DEMOCRATIC AND POPULAR REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

IBN KHALDOUN UNIVERSITY – TIARET

THESIS

Posted to :

MATHEMATICS AND COMPUTER SCIENCE FACULTY
COMPUTER SCIENCE DEPARTMENT

For the graduation of :

MASTER

Specialty : Software Engineering
Presented by :

BOUDERBALA Mohamed

On the subject :

Technological-Pedagogical Implementation of SRL Scaffolds

Publicly supported on 09/07/2023 in Tiaret in front of the jury composed of:

Mr. Mebarek BENDAOUD.	Prof	Ibn-Khaldoun Tiaret University	President
Mr. Cheikh BOUMEDIENE.	MAA	Ibn-Khaldoun Tiaret University	Supervisor
Mr. Habib BENAOUDA.	MAA	Ibn-Khaldoun Tiaret University	Examiner

2022 - 2023

DEDICATION

This dissertation marks the end of an 18-year chapter of my life and the start of something new. I am eager to see what the future has in store for the next chapter of my life.

I dedicate my master's Dissertation work to my deceased father, Khaled BOUDERBALA. His last words to me were that I must succeed in my educational journey. I am sure he is proud of me now. May God have mercy on his soul.

I want to thank my mother, my brother, and my two sisters, for their help during these challenging times and for teaching me the essential values and manners that have helped shape the man I am today. May Allah bless them.

I also dedicate this to all my friends and classmates.

Acknowledgements

All the praise goes to ALLAH for giving me the power and will to complete this work.

I would first like to express my deepest thanks to my supervisor, Mr. **BOUMEDIENNE Cheikh**, for sharing his knowledge, guidance, and patience with me. I thank you for the honor you have given me by directing this project. Without your invaluable guidance and unwavering support, this work could not have been completed.

I would also like to express my sincere thanks to the members of the jury, Mr. **BENDAOUD Mebarek** and Mr. **BENAOUDA Habib**. It is a great honor and a privilege to have you as jury members to judge my modest work.

A special thanks goes to Mr. **CHADLI Abdelhafid** for accepting this subject. I am thankful for his openness and support, which have greatly contributed to the progress and achievement of my work.

Finally, I would like to express my gratitude to all the people who have helped me both near and far, especially our faculty's staff, for their advice and their help in the realization of my work.

Abstract

Self-regulated learning (SRL) scaffolding connect two **complementary** processes. SRL is an active constructive controlled process promoting an "autonomous" learning when scaffolding is a temporary adaptive designed process "supporting" a learning task accomplishment. SRL Scaffolding is perceived as a teaching-learning construct that bring out potential ways for effective design of learning environments; where learners have more autonomy and teaching-learning support is more mediated by technology.

Theoretically, this project explore - scaffolding and SRL - as two asymmetric processes in order to understand key (cognitive, pedagogic, technologic …) aspects. The exploration phase aim to capture relevant characteristics and functions that contribute to the alignment and integration of these processes. **Practically**, this project implements SRL scaffolding as temporary software entity called "SRL scaffold". The prototyping phase aim to reflect the theoretical-practical background of this project and to bring out pedagogical-technological potentials of SRL scaffolds.

Key words: Self-regulated Learning, Scaffolding, Technology-Enhanced Learning, Teaching-learning, Pedagogy, Cognition.

Table of Contents

List of Figures

General Introduction

General Introduction

Technology-Enhanced Learning (TEL) refers to the use of technology to facilitate and support teaching and learning activities in an institutional, professional, or personal (computer based) context. TEL offers more than just the ability to access Learning Environments (LE) for those in remote locations, more than just the delivery of online digital materials and more than just creating spaces for online discussion. TEL has the potential to provide greater (temporal, spatial, economic, pedagogical, social …) flexibility in learning, allowing students to progress at their own pace and focus on areas of their choice (Laurillard, 2008).

However, implementations of TELE are often based on a simplistic replication (re-hosting) of the relationship between teachers, "knowledge" and students (Hannafin, 1997; Coates, 2005; Laurrillard, 2008). Teaching and learning are often implemented as the transmission/reception of decontextualized and discrete pieces of information, rather than as the structuring/interpreting of contextualized information, rather than as the accomplishment/achievement of authentic tasks and rather than as articulation/reflection of meaningful knowledge (Jonassen, 1999).

Teaching is a complicated activity in which the teacher is challenged to develop new pedagogical (design and assistance) practices, that introduce students to new ways of reasoning and interpreting and scaffold (support) them by motivation and instruction (Wood, 1986). Learning is an individual activity in which the learner is challenged to master his/her mental (cognitive and metacognitive) abilities to regulate (control) his/her learning for the achievement of specified tasks and the construction of meaningful knowledge (Pintrich, 2000).

To implement (analyze, design, develop, implement, and evaluate) effective TELE, interdisciplinary research is required. Central problematic issue, in this **project**, is to develop effective teaching and learning practices that support grounded (balanced) technological and pedagogical implementations of TELE (Hannafin, 1997). Closely aligned with this research issue, our project aims to implement software temporary entities - called "SRL scaffolds" - that integrate two potentials perspectives: self-regulated learning (SRL) as a learning perspective and scaffolding as a teaching perspective. Thus, the implementation of SRL scaffolds focuses on aligning task's (objective) specifications and learner's (subjective) activities.

SRL scaffolds temporarily support self-regulated learners (SR learners) in the accomplishment of specified tasks (Azevedo, 2018). Functions of SRL scaffold are designed according to theoretical roots of scaffolding that define six functions: recruitment, reduction in the degrees of freedom, direction maintenance, marking critical features, frustration control, and demonstrating (Wood et. al., 1976). The actions of these SR learners are organized cyclically on three phases: forethought, self-control, and self-reflection (Zimmerman, 1990).

After a general introduction that frame the context of the project, the first chapter summarizes three approaches for the design of LE respectively rooted in three teaching and learning assumptions: instructivism, constructivism and sociocultural constructivism. The second and third chapters respectively give a brief exploration of scaffolding and SRL. The fourth chapter explains the integration of SRL and scaffolding. In this chapter, we propose an integration perspective of SRL and scaffolding as well as a design approach of SRL scaffolding.

The specification of the components (task, tools … etc.) of the SRL scaffold is outlined in chapter five. The process of implementation (including real-time scenarios) is illustrated in chapter six. Finally, our work is summarized, and perspectives are discussed in a general conclusion.

Design of Learning Environments

1.1 Introduction

Learning Environments (LE) are psychological and physical spaces involving complex cognitive and social interactions between different actors, particularly, teachers and learners. In an effort to supplement or replace traditional classroom-based LE, TELE often uses technology to replicate the ineffective methods that limit teaching and learning in face-to-face pedagogy (Jonassen, 1995; Laurillard, 2009).

To implement (analyze, design, develop, implement, and evaluate) effective TELE, researchers are requiring technological/pedagogical balancing (Laurillard, 2008). On one hand, technology is increasing the speed of change, challenges and innovation providing various opportunities, tools, and services for processing knowledge and connecting people. On the other hand, pedagogy requires continuous revisions and evolutions of teaching and learning assumptions, methods, and practices.

This chapter presents an overview of three approaches for the design of computer-based LE and has two objectives. Firstly, this chapter aims to frame the main theoretical aspects that influence the design of effective LE. Thus, these three approaches are related respectively to three teaching and learning assumptions: instructivism, constructivism and sociocultural constructivism. Secondly, this overview provides a theoretical background that is required to understand the research problematic in this project and develop next chapters.

1.2 Design of "Instructivist" LE

Instructivism is a teaching and learning assumption that emphasizes the teacher's role in providing students with explicit instruction and guidance. In instructivism, the teacher takes an active role in directing the learning by providing clear and explicit instructions and modeling how to complete tasks or solve problems (Jonassen, 1991).

Knowledge, in instructivism, is transmitted in a clear and orderly manner. Using clear and concise language or visual aids like charts, diagrams, or slides may be required for this. Instruction involves complex tasks which are broken down into small, manageable steps, if necessary.

The teacher, as transmitter of objective knowledge (see Figure 1.1) helps students learn about the real world. Students are not encouraged to make their own interpretations which they perceive; it is the role of the instruction to interpret events for them (Jonassen, 1991). Learners are told about the world and are expected to replicate its content and structure in their thinking.

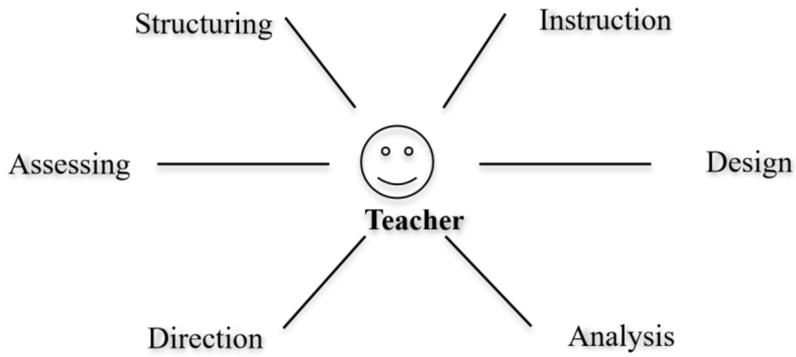

Figure 1.1. Instructivism as teacher-centered assumption.

From a contemporary view, instruction is a systematic process in which every component (i.e., teacher, learners, materials, and learning environment) is crucial to successful learning. This perspective is referred to as the systems point of view (Dick & Carey, 1990), that uses the systems approach to design instructivist LE (ILE).

The Dick & Carey instructional design model is a nine-step process for planning and designing effective systematic instruction. The steps refer to sets of procedures and techniques employed by the instructional designer to design, develop, evaluate, and revise instruction. The steps will be described in sequence below (Dick & Carey, 1990):

1) **Instructional goals analysis:** The teacher determines what learners should be able to do when they have completed their instruction. The instructional goal may be derived from a list of goals, from a needs assessment, from practical experience with the different learning difficulties of students, from the analysis of people who are doing a job, or from some other requirement for new instruction.

2) **Instructional analysis:** After the teacher has identified the instructional goal, he will determine step-by- step what people are doing when they perform that goal. The final step in the instructional analysis process is to determine what skills, knowledge, and attitudes, known as entry behaviors, are required of learners to be able to begin the instruction.

3) **Contextual analysis** *(learners and settings)***:** In addition to analyzing the instructional goal, there is a parallel analysis of the learners, the settings in which they will learn

the skills, and the context in which they will use them. Learners' current skills, preferences, and attitudes are determined along with the characteristics of the instructional setting and the setting in which the skills will eventually be used.

4) **Performance objectives analysis:** Based on the instructional and contextual analysis, the teacher will identify specific statements of what the learners will be able to do when they complete the instruction. These statements, which are derived from the skills identified in the instructional analysis, will identify the skills to be learned, the conditions under which the skills must be performed, and the criteria for successful performance.

5) **Developing assessment instruments:** Based on the written objectives, develop assessments that are parallel to and measure the learners' ability to perform what is described in the objectives. Major emphasis is placed on relating the kind of behavior described in the objectives to what the assessment requires.

6) **Developing an instructional strategy:** The strategy will include sections on preinstructional activities, presentation of information, practice and feedback, testing, and follow-through activities. The strategy will be based on current theories of learning and the results of learning research, the characteristics of the medium that will be used to deliver the instruction, the content to be taught, and the characteristics of the learners who will receive the instruction.

7) **Developing instructional materials:** The teacher will use an instructional strategy to develop instructional materials. These materials include all forms of instruction such as instructor's guides, student modules, overhead transparencies, videotapes, computer-based multimedia formats, and web pages for distance learning.

8) **Developing a formative evaluation:** The three types of formative evaluation are referred to as one-to-one evaluation, small-group evaluation, and field evaluation. Each type of evaluation provides the designer with a different type of information that can be used to improve the instruction.

9) **Revising instruction:** Data from the formative evaluation are interpreted to attempt to identify difficulties experienced, by learners, in achieving the objectives and relate these difficulties to specific deficiencies in the instruction. The instructional strategy is reviewed and finally all this is incorporated into revisions of the instruction to make it a more effective instructional tool.

1.3 Design of "Constructivist" LE

Instructivists suggests that "while it is an effective means of teaching factual content", there is less evidence that this instruction transfers to higher order cognitive skills such as reasoning and problem solving, nor is there sufficient evidence that direct instruction teaching results in the flexibility necessary for students to use the targeted strategies in novel contexts (Palincsar, 1998).

Constructivism is a learning assumption that holds that students construct their own understanding and knowledge of the world through experiences and reflections. Constructivism suggests that individuals are responsible for their own learning and actively construct their own meaning and understanding through processes such as setting goals, monitoring their own progress, and seeking feedback (Jonassen, 1991).

Individuals are the primary agents of their own learning (see Figure 1.2) and they construct their own understanding by reflecting on their experiences and adjusting their strategies as needed. Learning is presented in constructivism as a constructive process in which the learner constructs an internal illustration of knowledge, a personal interpretation of experience (Pintrich, 2000).

This perspective on knowledge does not necessarily deny the existence of the real world, rather it acknowledges that reality constrains existing concepts and contends that all individuals' knowledge of the world is the interpretation of their experiences (Jonassen, 1991). Furthermore, conceptual growth is the result of multiple perspectives and the concurrent shifting of individuals' internal representations in response to those perspectives as well as their experience.

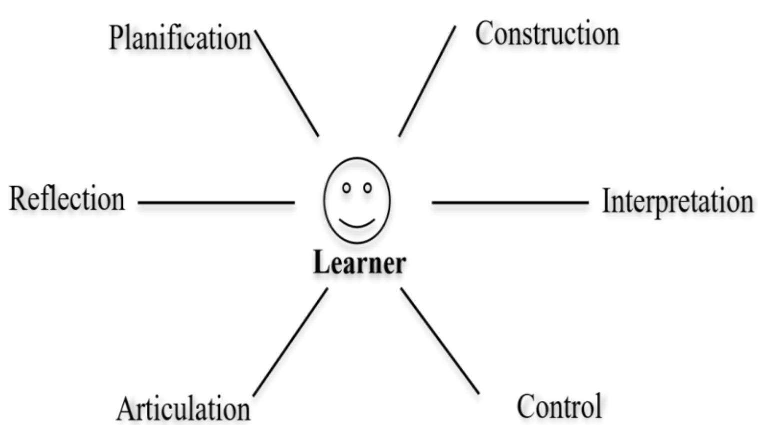

Figure 1.2. Constructivism as learner-centered assumption.

The focus of any Constructivist Learning Environment (CLE) is the question or issue, the case, the problem, or the project that learners attempt to solve or resolve (Jonassen, 1999). It constitutes a learning goal that learners may accept or adapt. The fundamental difference between CLEs and ILE is that the problem drives the learning, rather than acting as an example of the concepts and principles previously taught. Students learn domain content in order to solve the problem, rather than solving the problem as an application of learning.

The Jonassen model for designing CLEs conceives a problem, question, or project as the focus of the environment, with various interpretative and intellectual support systems surrounding it. The goal of the learner is to interpret and solve the problem or complete the project. This model can be explained in six components :

1) **Problem selection:** select an appropriate problem for the learning to focus on. The problem should be interesting to foster learner ownership. The problem is designed to be:

(a) ill-defined or ill-structured.

(b) authentic (refers to supporting the performance of real-world tasks).

(c) relevant in its context, representation, and manipulation space.

2) **Related cases selection:** select appropriate worked examples to enhance cognitive flexibility and to convey the complexity that is inherent in the knowledge domain. Understanding any problem requires experiencing it and providing multiple themes or interpretations (cases) on the problems being examined by the learners. What novice learners lack most is experience. This lack is especially critical when trying to solve problems. It is important that CLEs provide access to a set of related experiences to which novice students can refer.

3) **Information just-in-time selection:** select relevant and easily accessible kinds of information the learner will need in order to understand and interpret the problem. Rich sources of information are an essential part of CLEs. CLEs should provide learner-selectable information just-in-time. CLEs assume that information makes the most sense in the context of a problem. Based on the activity structures that support the problem's solution, information needed to perform each of the tasks should be linked to those activities. With learners who are new to CLEs, simply pointing to Web resources may provide serious distractions to thinking necessary for solving the problem.

4) Cognitive tools selection: select digital tools that are intended to engage and facilitate specific kinds of cognitive processing. Some cognitive tools replace thinking, while others engage learners in generative processing of information that would not occur without the tools. These tools scaffold required skills, including problem-representation tools, knowledge modeling tools, performance-support tools, and information-gathering tools. They are intellectual tools that are used to visualize (represent), organize, and automate thinking skills.

As students study phenomena, it is important that they articulate their understanding of the phenomena, using different static knowledge representation tools, such as databases, spreadsheets, semantic networks, expert systems, and hypermedia construction. Learners can use dynamic modeling tools for building simulations of this phenomena and processes and for testing it. Building models of real-world phenomena is at the heart of scientific thinking and requires diverse mental activities such as planning, data collecting, accessing information, data visualizing, modeling, and reporting.

5) Collaboration tools selection: select shared information and shared knowledge building tools to help learners to collaboratively construct socially shared knowledge. Learning most naturally occurs not in isolation but in teams of people working together. Computer networks have evolved to support discourse communities through different forms of computer conferences (electronic mail, forums, chats … etc.).

6) Providing contextual support: develop pedagogical, social, and cultural supports, such as modeling, coaching, and scaffolding. Learners need to know how to develop arguments to support their solutions to the problem, why they should perform, as well as how to perform. Modeling is focused on the expert's performance. Coaching is focused on the learner's performance. Scaffolding is a more systemic approach to supporting the learner, focusing on the task, the environment, the teacher, and the learner.

Cognitive modeling articulates the reasoning (reflection-in-action) that learners should use while engaged in their tasks. Coaching may prompt appropriate kinds of thinking, such as suggestions to make inferences, generalize another idea, generate questions, use of related cases or particular information resources, use of specific cognitive tools, use of an analogy, summarize results, or draw an implication. Scaffolding provides temporary frameworks to support this accomplishment of tasks.

1.4 Design of "Sociocultural Constructivist" LE

There are many versions of constructivism, suggesting a continuum anchored by trivial constructivism at one end, which stresses the individual as constructing knowledge but is concerned with whether or not the constructions are correct representations, to radical constructivism, which rejects the notion of objective knowledge and argues instead that knowledge develops as one engages in dialogue with others (Palincsar, 1998).

Social constructivist assumption focuses on the interdependence of social and individual processes in the co-construction of knowledge. This assumption views that the locus of knowledge is in the individual; learning and understanding are regarded as inherently social; and cultural activities and tools (ranging from symbol systems to artifacts to language) are regarded as integral to conceptual development (Palincsar, 1998).

One of the challenges for those interested in the application of social constructivism is the development, among learners, of an intersubjective attitude about the joint construction of meaning; a commitment to find a common ground on which to build shared understanding (Wertsch, 1984). Assessment informed by social constructivist perspectives is frequently referred to as "dynamic assessment" (van de Pol el al., 2010). It characterizes approaches in which the performance of the individual being assessed is mediated or guided by another individual to determine the individual's potential to profit from assistance. Furthermore, the response of the learner to the assistance is intended to inform instruction.

From a socio-cultural perspective, cognition is a collaborative process; the purpose of cognitive development is to foster the transformation of socially shared activities into internalized processes (Collins et. al., 1989). As learners participate in a broad range of joint activities and internalize the effects of working together, they acquire new strategies and knowledge of the world and culture.

Cognitive Apprenticeship (CA) is based on general concerns of apprenticeship that is the "embedding" socio-cultural constructive context in which learning takes place (Collins et. al., 1989). Cognitive apprenticeship requires extended techniques to encourage the development of cognitive and metacognitive skills. The CA Model is based on two basic means of fostering these crucial metacognitive skills (Collins et. al., 1989).

First, CA encourages reflection on differences between novice and expert performance by alternation between teacher and learner efforts. In a shared problem-solving context, this alternation sensitizes students to the details of expert performance as the basis for incremental adjustments in their own performance. CA recognizes that cognitive and metacognitive strategies and processes, more centrally than low-level subskills or abstract conceptual and factual knowledge, are the organizing principles of expertise.

Second, CA encourages the problem solver to alternate among different cognitive activities while carrying out a complex task. Complex cognitive activities involve some version of both generative and evaluative processes. CA should extend situated learning to diverse settings so that students learn how to apply their skills in different contexts.

Collins et al. suggests a framework for designing “sociocultural constructivist” learning environments (SCLE) based on CA that provides a critical lens for evaluating the strengths and weaknesses of different learning environments and teaching methods. The framework describes four dimensions that constitute any learning environment (see Figure 1.3): content, method, sequence, and sociology.

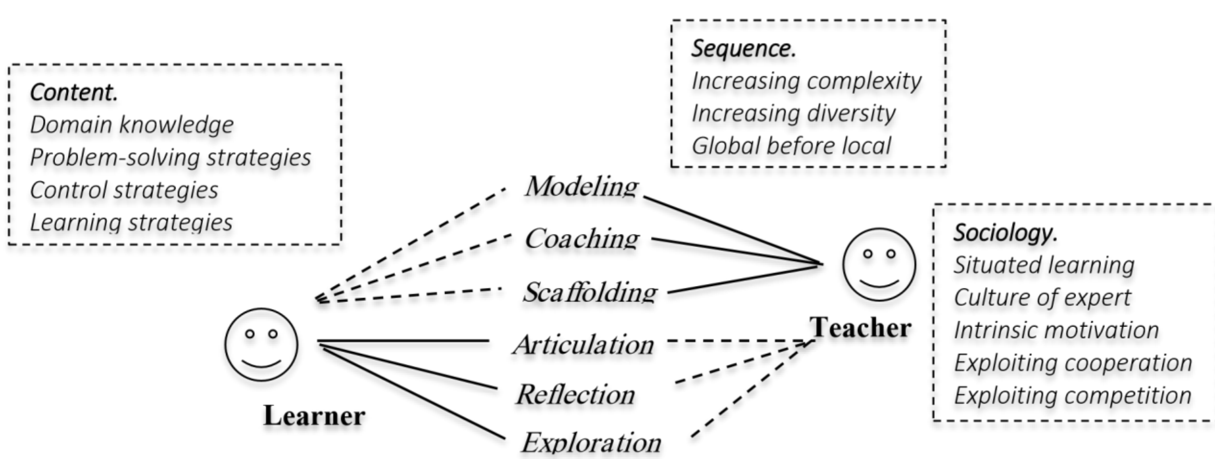

Figure 1.3. Cognitive apprenticeship as socio-cultural constructivist framework.

Content. CA distinguishes between the explicit conceptual, factual, and procedural knowledge associated with expertise, and various types of strategic knowledge. CALE implements all four categories of expert knowledge.

1) Domain knowledge: includes the conceptual and factual knowledge and procedures explicitly identified with a particular subject matter. Examples of domain knowledge in reading are vocabulary, syntax, and phonic rules.

2) Problem-solving strategies and heuristics: include effective techniques and approaches for accomplishing tasks. An example of heuristics for mathematical problem-solving is Polya (1945).

3) Control strategies: includes monitoring, diagnostic and remedial components, decisions about how to proceed in a task generally depends on an assessment of the current state relative to one's goals, on an analysis of current difficulties, and on what strategies are available for dealing with difficulties.

4) Learning strategies: includes any of the other kinds of content described above. For example, if students want to learn to solve math problems better, they try to solve the example problems presented in the text before reading the solution to provide a basis for comparing one's own solution method to the solution method in the book.

Method. CA's key goal should be to help students acquire and integrate cognitive and metacognitive strategies for using, managing, and discovering knowledge. Thus, teaching methods should be designed to give students the opportunity to observe, engage in, and invent or discover expert strategies in context.

1) Modeling: involves showing an expert carrying out a task so that students can observe and build a conceptual model of the processes that are required to accomplish the task. Modeling is the easiest implemented instructional strategy in CLEs. Worked examples include a description of how problems are solved by an experienced problem solver.

2) Coaching consists of observing students while they carry out a task and offering hints, feedback, modeling, reminders, and new tasks aimed at bringing their performance closer to expert performance. Coaching motivates learners, analyzes their performances, provides feedback and

advice on the performances and how to learn about how to perform, and provokes reflection on and articulation of what was learned.

3) Scaffolding: refers to the temporary support the teacher provides. It involves the teacher carrying out parts of the overall task that the student cannot yet manage. Scaffolding involves supporting the learner by adjusting task difficulty, restructuring the task, and/or providing alternative assessments. Fading consists of the gradual removal of support until students are on their own.

4) Articulation: includes any method of getting students to articulate their knowledge, reasoning, or problem-solving processes in a domain. For example, an inquiry teacher in reading might systematically question students about why one summary of the text is a good one while another is poor, in order to get the students to formulate an explicit model of what makes a good summary.

5) Reflection involves enabling students to compare their own problem-solving processes with that of an expert or other students. Reflection is enhanced by the use of techniques for "replaying" the performances of both expert and novice for comparison.

6) Exploration involves pushing students into a mode of problem solving on their own. Exploration as a method of teaching involves setting general goals for students but encouraging them to focus on particular subgoals of interest to them.

Sequencing. CA recognizes the changing learning needs of students at different stages of skill acquisition and, consequently, to sequence and structure materials and activities appropriately for those stages. CA identifies some dimensions or principles that should guide the sequencing of learning activities to facilitate the development of robust problem-solving skills.

1) Increasing complexity: refers to the construction of a sequence of tasks and task environments or microworlds such that more and more of the skills and concepts necessary for expert performance are required.

2) Increasing diversity refers to the construction of a sequence of tasks in which a wider and wider variety of strategies or skills are required.

3) Global before local skills: refers to the construction of a sequence of lessons such that students have a chance to apply a set of skills in constructing an interesting problem solution before they are required to generate or remember those skills. This allows students to build a conceptual map of the overall task that acts as a guide for the learner's performance; thus, improving his ability to monitor his own progress and to develop attendant self-correction skills.

Sociology. CA recognizes the role of the social organization (surrounded by both masters and other apprentices) of apprenticeship in fostering learners' motivation, confidence, and, most importantly, their orientation toward problems that they encounter as they learn. Such organization encourages learners to understand learning as, in part, using multiple resources in the social context to obtain scaffolding and feedback. CA abstracted five critical characteristics affecting the sociology of learning.

1) Situated learning: serves several different purposes and involves carrying out tasks and solving problems in an environment that reflects the multiple uses to which their knowledge will be put in the future. Students actively learn using knowledge, rather than passively receiving it, and will come to understand the uses of the knowledge and the different conditions under which their knowledge can be applied. Learning in multiple contexts induces the abstraction of knowledge, so that students acquire knowledge in a dual form.

2) Culture of expert practice: refers to the creation of a learning environment in which the participants actively communicate about, and engage in, the skills involved in expertise, where expertise is understood as the practice of solving problems and carrying out tasks in a domain.

3) Intrinsic motivation: refers to the creation of a learning environment in which the students perform tasks because they are intrinsically related to an interesting or at least coherent goal, rather than for some extrinsic reason like getting a good grade or pleasing the teacher.

4) Exploiting cooperation: refers to having students work together in a way that fosters cooperative problem solving. Students are often able to help each other grasp the rationale for, or distinguishing characteristics of, some new concept or skill because they are closer to the problem of learning about it.

5) Exploiting competition: refers to the strategy of giving students the same task to carry out, and then comparing what each produce.

1.5 Conclusion

The motivating value of this project is the reciprocal relationship between technology (Media, services, tools … etc.) and pedagogy (knowledge, practices of teaching and learning … etc.) – each opens new possibilities for the other. This chapter concludes that the design of LE requires effective teaching and learning assumptions, methods, and practices.

Effective teaching promotes well-designed, mediated instruction that moves the teacher from transmitter of knowledge to motivator and facilitator of personal meaning making (Jonassen, 1991). Effective learning foster students to critically examine and articulate concepts and facts, individually master new knowledge and skills, and socially engage authentic and collaborative tasks (Jonassen, 1991).

Scaffolding

2.1. Introduction

Teaching is a dynamic pedagogical process of imparting knowledge, skills, and values to students. Planning, instructing, guiding, and assessing are examples of pedagogical activities that teachers use to engage students and foster a positive learning environment. Thus, pedagogy refers to instructional methods involved in designing, supporting, and evaluating learning.

Critically, because students have individual differences, effective teaching necessitates a variety of pedagogical approaches and methods to accommodate diverse learners. In this context, scaffolding is crucial for teachers to support student's performances in the achievement of their learning tasks. Scaffolding can have a significant impact on learners cognitive and metacognitive development.

2.2. Components of Scaffolding

As most people are aware, scaffolding is put up around the exterior of new buildings to give construction workers access to the developing structure as it rises from the ground. The builder takes down the scaffolding once the structure can stand on its own. The idea of scaffolding has been widely used in recent years to support the idea that teachers need to provide temporary supporting structures that will help students develop new understandings, concepts, and abilities, much like builders provide necessary but temporary support. Teachers must withdraw support as the student gains control, only to reapply for new or more difficult tasks, concepts, and understandings (Hammond, 2001).

Wood et. al. used the term scaffolding as a metaphor to conceptualize a particular form of instructional intervention whereby a teacher guides a learner "to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (Wood et. al., 1976). Scaffolding does not involve simplifying the assigned task but simplifying the role of the learner while keeping the task constant. Thus, scaffolding involves the teacher controlling "those elements of the task that are initially beyond the learner's capacity", and the learner focusing on "those elements that are within the range of competence" (Wood et. al., 1976). Effective scaffolding, human-based or machine-based, must be based on at least two theoretical components (see Figure 2.1): a theory of the task and a theory of the "learner" (Wood et. al., 1976, P97).

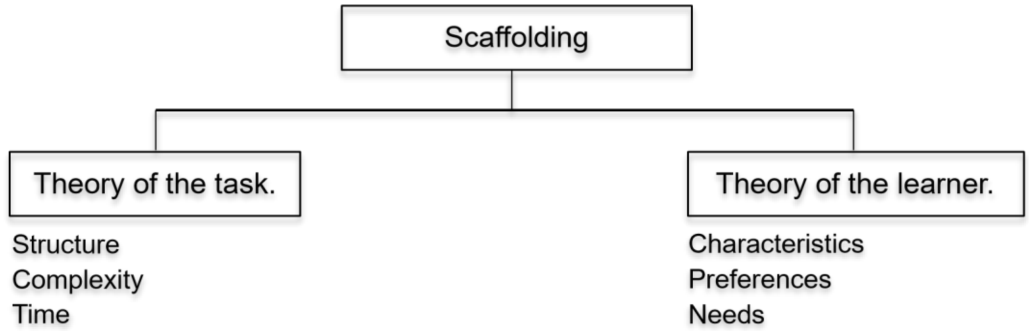

Figure 2.1. Components of Scaffolding.

Firstly, a theory of the task and how it may be completed. Secondly, a theory of the performance characteristics of the learner and how it can be interpreted and optimized to ensure a successful completion of the task. Thus, scaffolding requirements are generated by the interaction of these two theories. They argue that individualized scaffolding might be most difficult to realize considering the questions: how the task is structured, how to interpret learner's responses appropriately and how to generate appropriate feedback for this learner in this task at this point in task mastery.

Depending on the task and the needs of the learner, scaffolding can take many different forms. Breaking a task down into smaller, more manageable pieces, providing examples or models of how to complete the task, providing feedback and guidance, and offering prompts or cues to keep the learner on track are a few examples of scaffolding techniques.

One of the key characteristics of scaffolding is that it is temporary and is gradually removed as the learner gains proficiency and independence. As the learner's confidence and competence grow, the scaffold's support can be gradually reduced or removed, allowing the learner to complete the task independently.

Scaffolding can be especially beneficial for students who are struggling to learn new skills or knowledge or who are faced with a particularly difficult task. Scaffolding can assist learners in overcoming obstacles and increasing their confidence and competence by providing targeted support and guidance.

2.3.Functions of Scaffolding

Wood et. al. suggested six functions to describe the functional process of scaffolding (see Figure 2.2): recruitment, reduction in the degrees of freedom, direction maintenance, marking critical features, frustration control, and demonstrating (Wood et. al., 1976).

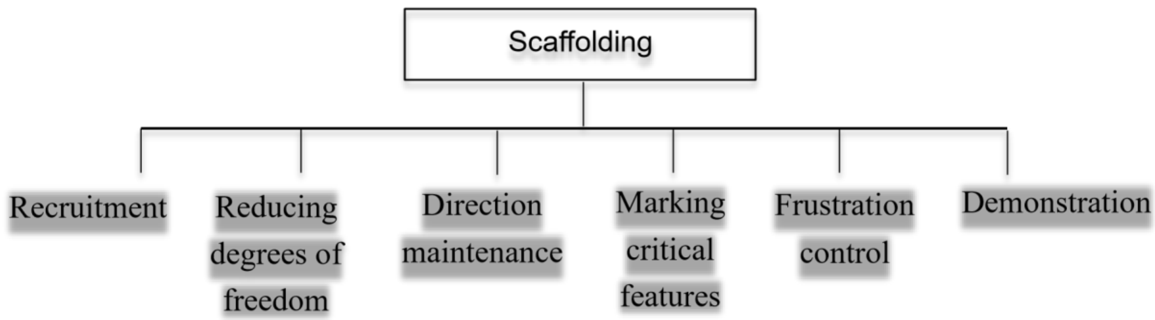

Figure 2.2. Functions of Scaffolding.

Recruitment is the first function. During recruitment, the teacher draws the student into the task by gaining their attention, stimulating their interest, and fostering a level of commitment to the learning task.

In **reducing degrees of freedom**, as the second function, the teacher reduces task difficulty to the appropriate level for the student's ability level. It involves reducing the size of the task and letting the student focus on the components of the task he can manage. No intervention should be made if the current task is within the learner's grasp.

Direction maintenance: During learning, learners lag and regress to other aims, given limits in their interests and capacities. The third function provided by the teacher is to keep the student focused on the current goal and provide affective and motivational support when needed.

Marking critical features is the fourth function, by which the teacher draws attention to relevant task features, such as highlighting incorrect solutions.

The fifth function is **frustration control**. Frustration control by the teacher helps reduce a negative affect that would impede successful learning. The major risk is in creating too much dependency on the teacher.

The sixth function is **demonstration**. Modeling can consist of a complete demonstration (explication) of the solution, or a partial demonstration based on the student's current attempt. It involves an idealization, with an expert model, of the act to be performed so that the learner can imitate it back in a more appropriate form.

2.4. Scaffolding in TELE

Scaffolding has proven an especially interesting and promising area for supporting teaching and learning practices. In TELE, the scaffolding design has focused on two distinct complementary design components: cognitive design explicates thinking processes in the achievement of a learning goal, while interface design focuses on representational formats that convey the cognitive intent of the scaffolds. In TELEs, scaffolding can be conceptualized as the provision of technology mediated support to learners as they engage in a specific learning task. Technological scaffolds can provide procedural and metacognitive support for routine tasks, and thereby support learning in classrooms (Hannafin, 2007).

However, technology-enhanced scaffolding also differs from face-to-face interactions. Software constraints often limit dynamic scaffolding to interactions that can be anticipated in advance (Hannafin, 2007). Thus, TELE scaffolds are often static and do not change dynamically as individual actions evolve. While scaffolding has been reduced at predetermined points based on specific algorithms, fading has rarely been predicated on an individual's needs or performance.

Effective scaffolding requires accommodating differences in understanding for a specific task and creating tools and agents to address individual needs. Thus, designers must consider the specific affordances of computer-based scaffolds and their effective integration within LE. For example, multiple types of scaffolds may be designed to address varied developmental levels and address levels of granularity: As students' progress toward independent performance, detailed scaffolding may be faded initially followed by fading increasingly general scaffolding (Puntambekar & Kolodner, 2005).

2.5. Conclusion

According to its original definition, scaffolding enlists the teacher as an "activator" whose role is to facilitate the student's incremental mastery of a task. "Fading" is the process of gradually removing the scaffolding that was put into place for the student until he internalizes the information and becomes a self-regulated, independent learner. Scaffolds may provide opportunities for students to deepen their understanding by externalizing and comparing their knowledge and beliefs with those of peers and experts. Scaffold design needs to be consistent with learners' understanding and cognitive development (Hannafin, 2007).

Self-Regulated Learning (SRL)

3.1. Introduction

Learning is a complex cognitive process in which new knowledge, skills, or attitudes are obtained. Attention, perception, memory, and reasoning are examples of cognitive activities that allow students to acquire new information and transform that information into knowledge that can be stored and retrieved when needed. Thus, cognition refers to mental actions involved in acquiring, processing, and using information.

Critically, because students are strongly influenced by their cognitive strengths and limitations, effective learning necessitates self-regulation skills to promote their strength and overcome their limitations. Self-regulation is crucial for students to construct their own meaningful knowledge, achieve complex tasks and reach their own learning goals. Self-regulation can have a significant impact on learners, in both academic and personal success.

3.2. Components of SRL

When academic learning strategy training is combined with self-regulation, known as self-regulated strategy development, learners gain confidence in modifying strategies reflectively and flexibly within recursive cycles of task analysis, strategy usage, and monitoring. Many SRL strategies and techniques are applicable across multiple topic domains. SRL is made up of three theoretical components (see Figure 3.1): motivation, cognition, and metacognition (Sitzmann & Ely, 2011).

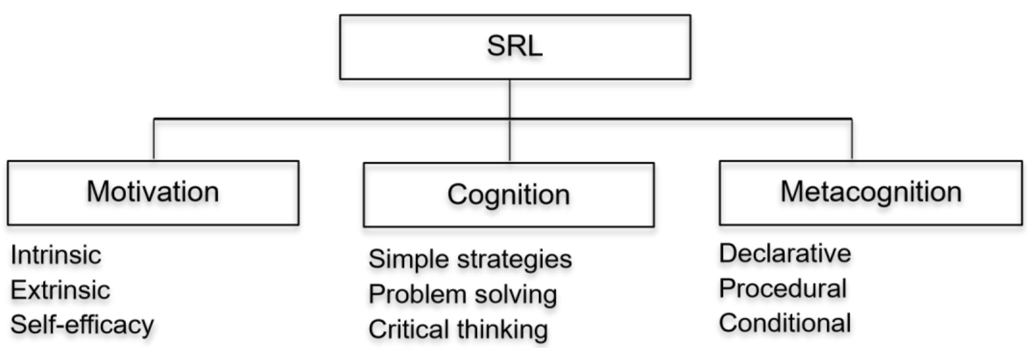

Figure 3.1. Three-Components of SRL.

The motivation component is at the core of cognitive and social regulation and concerns all aspects of activation, direction, and self-efficacy (Reeve et. al., 2007). Reeve et al. distinguished two approaches (supportive or controlling) where teachers are sources of motivation fostering learners to act (Reeve et. al., 2007). When autonomy is supportive, teachers "catalyze" in their learner’s "greater" intrinsic motivation to align and harmonize their inner motivational resources (interests, preferences, goals, values…) with their learning activities (selection, internalization, communication, integration…). When controlling, teachers "provide" extrinsic incentives to influence and align learner’s learning activities with the teacher’s agenda (external interests, preferences, goals, values…).

The **cognitive component** includes simple strategies that are domain or subject specific. Problem-solving techniques and critical thinking abilities are also required. Critical thinking requires a range of abilities, such as recognizing a specific source of information and considering whether or not that information is compatible with one's existing knowledge. Comprehension activities such as student-generated questions before or during reading to focus the learner's attention, constructing graphs and tables of real-world issues, and engaging in classroom debate to articulate arguments for writing a persuasive essay are examples of activities to help adults articulate and practice critical thinking. These activities help to increase the adult learner's ability to assess, analyze, and interpret information while also helping to develop problem-solving strategies (Zimmerman, 1990).

The **metacognitive component** includes declarative knowledge (knowledge about oneself as a learner, factors that affect performance), procedural knowledge (knowledge about strategies and other procedures), and conditional knowledge (knowledge about why and when a particular strategy is used). The goal of SRL is to make these strategies visible to students and then become automatic. One way to make the three types of knowledge visible in the classroom is to have learners demonstrate. When demonstrating (such as cooking a particular dish), it is easier to find the specific words needed to express what one is doing and how to do it. Questions evoke more language. Post-demonstration debriefing can visualize the distinction between declarative, procedural, and conditional knowledge, allowing explicit indications of how this knowledge can be transferred to academic tasks (Zimmerman, 1990).

3.3. Phases of SRL

Self-regulated learning (SRL) refers to the process in which individuals take an active role in monitoring and managing their own learning. SRL entails managing information, resources, and time effectively in order to obtain and process new knowledge and skills, relate them to prior learning and experience, and make good use of guidance.

The term "self-regulated learning" emerged in the 1980s as a result of an increased emphasis on self-regulation in academic settings. Researchers began to investigate how students become masters of their own learning processes. SRL is a fundamental conceptual framework for comprehending cognitive, motivational, and emotional aspects of learning. SRL has made significant contributions to educational psychology since the first papers in which scholars distinguished SRL from metacognition (Zimmerman, 1990).

SRL is composed of three cyclical phases (see Figure 3.2): forethought, self-control, and self-reflection.

The **forethought phase** is a preparatory phase that reveals the main difference between self-regulated learners and non-self-regulated learners. The self-regulated learner analyzes a task before learning something new, and the most important aspect of this step is goal setting. A novice learner may even begin by establishing a learning goal, but in many cases, this is not followed by a specific plan. When setting a learning goal, strategic planning should be done. During this preparatory phase, the learner should also have self-motivation about their efficacy and expected learning outcome.

The **performance phase** is the learning phase that most students confuse with the overall learning process, but keep in mind that this is only one of three phases in SRL. The learner is now managing their own learning through the self-control process. Students implement the strategies that they chose during the forethought phase. The self-control process should be accompanied by self-observation, which most novice learners overlook.

When learning something, the self-regulated learner monitors and observes their own learning, for example, by recording or experimenting on themselves. The results of this self-monitoring phase provide feedback for the self-control process, allowing the learner to re-develop or modify their learning strategies. Learning does not end until the self-reflection phase is completed.

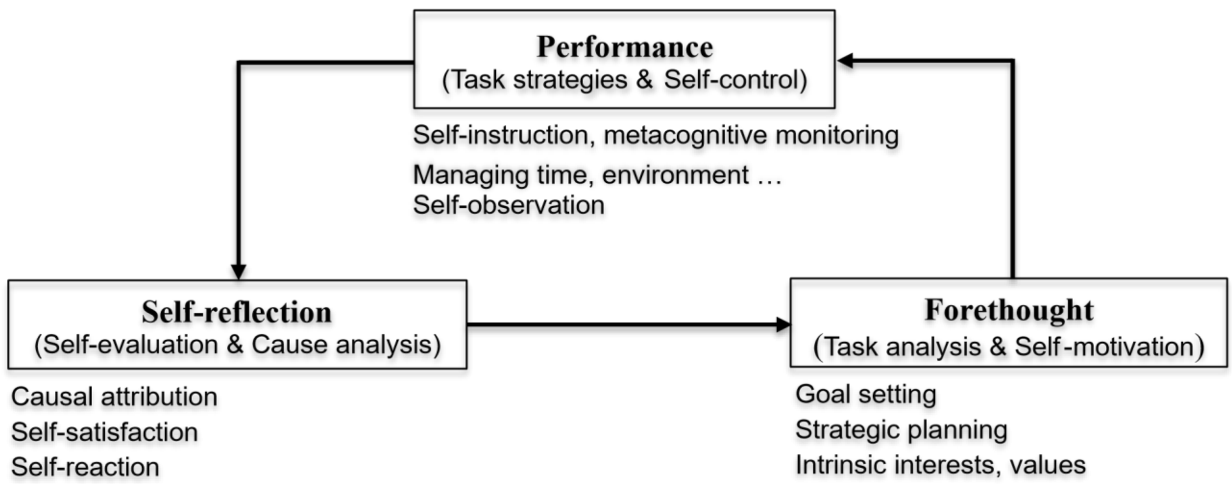

Figure 3.2. Three phases of SRL.

The **self-reflection phase**. The self-reflection process includes self-evaluation, which includes cause analysis, such as considering what caused learning success or failure. The self-regulated learner can use self-evaluation and analysis to determine whether they met their learning objectives and, more importantly, to gauge their level of self-satisfaction.

3.4.SRL in TELE

Advancements in TELE are generating a strong interest in supporting SRL processes. A particular emphasis has been placed on real-time measurement (recording, detecting, tracing, modeling) provided as learners are engaged in learning activities where self-regulation changes over-time and in responses to changes in environmental conditions (Järvelä et. al., 2019). Learning analytics dashboard (LAD) and educational data mining (EDM), as tools for measuring SRL, have the potential of capturing and analyzing real-time learner traces.

However, there is an absence of "metrics" for measuring self-regulation actions and effective tools for examining, tracing, and understanding the sequential, temporal and dynamic characteristics of the regulation of learning (Järvelä et. al., 2019). Thus, this regulation involves cyclical processes, which are hard to capture.

3.5.Conclusion

In this chapter, we explored self-regulated learning from a constructivist learning perspective. SRL refers to the process in which individuals take an active role in monitoring and managing their own learning. SRL includes three main components: cognition, metacognition, and motivation. SRL entails managing information, resources, and time effectively in order to obtain and process new knowledge and skills, relate them to prior learning and experience, and make good use of guidance. SRL is composed of three cyclical phases: forethought, self-control, and self-reflection.

SRL Scaffolding

4.1. Introduction

Teaching and learning are two complementary processes involving shared activities. For the successful accomplishment of tasks, teachers and learners must provide synergetic actions. SRL scaffolding brings out potential ways for effective implementations of TEL where teaching is more mediated by technology, and learners have more autonomy.

SRL scaffolding is a critical research issue that necessitates further interdisciplinary research (psychological, social, pedagogical, cultural, and technological). On one hand, SRL scaffolding requires explicit conceptualization that aligns and integrates theoretical roots and accounts. On other hand, SRL scaffolding requires developing operational structures and processes that optimize its implementation (analyze, design, develop, implement, and evaluate). In this context, this chapter presents our approach for the alignment and integration of SRL and scaffolding as well as a perspective for the design SRL scaffold.

4.2. Components of SRL scaffolding

SRL and **scaffolding** bring out potential ways for the co-construction of knowledge and accomplishment of tasks. To meet theoretical accounts, our approach for the alignment and integration of SRL scaffolding keep the two theories related to scaffolding: theory of the learner and theory of the task.

The support of SR learners conceptualized as SRL scaffold needs a third theory that we call "theory of the scaffold". Thus, we explain our conceptualization of three theories (see Figure 4.1).

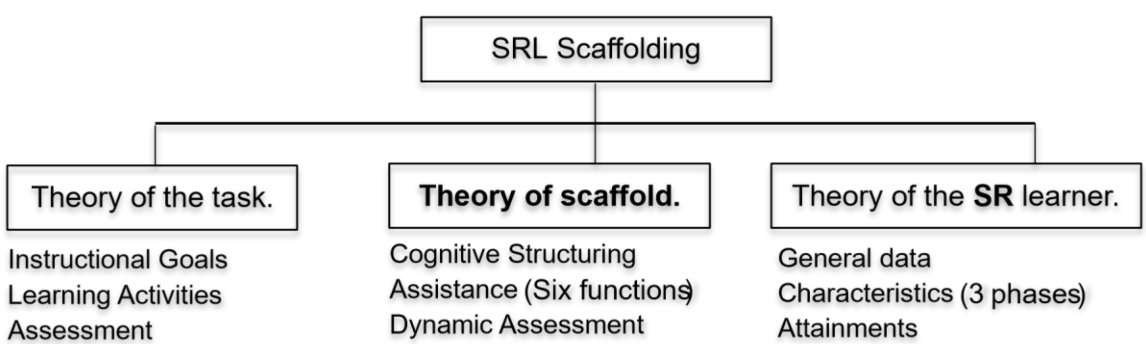

Figure 4.1. Components of SRL Scaffolding

Theory of the task conceptualized on three levels (Rienlugh, 2015):

1) **Instructional goals** specified by the teacher; and refers to concepts or skills to be internalized by the learner. These goals are hierarchized and linked to the structure of activities and the map of subjective attainments.

2) **Learning activities** designed by the teacher include all required and optional "objective" activities. These activities are structured and broken down in a hierarchical manner to individual attainments such as skills, understandings, dispositions, and so on. This "objective" structure displays the attainments in a customizable domain map.

This map enables the learner to navigate through the attainments; the map indicates the more advanced attainments that are now within reach. In essence, this structure presents a list of things that should or can be learned, along with levels, activities, and criteria at which they should or could be accomplished.

3) **Assessment** implemented by the teacher include for each attainment a criteria or a rubric for evaluating mastery. The assessment refers to evaluating the accomplishment of the tasks and the satisfaction of instructional goals.

Theory of the learner conceptualized on three levels (Rienlugh, 2015):

1) **General student data** such as name, age, address, birthdate…etc.

2) **Characteristics** define learning styles (cognitive, metacognitive abilities… etc.) including levels of self-regulation performance in each phase of SRL (frogmouth, performance, reflection). These characteristics are continuously updated through automatic collection of data from the instruction and assessment of tasks.

These characteristics are useful for (a) decisions about learning goals, (b) teacher scaffolding for the student, and (c) customization of learning activities.

3) **Attainments** keeps a trace of all achieved activities, performed by the learner and refers to the student's current attainments. These (subjective) personal attainments support student learning by keeping track of each student's progress on attainments.

The student's progress is indicated, for example, by an attainment in the map automatically turning a darker and darker shade from when a student starts working on it, to when he or she masters it, along with date and time mastered. This way, teachers can easily see how the student is doing and offer support when needed.

Theory of the scaffold conceptualized on three levels (Rienlugh, 2015):

1) **Cognitive Structuring** specified by the teacher refers to the (map) hierarchy of all concepts or skills required for the accomplishment of the task. Each concept is defined, decomposed, and contextualized to facilitate the examination and assistance of learner's understandings of this concept.

This hierarchy is linked to the structure of activities to contextualize attainments of learner.

2) **Assistance** designed by the teacher refers to the implementation of the six functions of scaffolding to support individual progress (attainments). Exploiting the theory of the learner and the theory of the task, these functions are linked to the map of concepts, the map of activities and the map of personal attainments.

3) **Dynamic Assessment** implemented by the teacher refers to real-time moment by moment evaluation of the learner's progress. It requires a cyclical process of diagnosis-feedback response. Dynamic assessment collects data on student performance on each attainment and makes it available to the student (for self-regulation) and the teacher (for scaffolding).

4.3. Functional integration of SRL scaffolding

SRL scaffolding refers to joint (individual and social) regulation of learning. To meet theoretical roots, our alignment and integration approach combines the six functions of scaffolding and the three phases of SRL (see Figure 4.2). Each phase of SRL is supported by scaffolding functions.

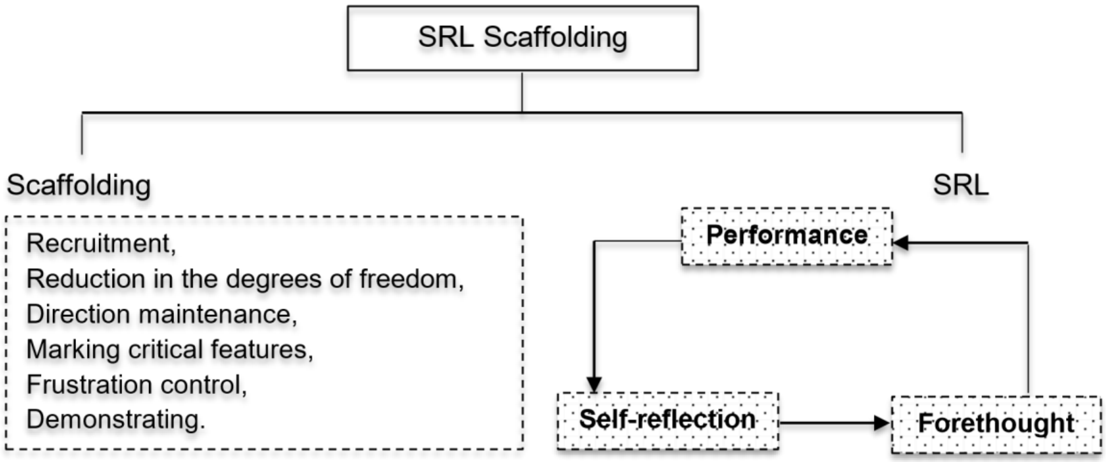

Figure 4.2. Functional integration of SRL Scaffolding.

The **forethought phase.** The self-regulated learner analyzes the specified task, while critical features are highlighted to recruit the learner to optimize goal setting. When setting a learning goal, the learner is directed to identify adequate strategies. During this preparatory phase, the learner's understandings of critical concepts should be examined before engaging in the next phase and in order to limit risk of frustration.

The **performance phase.** The self-regulated learner is managing his or her own learning through the self-control process. When implementing the strategies that he chose during the forethought phase, the learner's activities should be examined to keep direction and reduce degrees of freedom if necessary. The self-control process should be accompanied by partial demonstrations to maintain self-satisfaction or to engage the next phase for possible corrections.

During this phase, the self-regulated learner monitors and observes his/her own learning. The results of this self-monitoring phase provide feedback for scaffolding functions, allowing adjusting the activities according to the current performance.

The **self-reflection phase**. The self-regulated learner is self-evaluating to determine whether his/her goals are achieved. When self-reflecting, the learner should be scaffolded to provide cause analysis, such as considering what caused learning success or failure. The scaffolding can take the form of a general demonstration of achieved activities and recommendation to adjust goals and strategies.

4.4. Design of SRL Scaffolds

SRL scaffold refers to a software temporary entity designed by the teacher to support the accomplishment of a specified by a SR learner. On one hand, this entity implements three theories and related maps (activities, concepts, and attainments) and six functions of scaffolding and related strategies. On the other hand, this entity shapes the three phases of SRL. The SRL scaffold is played in a LE.

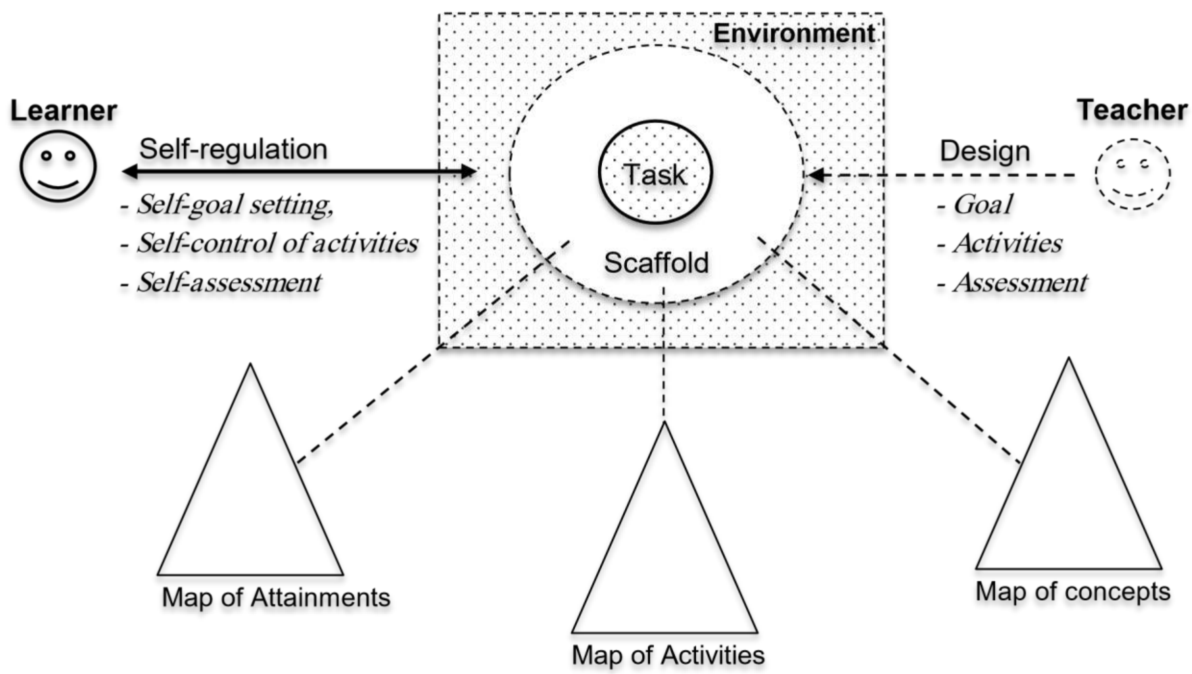

Figure 4.3. Design of SRL Scaffold

Our perspective for the design of SRL scaffold is restricted on three levels representing respectively an issue of implementation of each phase of SRL:

1) Scaffolding self-goal setting
2) Scaffolding self-control of activities
3) Scaffolding self-assessment

4.5.Conclusion

In this chapter, we have presented an approach for the integration of SRL and scaffolding. This approach conceptualizes three theories for the scaffolding of SRL learners and suggests operational ways to implement these theories. Three types of maps are proposed: map of activities, map of concepts, and map of attainments.

In this chapter, we have also proposed a perspective for the design of SRL scaffold around three levels: scaffolding self-goal setting, scaffolding self-control of activities, and scaffolding self-assessment.

Design of SRL Scaffolds: Technological-Pedagogical Prototype

5.1. Introduction

This chapter focuses on developing our perspective for the design of SRL scaffolds. The components of a design prototype are specified:

Learners: *students in the University Ibn-khaldoun of Tiaret, Computer Sciences, license 1.*

Subject: *matter of algorithmic, concept: "instruction of affectation".*

Task: *solving a problem of three variables' permutation by writing an algorithm.*

5.2. Structuring the Task

The task is specified to the student like:

"Write an algorithm that permutes the values of two entire variables." Based on this task, the teacher specifies the task's settings :

(a) Pedagogical goals, activities, and assessment.

(b) Maps of activities and concepts.

Specification of pedagogical goals:

The teacher specifies goals (G) and sub-goals (SG) intended from the learner after accomplishing the task:

G1: Examining the understanding of the concept of "variable" in computer science.

SG1.1: Examining the understanding of the physical nature of the variable.

G2: Fostering understanding the instruction of affectation.

SG2.1: Examining the understanding of the operation of read.

SG2.2: Examining the understanding of the operation of write.

Specification of pedagogical activities:

The teacher structures the learning activities (A) and sub-activities (SA) required to solve the problem:

A1: Give a noun to the algorithm, *"permutation"* in **1 mn**.

A2: Identifying data (variables),

A2.1: Identifying two variables, like *"X and Y"*, in **2 mn.**

A2.2: Identifying the third variable, like *"Z"*, in **5 mn.**

A3: Identifying treatments (instructions), **A3.1:**

Reading first variable, in **5 mn.**

A3.2: Reading second variable, in **5 mn.**

A3.3: Identifying first instruction, like Z←X, in **5 mn.**

A3.4: Identifying second instruction, like X←Y, in **5 mn.**

A3.5: Identifying second instruction, like Y←Z, in **5 mn.** **A3.6:** Writing first variable, in **5 mn.**

A3.7: Writing second variable, in **5 mn.**

Specification of pedagogical assessment:

The teacher specifies assessment (AS) and sub-assessment (SA) according to the pedagogical goals:

AG1: Assessing the understanding of the concept of "variable" in computer science. **ASG1.1:** Evaluating the understanding of the physical nature of the variable.

AG2: Assessing the understanding of the instruction of affectation.

ASG2.1: Evaluating the understanding of the operation of read.

ASG2.2: Evaluating the understanding of the operation of write.

Maps of Activities

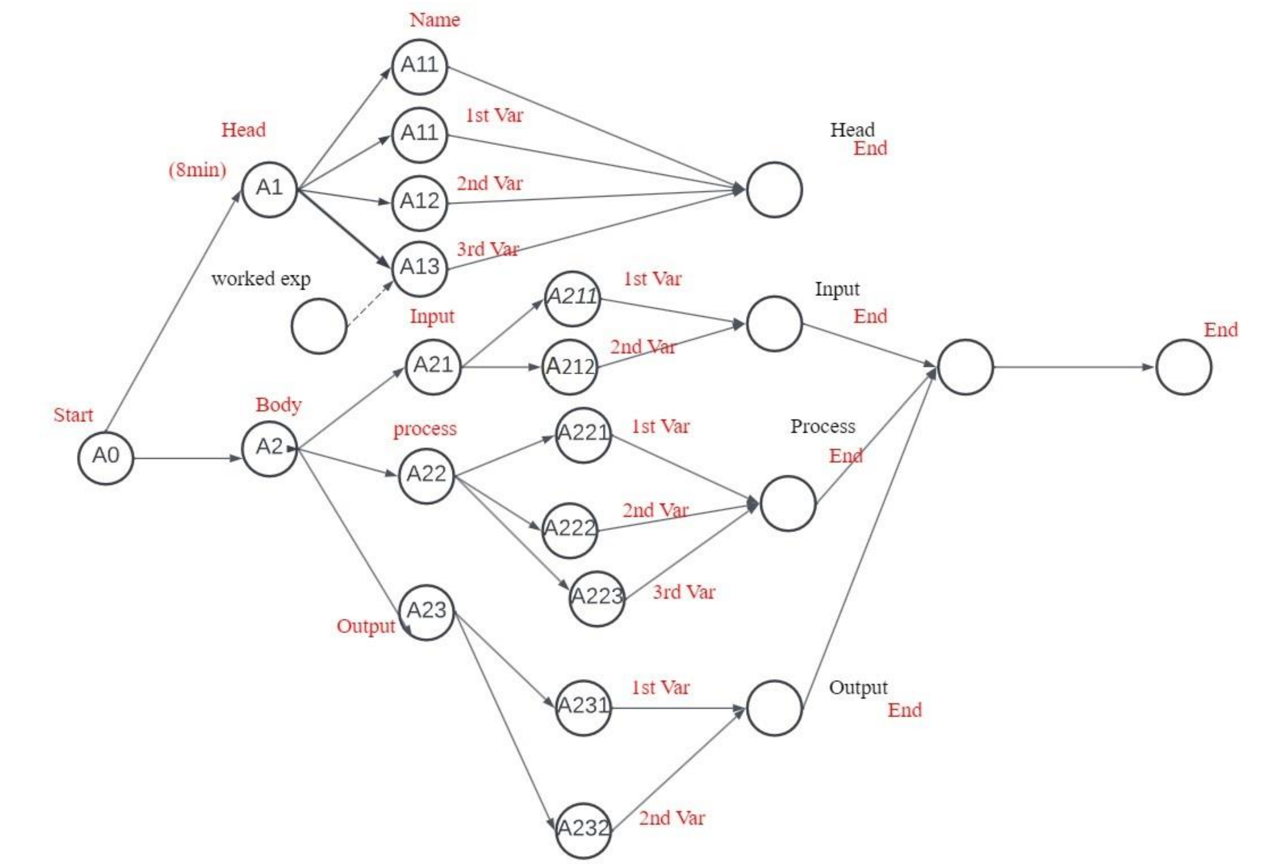

Figure 5.1. Maps of Activities

Maps of Concepts

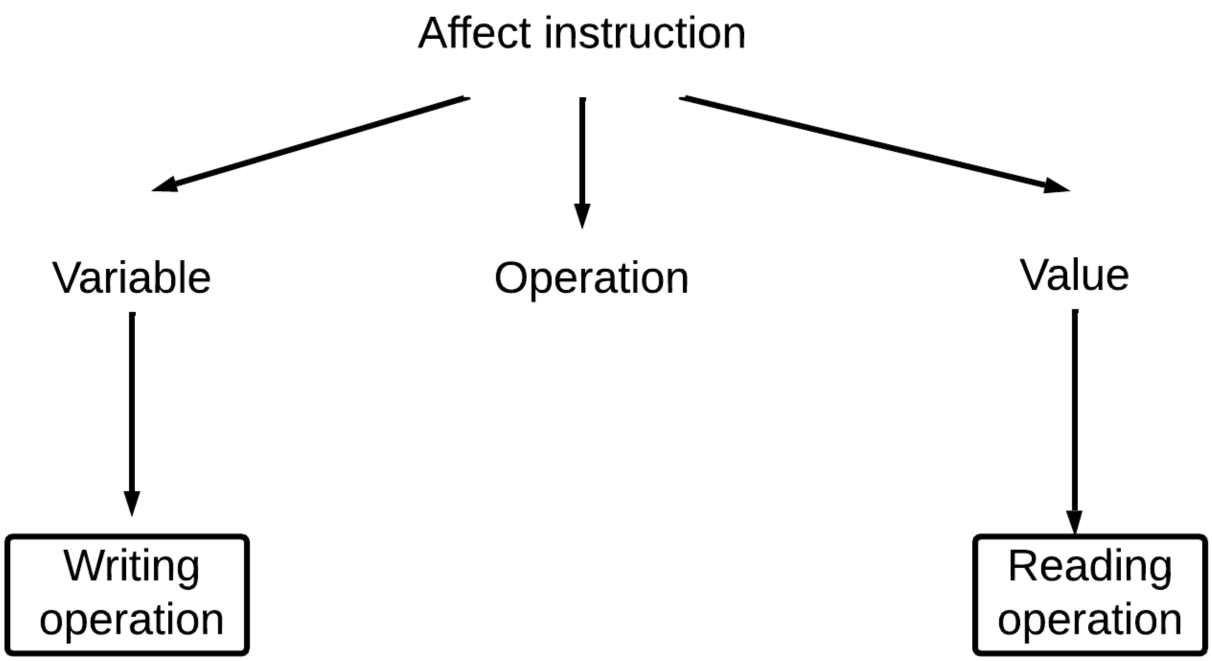

Figure 5.2. Example of Concept Map

Specification of the Scaffold

Based on the structure of the task, the teacher specifies the scaffold's settings:

(a) Scaffolding personal goals, activities, and assessment.

(b) Dynamic assessments.

(c) Maps of attainments.

Scaffolding Personal Goals

The teacher specifies goals (g) and sub-goals (Sg) that direct the learner in the self-goal and plan settings. For example: **g1:** Identifying data. **g2:** Identifying treatments, **in 10 mn**

Sg2.1: Identifying reading instructions.

Sg2.2: Identifying permutation instructions.

Sg2.3: Identifying writing instructions.

Scaffolding personal activities

The teacher specifies how to scaffold the learner in the process of solving the problem. (b) Specify problem-solving strategies, using algorithm execution table.

Scaffolding personal assessment

The learner is directed to assess the goal and plan specified. For example:

Ag1: Assessing identified data,

Ag2: Assessing identified treatments,

ASg2.1: Assessing reading instructions.

ASg2.2: Assessing permutation instructions.

ASg2.3: Assessing writing instructions.

5.3.Specification of the Scaffold

Based on the task's setting and the scaffold's setting, the teacher, and the LE developer:

(c) Design the technological interface of SRL scaffold.

(d) Integrate elements of SRL scaffold in the LE.

5.3.1. Design the interface

The interface of the SRL scaffold can be designed around three components:

(a) Left layout for pedagogical activities and scaffolding settings.

(b) Right layout for learner's actions and self-regulation settings.

(c) Middle layout for writing the algorithm and interacting with the scaffold.

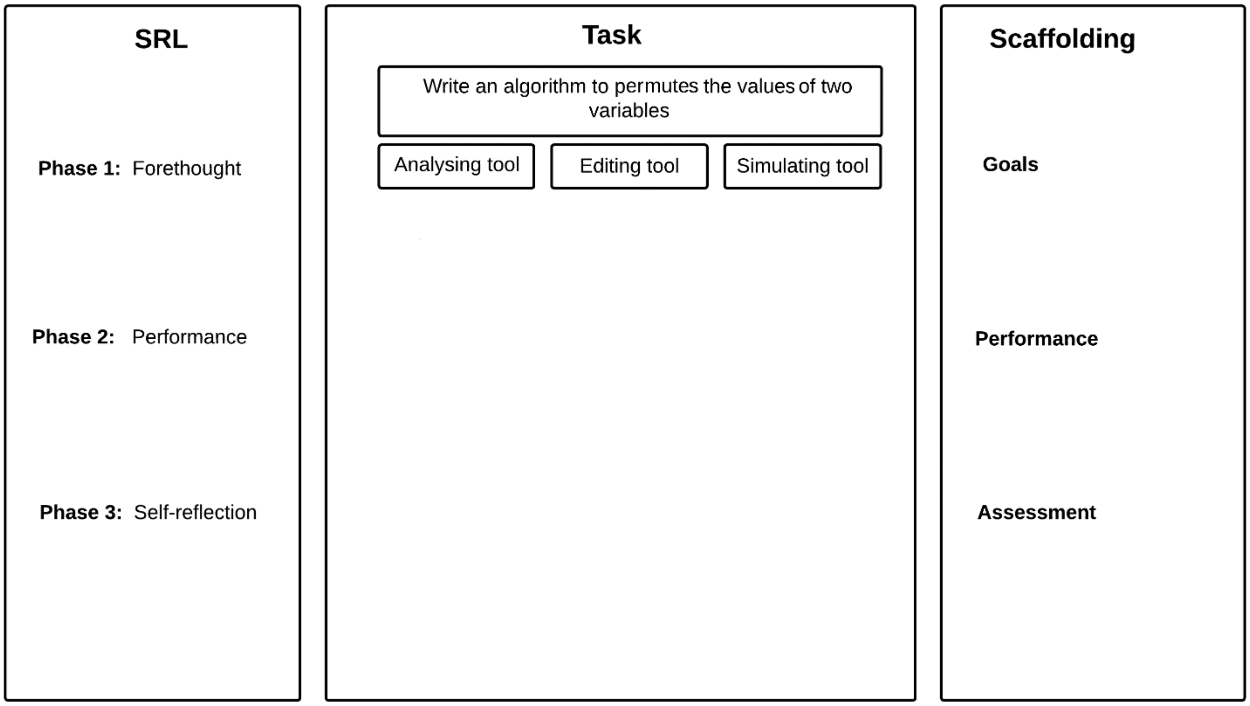

Figure 5.3. Interface of the SRL Scaffold

5.4. Conclusion

This chapter has presented the development of a perspective for designing SRL scaffolds. We have specified the task structure, pedagogical goals, activities, and assessment to guide learners in understanding the concept of variables and the instruction of affectation. The scaffolding settings, dynamic assessments, and maps of attainments have been outlined to provide support and evaluation throughout the learning process.

Implementation of the Prototype

6.1. Introduction

This chapter focuses on implementing our designed prototype SRL-SP (SRL-Scaffolding Prototype). The tools of implementation are specified:

Coding language: Java is a powerful, high-level, object-oriented programming language known for its versatility. It is widely used for developing various applications, including desktop applications.

JavaFX, on the other hand, is a library and framework specifically designed for creating user interfaces in Java. It emerged from the OpenJFX project and offers developers a range of tools and components to build visually appealing and interactive graphical interfaces for desktop applications, as well as web applications and mobile applications for smartphones and tablets.

Integrated Development Environment (IDE): IntelliJ, a popular IDE, offers advanced features and productivity-enhancing tools, simplifying the process of software development in Java and other programming languages.

The phase of teaching-learning with the SRL-scaffold are illustrated using three scenarios of execution.

6.2. Interface of the Prototype

Figure 6.1 presents the interface of our prototype. The SRL side includes three sections related to three SRL's phases. Each section is linked to a dynamic assessment script that calculates a rate associated with the achievement of the correspondent phase. Respectively these sections are connected with three tools: Analyzing tool, Editing Tool and Simulating Tool. Dynamically, the learner is assessed in each action provided within (the objects of) these tools.

These sections can be developed to include various other tools such (in section three): demonstration, cause analysis, and self-satisfaction.

The scaffolding side includes three sections: objective goals; assistance for performance, and objective assessment. Not completely developed, these sections reflect the objective settings provided by the teacher.

The middle side that focuses on the task to be achieved by the learner includes three tools. The analyzing tool permits to recruit the learner to engage in the task by scaffolding the learner in understanding the task and to select a plan. The editing tool reduces the cognitive **load** and the degree of freedom of the learner and to **direct** the learner for a successful accomplishment of the task. The simulating tool provides opportunities to evaluate the edited algorithm and scaffold the learner to self-reflect his/her efforts. For example, demonstration and cause analysis can **control frustration and motivate** the learner to adjust and correct his/her actions.

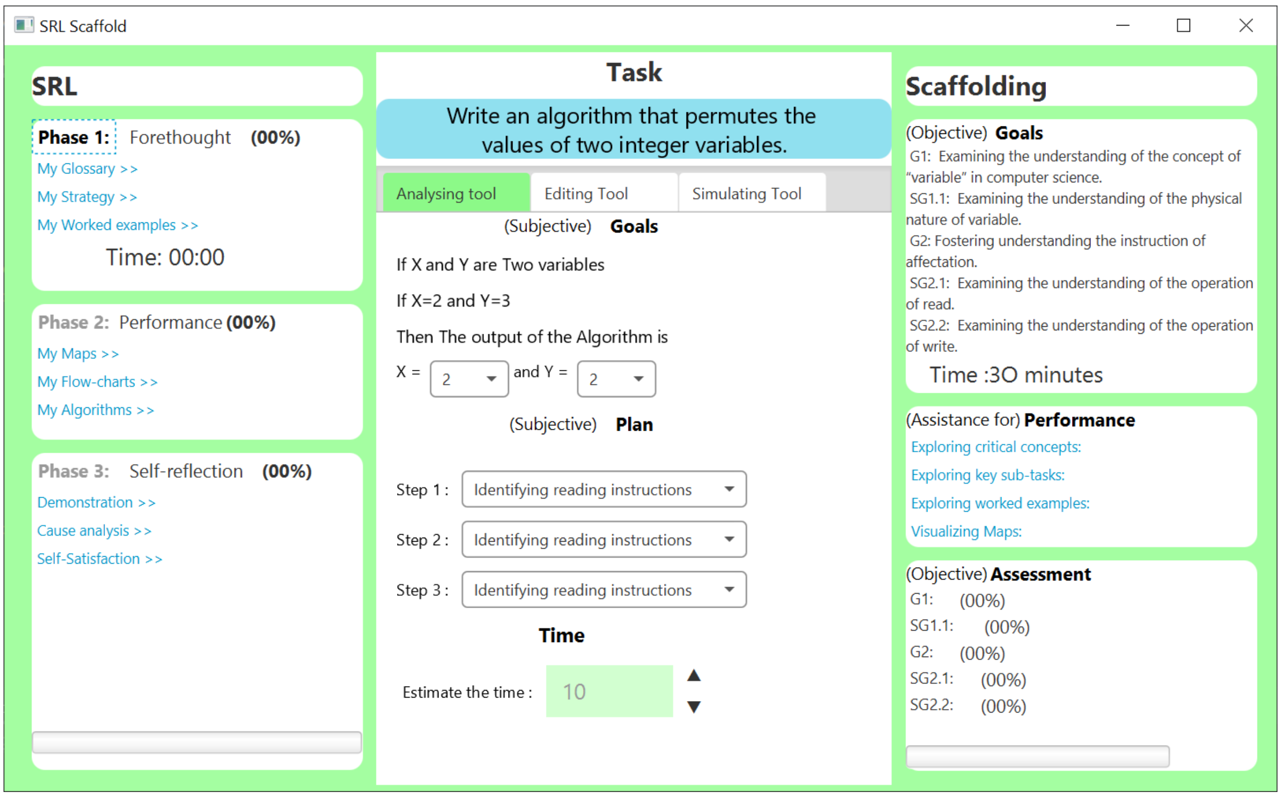

Figure 6.1. Interface of the SRL Scaffold.

6.3. Scenarios of Execution

Figure 6 illustrates the result of analyzing the task. The dynamic assessment evaluates five objects; each object is associated with a 20% rate. The figure shows an 80 % rate for the analysis of the task. The learner caused an error when he/she selected the value 3 for Y.

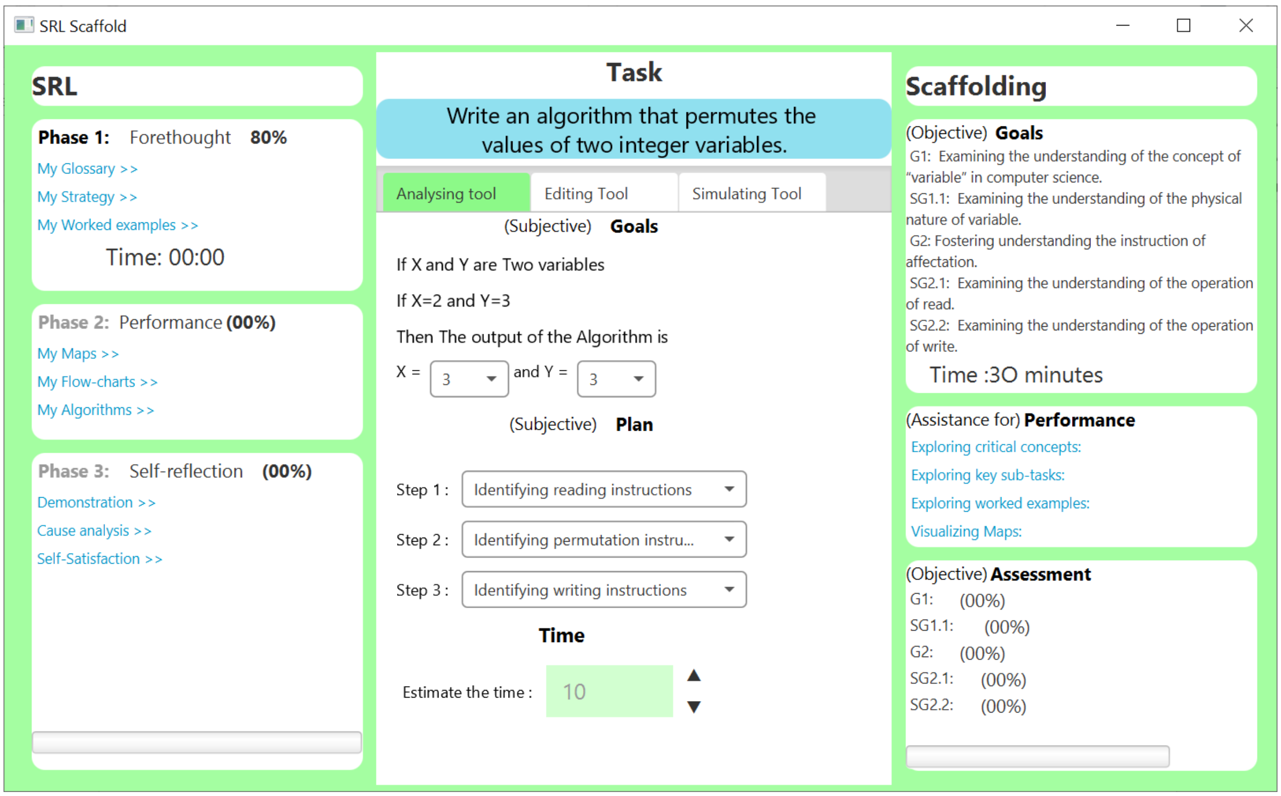

Figure 6.2. Forethought Phase.

Dynamically, the learner corrects their errors signaled by the rate calculated. Then after the correction of the previous error the new interface is illustrated by Figure 6.3

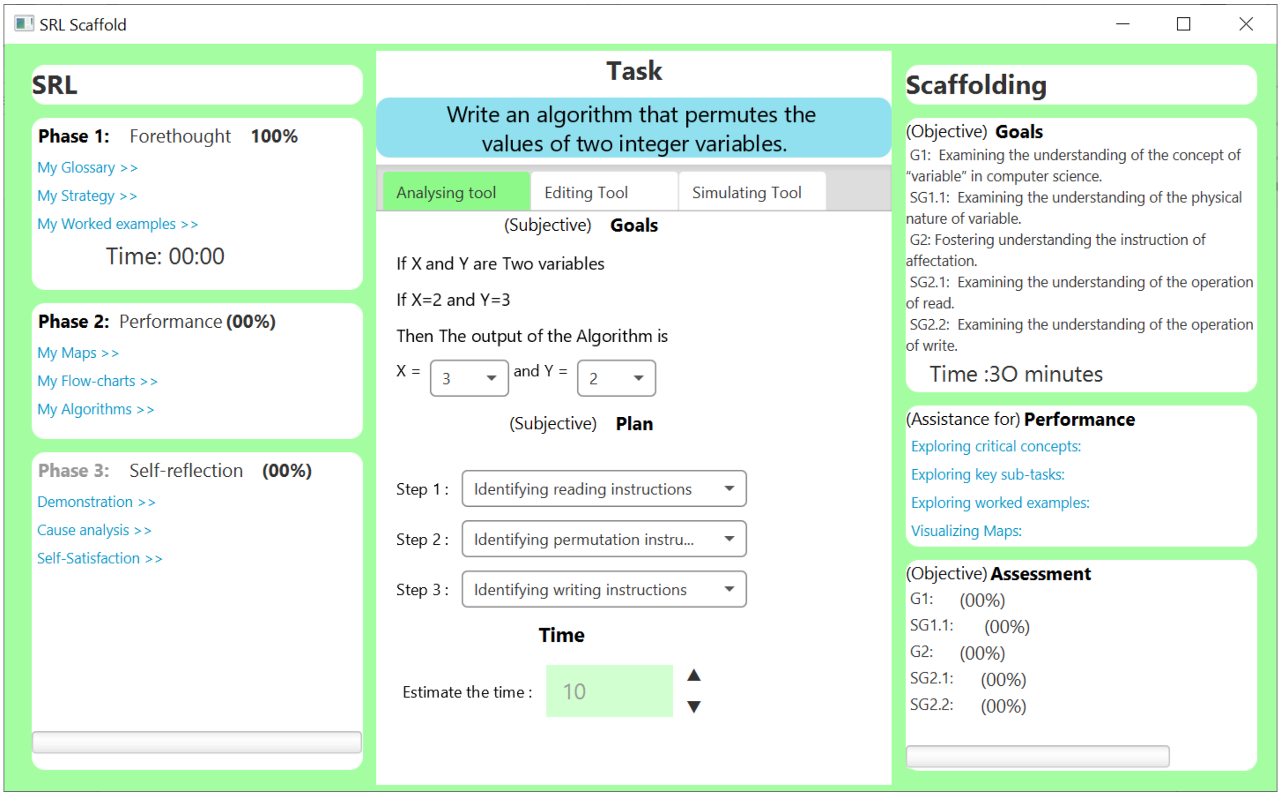

Figure 6.3. Forethought after Correction.

If the rate related to the phase of forethought is 100 then the phase 2 link is activated, and the learner can access the editing tool. As illustrated by Figure 6.4, the learner engages in writing the algorithm. The current state is evaluated by 30%. Each object in the editing tool is estimated at a 5% rate. Only the third variable and the third instruction (as illustrated in Figure 6.6) are evaluated at 25%.

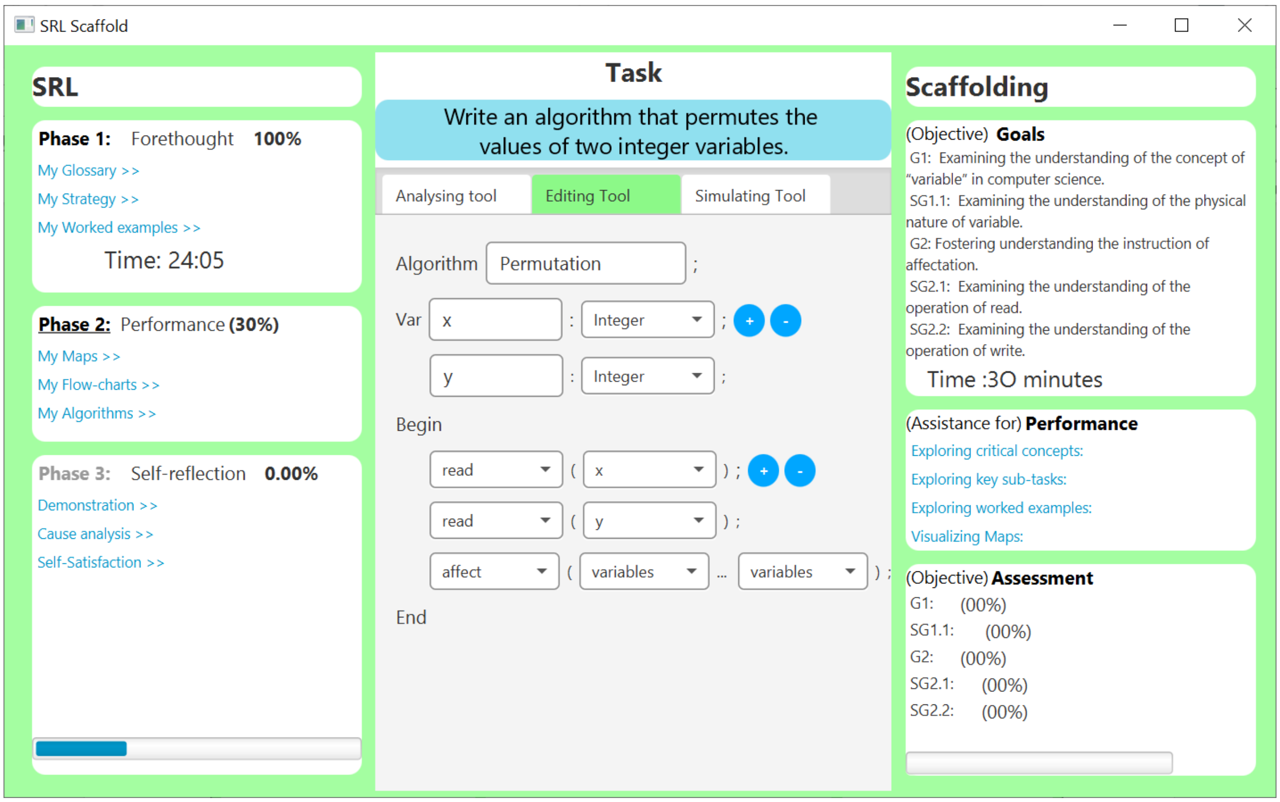

Figure 6.4. Performance

If the performance rate is superior to 50% then the learner can access phase 3. In this phase, the simulating tool (under development) permits to evaluate the input/output values of the algorithm. The learner is supported by various tools (under development) to reflect and analyze their actions. For example, the learner is recommended to adjust their goals and plan using worked examples.

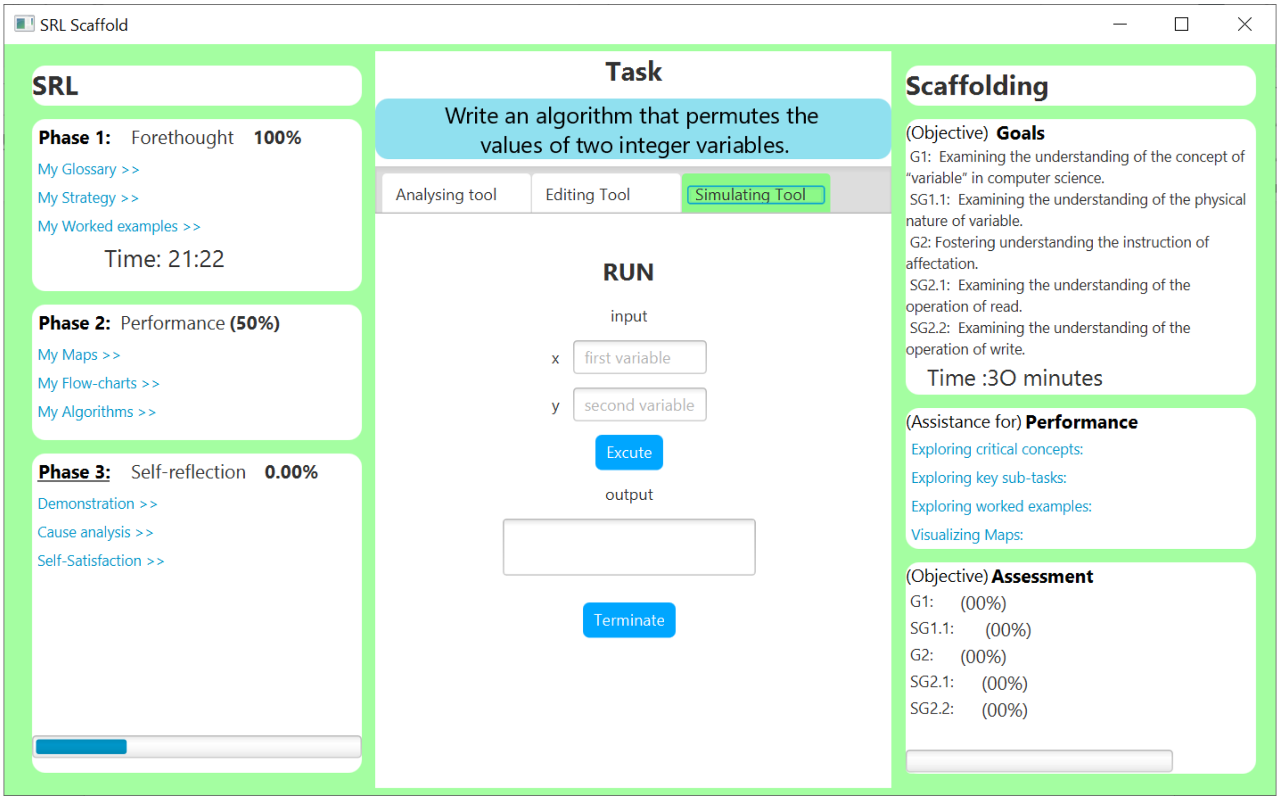

Figure 6.5. Self-reflection

Figure 6.6 illustrates a complete algorithm. The learner in this case understands the role of the third variable and also of the third affectation instruction.

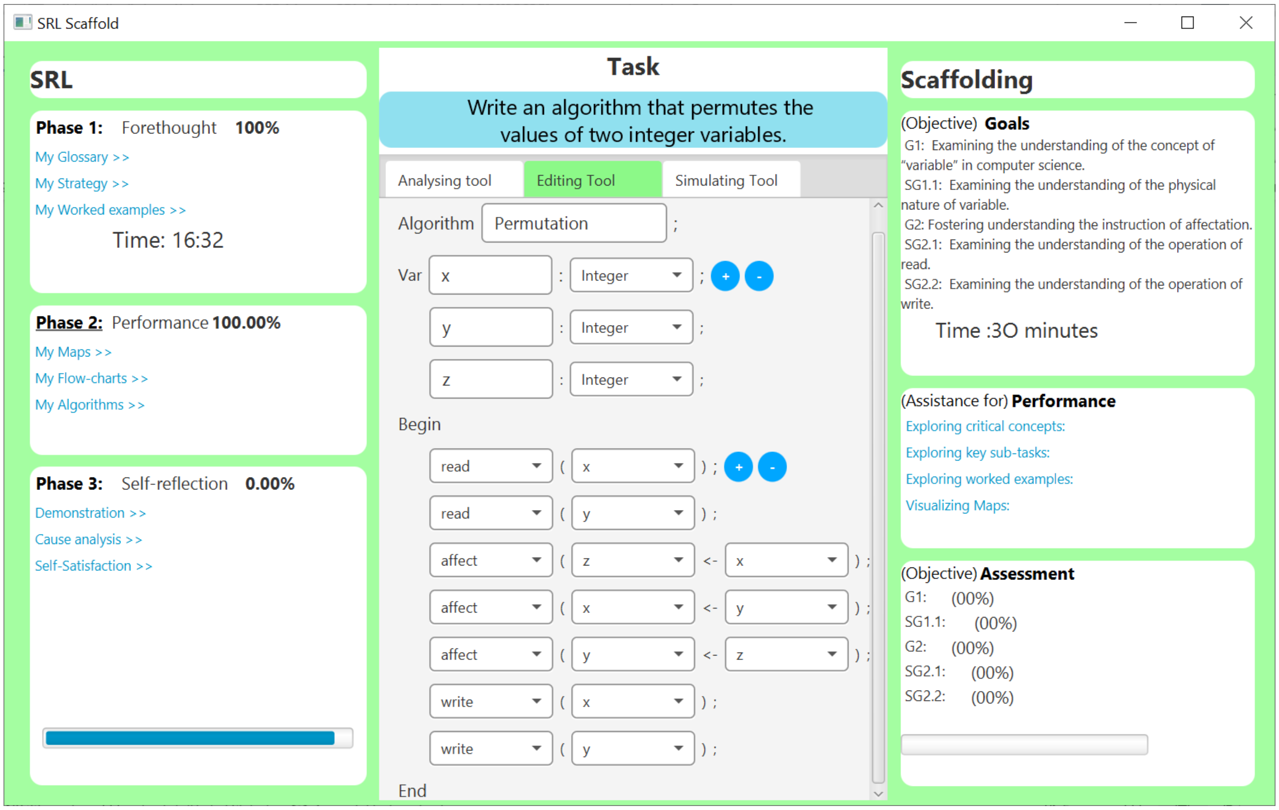

Figure 6.6. Performance

In the self-reflection phase, the learner simulates the algorithm and finds the right results corresponding to their goals. The learner can evaluate his/her self-satisfaction via a general demonstration.

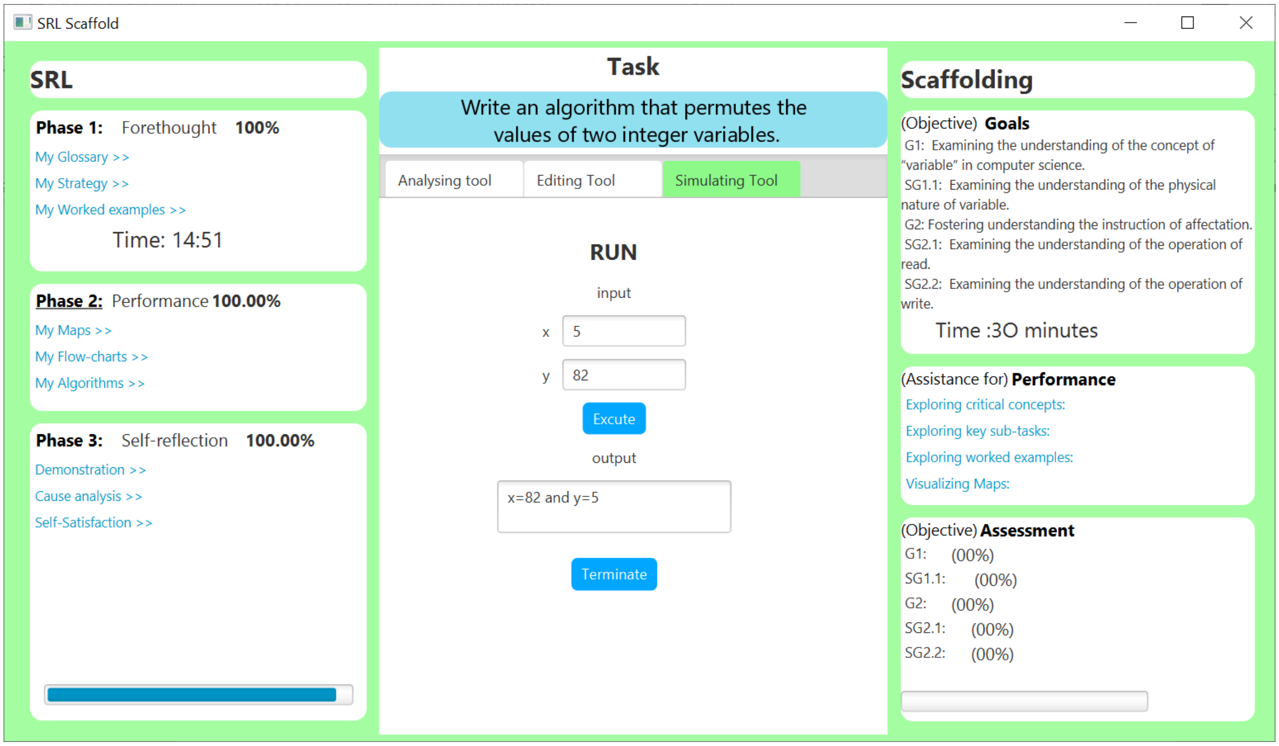

Figure 6.7. self-reflection after testing.

6.4. Conclusion

The SRL-Scaffold Prototype (SRL-SP) developed under Java and JavaFX illustrate and reflect the theoretical background of SRL scaffolding construct. The prototype's interface, and integrated tools offer valuable (pedagogical and technological) support for self-regulated learners. By providing scaffolding and guidance throughout the learning process, the SRL-SP demonstrates its potential to enhance learner motivation and engagement for the accomplishment of the task.

General Conclusion

General Conclusion

LE are psychological and physical spaces involving complex cognitive and social interactions between different actors, particularly teachers and learners. In an effort to supplement or replace traditional classroom-based LE, TELE uses technology to replicate the ineffective methods that limit teaching and learning in face-to-face pedagogy (Jonassen, 1995; Laurillard, 2009). To implement (analyze, design, develop, implement, and evaluate) effective TELE, interdisciplinary and further research is required.

In this context, our project explores a central problematic issue of how to design computer based LE that implements effective teaching and learning (Hannafin, 1997). Various assumptions, methods and practices used to design LE are discussed, in order to understand theoretical and practical requirements for effective implementations of LE. In the present thesis, we have presented three complementary assumptions: instructivism, constructivism and sociocultural constructivism. Respectively, three models of design are explained: systematic design (Dick & Carey, 1990), constructivist design (Jonassen, 1999) and sociocultural design (Collins et. al., 1989).

In the present thesis, we have briefly explored SRL and scaffolding and summarized main components, phases, and functions. Our approach for the integration of SRL and scaffolding is explained in chapter four, as well as a perspective for the design of SRL scaffold. The design of SRL scaffolds focuses on aligning the task's specifications and the learner's actions. The alignment has focused on goals, learning activities, and assessment. Different maps are used to structure the SRL scaffold: map of activities, map of concepts, and map of attainments.

To illustrate our contribution, we have designed a prototype for SRL scaffolding. Different levels of specification are advanced: specification of the task and specification of the scaffold. These detailed specifications bring out potentials of SRL scaffold to support autonomous learners in the accomplishment of the specified task. The prototype has been developed using the Java-based environment: JavaFX. Various scenarios are executed to illustrate the functional behavior of the designed SRL scaffold. Our project has explored SRL scaffolding and concluded some perspectives:

a) SRL scaffolding requires further research that could lead to effective conceptualization and integration in forms of patterns and frameworks that promote the exchange of design practices.

b) SRL scaffold, as software entities, requires a principled design that could be generalized for the development of SRL design tools, and environments supporting, facilitating, and promoting teachers' tasks.

c) SRL scaffold, as technological entities, require advanced technologies to shape the dynamic nature and the complex interactions involved in SRL scaffolding.

The present thesis has provided an interesting experience to explore teaching and learning from theoretical (cognitive, social, cultural etc.), methodological (instructional, pedagogical etc.) and practical (interactional, technological etc.) perspectives.

References

References

Amineh, R. J., & Asl, H. D. (2015). *Review of constructivism and social constructivism. Journal of Social Sciences, Literature, and Languages*, 1(1), 9-16.

Bliss, J., Askew, M., & Macrae, S. (1996). *Effective teaching and learning: Scaffolding revisited. Oxford Review of Education*, 22(1), 37-61.

Bruner, J. S. (1964). *The Course of Cognitive Growth. American Psychologist*, 19(1).

Collins, Allan & Halverson. (2009). Rethinking Education in the Age of Technology: The Digital Revolution and the Schools.

Coates, H., James, R. & Baldwin, G. (2005). *A critical examination of the effects of learning management systems on university teaching and learning*. Tertiary Education and Management, 11(1), 19-36.

Dick, W., & Carey, L. (1996). *The systematic design of instruction*, 4th edition. New York: Harper Collins College Publishers.

Dron, J. (2022). *Educational Technology: What it is and How it Works*. AI & SOCIETY, 37(1), 155-166.

Gray, A. J. (1997). *Constructivist Teaching and Learning* (pp. 97-07). Saskatchewan School Trustees Association.

Hammond, J. (2001). *Scaffolding: Teaching and learning in language and literacy education*. Primary English Teaching Assoc., PO Box 3106, Marrickville, New South Wales, 2204, Australia.

Hannafin M. J., Hannafin, K. M., Land, S. M., Oliver, K. (1997). *Grounded Practice and the Design of Constructivist Learning Environments*. Springer. 45(3), 101-117.

Järvelä, S., Järvenoja, H., & Malmberg, J. (2019). *Capturing the dynamic and cyclical nature of regulation: Methodological Progress in understanding socially shared regulation in learning*. International journal of computer-supported collaborative learning, 14, 425-441.

Jonassen, D. H. (1991). *Objectivism versus constructivism: Do we need a new philosophical paradigm?* Educational Technology Research and Development, 39(3), 5-14.

Jonassen D., (1999). *Designing constructivist learning environments*, C. M. Reigeluth (Ed.), Instructional design theories and models, Vol. 2, 1991, pp. 215–239, Lawrence Erlbaum Associates.

Laurillard, D. (2008). *Technology enhanced learning as a tool for pedagogical innovation.* Journal of Philosophy of Education, 42(3-4), 521-533.

Palincsar, A. S. (1986). *The role of dialogue in providing scaffolded instruction. Educational psychologist*, 21(1-2), 73-98.

Panadero, E. (2017). *A review of self-regulated learning: Six models and four directions for research. Frontiers in psychology*, 422.

Pea, R. D. (2004). *The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity.* The journal of the learning sciences, 13(3), 423-451.

Persico, D., & Steffens, K. (2017). *Self-regulated learning in technology enhanced learning environments. Technology Enhanced Learning: Research Themes*, 115-126.

Puntambekar, S., & Kolodner, J. L. (2005). *Toward implementing distributed scaffolding: Helping students learn science from design.* Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 42(2), 185217.

Reeve, J., Ryan, R., Deci, E. L., & Jang, H. (2008). *Understanding and promoting autonomous self-regulation: A self-determination theory perspective*. In D. H. Schunk & B. J. Zimmerman (Eds.), Motivation and self-regulated learning: Theory, research, and applications (pp. 223–244). Lawrence Erlbaum Associates Publishers.

Seidel, T., & Shavelson, R. J. (2007). *Teaching effectiveness research in the past decade: The role of theory and research design in disentangling meta-analysis results. Review of educational research*, 77(4), 454-499.

Sharma, P., & Hannafin, M. J. (2007). *Scaffolding in technology-enhanced learning environments. Interactive learning environments*, 15(1), 27-46.

Sitzmann, T., & Ely, K. (2011). *A meta-analysis of self-regulated learning in workrelated training and educational attainment: what we know and where we need to go. Psychological bulletin*, 137(3), 421.

Tam, M. (2000). *Constructivism, instructional design, and technology: Implications for transforming distance learning. Journal of Educational Technology & Society*, 3(2), 50-60.

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). *Scaffolding in teacher–student interaction: A decade of research. Educational psychology review*, 22, 271-296.

Wertsch, J. W. (1984). The zone of proximal development: Some conceptual issues. In B. Rogoff & J. V. Wertsch (Eds.), New directions for child development: No. 23. Children's learning in the “zone of proximal development” (pp. 7-18). San Francisco: Jossey-Bass.

Wood, D., Bruner, J. S., & Ross, G. (1976). *The role of tutoring in problem solving*.

Child Psychology & Psychiatry & Allied Disciplines.

Zimmerman, B. J. (2002). *Becoming a self-regulated learner: An overview. Theory into practice,* 41(2), 64-70.

Zimmerman, B. J. (1990). *Self-regulated learning and academic achievement: An overview.* Educational psychologist, 25(1), 3-17.