



Past and Present of Self-Regulated Learning (SRL) in Digital Learning Environment (DLE): A Meta-Empirical Review

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Abstract

Taking into consideration all the work that has been done in the field of regulating the learning processes that happen in one's own mind, there arises a thirst to review all the existing models of self-regulated learning that have been discovered and implemented until now. A considerable number of researchers and their research have long recognized the potential and benefits of the instructional tools available in digital learning environments (DLEs) which are particularly helpful for learners to develop self-regulated learning (SRL) behaviors. This has led to the discussion of a comprehensive analysis and zooming in to novel features in sheer volume of available literature, which is covered in this paper. A comprehensive analysis over models in chronological order is conducted under following aspects: model evaluation, measuring instruments for learning strategy and supported empirical results. Accumulating all this knowledge into this paper will rather be beneficial to researchers as they will obtain the required theoretical insights gained from the provided meta-analytic evidence. This will enable those people who work with digital learning environments to think about and explicitly take note of the degree to which learners have gained this novel capacity of self-learning.

Keywords: Self-regulated learning models; Instruments and measuring tools of self-regulated learning; Phases of self-regulated learning; Learning strategies; Instructional technology; Metacognition; Self-efficacy; Self-evaluation

Introduction

Mobile Self-regulated learning (SRL) is a process that is ongoing in nature, one that is not easy to be depicted as a frozen snapshot in time [1]. There are many aspects of learning such as behavioral, cognitive, metacognitive, emotional/affective and motivational that makes up the basis of self-regulated learning. Looking through the lens of the term 'metacognition', one has to understand that it is a process of monitoring the effectiveness of strategies used while satisfying task requirements to achieve the desired outcome after the cyclic process of understanding and developing a plan for a required task [2].

1960s was the era that first brought us the term self-regulation (i.e., actions collectively used to push towards an intended goal) through

various educational literatures. 1980s saw the concept of self-regulated learning (SRL) emerge in the domain of education which became prominent in 1990s.

Cognitive strategies such as motivational, rehearsal, elaboration, organization, emotional and metacognition under a core conceptual framework are theoretically self-regulated learning. An effective means of promoting SRL through digital technology is through its instructional applications [3,4]. "The limits of space and time have been banished by e-learning systems giving learners the power to perform self-directed learning making it the main advantage of e-learning", says Wang in his paper [5]. This could be viewed as fortunate because, the increase of human autonomy in today's world, pushes "online learners to possess a higher responsibility to take control and manage their academic progress on their own".

Over the last three decades, SRL has played an important role understanding the learning psychology of students, with empirical facts; hence this field has become a highly focused research area in educational psychology.

Since the early papers in 1986 wherein which, SRL and metacognition were being distinguished by researchers, major contribution has been made by SRL towards educational psychology [6,7]. The field of SRL has been conceptually developing ever since, through the increase and expansion of publications, now there are several models of SRL that are available [8]. Boekaerts, Borkowski, Pintrich, Winne, and Zimmerman, published a theoretical review in 2001, which described the most relevant models of that time and Efklides, Hadwin and Zimmerman published another theoretical review in 2017, which describe the evaluation in models and current existing models of SRL [9].

This field has developed significantly since the year 2001.

The current existence of three meta-analyses of the effects of SRL poses like a first sign of this evolution [10-12].

Secondly, there has been an introduction of many new SRL models in the field of educational psychology, many of which did not exist back in 2001 [13,14].

Lastly, there exists a new handbook that encompasses multiple SRL evaluation methods that are well established. The maturity and evolution of this field is seen in the absence of sections dedicated to presenting new models focused on only some specifics of SRL (e.g., instructional issues, basic domains, methodological issues), in the recent handbook, compared to the previous one [10].

Therefore, this is the time, to reexamine what is known based on the development germane to SRL models by conducting a comparative study on them and extracting theoretical and practical implications that can be gained.

Thus, the aim of this review is to investigate, examine and compare the various SRL models that exist today.

Methods of Paper Selection and Inclusion Criteria

Inclusion criteria

Included within this review are SRL models that have a consolidated theoretical and empirical background. To select a model it is selected under the following criteria.

Primarily shift

Relevance: Does the paper under consideration include proper 'boundary spanning' for the SRL model conducted by individuals or groups in SRL environments?

Specificity: What are the processes followed for the vertical and horizontal integration of services facilitated to improve learner self-regulation within the spanned boundary?

Reputation: The paper should have appeared in SRL handbooks or a reputed journal, with a good number of minimum cites making it well peer-reviewed.

Secondary shift

Depth: How far does the paper go beyond superficial descriptions and commentary? To what extent is it empirical? Can it be categorized as an enquiry, research, a study or an investigation that properly describes the boundary spanner's role considering the vertical and horizontal integration of services?

Utility: What potential does the paper provide for enhancing the link between the theoretical and practical implications?

Paper selection procedure

The first step taken was to analyze the models that were included in the review of 2001 and contrast those that have been used actively with those that didn't make it to regular usage. The widely used models that were included are those by Boekaerts, Winne, and Zimmerman who are also active SRL scholars whose work is published in the latest handbook of 2011. Further consideration however leads towards two models from the 2001 review, the ones of Pintrich and Borkowski. Even though it was really unfortunate that Pintrich wasn't able to develop his work further [15-17], his models and his work on the Motivated Strategies for Learning Questionnaire (MSLQ) [18], are widely used in current research [19]. A strong basis in metacognition was shown in the model by Borkowsky [20], but the current research in the field of SRL doesn't have much of a presence of this model, the main author also digressed his focus of interest towards "exceptionality" (e.g., learning disabilities). Hence this review has this model excluded.

The next step was to consider newer models of SRL following which two actions were taken. The first was performing a literature search in many online research libraries such as 'Resources for Psychology', 'JSTOR', etc. using the keywords "self-regulated learning model". Further we consider a current review paper of SRL models which covered six SRL models working in education environment. By further proving with that and few new models were identified after reviewing these searches. Our understanding of SRL is broadened by the exploration of how motivation and emotion interact with metacognition with a different top-down/bottom-up processing presented by Efklides' (2011) model compared to Boekaerts' model. An emerging line of research within the field of SRL is "the social aspects of the regulation of learning", mentioned in Hadwin et al. model [21].

An upgraded research by Michelle et al. [22] model provides for an intervention of the learner within the SRL environment, where the concept of task selection by the learner at the completion of a defined task has been addressed. SRL models used to provide analyses of task aspects and problem-solving strategies for specific tasks by including interactions between monitoring processes and controlling actions

[23-30] before this model. In one of the phases of Winne and Hadwin planning for future learning has also been discussed. Even though, these models do not focus specifically on selection of tasks, Nugteren et al. SDL (self-directed learning) models focus more on students choosing their own goals, which provide for the future aspects of SRL research, which is why it has been excluded from this review.

To sum up, the models from Zimmerman, Boekaerts, Winne, Pintrich, Efklides, and Hadwin, Jarvela, and Miller will be analyzed with new sources or lens based on the research areas of recent years. Additionally, one new model of Nugteren et al. - will be introduced and compared to the more established models. In the next section, the evaluation of models is discussed in chronological order to provide clearer understanding to the learners.

Chronological review of models of self-regulated learning

There exist various theories and models that explain how self-regulated learning (SRL) works. All these theories share the common ground of self-regulation being composed of different processes (e.g., monitoring, task setting, controlling, behavior, emotions and motivating etc.). They are cyclic also, meaning that feedback is provided by each performance of a task to develop strategies to be used in future tasks.

Zimmerman: A social cognitive perspective of SRL models

When we talk about the field of SRL Zimmerman is one of the pioneers who initiated most of the initial work. His exploration was directed towards the variety of specific sub processes that students have been using in academics for self-regulation, such as those involved in metacognition, instructional context management, self-verbalization and socialization. He started his work with cognitive modeling research which influenced SRL with good empirical evidence [29-36].

His understanding of this field has led to the conclusion that self-regulated learning theories have a really good potential for guiding research on students' study patterns leading to making students more self-reliant and effective learners [29].

Furthering his work on SRL, Zimmerman developed three models. Starting with cognitive modeling, he moved on to an exploration of knowledge and skills acquired by an individual learner. In his initial triadic analysis of the self-regulated functioning model, he divided SRL into three classes of strategies to influence the person (self) - process namely, environment, behavior, and the covert processes on the self [35]. Various empirical sources including interviews and interactions with experts have aided his research to identify the most effective processes and arrive at solutions to the interrelation and cyclic sustainability of the processes of SRL. Further on, his work gained focus on the individual learner's metacognition and motivation leading to the creation of a cyclic model of SRL. In his next move, he was highly interested to explore the aspects of metacognition and motivation in the development of SRL, hence he modified the performance phase by giving it a new base of volitional and metacognitive strategies. It has also been noted that motivational beliefs have an influence on active learning strategies. Metacognition on the other hand upgrades the same phase with a number of self-control strategies and keeps the learner cognitively engaged to finish the task. In the self-reflection phase of the same model, the learners assess their performance and formulate attributes about their own success or failure. These attributes may help to generate self-reaction by a learner which can positively or negatively influence their learning

approach. For all his empirical work in field of self-regulating learning he received the Thorndike career achievement award by American psychological association's division of education psychology. The Table

1 in Annexure-1 condenses all important pieces of Zimmerman's research comprising the focused area, empirical facts and testing tools in a chronological fashion for the better understanding of the reader.

Model name	Supporting hands	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
Tradic Analysis of SRL	Albert Bandura, Ted L. Rosenthal	1989	Cognitive Modeling	(1) Environment, Behavior, (2) Person self	1. Kitsantas (1997)[73] – 90 high school girls dart throwing skills analysis. 2. Kitsantas (1999)[74] – 84 High school girls writing skills practice analysis.	Hypothesis test using Regulated Learning Interview Schedule (SRLIS) and Academic Self-Regulation Scale (A-SRL)
Cyclic process of SRL	Campillo	2000	Individual learner acquire, Interrelate metacognition and motivational	(1) Forethought, Performance, (2) Self Reflection (3)	1. Cleary (2001)[16]–43 Adolescent boys examine in basketball practice to predict novice, experts, non-expert. 2. Kitsantas (2002)[35]-College women examine in volleyball practice to predict expert and non-expert. 3. Cleary et.al, (2006)[17]–50 college students trained and examine in basketball practice. 4. DiBenedetto (2010)[19]- 51 high school students examine during science course.	Hypothesis test and Chi-Square test using Self-Regulated Learning Interview Schedule (SRLIS) and Academic Self-Regulation Scale (A-SRL)
Multi leveled Model	Moylan	2009	Metacognitive and volitional strategies	(1) Forethought, Performance/Volitional control, (2) Self-reflection (3)	1. Moylan AR et. al (2011)[75]- 496 technical students examine in practice math problems.	Motivated Strategies for Learning Questionnaire (MSLQ) and Learning and Study Strategies Inventory (LASSI) quizzes and hypothesis test

Table 1: Chronological evaluation of SRL model presented by Zimmerman.

Boekaerts

A motivation, emotion metacognition perspective learning SRL model of adaptable learning Boekarts is also an early author in the field of SRL and her work can be traced back to the 1980's [37]. Her focus was on the role of cognitive function that shows that there is no strong link between learners that score high grades and those that have high motivation and commitment. She proposed her first psychological framework of increasing knowledge and skills linked with cognitive functions of positive and negative emotions. While exploring the diverse psychological framework of motivation, emotion, metacognition and learning, she initially developed an adaptive learning model [38-41] that helped to build a theoretical scaffold to quantify her findings.

She was the first to evaluate motivation through the use of self-regulation and emotion regulation with different situation specific measures in SRL. In her adaptive learning model she integrates and extends the fragmented research by describing two parallel processing domains: a) A mastery domain, that includes learning, motivation and anxiety; b) A coping domain that includes stress and action control. After a long break, further advancements with the notations on the goal path of top-down and bottom- up theories were made to the model in 2000. An extended version this model was later named 'Dual processing self-regulation model' which had clear and defined

theoretical insights [41-43]. This extended version points to the purposes of self-regulation, which are: a) broadening one's domain specific knowledge and skills; b) Shielding the commitment towards an activity; c) Avoiding threats to the self; with emphasis on the positive and negative emotions as a key role in SRL.

Her other model that she developed, divides SRL into six components, which are domain specific knowledge and skills, cognitive strategies, cognitive self-regulatory strategies, motivation strategies, motivational self-regulatory strategies. She considered two basic mechanisms in this model: cognitive and motivational / affective self-regulation. The main use of this model is to: a) gain more insights into domain specific components of SRL; b) train teachers; c) construct new measuring instruments for further research in SRL. According to her there are three different purposes of self regulation: a) The 'top-down' approach which is driven by the learner's individual needs and goals by his level of mastery/growth-path; b) The 'bottom-up' approach that looks over the protection of the self by his level of well-being pathway; c) When the learner tries to switch their strategy from well-being to mastery pathway [8]. The Table 2 in Annexure-1 below condenses all important pieces of Boekaert's research comprising the focused area, empirical facts and testing tools in a chronological fashion for the better understanding of the reader.

Model name	Supporting hands	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
Adaptable Learning	-	1991	Motivation, emotion, metacognition, self-concept, and learning	(1) Task Demands (2) Competence (3) Traits & Self-concept (4) Appraisals	1. S.E. VOLET (1994)-92 undergraduates enrolled in a 1st year Foundation course at a Western Australian University, study the student nature with parameters like direction of their goals, their effort or commitment to achieve their goals.	On-line Motivation Questionnaire (OMQ) and Grade Point Average
Structural model or six-component model of SRL	-	1996	Goals orientation, Situation specific measures	(1) Domain-specific Knowledge/ skills (2) Cognitive Strategies (3) Cognitive Self-regulatory Strategies (4) Motivational beliefs and theory of mind (5) Motivation Strategies (6) Motivational self-regulatory strategies	1. Vermeer et.al. (20S01) [55]-158 sixth std. students mathematical problem-solving behavior analysis with 2 mathematical tasks-computations and applications	On-line Motivation Questionnaire (OMQ) and trait measure of Fear of Failure, Hypothesis test using Cognitive and Motivational variables
Dual Processing self-regulation model	Boekaerts and Corno, 2005; Boekaerts and Cascallar, 2006	2006	Advanced version adaptable learning model	(1) Task-in-Context (2) Meta-cognitive strategy use (3) Motivational beliefs (4) Appraisal (5) Assessment	1. Rachel L. Gunn and Peter R. Finn (2016)[29]-86 undergraduate students at a large Midwestern university to examine executive working memory capacity, negative urgency, and negative mood	Explored the influence of positive and negative emotions variables during a task Neural Network Methodology (family of statistical learning models inspired by the central nervous systems)

Table 2: Chronological evaluation of SRL model presented by Boekaerts.

Winne and Hadwin

A metacognitive guided behavior enabling SRL model. Winne and Hadwin strongly lay the basis of strategies and tactics of metacognition in SRL. During their time of research they had very few resources for their reference and they found a lot of differences among individuals while using previous models. Hence they went on to create a sophisticated metacognitive model with a focus on individual differences. Their models are vastly used in research of implementing computer supported learning. Working on further advancements, Winne and Hadwin proposed a new model that conceptualizes the fusion of processed information with the function of information processing itself. They named this model the 'information processing theory' (IPT) that explores the cognitive and metacognitive aspects of SRL. They divided the process of SRL into four phases while hypothesizing that each phase contains an IPT-influenced set of processes. The four phases are: a) Task definition; b) Goal setting and planning; c) Enacting study tactics and strategies; d) Metacognitive adaptive study. They described these four phases by using COPES (conditions, operations, products, evaluations and standards) which are the kinds of information that a person uses or generates while learning. They explain COPES as: a) conditions: they are the resources available to a person and the constraints inherent to a task or an

environment, they come in two types, cognitive conditions - represents memories of past learning experiences, and task conditions - akin to external resources, instructional cues, time and local context; b) operation: They are the actual information manipulation process that occur in learning including searching, monitoring, assembling, rehearsing and translating (SMART), for e.g., planning conducted to perform a task; c) product: These refer to the information created by operations, e.g., new knowledge, it also has the ability to recall a specific piece of information for a test; d) evaluation: gives a feedback about the fit between the product and the standards that is generated internal or external sources i.e., teacher or peer feedback by the student; e) standard: creates a certain criteria to monitor a product and determine whether they have met the objectives or not. This is the basis of an object-level of focus for monitoring [44-49].

Further, research was conducted on the cognitive processes of the mechanisms of planning and processing while students perform their leaning tasks, which progressed towards self-assessment research.

The Table 3 in Annexure-1 below condenses all important pieces of Winne and Hadwin's research comprising the focused area, empirical facts and testing tools in a chronological fashion for the better understanding of the reader.

Model name	Supporting hands	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
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Sophisticated metacognitively-based models of SRL	-	1996	Metacognition role and individual differences in Self-regulation	(1) Constructive, (2) Metacognitive	1. Winne PH (1997) [49]- SRL modeled as a bootstrapped accomplishment and Recursive information processing applied on Carla (an imaginary second grade student) to arithmetic problem solving	COPES scripts, and AEIOU relations
Information-Processing Theory (IPT) model of SRL	A.F. Hadwin	1998	Recursive information process	(1) Task definition, (2) Goal setting and planning, (3) Enacting study tactics and strategies, (4) Metacognitive adaptive study (these four linked phases are open and recursive and are comprehended in a feedback loop)	1. Perry Nancy E et. al, (2000)-used seven measurement protocols self-report questionnaires, structured interviews, teacher judgments, think aloud measures, error detection tasks, trace methods, and observations of performance. 2. Perry NE (2006)[42]- supports grade 1 students learning about the life cycles of humans and frogs. 3. Greene JA, and Azevedo R(2007)[28]- Theoretically analysis, model has much potential to influence to understand the phenomenon of learning.	1. COPES scripts, and AEIOU relations 2. gStudy learning tool 3. Hypothesis test

Table 3: Chronological evaluation of SRL model presented by Winne and Hadwin.

Pintrich

Senescing and incorporate importance of motivation in SRL model. Pintrich continued the ongoing work and produced his own conceptual framework towards classifying SRL [50]. He conducted several crucial empirical works that served as a strong basis to prove the relation between SRL and motivation [51,52]. He uses four general motivational constructs as goals, values, self-efficacy, and control beliefs, which are suggestive potential mediators for the process of conceptual changes in the learning mechanism of students. Pintrich had his focus on empirically analyzing and theoretically formulating the importance of motivation in SRL and also the importance of motivation in cognition. He also made many clear points that distinctly differentiate metacognition from self-regulation. Even though he has only one model [53-55] to be recognized by, his work points towards the areas that require further exploration as well.

According to his model SRL is composed of four phases [56]: a) Forethought, planning and activation phase; b) Monitoring phase; c) Control phase; d) Reaction and reflection phase. Each one of these phases have four different areas of regulation which are, cognition, motivation and affects, behavior and context. The amalgamation of

both the four phases and four areas of regulation offer a significant number of SRL processes for e.g., prior content knowledge activation, ease of learning judgment, self- observation behavior, monitoring changing task and context conditions [57-75]. In this proposed model he explained in great detail about the deployment of the different SRL phases/areas. His first area of focus was that of judgment of learning and the feelings of knowing to help understand metacognition in terms of regulation of cognition. The second focus area was of the fact that motivations and its affects could be based on the students' regulation of their own work. His third focus was on the regulation of behavioral changes in which he incorporated the individual's attempts to control their own overt behavior. This feature makes Pintrich's model distinctly stand apart. In his final focus he looks at regulating the context in which he attempts to monitor control and regulate the learning context.

The Table 4 in Annexure-1 below compiles all important pieces of Pintrich's research comprising the focused area, empirical facts and testing tools in a chronological fashion for the better understanding of the reader.

Model name	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
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Pintrich Self-regulated learning model	2000	Judgment of learning, Analyze relationship between SRL and motivation empirically	(1) Forethought, planning and activation (2) Monitoring (3) Control (4) Reaction and reflection	1. Chowdhury MS, Shahabuddin AM (2007) [15]-Bangladesh N=125, university students to measure Self-efficacy significantly correlated with performance. 2. Cho MH, Shen D (2013)[14]-USA N=64 (6M, 58F) students Academic Self-efficacy measured through MSLQ. 3. Roth et al. (2016)[51]-MSLQ is most verified instrument in measuring motivation and good balance between differentiated assessment and economical implementation. 4. B Çetin (2017)[13]- Canakkale 18 Mart University, N=39 (5M, 34F) aged (20–25yr) teach Life Science courses material.	Self-report questionnaires, such as the MSLQ composed of 15 scales, divided into a motivation section with 31 items, and a learning strategies (SRL) section with 50 items which are subdivided into three general types of scales: cognitive, metacognitive, and resource management. Self-regulated Learning Perception Scale (SLPS) and the Personal Information Form (PIF)
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Table 4: Chronological evaluation of SRL model presented by Pintrich.

Efklides

Evaluate relation among self-regulated learning, metacognition, motivation, and affect. When the whole research fraternity was behind differentiating metacognition from SRL, Efklides was the one trying to find strong relations between the two. She used metacognition in the form of two halves, i.e., a) metacognitive knowledge - which is a kind of knowledge used by a learner to select strategies to regulate learning; and b) metacognitive experience - which manifests as a cognition monitoring mechanism when the person comes across a task to be processed, based on feelings, estimates, or judgements which are features of learning tasks [58,59]. In 2011 Efklides presented the Metacognitive and Affective model of Self-Regulating learning - MASRL, in which she incorporated the theoretical aspects that she formulated before [58,59]. In her model she distinguished two levels of functioning in SRL namely: a) The person level; b) Task x Person level. When she talks about the person level of functioning she bring to perspective the person's point of view of oneself, the task at hand and the situations within all the conditions of one's environment [60]. Hence it acts as an intermediate level of self-assessment representing self-actuation before the person actually performs any given task. This intermediate level is always accessed by the person in a subconscious

level before performing any task as well as during the performance of the task. By the use of task x person level the author tries to create an interactive relation between the type of task and the characteristics of the student (person level) takes place. This level of the model works in the bottom-up fashion in which metacognitive activities are controlled by the student's actions, with the target on addressing the demand of the specific goals in learning tasks (like checking spelling mistakes). Following which she identified four basic functions of any person's performance for a learning task which are: a) cognitions; b) metacognition; c) affect; d) regulation of affects and effects.

In 2014 she addresses issues related to the accuracy related to the metacognitive monitoring as well as efficiency of self-control [61,62]. She suggests that monitoring using metacognitive knowledge and metacognitive experience is insufficient, but prior knowledge feedback and task context attention and response may increase the accuracy of personal level awareness in SRL.

The Table 5 in Annexure-1 below compiles all important pieces of Efklides research comprising the focused area, empirical facts and testing tools in a chronological fashion for better understanding of the reader.

Model name	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
Metacognitive and Affective Model of Self-Regulated Learning (MASRL) model.	2011	Metacognition, motivation and affect	(1) Person level or Macrolevel-Composed of: (a) cognition, (b) motivation, (c) self-concept, (d) affect, (e) volition, (f) metacognition as metacognitive knowledge, and (g) metacognition as metacognitive skills. (2) Task x Person level or microlevel –indicate interaction between the type of task and the student's characteristics.	1. Georgia Papantoniou et.al. (2012) [27] – N=180, undergraduate students, mean age=21.1 years, to predict positively or negatively didactics of mathematics course attainment.	Positive and Negative Affect Schedule (PANAS), Cognitive Interference Questionnaire (CIQ), Motivated Strategies for Learning Questionnaire (MSLQ)

Table 5: Chronological evaluation of SRL model presented by Efklides.

Hadwin, Järvelä, and Miller

Collaborative and co-regulation in learning model of SRL. These researchers brought in a new wave of thought in the SRL landscape of that of collaborative learning. This created new views on the effect of

learning based on various types of social encounters, while considering the interactive modes of learning. The interactive modes of learning mentioned include the likes of digital learning environments such as, information and communication technology (ICT) and computer-supported collaborative learning (CSCL)[63,64].

In 2010 Hadwin mentioned that effective collaboration can be achieved only if members properly established [65] a common ground to which they are committed and if they effectively negotiated their perceptions, goals and strategies. This made each member of the group share the regulation of their learning (SSRL). Later in 2013 Järvelä identified that there were many issues while considering the collaborative form of learning challenges such as motivational, cognitive, environmental, and social challenges. Miller too had similar perceptions, hence the model proposed by Hadwin, Järvelä, and Miller is known as the SSRL model as mentioned above [66]. This model can be used only in a collaborative setting and cannot be reduced to an individual level. This model proposed three existing modes of

regulation: a) self-regulated learning (SRL) - refers to the strategic control of the individual learner's regulatory action through, cognitive, metacognitive, emotional, motivational and behavioral mechanisms to achieve personal goals; b) co-regulation in learning (CoRL) - refers to the planning and interaction that occurs among students within the group; c) shared self-regulated learning (SSRL) - this refers to the deliberate decisions, plans and strategies taken by the group as a whole. The Table 6 in Annexure-1 below condenses all important pieces of Hadwin, Järvelä, and Miller research comprising the focused area, empirical facts and testing tools in a chronological fashion for the better understanding of the reader.

Model name	Supporting hands	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
Socially shared regulated learning (SSRL) model	Hadwin, Järvelä and Miller	2013	Collaborative learning, Computer supported Celebrative, social and interactive learning	(1) Self-regulation (SRL), (2) Co-regulation (CoRL), (3) Shared regulation (SSRL)	Järvelä et. al. (2016)[33] - 44 second-year teacher education students (36=F; 8=M; mean age=24.9 years) in a math didactics course lasting for 7 weeks. Data analysis from 84 hours of video data were coded and analysis using NVivo video analysis software. Result calculates the engagement in collaboration learning.	Information and Communication Technology (ICT) and computer-supported collaborative learning (CSCL), NVivo video analysis software

Table 6: Chronological evaluation of SRL model presented by Hadwin, Järvelä, and Miller.

M.L. Nugteren

SRL model with Self-assessment and Task selection. Nugteren reviewed the self regulated learning models that include an interaction between monitoring processes and controlling actions that were designed for one task at a time [67]. She took this research one step ahead by focusing on the self-regulated method of selection of new learning tasks among the option of multiple next tasks. The learner can use this model as a normative model to decide what might be a suitable next task based on their self-assessments. Since this model has just

recently been introduced there is a lack of cited evidence and facts about its efficiency. We have still considered this new model as it provides a new direction with a display of empirical measures in its supporting paper by Nugteren et al.

The Table 7 in Annexure-1 condenses all important pieces of Nugteren research comprising the focused area, empirical facts and testing tools in a chronological fashion for the better understanding of the reader.

Model name	Supporting hands	Year	Focused area	Phases/Components	Empirical facts and evidences	Instruments and measurements
Self-regulated learning-task selection (SRLTS) model	Halszka Jarodzka, Liesbeth Kester, Jeroen J. G. Van Merriënboer	2018	Task selection, Judgment of learning	(1) Task selection; (2) Learning task performance; (3) Self-Assessment	Dutch-Pre-university secondary school (N=15; M=7, F=8; Mage=13.93; SD=1.49 years), through 75 genetic task with 5 different levels observe the judgment of learning.	Mean, Median, Standard deviation and Correlation statistics analysis to evaluate the various question of judgment of learning.

Table 7: Chronological evaluation of SRL model presented by M.L. Nugteren.

Conclusion

An exhaustive exploration of this broad field of SRL has been conducted in this review. We reviewed all the existing models of self-regulating learning and gained a better understanding about the variables that influenced the self-regulation of a student's learning mechanism. Through this review our understanding of the current advancement in learning strategies in SRL through digital interfaces will continue pushing work in this field. We extracted a notable conclusion after reviewing all the models of SRL that a learner can be helped in self-regulation through the understanding of SRL mechanisms that includes cognition, metacognition, motivation, emotion and behavior. The benefits of various models and the ways in which learners interact with the environment and amongst themselves have given us a broader perspective about this field. This review addresses the new research areas in the field of SRL for such as emotion regulation, individual adaptive learning, collaborative learning in digital environments, and the like. Also this review helps researchers to speedily acquire inferences about the various models available to achieve their own goals in the future.

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