Regulated Learning in Flipped Classrooms: Key Findings, Measurement Methods, and Potential Directions

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ABSTRACT Online instruction through a flipped classroom approach has continued to gain popularity in recent years. Engaging learners' attention in achieving learning outcomes while embracing the flexibility of online learning via flipped classrooms remains an essential topic among educators, educational institutions, and society. Studies have found that students equipped with self-regulated learning strategies thrive in such learning environments. The present study describes and analyses the state of research in self-regulated learning strategies and their association with the flipped classroom based on the review of articles published in Q1 and Q2 journals from 2016 to the middle of 2021. The instructions in PRISMA guided the development of systematic review protocols. Thirty-two scientific texts from four search databases, Science Direct, Scopus, ERIC, and ProQuest, were reviewed. The key findings present the effects of self-regulation on academic and non-academic outcomes and the factors that influenced the outcomes. The findings also revealed six preferred methods to measure self-regulated learning in a flipped classroom, specifically through self-report questionnaires, as the most preferred approach, followed by learning analytics, interviews, think-aloud protocols, reflective documents, and observation. Furthermore, the potential future areas of study are detailed as prospect references. In conclusion, it is highly recommended for educators and future studies to integrate the essential characteristics of flipped learning as pointed out by the four pillars (F-L-I-P): flexible environment, learning culture, intentional content, and professional educator. Ultimately, this justifies the successful integration of the flipped classroom into learning and facilitates the development of self-regulated learning strategies.

INDEX TERMS Flipped classroom, inverted classroom, measurement methods, self-regulated learning strategies.

I. INTRODUCTION

Flipped classrooms (FC) have gained considerable attention over the past two decades. Nevertheless, the FC approach is gaining popularity as educational institutions shift towards student-centred learning approaches. Reference [1] reported the increasing trend of flipped learning studies from 4 in 2012 to 366 in 2018 found in the SCOPUS database alone. The growth of technology in education has uncovered new possibilities for exploring FC using effective strategies to enhance learning.

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According to [2], flipped learning is ''a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space; further, a transformed, dynamic, and interactive learning environment for the group space, allowing students to apply concepts and engage creatively in the subject matter with the educator's guidance.''

However, flipped learning and FC are not interchangeable. [3, p.32] describes FC as ''the events that have traditionally taken place inside the classroom that now take place outside the classroom and vice versa.'' Furthermore, FC is comprehensively explained as a pedagogical approach that uses class time for active learning to intensify students'

conceptual understanding by providing instructional materials to be completed out-of-class time. During class, active learning strategies such as peer collaboration engage students in critical thinking and problem-solving activities [4], [5]. Many educators regularly flip their classes, but to achieve flipped learning, educators must combine the four pillars into their practice: flexible environment, learning culture, intentional content, and professional educator [2].

Previous studies have reported several advantages of FC to students. One of the advantages is that complex or abstract theories are presented in simpler representations with multiple resources in FC to deepen students' understanding. Besides that, videos shared via FC also allow students to review the content multiple times and comprehend the concept better, supporting personalised and independent learning [6]. Using FC, students appeared to be more prepared and confident during the in-class activities [7]. These are consistent with the findings reported by [8], where the FC environment exhibits high learning motivation and promotes learner autonomy among students. Besides, discussion and collaboration in FC stimulate students' interest in learning as they internalize the knowledge [9]. In some studies, FC strengthens lifelong learning skills such as critical thinking [10], problem solving [11], creativity [12], communication [13], collaboration [14], and self-regulation [15], [16]. Moreover, FC has also shown improvement in academic performance [9], [17] and course grade [15].

Despite the advantages of FC, several studies highlight the drawbacks of this model. This approach demands students to perform tasks independently, but some students lack self-discipline [18] and feel an increase in workload to be well prepared for in-class lessons [17], [19], [20]. Some students find it challenging to cope and progress through the pre-class learning material when the task structure lacks spontaneous feedback [19]. Furthermore, failure to comprehend the flipped content may result in disengagement and ineffective learning during in-class activities [13], [21], [22]. Inadequate guidance or interactivity aspects during FC are challenges students face that make them feel helpless and discouraged [23]. This incompatible structure of FC may lead to low learning motivation and frustration among students [24]. Additionally, this results in negative feelings when their efforts in FC are not reflected in their academic evaluation [17].

Sustaining learning in an online environment appeared to be the most significant challenge in FC. The learning process demands students to constantly reflect, evaluate, modify, and monitor their strategies as they progress through the learning [24]. Students with low self-regulation, in general, face challenges adapting to flipped learning [25], [26]. According to [4], students can take responsibility for their learning by applying self-regulated learning (SRL) skills. Reference [27] adds that the rationale for flipped learning is to cultivate the SRL strategies among students. SRL strategies are essential in the learning process to successfully implement flipped learning and achieve learning goals [15]. In addition, SRL is gaining attention as the current society emphasizes life-long learning and informal learning environments that require SRL skills to thrive [28].

A. SRL STRATEGIES

[29, p.453] defined self-regulation as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and contextual features of the environment." As reported by [30], there are six models of SRL which are: (1) the cyclical phases model by Zimmerman; (2) six-component model of SRL by Boekaerts; (3) Winne's SRL model; (4) Pintrich's SRL model; (5) metacognitive and affective model of SRL (MASRL) by Efklides; and (6) socially shared regulated learning model by Hadwin *et al.*

Primarily, Zimmerman is the pioneer in enlightening SRL through his article in 1986, highlighting the key subprocesses among SRL learners. His work extended from the triadic model (1989), the cyclical phases model (2000), the multilevel model (2000), and the current version of the cyclical phases model (2009). The current version of the cyclical phase model has new metacognitive and volitional tactics in the performance phase essential in SRL, such as time management, environmental structuring, and help-seeking [30].

Since there are numerous strategies concerning SRL, the cyclical model surpasses other models owing to the clear distinction between phases and the clarity of various processes involved in SRL. Additionally, the cyclical model is commonly used in SRL studies, apart from Pintrich's SRL model [31]. Hence, in this study, the SRL strategies and processes were defined based on the three phases: forethought, performance, and self-reflective, as indicated in the current version of the cyclical phases model [32]. Figure 1. shows the cyclic phases and processes of SRL.

B. FORETHOUGHT PHASE

The forethought phase involves task analysis (goal setting and strategic planning) and self-motivation beliefs (self-efficacy, outcome expectations, task interest/value, and goal orientation). In this phase, learners must analyse the task, set appropriate goals, plan their learning to achieve their goals, and make personal judgments based on their motivational beliefs that affect their learning strategies. Task analysis is the first method in the forethought phase that involves goal setting and strategic planning [32]. Goal setting is a learner's ability to consider their circumstances as they set their own goals and have a clear vision that guides their doings in achieving their goals [33]. This eases the next step of strategic planning, which requires learners to progressively organize their actions with resources.

On the other hand, the construct of motivational belief in the forethought phase has four motivational variables that affect learners' direction, intensity, and perseverance of learning behaviour [34]. Firstly, outcome expectation is the learner's belief that their behaviour will influence the

desired outcome. Meanwhile, self-efficacy refers to learners' confidence in performing the intended behaviour to achieve the desired outcome [35]. Further, task value requires learners to evaluate the significance and value of the task. In contrast, goal orientation is the learner's purpose in participating in the task instead of being driven by the goal set [36].

C. PERFORMANCE PHASE

The next phase in SRL is performance or volitional control that involves self-control (task strategies, self-instruction, imagery, time management, environmental structuring, help-seeking methods, interest incentives, and self-consequences) and self-observation (metacognitive monitoring and self-recording). In this phase, learners perform the task while examining their progress using self-control strategies to remain focused [32]. According to [37], task strategy refers to effective planning in identifying a suitable strategy to perform the task cyclically while focusing attention on the goal-related behaviours by avoiding distractions from irrelevant matters. Meanwhile, self-instruction is a self-control method that refers to the visible learning efforts such as verbalization as learners perform the task. Imagery is another component that engages learners in forming mental images to aid in learning and retention [37].

Time management is another self-control method that requires learners to manage the time available and monitor progress in accomplishing the task on schedule. It is also crucial that there is ''environmental structuring,'' which means choosing an appropriate working space that is right to accomplish their goals, keeping in mind the right balance between when and where to study. Help-seeking is another strategy where learners initiate help when needed in their learning process [38]. Besides, interest incentives and self-consequences are self-control methods learners employ to enhance motivation rather than metacognitive strategies. Portraying a tedious task as more attractive or motivating is called ''interest incentives.'' In contrast, self-consequence refers to the setting of rewards or punishments to engage in the process of accomplishing the task [32].

Another construct in the performance phase is self-observation, which involves systematic observation and documentation of ideas, emotions, and actions about goal attainment. Self-observation comprises two processes, metacognitive monitoring and self-recording [34]. Metacognitive or self-monitoring refers to learners' ability to assess any inappropriateness between their targeted goal and their present state of knowledge [39]. Meanwhile, self-recording is the process of keeping track of personal details in situations where there is the possibility of changing one's behaviour [34].

D. SELF-REFLECTION PHASE

The last phase in the SRL cyclic model is self-reflection, which involves self-judgment (self-evaluation and causal attribution) and self-reaction (self-satisfaction and adaptive-defensive). In this phase, learners assess their performed tasks and acknowledge their accomplishments or failures, which activates learners' self-reactions that can influence their actions in the future [30], [40]. Self-evaluation or self-assessment is the process of assessing one's learning progress, learning outcome, and the reasons for success or failure [41]. According to [37], self-evaluative judgments are associated with causal attributions involving one's behaviour, which could result from personal or circumstantial factors such as one's ability, environmental affordances, or constraints. In the self-reaction construct, [37] explained self-satisfaction as the affections of satisfaction or dissatisfaction concerning one's performance. These are closely associated with adaptive or defensive interferences that affect one's need to modify approaches throughout subsequent learning efforts. Consequently, the processes involved in self-reactions will shape the forethought processes, hence completing the SRL cycle.

E. PAST STUDIES AND THE PURPOSE OF THE STUDY

A variety of reviews have been conducted on FC. A review by [42] reported on FC research trends, and the results showed the preferred pre-class assignment being instructional videos, animation, or e-books with hardly any online collaborative discussions. In addition, the desired in-class assignments are issue discussion, doing practice, or problem-based learning, but there is no after-class task to follow up with the lessons. Echoing the findings of the previous review, [43] proposed the central aspects of FC, detailing features necessary such as the format and duration of the pre-class, in-class, and post-class assignments, as well as assessment of students' learning.

Apart from that, [44] and [45] reviewed the advantages and challenges of FC and discovered that flexibility, improving learners' engagement, satisfaction, and learning performance are the frequently highlighted advantages. Meanwhile, the main disadvantages of FC were that it was time-consuming and it increased the workload from both students' and teachers' perspectives. Furthermore, [46] provided several guidelines to address the challenges students, faculty, and operationally face. A suitable platform improves student-teacher communication and gives explicit instructions to learn via FC, addressing student-related challenges. Other suggestions include strengthening teachers' training and professional development and increasing the financial support to develop the school's IT resources for students and teachers with technological limitations.

These past reviews have provided valuable information on various aspects of FC. This revealed the lack of comprehensive analysis on SRL in FC, which stresses the need for such a review since FC requires SRL to thrive [21], [24], [27], [47], [48]. However, a significant number of studies have found that SRL strategies are vital in learning processes. A study by [49] reviewed SRL strategies and their correlation to academic achievement, and the findings reported that effort regulation, metacognition, critical thinking, and time management positively correlate to

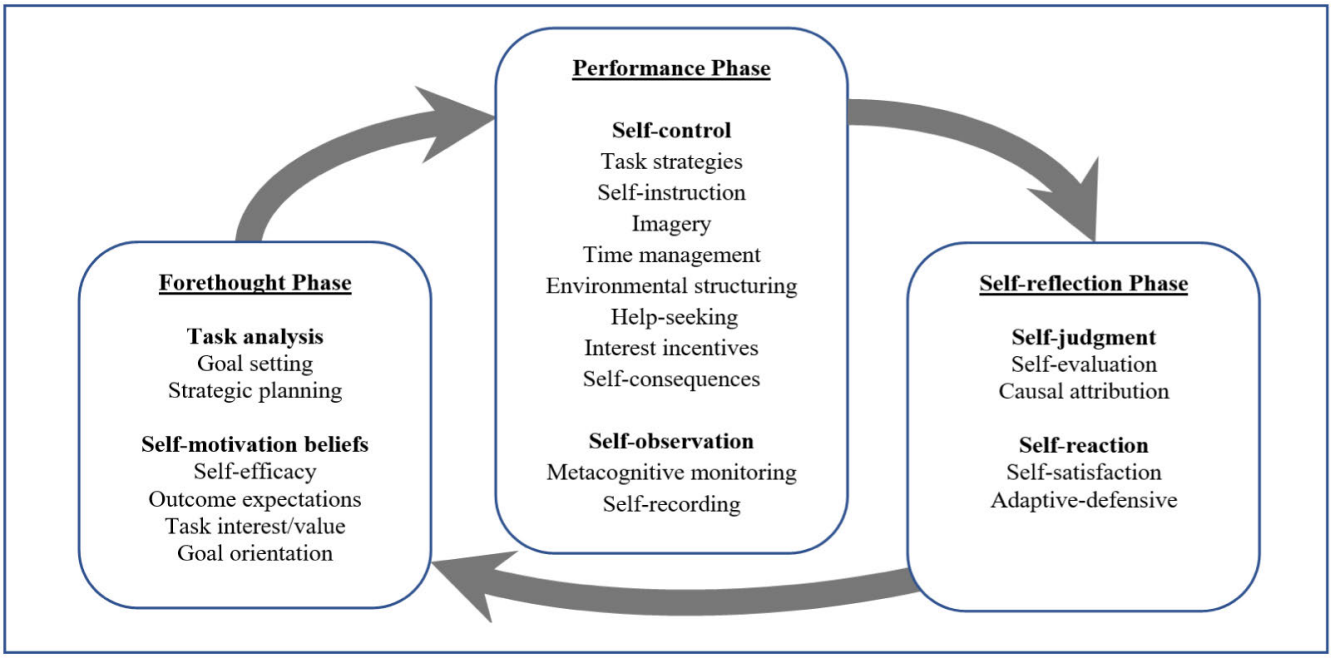

FIGURE 1. Cyclic phases and processes of SRL [32, p.301-304].

academic outcomes. Another study [50] reviewed 211 articles published between 1988 and 2013 on self-report instruments used to measure SRL. This study showed that almost 95% of the SRL instruments focus on behavioural strategies, with the Motivated Strategies for Learning Questionnaire (MSLQ) being the most widely used instrument.

All these reviews reflect the growing interest in both FC and SRL studies. Nevertheless, it was important to highlight that the reviews on SRL and FC were studied independently. According to [51], SRL involves learners taking responsibility for identifying their learning needs and applying micro-level task execution strategies to achieve their learning goals. In other words, the skills of SRL are the primary step to self-directing one's learning. At present, one review explores SRL in the context of FC, which makes this current study vital. Reference [52] reviewed 14 articles to address the types of support proposed to improve SRL in the FC environment. The findings revealed that online discussion boards or tutoring systems support help-seeking aspects, and the use of scaffolds in instructional strategies supports self-regulation.

The implications of these past studies necessitate a review that focuses on SRL in FC on the wide-ranging effects of different SRL strategies using the current version of the cyclical phases model by Zimmerman. A significant gap exists between students' self-regulation strategies and the SRL skills developed through FC. While most of the current literature acknowledges the implications of FC and SRL independently, the present study aims to synthesize selected articles using eligibility and exclusion criteria to answer specific research questions through in-depth analysis. This study also lists the types of pre-class and in-class activities in the FC environment that support SRL, its measurement tool, analysis methods, and the key findings, as the design and processes involved wholly influence the academic and non-academic outcomes of the studies. Hence, this study has the following research questions:

RQ1: What are the characteristics of included studies?

RQ2: What are the effects of SRL measures in FC?

RQ3: What are the effects of SRL in FC on academic outcomes?

RQ4: What are the SRL measurement methods used in FC?

RQ5: What is the direction of future studies to explore SRL in FC?

II. METHODS

A systematic review is ''a review of existing research using explicit, accountable, and rigorous research methods'' [53, p.2]. The systematic review is guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as described by [54] to make this study easier. The use of this protocol strengthens the methodological quality and reliability.

A. RESOURCES

This review began with an extensive search of the literature on four central journal databases: the Education Resources Information Center (ERIC), Scopus, Science Direct, and ProQuest. The selection of databases is due to the size and coverage of the research topics [55]. ERIC provides access to roughly 1.5 million bibliographic records of journal articles, with more than 80% of them being education-related articles [56]. Scopus is the largest abstract and citation

database covering more than 25,100 titles from approximately 5,000 publishers worldwide, of which more than 90% are peer-reviewed journals [57]. Meanwhile, ScienceDirect provides an extensive database of medical and scientific publications with more than 1.4 million articles from over 4,500 academic journals [58]. Finally, ProQuest delivers over 12,000 full-text scholarly journals in diverse subject areas such as education, science, and social science [59].

B. ELIGIBILITY AND EXCLUSION CRITERIA

The articles selected were restricted to peer-reviewed journal papers with empirical data. According to [60], peer-review by experts warrants the publication of high-quality research due to thorough scrutiny. Second, articles published between 2016 and the middle of 2021 are chosen, given a sufficient period of recent research in the field of study, supported by the increasing trend in FC research from 2015, as reported by [1]. Thirdly, to avoid problems with translation and misinterpretation, articles published in English are chosen. Fourthly, in line with the research questions, articles that reflected studies that examined SRL application by students enrolled in FC were included.

Next, only Q1 (i.e. first quartile) journals that occupied the top 25% of journals in the SJR citation index in the year 2020 (i.e. SCImago Journal and Country Rank) distribution, and Q2 (i.e. second quartile) journals that were occupied by journals in the 25 to 50% group, were included in this study. In particular, the selection of Q1 and Q2 journal articles is influenced by the findings reported in the respective articles, as they have a more significant scientific impact with a higher number of endorsements through citations [61].

Next, the articles selected only report on studies in a formal education setting related to intervention type. According to [62, p.113], formal education has a district-wide set of features and is ''a systematic, organized education model, structured and administered according to a given set of laws and norms, presenting a rather rigid curriculum.'' This review excluded studies on non-formal and informal learning settings.

Finally, with regards to participants, this review included articles with participants from all levels of education. The articles selected were not limited to participant gender, age, ethnic group, type of course commencement, and any other demographic information. This review excluded articles if the participants in the study were not identified as students.

C. SEARCH STRATEGY

The search for relevant articles entailed the following process. In the first stage, two authors identified keywords that are closely related to the purpose of this study and to aid in searching for the articles. Accordingly, the keywords used are as follows: ''(flipped or inverted) and (learning, or instruction, or classroom),'' together with ''self-regulated learning.'' The advanced search function in electronic databases includes those keywords in the second stage. The database search was conducted in August 2021.

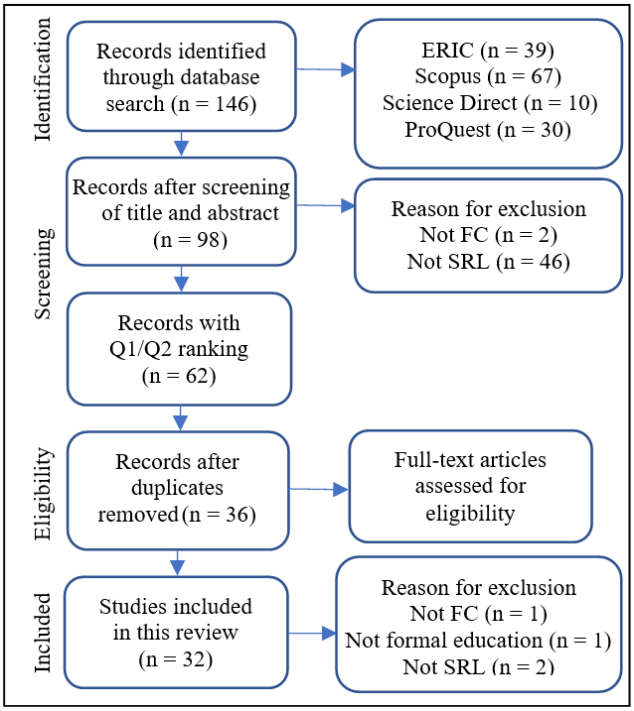

FIGURE 2. A flow diagram of article selection.

D. SELECTION OF STUDIES

The screening process is divided into four stages: (1) screening of the title and abstract; (2) screening for Q1 and Q2 articles; (3) screening of duplicate articles; and (4) screening of full-text articles. In phase 1, the titles and abstracts of articles found by the search were screened for eligibility by the first author. In phase 2, the listed articles' journal ranking were identified using SJR, where Q1 and Q2 journals were selected for review. In phase 3, duplicate articles are removed within the same databases and between searched databases. Lastly, in phase 4, the full text of the articles was reviewed for inclusion eligibility independently by the two authors.

E. DATA EXTRACTION AND MANAGEMENT

The same coders were also involved in this stage to ensure their decisions in the previous screening phase were accurate. The abstract of the journal article is thoroughly read, followed by a comprehensive read-up on the articles' finding data in line with the objectives of this study. Data from eligible articles were independently assessed, analysed, and extracted by two authors before being recorded on a standardized electronic data collection form on MS Excel. A standardized coding sheet was completed for each article independently by both authors. This step is carried out to determine whether all inclusion criteria were met or any reason for exclusion. The coders maintained consistency, and when discrepancies arose, they discussed them with a third author to ensure the validity of the analysis.

TABLE 1. Summary of studies included in this review.

No.	Study (Year) [Ref]	Participant, method design, and study duration	Pre-class activity	In-class activity	Findings
1	Al Mulhim (2021) [105]	Participant type: Diploma students Sample size: 60 Design: Experimental Duration: 2 weeks	Videos and other resource, note-taking	Group activities	Students with an internal locus of control showed significantly higher SRL skills and learning retention compared to students with an external locus of control.
2	Jung et al. (2021) [67]	Participant type: Undergraduate Sample size: 87 Design: Quasi-experimental Duration: 4 weeks	Video lectures, summary writing, quizzes, and online discussion forum	Self-explanation and feedback, collaborative group work After class: Reflective writing	The regulated learning-supported (RL) FC group engaged in shared or co-regulation showed no significant difference in online learning and discussion efficacy. However, students' individual performance in RL-FC was significantly higher than in the control group.
3	Park & Kim (2021) [79]	Participant type: Undergraduate Sample size: 221 Design: Experimental Duration: 15 weeks	Videos and quizzes	Mini-lecture, group activities	Self-regulation was found to have a significant effect on academic performance, while co-regulation and behavioural engagement showed insignificant effects on academic performance.
4	Perez-Sanagustin et al. (2021) [81]	Participant type: Undergraduate Sample size: 242 Design: Observational study Duration: 8 weeks	Video lectures, read case study, weekly planning report	Quiz, group work, seminar	The experimental group showed slightly higher engagement compared to the control group. However, there was no statistical difference in the final grades of students in both groups.
5	van Alten et al. (2021) [82]	Participant type: 8th grader Sample size: 150 Design: Quasi-experimental Duration: 8 weeks	Videos and quizzes (on workbook)	Micro-lecture, discussion, and engaging learning activities	Five distinct online SRL profiles were identified, which are: low-completion (no activity), medium completion (low activity), high completion (medium, high and very-high activity), but with no clear distinguishing SRL behaviours among the groups.
6	Yoon et al. (2021) [80]	Participant type: Undergraduate Sample size: 145 Design: Experimental Duration: 3 weeks	Videos and quizzes	Team discussion and project work (interview, report, lesson plans)	Students with support for SRL (SSRL) obtained a higher SRL score, showed greater pre-class behavioural engagement, and better in-class cognitive engagement than the non-SSRL group.
7	Ahmad Uzir et al. (2020) [25]	Participant type: Undergraduate Sample size: 1134 Design: Exploratory study Duration: 13 weeks	Videos and reading materials with multiple-choice questions, also problem-based activities	Lecture, tutorial and hands-on laboratory session	High performing students demonstrated more consistent efforts and diverse time management strategies throughout the course than their peers. Additionally, time management strategies adopted by students were related to academic performance.
8	Saint (2020) [93]	Participant type: Undergraduate Sample size: 290 Design: Exploratory study Duration: 13 weeks	Not specified	Not specified	Four learning strategy groups were identified: (1) active agile, (2) active cohesive, (3) semi-engaged, and (4) summative gamblers. Both active agile and cohesive involve high-performers where their learning patterns showed functional SRL behaviours; while semi-engaged and summative gamblers involve low-performers where their learning patterns show lack of cohesion and SRL behaviours.

TABLE 1. *(Continued.)* **Summary of studies included in this review.**

No.	Study (Year) [Ref]	Participant, method design, and study duration	Pre-class activity	In-class activity	Findings
9	van Alten et al. (2020) [77]	Participant type: 8th grader Sample size: 154 Design: Quasi-experimental Duration: 6 weeks	Videos and quizzes (on workbook)	Micro-lecture, discussion, and engaging learning activities	Students in the SRL-support condition performed more help-seeking and had a higher video completion rate, but there was no significant difference in the learning outcome compared to the control group.
10	van Alten et al. (2020) [75]	Participant type: 8th grader Sample size: 115 Design: Quasi-experimental Duration: 8 weeks	Videos and quizzes (on workbook)	Micro-lecture, discussion, and engaging learning activities	Both the experiment and the control group showed no significant difference in their SRL strategies. Also, students in the SRL-support condition were either neutral or negative in their satisfaction with the learning environment.
11	Zarouk et al. (2020) [64]	Participant type: Undergraduate & Postgraduate Sample size: 84 Design: Quasi-experimental Duration: 8 weeks	Not specified	Not specified	Students have improved motivational beliefs, SRL, and collaborative strategies after completing their flipped SRPBL (self-regulated project-based learning) course.
12	Zheng & Zhang (2020) [73]	Participant type: Undergraduate Sample size: 146 Design: Survey Duration: 10 months	15 hrs of online readings and video	Group discussion, also clinical simulation lab, virtual imaging lab and gross anatomy lab	Use of cognitive strategy rehearsal was negatively associated with students' learning outcomes (performance), while use of resource management strategies (peer learning and help-seeking) was positively associated with student learning outcomes.
13	Zheng et al. (2020) [21]	Participant type: Undergraduate Sample size: 26 Design: Not specified Duration: 4-5 months	15 hours of online readings and videos	Basic science and clinical experiences	Students often use SRL strategies in the stages of planning and reflection, but seldom during the learning or monitoring phase. However, high-achieving and senior (second-year) students perform more learning strategies during the monitoring stage than their counterparts.
14	Jdaitawi (2019) [100]	Participant type: Preparatory Year College students Sample size: 160 Design: Experimental Duration: 4 weeks	Teaching materials, videos and reading text on LMS	Practical activity and group discussion	FC group showed a higher mean in SRL compared to the traditional group.
15	Montgomery et al. (2019) [74]	Participant type: Undergraduate Sample size: 157 Design: Correlational Duration: Not specified	Instructional videos, assignment and formative quizzes on Moodle	Experiential modelling and collaborative group discussion	Regularity in access to review modules and quizzes has a significant relationship with academic achievement (course grade), where access regularity was the most prominent SRL behaviour during online learning.
16	Wang & Zhu (2019) [83]	Participant type: Undergraduate Sample size: 73 Design: Quasi-experimental Duration: 6 weeks	Micro lectures on MOOC platform and online exercises	Group discussion and focused explanation	MOOC-based FC provided a favourable experience, in terms of peer interaction, learning resources, and active learning results, which resulted in improved performance, but no changes in self-efficacy and SRL were detected.
17	Wang (2019) [4]	Participant type: Undergraduate Sample size: 431 Design: Exploratory study Duration: Not specified	Online material on Moodle	Collaborative group work on problem-based activities After class: Quizzes	In-class behavioural engagement had a direct positive effect on engagement in self-reflection and self-assessment, as well as a direct positive effect on out-of-class behavioural engagement. However, there is no significant direct effect of in-class problem solving on achievement.

TABLE 1. *(Continued.)* **Summary of studies included in this review.**

No.	Study (Year) [Ref]	Participant, method design, and study duration	Pre-class activity	In-class activity	Findings
18	Zhang (2019) [76]	Participant type: Undergraduate Sample size: 19 Design: Exploratory study Duration: 4 weeks	Videos, note-taking, and speaking practice via VoiceThread	Listening, speaking and writing activities, also quizzes	Most students set goals for their learning, engaged in learning strategies and structuring of their environment, and sought help. However, very few students were involved in time management and self-reflection.
19	Chen & Hwang (2018) [70]	Participant type: Undergraduate Sample size: 85 Design: Quasi-Experimental Duration: 6 weeks	Instructional videos (online lecture) and questions on learning sheet	Group discussion and interactive response system (IRS) questions	The use of IRS-facilitated learning model, fostered students' interaction and engagement in the discussion section. Additionally, learning achievement, collective efficacy, and satisfaction in the experimental group were reported to be higher than in the control group.
20	Fincham et al. (2018) [65]	Participant type: Undergraduate Sample size: approximately 1300 Design: Not specified Duration: 13 weeks (for 3 years)	Videos and reading materials with multiple-choice questions, also problem-based activities	Plenary session (lecture)	High-performing students engage themselves critically and thoroughly with course resources, and the use of meta-cognitive resources is associated with more effective SRL. Additionally, weekly feedback on students' engagement and performance could meaningfully inform tactic changes and gradually lead to strategy changes.
21	Ng (2018) [27]	Participant type: Undergraduate Sample size: 73 Design: Not specified Duration: Not specified	Videos and reading materials	Individual and group task (editing photographs)	Students achieved all the 7 SRL strategies and were able to apply their self-learned knowledge to editing images both collaboratively and individually.
22	Shih et al. (2018) [48]	Participant type: Undergraduate & Postgraduate Sample size: 576 Design: Survey Duration: Not specified	Not specified	Not specified	The quality of students' in-class interactions influences students' intention to attend FC. Online SRL are predictors of their perceived usefulness of online learning activities and positive experience of FC, and these, in turn, are associate with their intentional behaviours of participating in FC.
23	Shyr & Chen (2018) [26]	Participant type: Undergraduate Sample size: 81 Design: Quasi-Experimental Duration: 9 weeks	Video lectures	Quizzes and collaborate group work on problem-solving tasks	Flip2Learn reported higher SRL ability that better prepares students for FC and improved learning performance compared to conventional FC.
24	Sun et al. (2018) [66]	Participant type: Undergraduate Sample size: 151 Design: Correlational study Duration: 14 weeks	Video lectures, homework	Recitation session involving group discussion and presentation After class: Assignment and quiz	Students' self-efficacy in learning maths and the use of metacognitive and help-seeking strategies have a significant positive correlation to both pre-class and in-class math achievements.
25	Blau & Shamir-Inbal (2017) [24]	Participant type: Undergraduate Sample size: 36 Design: Not specified Duration: Not specified	Videos and reading materials, group discussion and individual assignment, forum (Moodle)	Video-conferences, collaborative group work	The re-designed model (with extensive independent learning, learning regulation, continuous dialogue, and collaborative) was received positively by the students.

TABLE 1. *(Continued.)* **Summary of studies included in this review.**

No.	Study (Year) [Ref]	Participant, method design, and study duration	Pre-class activity	In-class activity	Findings
26	Çakiroğlu & Öztürk (2017) [69]	Participant type: Undergraduate Sample size: 30 Design: Not specified Duration: 10 weeks	Couse module (video, handout), test, module, task module (collaborative group work on problems)	Collaborative group work on problem-based activities	In the problem-based in-class learning sessions, the goal setting and planning, task strategies, and help-seeking skills of the students were high. In the home sessions, environment structuring, goal setting, and planning skills were developed at a high level, while task strategies, help-seeking, time management, monitoring, self-efficacy, and self-evaluation skills were moderate, and monitoring skills were lower.
27	Sletten (2017) [47]	Participant type: Undergraduate Sample size: 76 Design: Cross-sectional survey Duration: 16 weeks	Video lectures	Discussion on case-study and problem-based activities	There is a strong positive relationship between the value placed on active learning and learning enhancement. However, the overall SRL model has no influence on course grades.
28	Sun et al. (2017) [71]	Participant type: Undergraduate Sample size: 181 Design: Quasi-Experimental Duration: Not specified	Instructional videos on OpenCourseWare (OCW)	Collaborative learning activities	There was no significant difference between the groups on overall self-regulation, but learners from the experimental group showed a significantly higher score in help-seeking compared to the control group.
29	Yılmaz et al. (2017) [16]	Participant type: Undergraduate Sample size: 102 Design: Experimental Duration: 11 weeks	Lecture videos and notes with MS interaction	Application tasks and forum-based discussion	Use of metacognitive support (MS) by the pedagogic agent significantly improved the level of self-regulation skills.
30	Butzler (2016) [15]	Participant type: Undergraduate Sample size: 197 Design: Comparative Duration: Not specified	Flipped: Video lectures Stealth flipped: vodcasts, related readings, individual assignments, formative assessment Stealth SRL: Similar to stealth flipped with note-taking	Flipped or stealth flipped: Collaborative group discussion on chemistry problems Stealth SRL: Collaborative group discussion on chemistry problems, and exam wrapper	Any increase in overall course grades indicated a positive influence of the SRL tools and learning environment. The results did not reveal a significant difference upon the addition of Cornell note-taking and exam wrappers in a FC learning environment.
31	Lai & Hwang (2016) [68]	Participant type: Primary school Sample size: 44 Design: Experimental Duration: 4 weeks	e-book, videos and quizzes	Interactive learning activities and discussion	Students who engaged in higher self-regulation (goal setting, task strategies, time management, help-seeking, and self-regulation) showed significantly higher achievement than those with lower self-regulation while learning with the self-regulated FC.
32	Moos & Bonde (2015) [72]	Participant type: Undergraduate Sample size: 32 Design: Experimental Duration: Not specified	Videos with embedded SRL scaffolds	Not specified	Monitoring of understanding is significantly related to pausing a video during learning. Also, there is a positive association between participants who received embedded prompts in the video while learning and self-regulatory processes, following a significantly better performance on the post-test.

III. RESULTS AND DISCUSSION

A. DESCRIPTION OF INCLUDED ARTICLES

The initial database search resulted in 146 peer-reviewed journal articles. A total of 114 articles were removed, as a result of the title and abstract screening (n = 48), not listed as Q1 or Q2 journals using the SJR citation index (n = 36), duplicate articles (n = 26), and full-text assessment for eligibility (n = 4). The remaining 32 articles were considered relevant for this systematic review, consisting of 23 articles listed in Q1 journals and 9 in Q2 journals. Figure 2 outlines the process of article selection.

The sample size used in this review is small (n = 32) yet adequate to emphasize the case-oriented analysis using information-rich cases classified by the inclusion criteria of this study. Additionally, 32 samples were substantial enough to successfully capture the complexity of experience the studies offer, allowing the presentation of richly-textured information to provide a detailed understanding of the phenomenon studied [63].

B. CHARACTERISTICS OF INCLUDED STUDIES

The studies presented in this review represent various countries where the research was conducted rather than the researcher's affiliation. Most of the studies originated from the United States (n = 7), followed by Taiwan (n = 6), Australia (n = 3), the Netherlands (n = 3), China (n = 2), Saudi Arabia (n = 2), South Korea (n = 2), Turkey (n = 2), Canada (n = 1), Israel (n = 1), Portugal (n = 1), and two studies were not clearly specified.

Besides that, the most frequently studied field is STEM-related (Science, technology, engineering, and mathematics) with nine articles. This is followed by education (n = 4), history (n = 3), language (n = 2) and health science (n = 2). Subsequently, one article contributed to the business, computer science, career planning, music, organizational behaviour, social science, and BYOD (Bring Your Own Device). Meanwhile, a study by [64] engaged four different disciplines: business, commerce, counselling and translation, and management. The remaining four articles did not specify the field of study.

Table 1 presents the summary of studies included in this review. The most frequently used research methodology is the quantitative approach (n = 21), followed by a mixed method (n = 8), and the remainder of studies employed qualitative approaches (n = 3). The common research designs used by studies in this review are quasi-experimental (n = 9), experimental (n = 7), exploratory (n = 4), correlational (n = 2), survey (n = 2), cross-sectional survey (n = 1), comparative (n = 1), and observational study (n = 1), while five studies did not specify the study design.

Our analysis also revealed that undergraduates (n = 25), 8th graders (n = 3), both undergraduate and postgraduate (n = 2), diploma students (n = 1), and 4th grader students (n = 1) are the student samples used in the reviewed studies. There are five different categories of sample size found in our analysis, which are less than 50 (n = 6), between 50 to 100 (n = 8), between 100 to 200 (n = 11), more than 200 (n = 5), and more than 1000 (n = 2). In regards to study duration, there were several categories which were below 4 weeks (n = 2), between 4 to 6 weeks (n = 7), between 8 to 10 weeks (n = 6), between 11 to 15 weeks (n = 5), between 16 to 20 weeks (n = 2), and about 40 weeks (n = 1). A study by [65] was conducted for 13 weeks over three consecutive years, while the remaining eight studies did not specify the duration of the study.

TABLE 2. Type and frequency of pre-class and in-class activities.

Pre-class		In-class	
Videos	29	Collaborative group work/discussion	21
• Online reading/notes/e-book	12	Lecture/Micro-lecture	6
• Quizzes	11	Engaging learning activities	6
• Online exercise/problem-based activities	6	Hand-on experience (lab/practical/clinical)	4
• Assignment	3	Quizzes	3
• Note-taking/summary writing	3	Video-conferences/Seminar	2
• Online discussion/forum	3	Self-explanation and feedback	1
• Speaking practice	1	Not specified	4
• Weekly planning report	1		
Not specified	3		

Table 2 presents the type and frequency of pre-class and in-class activities engaged in the reviewed studies. Almost all studies (n = 29) employed videos as the pre-class activity, while three articles did not specify the activities used. Generally, the videos are complemented with other materials such as reading notes, quizzes, and practice or problem-based questions. The most frequently used in-class activity is collaborative group work or discussion (n = 21). A few studies employed after-class activities, which included quizzes [4], [66], assignments [66], or reflective writing [67].

C. EFFECTS OF SRL MEASURES IN FC

Table 3 shows the frequency of SRL skills investigated in the reviewed studies. The outcomes associated with SRL strategies are presented based on the three SRL phases: forethought, performance, and self-reflection. Reference [16] found a significant positive effect on SRL forethought skills by students exposed to pedagogical agents with metacognitive support than the control. Besides that, [21] found that Year 2 medical students were more engaged in task analysis skills in the planning stage than Year 1 students. In the aspect of goal setting, a study by [68] showed that an experimental group with self-regulated FC obtained a

TABLE 3. Frequency of SRL skills investigated.

Constructs	Processes	Frequency
Forethought Phase		4
Task analysis (n=1)	Goal setting	10
	Strategic planning	5
Self-motivation beliefs (n=1)	Outcome expectations	
	Self-efficacy	9
	Task interest/value	3
	Goal orientation	3
Performance Phase		4
Self-control (n=2)	Task strategies	12
	Self-instruction	1
	Imagery	
	Time management	14
	Environmental structuring	14
	Help-seeking	15
	Interest incentives	1
	Self-consequences	1
Self-observation	Metacognitive monitoring	10
	Self-recording	
Self-reflection Phase		7
Self-judgment	Self-evaluation	12
	Causal attribution	
Self-reaction	Self-satisfaction	
	Adaptive-defensive	

higher score than the control group. Likewise, [69] found that problem-based learning activities in FC positively affect students' goal setting. However, the studies by [70] and [71] showed insignificant differences between the experimental and control groups in the aspect of goal setting. On the other hand, students in SRL prompt conditions showed a higher mean score in strategic planning [72]. Moreover, the experimental group exposed to self-regulated FC showed significantly higher self-efficacy than their counterparts [68]. Reference [69] found that students showed self-efficacy skills moderately during both in-class and home sessions. Nevertheless, this finding contradicts those reported by [71], where students engaged in Massive Open Online Courses (MOOCs) based FC and traditional classrooms showed an insignificant difference in their self-efficacy skills.

Concerning the performance phase, [16] found that the experimental group showed a significantly positive effect on self-control and self-observation skills than the control group. Several studies [68], [69], [70], [72] found positive effects on task strategy skills. Another study found that students' positive study skills are related to their viewing frequency [47]. Despite this, [73] found that cognitive strategies skills significantly negatively affect Year 1 and 2 medical students' learning growth. Besides that, a few studies showed positive outcomes in the regulation of time management [68], [69], [74]. In contrast, several studies found no significant difference in their time management strategies when compared with the control group [70], [71], [75]. Moreover, [73] found that time management skills were negatively associated with Year 1 medical student learning outcomes, while positively towards Year 2 students. A qualitative study by [76] reported that 13 out of 19 students procrastinate for various reasons, such as laziness, working faster at the last moment, and other priorities. In regards to environmental structuring, results from [68] and [71] showed no significant difference between the experiment and control group, whereas [64] and [70] showed a positive effect. On the other hand, [69] and [74] found that students were more actively engaged in environmental structuring skills during off-campus sessions. Reference [69] found that students use low metacognitive skills during home sessions, while [72] found that monitoring skills are higher in the SRL prompt experimental group than in control. Furthermore, help-seeking, an essential skill in SRL, was found to have positively affected numerous studies [64], [68]–[71], [77]. There is a positive association between help-seeking and peer learning with student learning outcomes [73]. In the aspect of help-seeking [75], the experimental group with SRL-support showed no significant difference from the control group. Reference [76] found that students obtained help from their instructor, peers, and teaching assistants.

Apart from that, in the self-reflection phase, [16] reported a significant positive effect on SRL self-reflection skills in the experimental group compared to the control group. In addition, [4] found that students' self-reflection and self-evaluation skills positively affect their involvement in out-of-class activities, including online study, problem-solving, and social interaction. Another study by [21] revealed that Year 1 and Year 2 medical students have an insignificant difference in their self-reflective skills in learning. Meanwhile, [76] found that students have different understandings of reflection. Some recognize it as a review of their learning and mistakes on an assigned task or exam; only 2 out of 19 students truly reflected on their learning methods. For self-evaluation skills, [68] reported the experimental group obtaining a higher mean than the control group, which contradicts results from [70] and [71] that show insignificant differences in self-evaluation skills between the experimental group and the control group. Meanwhile, [69] found that students engaged in self-evaluation skills moderately during both in-class and home session learning environments.

D. EFFECTS OF SRL IN FC ON ACADEMIC OUTCOMES

This review included studies that focused on the impact of SRL strategies on students enrolled in FC. Both academic and non-academic outcomes were incorporated. According to [78], academic outcomes are achievements explained in curriculum documents and supported by evidence at a system and school level. Non-academic outcomes, on the other hand, compel thought processes and self-reflection, both of which require academic elements to thrive. Self-reflection on academic outcomes may or may not provide an accurate foundation for student learning achievement. Nevertheless,

the process of self-reflection is generally exploited as a pedagogical tool to reinforce student understanding of the learning area and sustain student learning growth. Moreover, both internal and external reflections are essential to the student's development of non-academic outcomes.

In terms of students' achievement in learning, there are several ways to measure students' performance. Reference [4] reported final grades based on formative and summative assessments, including classroom performance, whereas [15] had a 10% contribution from notetaking scores to overall course grades. Meanwhile, [65] had students' efforts to solve exercises in online flipped learning before the face-to-face lecture contributed towards the final course grade. In contrast, [25] had 2% weightage for each weekly exercise that accounted for 20% of the final grade. Likewise, [79] awards 20% of the final grade for reviewing the videos before the in-class lesson (10%) and class participation (10%). Another study by [66] awarded 11% for pre-class tasks and 10% for after-class tasks.

All the reviewed studies reported on non-academic outcomes of SRL strategies, while only 13 studies included academic outcomes in terms of course grade or learning performance. Table 4 shows the factors affecting academic outcomes and their effects in the reviewed studies. Academic outcomes revealed a more positive effect of SRL processes on learning performance, with some reporting an insignificant effect. Several studies found that students who use SRL strategies perform better in school [67], [68], [79], [80]. Reference [74] discovered a significant relationship between frequent access to online flipped content and course grades. Furthermore, [47] found that students who demonstrate greater effort in the subject will view the video, understand the value presented, and subsequently employ metacognitive strategies to enhance their learning.

However, the results from [47] contradict [74], where the frequency of access does not influence course grades. Additionally, [47] found that students' course grades are weakly correlated to effort within the academic behaviour dimension of SRL and did not correlate with any of the flipped perception subscales such as preference, value, or viewing frequency of videos. Similarly, [77] and [81] found no statistical differences in students' learning performance between the experimental and control groups. Apart from that, findings also revealed that high-achievers could engage critically and thoroughly in learning resources through effort regulations and excellent time management techniques. On the contrary, low-achievers were associated with students' displaying inadequate engagement and time management tactics [25], [65], [82]. Nevertheless, [83] specifies that students can self-regulate their learning processes, but their motivation influences the extent to which they exercise SRL.

Most of the studies in this review employed features in the FC to stimulate SRL strategies, which is in accordance with the findings by [15] that affirm the improvement in course grade is a positive influence of SRL features integrated into the learning environments. Given that, [26] used the Flip2Learn system to support SRL processes through sequenced, coordinated, and integrated cognitive activities that positively reinforced SRL abilities. Similarly, [67] and [80] used comprehensive support to foster SRL processes. Additionally, [67] employed scaffolded learning to facilitate pre-class learning (planning phase), in-class (monitoring phase), and after-class (evaluation phase). Meanwhile, [16] used metacognitive support (MS) as a scaffolding technique with FC pedagogical agents, which improved students' SRL strategies in the forethought, self-control, self-observation, and self-reflection dimensions. Apart from this, the embedded SRL prompt in videos is another feature that facilitates active engagement in SRL processes [72], [75], [77], [82]. Using SRL prompts can encourage the importance and use of the SRL processes, enhancing learning through questioning [75]. In contrast, [70] engaged students with an Instant Response System (IRS)-facilitated collective issue-quest strategy in FC. Findings show that students actively engage in SRL strategies on task strategies, environmental structuring, and help-seeking. The most commonly used feature in flipped learning is integrating quizzes into flipped resources to assess content knowledge before in-class learning [25], [65], [68], [69], [74]. In a nutshell, [47] found that students' positive perception of FC is associated with SRL strategies in that learning environment.

TABLE 4. Factors affecting academic outcome and their effects dies Frequency of SRL skills investigated.

Factors	Positive effect	No/Negative effect
Frequency of access to FC materials	There is a significant relationship between frequent access to FC content and course grade [74].	The frequency of access does not influence course grades [47].
SRL features in FC	There is an improvement in learning performance and course grade [15].	
Students demonstrate SRL strategies	Showed improvement in their learning performance [67][68][79][80].	There are no statistical differences in students' learning performance [77][81].
Motivation	Their motivation influences students' ability to demonstrate SRL in learning [83].	Unstructured FC results in low learning motivation, frustration, or even failure [24][26].

Several factors influence learners' engagement in flipped learning resources that affect their SRL skills: the quality of the instructional materials, instructional guidance, and support systems in learning. The quality of instruction in FC influences the outcome of academic achievement [24]. Regrettably, the unstructured FC approach may result in low learning motivation, frustration, or even failure [24], [26]. Moreover, [71] found that self-study using OpenCourseWare integrated with FC resources employed by the control group lacked help-seeking aspects, which made the students less proactive in getting help in learning. Relatively, even diligent students find it challenging to relate less-focused, task-oriented online learning to in-class activities [84]. Failure to embed SRL support well into the learning environment may result in students refusing to comply with the support. Hence, it should be presented thoughtfully as an option [75].

In general, students may resist when FC is initiated as they perceive it to be ineffective compared to traditional methods, thus making little effort to regulate their learning [47]. Moreover, assigning flipped tasks without proper guidance is perceived to be puzzling and challenging [83]. Learning new content through a technology-mediated learning environment is less preferred by students who possess low SRL abilities [24]. Therefore, educators need to develop well-structured guidance that is scaffolded to define activities in the FC model clearly. The flipped activities should correlate and be consistent with the in-class tasks, to facilitate learning goals [47], [85]. Essentially, the instructor has to model and guide students with SRL strategies for their flipped learning environment. Information such as learning goals, schedule for activities, instructions on performing the activities, due dates, obtaining feedback to authenticate participation and performance, and information on seeking timely support from instructors should be specified [85].

Moreover, it is challenging for learners to regulate their own cognitive and meta-cognitive processes through flipped learning. Nevertheless, this can be encouraged through co-regulation that stresses shared learning [21]. According to [24], there are three types of regulation, specifically self-regulation, co-regulation, and shared regulation. Self-regulation is the act of individual students taking responsibility for their learning, while co-regulation supports other team members in regulating their learning processes. In contrast, ''shared regulation'' is a collective action to regulate a team's learning processes that involves purpose, strategic planning and adaptation, monitoring, task performance, and shared reflection. In general, the design principle of FC is to cultivate self-regulation and co-regulation [85]. Furthermore, [86] describes co-regulated learning as a transitional process involving interdependency regulation among individuals, promoting self-regulation to strive independently.

Finally, selecting tasks that contribute to the overall course grade should accurately reflect the understanding of content shared through the FC model [47]. Unfortunately, the reporting of course letter grades as a measure of achievement may not be reliable and accurate. As mentioned by [87], non-academic measures such as participation level, attendance, effort, behaviour, or attitude should not be used to determine the grade. Though these factors may influence students' attainment of content knowledge, they result in complications in interpreting a grade and misrepresenting the true meaning.

E. SRL MEASUREMENT METHODS USED IN FC

Table 5 shows the SRL strategies, measurement tools, and analysis methods used in the reviewed studies. There were mainly three types of data collected from the SRL measurement tools, which are self-report data (n = 30), log data (n = 11), and instructor-report (n = 1). The reflection document, the concurrent think-aloud protocol, the interview, and the self-report questionnaire are options to collect self-report data. Moreover, learning analytics is produced from log data obtained from student logs and traces from Learning Management Systems (LMS) or Personal Learning Environments (PLE). In addition, the study [69] employed instructor-report data using an observation form. Table 6 presents the frequency of SRL measurement methods and examples of SRL strategies measured.

1) SELF-REPORT QUESTIONNAIRE

The self-report questionnaire is the most commonly used method to measure engagement in SRL strategies due to its economic aspects in the implementation, administration, and scoring [50]. Eight studies in this review employed the modified version of the Motivated Strategies for Learning Questionnaire (MSLQ), which was initially developed by [88]. The MSLQ is used to gather information on the motivation for learning (31 items), learning strategies (31 items), and the learner's study habits or resource management (19 items). A total of 81 items were present in the initial version of MSLQ. The motivation scale comprises three components, which are: value (intrinsic goal orientation, extrinsic goal orientation, and task value), expectancy (control of learning beliefs, self-efficacy for learning and performance), and affective (test anxiety). In addition, the learning scale comprises two components that are: (1) cognitive and metacognitive strategies (cognitive and metacognitive strategies: rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation); and (2) resource management strategies (time and study environment, effort regulation, peer learning, and help-seeking) [89].

Another four studies in this review employed a modified version of the Online-Self-regulated Learning Questionnaire (OSLQ) developed by [90]. The original OSLQ is a 24-item scale to assess how the online course delivery facilitates and develops SRL skills. OSLQ measures learners' SRL strategies, which are goal setting (5 items), task strategies (4 items), environmental structuring (4 items), time management (3 items), help-seeking (4 items), and self-evaluation (4 items). Two studies [68], [70] used a 24-item OSLQ, while [48], [71] used a 26-item OSLQ.

Meanwhile, three studies administered the Self-Regulated Online Learning Questionnaire (SOL-Q-R) with seven

constructs, which are: metacognitive activities before learning (4 items), during learning (6 items), after learning (4 items), time management (4 items), environmental structuring (3 items), help-seeking (4 items), and persistence (5 items) [75], [77], [82]. Other self-report questionnaires used were the SRL scale and the Student Learning Strategies Questionnaire (SLSQ). The SRL scale comprises three aspects: forethought, performance (self-control or self-regulation), and self-reflection, which comprises a 59-item scale [16]. Alternatively, the SLSQ, a revised 20-item scale administered to measure participants' engagement in SRL, comprises six constructs: goal setting, strategy planning, self-observation, self-instruction, self-instruction, feedback, and self-evaluation [80].

In general, the self-rating instrument poses an advantage as it promotes personal growth through self-evaluation of interpersonal skills. Nevertheless, higher self-ratings could result from psychological processes such as biasness and motivational influence, which increase an individual's performance assessment. Despite this, limitations in self-rating instruments are insufficient to overrule the benefit of using a self-rating instrument. To overcome this limitation, respondents need to be aware of the significance of their responses to the investigation, and there would be no right or wrong responses. Also, respondents need to be assured of confidentiality to improve the integrity of their responses [91].

2) LEARNING ANALYTICS

Learning analytics (LA) is a methodical approach to measuring, collecting, analysing, and reporting the learner's data or log data generated from various learning environments such as LMS, MOOCs, or PLE. Learning analytics interprets and improves learning and the environment in which it occurs [92]. In this review, 11 studies employed learning analytics, obtaining traces of log data from students' engagement with online learning. Reference [69] collected log data from the online learning platform on videos watched, comments or posts, and online test scores for their study. Results showed that students developed SRL skills such as task strategies through repeated video viewing, time management skills as they completed the assigned task in the stipulated time, and fostering help-seeking by directing their questions to the comment session of the communication channel.

Similarly, three studies collected log data from Edpuzzle PLE and categorized it into relevant SRL strategies [75], [77], [82]. Video timing is the average video watch time; video completion rate reflects strategy planning, time management, and effort regulation, while the rewind action indicates monitoring and self-reflection in learning. The findings by [75] showed no significant effect of the SRL-support condition on students' SRL online activities. Furthermore, [82] grouped students' SRL online activities based on patterns and found five distinct online SRL profiles, which are low-completion (no activity), medium completion (low activity), high completion (medium, high, and very high activity), but with no clear distinguishing SRL behaviours. Findings revealed that students with low completion did not adhere to instructions, showing poor video engagement and effort regulation; medium-completion students failed to complete the assigned video by the deadline, showing insufficient planning; and high-completion students showed monitoring activities and effort regulation, completing videos on time.

Meanwhile, a study by [74] collected log data from Moodle LMS, categorized as (1) activating (i.e. location, day of the week, and time of the day for online learning events); (2) sustaining (i.e. frequency of logging to access online content and entries for viewing modules); and (3) structuring (i.e. regularity based on weekly average logins and quiz review patterns) type SRL behaviours. Results showed that high-achievers regularly accessed the online content, while weaker students displayed a slow learning pace online. Regularity and quiz review patterns have stronger associations with academic achievement. Another study [4] employed behavioural constructs derived from LMS data on cognitive strategies through online learning, social interaction, problem-solving activities, and metacognitive strategies, revealed through self-reflection and self-assessment based on questionnaire and quiz responses. Findings showed a positive effect on quiz and achievement as an effect of involvement in out-of-class problem-solving activities.

Besides that, [65] gathered log data from formative and summative assessments, reading (content access), video actions, and meta-cognitive actions on LMS. Later, the Hidden Markov Models analyse and categorise students' study tactics based on their behavioural patterns. Following this, students are clustered based on the sequence of study tactics. Results showed that students' active learning strategies incorporating SRL skills are positively associated with academic outcomes. Additionally, a recent study [25] collected log data on study time to reveal time management tactics. It was measured by examining the time of a scheduled online task completed, categorised as preparing, revisiting, ahead, or catching up. Following this, students with similar behavioural patterns are grouped by using agglomerative hierarchical clustering. Next, cluster analysis is carried out to identify the sequence in study modes. Findings showed that students who explored various tactics and strategies were active in SRL, specifically greater metacognitive monitoring skills.

In general, trace data reveals the learners' engagement patterns and learning strategies inaccessible in traditional contexts [4]. The data is obtained unobtrusively without interfering with the learning processes [25]. Unlike self-report instruments, LA has a low risk of biasness as the technology-mediated learning environment can capture and store students' learning behaviours [25], [92]. Moreover, the LA approach has been gaining attention among researchers as it allows the measurement of intervention and SRL strategies [92]. Nevertheless, misleading events could occur. For instance, students accessed the resource page, but no engagement in learning occurred. Furthermore, confused students may navigate between resource pages in an online learning

environment; a practice misrepresented as active engagement [4].

Hence, [4] proposed excluding log data with any activity span of fewer than 5 seconds or more than 1 hour. Besides, students' SRL activity is not reflected before, after, or during the video, as the video is paused [77]. Therefore, there is no conclusive evidence to distinguish students' SRL behavioural data. However, the data can be used as preliminary inference in studies [82] and used to improve learning designs as it provides valuable insights to educators on students' behaviours [93].

3) INTERVIEW

The interview serves the purpose of obtaining information on retrospective or prospective behaviour regarding a learner's experiences through face-to-face communication [50]. There are three categories of interview protocols: unstructured, semi-structured, or structured. An unstructured interview is guided by conversation, with questions emerging over time as the interviewer learns about the setting. Meanwhile, a semi-structured interview is carried out with a set of pre-determined open-ended questions, and other questions emerge from the conversations. A structured interview utilizes closed-ended questions with standardized or fixed responses, usually applied in epidemiology and health services [94].

During the interview, the sessions are usually audiotaped and later transcribed. After that, a focused coding strategy is used to analyse the participants' interview responses. Later, the codes were categorized into emerging themes and mapped to SRL learning strategies [21]. The findings obtained found that students used seven SRL strategies in their flipped learning environment, specifically from the planning phase (task analysis and connecting), the monitoring phase (summarize, organize, and apply), and the reflecting phase (self-evaluation and adjustment) [21]. Meanwhile, [69] found that students' SRL strategies from the planning phase (goal setting and planning) and performance phase (environment structuring) were considerably higher in the home sessions, whereas monitoring skills were low. Students were highly engaged in SRL strategies during the in-class learning from the planning phase (goal setting and planning) and performance phase (task strategies and help-seeking). Students also employed SRL strategies involving time management, self-efficacy, and self-evaluation averagely during both pre-class and in-class activities.

Additionally, the study by [71] found that the responses from the interview provided an in-depth understanding of the high score in the aspect of help-seeking for the experimental group compared to the control group. The qualitative data showed that the teaching model with additional channels allowed learners to get clarification through discussion with teacher assistants or peers and motivated them to continue learning. In general, open-ended questions during interview sessions allow participants to elaborate on their responses. However, it depends on students' competencies as well. Furthermore, the interview data collection method is preferred if participants are from higher education, as the participants acquire adequate verbal skills and mature learning strategies. One drawback of the interview is the interviewer's presence, which leads to socially desired responses. Another drawback is the lower participation rate due to protocols that lack anonymity and greater self-exposure [50].

4) THINK-ALOUD PROTOCOL

A study by [72] uses the think-aloud protocol, precisely concurrent think-aloud. The think-aloud technique aims to evaluate strategies used throughout the actual learning process [50]. According to [95], there are two types of think-aloud protocol, namely retrospective and concurrent. Participants perform the task uninterrupted in retrospective think-aloud (RTA) protocols and only later verbalize their thoughts on task performance. In contrast, concurrent think-aloud (CTA) protocols require participants to verbalize their thoughts while executing the learning activity.

Both these protocols have their respective benefits and drawbacks. Firstly, RTA allows participants to perform the task at their own pace, which is unlikely to influence their performance; conversely, CTA allows reactivity within a structured working process, influencing participants' performance [95]. Secondly, the quality and quantity of data obtained from RTA resulted in more verbalization involving task-related and non-task-related (cognitive operations); whereas, CTA participants mostly verbalized on task-related matters [96]. Further, [95] found that CTA may lead to cognitive overload, resulting in fewer verbalizations and subsequently worsening performance. The disruption of thought processes is avoidable if participants express their sequence of thoughts without needing them to describe, explain, or reflect [72].

Despite the more significant benefits of RTA compared to CTA, participants in RTA can be biased and may fabricate the thoughts they have during task performance due to memory decay. Additionally, biasness could arise due to social desirability or self-presentation, as participants conceal, invent, or modify their thoughts. Since participants in the RTA reflect on their task performance after completion, they have a greater opportunity to be biased, even though CTA participants may make similar decisions. The recording of all events during the CTA protocols upholds that participants are unlikely to revise their thoughts than in the unaided RTA methods [95].

5) REFLECTION DOCUMENT

Reference [24] employed a reflective document approach in measuring participants' SRL abilities. The reflective piece reveals participants' involvement in course activities based on the features integrated into their learning, the role and processes involved in the educational technology tool, and their favourable or unfavourable experiences during their learning. The qualitative data obtained were analysed using thematic analysis, where common themes emerged from the

TABLE 5. Summary of SRL strategies and measurement tools used.

No.	Study (Year) [Ref]	SRL strategies	SRL measurement method	Learning environment	Type of data collected	Instrument used to collect data	Analysis method
1	Al Mulhim (2021) [105]	Goal setting, organizing, memory strategy, learning responsibility, environmental structuring, help seeking, self-evaluation	Self-report scale	LMS	Self-report	Academic SRL scale (55 items with 4-point Likert-type scale)	t-test
2	Jung et al. (2021) [67]	Efficacy	Self-report questionnaire	PLE	Self-report	OLE and DE (each has 10 items with 5-point Likert-type scale)	t-test, chi-square test
3	Park & Kim (2021) [79]	Not specified	Self-report questionnaire	LMS	Self-report	MSLQ (12 items with 5-point Likert-type scale)	Descriptive statistics
4	Perez-Sanagustin et al. (2021) [81]	Goal setting, organization, time management, self-monitoring, self-evaluation	Self-report questionnaire	MOOC	Self-report	Open-ended, close-ended and Likert type scale questions	t-test
			Learning analytics		Log data	Learning system logs	Process mining algorithm
5	van Alten et al. (2021) [82]	Metacognitive strategy (before, during, after learning), time management, environmental structuring, help-seeking, persistence	Self-report questionnaire	PLE	Self-report	SOL-Q-R (27 items with 7-point Likert-type scale)	Latent profile analysis, MANOVA, ANOVA
		Goal orientation (intrinsic, extrinsic), self-efficacy, task value	Self-report questionnaire		Self-report	MSLQ (16 items with 7-point Likert-type scale)	
		Forethought, performance and self-reflection phases	Learning analytics		Log data	Learning system logs	
6	Yoon et al. (2021) [80]	Goal setting, strategy planning, self-observation, self-instruction, feedback, self-evaluation	Self-report questionnaire	LMS	Self-report	SLSQ (20 items with 5-point Likert-type scale)	ANCOVA
7	Ahmad Uzir et al. (2020) [25]	Time management	Learning analytics	LMS	Log data	Learning system logs	Cluster analysis and process mining (using first-order Markov models, FOMM)
8	Saint (2020) [93]	Goal setting, strategic planning, task strategies, self-evaluation, self-reflection	Learning analytics	LMS	Log data	Learning system logs	Microlevel process analysis, process mining algorithm
9	van Alten et al. (2020) [77]	Metacognitive strategy (before, during, after learning), time management, environmental structuring, help-seeking, persistence	Self-report questionnaire	PLE	Self-report	SOL-Q-R (42 items with 7-point Likert-type scale)	MANCOVA, ANCOVA, MANOVA, ANOVA
		Goal orientation (intrinsic, extrinsic), self-efficacy, task value	Self-report questionnaire		Self-report	MSLQ (22 items with 7-point Likert-type scale)	
		Forethought, performance and self-reflection phases	Learning analytics		Log data	Learning system logs	

TABLE 5. *(Continued.)* **Summary of SRL strategies and measurement tools used.**

No.	Study (Year) [Ref]	SRL strategies	SRL measurement method	Learning environment	Type of data collected	Instrument used to collect data	Analysis method
10	van Alten et al. (2020) [75]	Metacognitive strategy (before, during, after learning), time management, environmental structuring, help-seeking, persistence	Self-report questionnaire	PLE	Self-report	SOL-Q-R (30 items with 7-point Likert-type scale)	MANCOVA, ANCOVA, MANOVA, ANOVA
		Goal orientation (intrinsic, extrinsic), self-efficacy, task value	Self-report questionnaire		Self-report	MSLQ (16 items with 7-point Likert-type scale)	
		Forethought, performance and self-reflection phases	Learning analytics		Log data	Learning system logs	
11	Zarouk et al. (2020) [64]	Metacognitive, time management, environment structuring, regulation persistence, help seeking	Self-report questionnaire	LMS	Self-report	SRPBL (47 items) adapted from MSLQ and OSLQ	t-test, ANOVA
12	Zheng & Zhang (2020) [73]	Cognitive strategies (rehearsal, elaboration, organization, critical thinking), meta-cognition, resource management (time management, effort regulation, peer learning, help-seeking), self-efficacy	Self-report questionnaire	Not specified	Self-report	MSLQ (56 items with 7-point Likert-type scale)	Regression analysis
13	Zheng et al. (2020) [21]	Task analysis, connecting, summarizing, organizing, applying, self-evaluation, adjustment	Semi-structured interview protocol	PLE	Self-report	Audio recordings	Content analysis
14	Jdaitawi (2019) [100]	Not specified	Self-report questionnaire	LMS	Self-report	LASSI (32 items with 5-point Likert-type scale)	Mean, standard deviation, ANOVA
15	Montgomery et al. (2019) [74]	Time management, environmental structuring, effort regulation	Learning analytics	LMS	Log data	Learning system logs	Spearman Rho correlation
16	Wang & Zhu (2019) [83]	SRL (not specified), self-efficacy	Self-report questionnaire	MOOC	Self-report	Questionnaire (13 items with 5-point Likert-type scale)	t-test
17	Wang (2019) [4]	Self-reflection, self- assessment	Learning analytics	Moodle LMS	Log data	Learning system logs	t-test, regression analysis
18	Zhang (2019) [76]	Goal setting, time management, strategy planning, environmental structuring, help-seeking, reflection	Self-report questionnaire	PLE	Self-report	Open-ended questions	Thematic analysis
19	Chen & Hwang (2018) [70]	Goal setting, environment structuring, task strategy, time management, help-seeking, self-evaluation	Self-report questionnaire	PLE	Self-report	OSLQ (24 items with 7-point Likert-type scale)	ANCOVA
20	Fincham et al. (2018) [65]	SRL (not specified)	Learning analytics	LMS	Log data	Learning system logs	MANOVA, ANOVA, chi-square
21	Ng (2018) [27]	Motivational beliefs and self-esteem, self-control, self-assessment, help-seeking	Self-report questionnaire	PLE	Self-report	Not specified	Mean, standard deviation

TABLE 5. *(Continued.)* **Summary of SRL strategies and measurement tools used.**

No.	Study (Year) [Ref]	SRL strategies	SRL measurement method	Learning environment	Type of data collected	Instrument used to collect data	Analysis method
22	Shih et al. (2018) [48]	Environment structuring, goal setting, task strategies, help-seeking, time management, self-evaluation	Self-report questionnaire	Not specified	Self-report	OSLQ (26 items with 5-point Likert-type scale)	Pearson correlational
23	Shyr & Chen (2018) [26]	Self-control, metacognition (goal setting, task analysis, monitoring-self-testing and questioning, regulating)	Self-report questionnaire	PLE	Self-report	MSLQ (12 items with 5-point Likert-type scale)	Mean, standard deviation
24	Sun et al. (2018) [66]	Self-efficacy, help-seeking, environmental structuring, metacognitive strategy	Self-report questionnaire	LMS	Self-report	MSLQ (23 items with 7-point Likert-type scale)	ANOVA, SEM
25	Blau & Shamir-Inbal (2017) [24]	Not specified	Reflection document	PLE	Self-report	Not specified	Thematic analysis
26	Çakiroğlu & Öztürk (2017) [69]	Goal setting and planning, task strategies, monitoring, Environment structuring, time management, help-seeking, self-efficacy, self-evaluation	Observation	PLE	Instructor - report	Observation form	Frequency
			Interview		Self-report	Interview form	
			Learning analytics		Log data	Learning system logs	
27	Sletten (2017) [47]	Study strategies, metacognition, self-talk, interest enhancement, environmental structuring; self-consequence, effort regulation, help-seeking	Self-report questionnaire	PLE	Self-report	MSLQ (52 items with 7-point Likert-type scale)	Pearson correlational, regression analysis
28	Sun et al. (2017) [71]	Goal setting, choice of learning environment, learning strategy, time management, help-seeking, self-evaluation	Self-report questionnaire	PLE	Self-report	OSLQ (26 items with 6-point Likert-type scale)	ANCOVA
29	Yılmaz et al. (2017) [16]	SRL: Forethought, Self-control, Self-observation, Self-reflection	Self-report questionnaire	LMS	Self-report	SRL scale (59 items with 10-point Likert-type scale)	ANCOVA
30	Butzler (2016) [15]	Not specified	Self-report questionnaire	PLE	Self-report	Not specified	t-test
31	Lai & Hwang (2016) [68]	Goal setting, time management, self-evaluation, environment structuring, task strategies, help-seeking, self-efficacy	Self-report questionnaire	PLE	Self-report	OSLQ (24 items with 5-point Likert-type scale)	ANCOVA
32	Moos & Bonde (2015) [72]	Planning, monitoring, strategy use	Concurrent think-aloud protocol	PLE	Self-report	Audio and video recordings	Content analysis, Pearson correlation

TABLE 6. Frequency of SRL measurement method.

SRL measurement method	Frequency	SRL strategies
Self-report questionnaire	26	SRL skills: Forethought (task analysis, self-motivation beliefs), Performance (self-control, self-observation), Self-reflection [16]
Learning analytics	11	Goal setting, strategic planning, task strategies [93]; Time management [25] [74]; Environmental structuring, effort regulation [74]; Self-reflection and self-assessment [4] [93]
Interview	2	Goal setting and planning, task strategies, monitoring, environment structuring, time management, help-seeking, self-efficacy, self-evaluation [69]
Concurrent think-aloud protocol	1	Planning, monitoring, strategy use [72]
Reflection document	1	Not specified [24]
Observation form	1	Goal setting and planning, task strategies, monitoring, environment structuring, time management, help-seeking, self-efficacy, self-evaluation [69]

types of responses obtained from the participants. Participants' reflections on the course components and learning processes obtained a positive reaction as stated by a student's response in [24, p.75] — "A significant part of all course assignments was ongoing self-evaluation and reflection. This encouraged metacognitive thinking, as well as monitoring learning strategies and collaborative work". According to [97], reflective thinking is a process of making informed and logical decisions on educational subjects, followed by assessing the outcomes of the decisions that result in true, purposeful, and meaningful learning. Nonetheless, this is not a spontaneous activity and requires time and effort to reflect. Regardless of the limitations, this practice cultivates self-awareness and control towards learning, which initiates positive growth.

6) OBSERVATION

According to [98], an observer uses an observation form to observe and record any emergent actions and interactions. Usually, the observer positions himself closer to the participants without being disruptive to the participant's task performance to witness any SRL behaviours. A study by [69] used an observation form to address participants' behaviours, perspectives, and interactions as either positive or negative. Additionally, the frequency of the respective SRL behaviours and their durations were computed and classified. A score of between "0 to 60" is considered low, between "60 to 85" is considered medium, and "above 85" is considered high. Furthermore, the observation data gathered is linked with the interview data and used for elaboration.

F. THE DIRECTION OF FUTURE STUDIES

The authors of the reviewed articles made several recommendations for future study, as displayed in Table 7. In regards to sample size, several studies proposed using a larger sample size compared to those engaged in their studies [67], [68], [70], [82], [83]. According to [99], small sample size is not viable for generalizability, while a large sample may magnify the difference in effect, which is objectively irrelevant. For methodological reasons, a sample size calculation such as Pocock's formula for continuous variables can be used, and studies without any calculation should be read and interpreted cautiously.

Another suggestion was to increase the duration of study as proposed by a few studies since they engaged in a duration of study between 4 to 6 weeks [68], [70], [83], [100]. According to [101], a duration of at least eight weeks for flipped learning is considered a positive situation to interact meaningfully with the learning environment in experimental studies. Future research should consider samples from diverse populations [75], such as different demographics [74], disciplines [66], [69], [100], or academic culture [79], [83]. According to [102], students with different backgrounds have distinct characteristics and preferences in learning. Likewise, [103] reported that students' different demographic variables have different effects on their learning. Aside from that, broadening the scope of the study, which includes adding more sections or topics, allows for more data to be gathered and validates the instructional approach to learning [15], [27].

Apart from that, a few studies have proposed ways to improve the nature of task design, such as using prompts [72], scaffolds [70], and considering the different task involvement loads [26] on how students may regulate their learning. The scaffolding technique can stimulate students' participation during in-class learning tasks such as discussion [70]. Furthermore, scaffolds with a prompting approach can better understand their effects on the various SRL phases, such as forethought, performance, or self-reflection, because the phases interact actively and cyclically [72]. Indeed, the involvement of Cognitive Load Theory needs to be investigated as students manage their cognitive load through the varied activities part of FC to improve learning [104].

Most of the studies suggested future research to explore integrating multiple data collection methods [27], [48], [65], [66], [70], [74]. Qualitative data must be collected to add richness and gain a deeper understanding of the factors that persuaded students' intentional behaviours in an FC environment [27], [48]. The data collected can also address the interconnection between pre-class and in-class activities in the FC model and the potential influence on SRL [74]. Individual interviews, focus group interviews, open-ended questionnaires, or teachers' observations can be conducted to identify the association between both activities [27], [74].

Besides, real-time learning processes can be captured using SRL microanalysis measures. This approach comprises a structured interview protocol administered immediately

TABLE 7. Summary of recommended future studies.

Themes	Recommendation of future studies	Study (Year)
Sample size	Use of large samples	van Alten et al. (2021) Jung et al. (2021) Wang & Zhu (2019) Chen & Hwang (2018) Lai & Hwang (2016)
Duration of study	Increase duration of the study	Jdaitawi (2019) Wang & Zhu (2019) Chen & Hwang (2018) Lai & Hwang (2016)
Type of participants	Samples from different disciplines	van Alten et al. (2021) Jdaitawi (2019) Sun et al. (2018) Çakiroğlu & Öztürk (2017)
	Sample from different academic culture	Park & Kim (2021) Wang & Zhu (2019)
	Sample from different demographics	Montgomery et al. (2019)
Content of study	More sections/topics to collect more data	Ng (2018) Butzler (2016)
	Multiple sessions of FC	Jung et al. (2021)
Nature of task design	Use scaffolding techniques for in-class learning tasks	Chen & Hwang (2018)
	Investigate different learning approaches	Shyr & Chen (2018)
	Examine the types of pre-class activities that are most effective in preparing students for in-class learning	Butzler (2016)
Data collection methods	Use qualitative methods to obtain in-depth information	Montgomery et al. (2019) Chen & Hwang (2018) Ng (2018) Shih et al. (2018)
	Use SRL microanalysis	Zheng & Zhang (2020)
	Conduct multimodal study	Fincham et al. (2018)
	Use multiple data sources	Sun et al. (2018)
	Use of learning analytics	Yılmaz et al. (2017)
	Use standardized assessment in a pre-test/post-test format	Butzler (2016)
Specific study areas	Effect of learning styles (i.e. field-dependency, independency, ambiguity tolerance, reflexivity, impulsivity) on SRL and learning retention.	Al Mulhim (2021)
	Examine students' experiences in FC in terms of collaboration, motivation, and teachers' knowledge.	Park & Kim (2021)
	Examine students' motivation for course engagement and academic achievement.	Perez-Sanagustin et al. (2021)
	Examine SRL behaviour to guide the design of SRL support.	van Alten et al. (2021)
	Provision of prolonged feedback on non-academic outcomes.	Ahmad Uzir et al. (2020)
	Factor that affects time management among active and passive procrastinators.	Ahmad Uzir et al. (2020)
	Examine the changes in students' SRL strategies during their FC learning.	Zheng & Zhang (2020)
	Factors that affect students' SRL strategy use.	Zheng & Zhang (2020)
	In what ways are SRL strategies tied to behavioural indicators in the FC model?	Wang (2019)
	In what way are contextual elements tied to behavioural engagement?	Wang (2019)
	How does behavioural engagement vary across tasks, contexts, and time?	Wang (2019)
	How is behavioural engagement in pre-class learning related to achievement?	Wang (2019)
	Analyse intra-tactic transitions and transition graphs relating to different learning strategies.	Fincham et al. (2018)
	Teachers' experience with FC and their perspectives on SRL implementation in FC.	Shyr & Chen (2018)
	How do different levels of task involvement load influence participation and engagement?	Shyr & Chen (2018)
	Investigate the degree to which long-term knowledge retention varies when using FC with SRL versus lecture.	Shyr & Chen (2018)
	Use the re-designed model, which is proposed in various courses.	Blau & Shamir-Inbal (2017)
	Investigate SRL monitoring skills in FC.	Çakiroğlu & Öztürk (2017)
	Investigate course perceptions and their impacts on achievement, mediated through SRL strategies.	Sletten (2017)
	How do community interactions facilitate SRL?	Sun et al. (2017)
	Examine the relationship between SRL phases and learning with videos.	Moos & Bonde (2016)
	The potential effect of prompting a single SRL phase in FC.	Moos & Bonde (2016)

before, during, and after a specific learning task, with a simultaneous think-aloud protocol requiring students to voice their thinking processes as they progress through the task [73]. Another approach involves using multimodal studies, which incorporate data obtained from think-aloud protocols, student-written reports, or self-reports to understand better students' engagement with SRL strategies [65]. Moreover, learning analytics of the learning environment [16] or collecting eye-tracking data can be performed to record student learning paths [73], adding depth to understanding learners' interaction processes in learning.

Several studies also suggested specific study areas based on their respective research findings, as listed in Table 7. A few studies specifically proposed future research on SRL aspects, such as time management [25], metacognitive control [25], and monitoring [25], [69]. One suggestion was that feedback is provided during the midst of a task or learning progression, for example, weekly for the first half of a semester, and how would students adapt to the aspect of metacognition control and monitoring their learning? On the other hand, future studies can also investigate the provision of prolonged feedback on students' non-academic outcomes. Additionally, future studies can identify active and passive procrastinators and how these students adjust their time management skills with feedback through personalized analytics. It should be noted that active procrastinators possess high confidence in their ability to manage time and choose to delay the completion of learning activities intentionally, as they balance all their other pending tasks. In comparison, passive procrastinators are incapable of making proper decisions promptly while recognizing the unfavourable outcome of their learning, which eventually leads to guiltiness and depression [25].

Moreover, some studies have highlighted certain subjects that are noteworthy. For instance, [15] suggested using standardized assessments such as the assessment from the American Chemical Society in a pre-test/post-test format that contributes to the overall course grade in studies, as grading can vary depending on course structure. Another suggestion by [4] was to investigate contextual elements such as teachers' efforts to promote students' autonomous learning or tasks' features that are suitable to prompt behaviour in students. Reference [82] suggested that students' SRL behaviours can guide the design of SRL support for future studies. Furthermore, the Partial Least Squares Structural Equation Modelling (PLS-SEM) method employed in this study can be adapted to work with the Experience Sampling Method (ESM) to analyse students' learning patterns. Likewise, [47] suggested using structural-equation modelling to understand students' perception of academic achievement, mediated through SRL strategies. The re-designed model emphasizes co-creation of course content, incorporating SRL strategies into out-of-class and in-class learning, and teamwork co-regulation to study in different courses [24].

Despite this, it is important to note that good quality flipped resources should incorporate essential characteristics as manifested in the four pillars of flipped learning (F-L-I-P), which are (1) flexible environment, (2) learning culture, (3) intentional content, and (4) professional educator [2]. Failure to incorporate all dimensions of the pillar indicates poor planning of a flipped learning environment, which may contribute to an unfavourable outcome. The first pillar on flexible environments underlines spaces and time frames that permit students to interact and reflect on their learning, provide feedback, adjust instructional processes, and achieve the learning outcome. The second pillar of learning culture emphasizes the need to embrace student-centred learning with scaffolded activities that allow students to control their learning independently. The third pillar on intentional content prioritizes concepts through flipped learning, prepares relevant content, usually videos, and differentiates learning approaches. Finally, the last pillar is the professional educator, which stresses the educator's role to provide real-time feedback, continuous evaluation of students' learning, and making reflections to improve practices [2].

IV. CONCLUSION AND IMPLICATIONS

In conclusion, this systematic empirical review provides an overview and analysis of SRL in FC from recent studies. RQ1 shows that quantitative research is the most commonly employed method in the reviewed studies. The most frequently used pre-class resources are videos, and collaborative group work is the preferred in-class activity. Meanwhile, findings on RQ2 show that task strategies, time management, help-seeking, environmental structuring, and self-evaluation are the frequently measured SRL skills. Although the findings on RQ3 generally revealed more positive effects of SRL processes on learning performance, few studies reported insignificant effects of FC on students' learning. These could result from a less appropriately structured flipped learning environment and poor interconnection with the in-class learning activities. Hence, instructors should instigate the SRL strategies among students through modelling and well-structured instructions or guidance and promote co-regulation.

Our finding on RQ4 demonstrated various methods for measuring SRL in FC, including observation, reflective documents, think-aloud protocol (RTA or CTA), interviews (unstructured, semi-structured, or structured), self-report questionnaires, and learning analytics. The most frequently used SRL measurement method is self-report questionnaires. Recent studies have uncovered students' SRL strategies from log data on online learning environments. The learning analytics presented from log data enriches our understanding of students' learning through the technology-mediated learning environment. Offline and in-person learning activities, on the other hand, cannot be recorded. Hence, a few integrated SRL measurement techniques can be implemented to obtain diverse data that can be used to better comprehend learners' SRL behaviours. Moreover, the findings propose the collection of qualitative data in addition to quantitative data to capture the learner's involvement and circumstances that

influenced learners' intentional behaviours in a flipped learning environment, further adding richness to the quantitative information.

Subsequently, the finding (RQ5) indicates numerous focus areas for future studies as proposed in the reviewed articles. Based on the reviewed articles, the lack of attention paid to the four pillars of flipped learning, which are (1) flexible environment, (2) learning culture, (3) intentional content, and (4) professional educator, as aimed by [2] in recommendations for future studies, is an exceptional detail. Therefore, it is recommended for future studies to use the indicators that underline the essential characteristics of the flipped learning environment to warrant effective integration of FC in learning. Efforts should also focus on the different flipped learning models and their influence on learners' SRL. Additionally, future studies should consider reviewing the different SRL models employed in the flipped learning environment.

Our study focused on 32 high-impact articles due to the rigour of the inclusion criteria. Nevertheless, the analysis provides comprehensive and notable findings on SRL strategies associated with FC and their selected measurement methods. Ultimately, this study fills the gap between current literature in FC and SRL in the education field by using the SRL cyclical phases model to outline the SRL strategies engaged in the reviewed studies. Apart from that, the findings and suggestions provide a roadmap for researchers, educators, and curriculum developers to improve the nature of instruction or guidance that supports students' development of SRL skills.

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