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Modelling of Educational Scenarios Based on the Coupling of Explicit Teaching and Guided Discovery Learning Approaches in an E-Learning Context

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ABSTRACT

The objective of this article is to present and illustrate an educational engineering approach relating to the use of structure (SD), activity (AD) and Vee (V) diagrams in the design and modeling of educational scenarios. in alignment with a model of hybrid pedagogical approach: explicit - by discovery strongly requested recently in the practices of distance and online education. We first analyze the basic pedagogical approach of distance education, then we present and illustrate how to use these diagrams in scriptwriting.

KEYWORDS: Pedagogical engineering, approach, design and Modelling of pedagogical scenarios, hybrid pedagogical approach (explicit / by discovery), structure diagram (SD), activity diagram (AD), Vee diagram (V),

I. INTRODUCTION

The problem of distance education or e-learning does not lie or is not limited simply to the availability of means of communication or interaction, the pedagogical and didactic strategy that will be adopted in this mode of teaching or training is no less important, it is now decisive. Distance education cannot be improvised.

A whole educational and didactic design and scripting work, carried out by the teacher, is requested upstream of the use of any distance education or training platform or e-learning.

The use of educational engineering has become crucial at a time when the demand for distance education or e-learning is increasing day by day and growing very rapidly, especially during and after the Covid19 pandemic. The pedagogical engineering approach will provide a lot of help to teachers, especially in the following practices:

- Design / adaptation / reorganization of online course content by scripting them and mediating them in the most rigorous way;
- Maintenance and development of teacher / learner and learner / learner interaction links;
- Adoption of digital tools while favoring the pedagogical and didactic scenario over technology.

The objective of this research work is to show, moreover, how important this pedagogical engineering approach is in the design and modelling of pedagogical scenarios in the context of e-learning teaching or training, by showing how to use the design and modelling tools inspired by software engineering to script the contents, the units and the didactic sequences, the modelling of the activities and the learning situations, while remaining aligned with the chosen pedagogical approach.

II. UPSTREAM, THE CHOICE OF THE EDUCATIONAL APPROACH IN E-LEARNING: THE HYBRID EXPLICIT / DISCOVERY APPROACH

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The specialized literature in the field of education, teaching and learning reveals to us a variety of teaching strategies which can be classified differently, according to the effort expended by teacher and learner (expository teaching or teaching by discovery); according to the role of the teacher or the learner (teacher-centred teaching or learner-centred teaching) or according to the method (direct / explicit teaching or indirect teaching).

In particular, the explicit and discovery approaches have long been the subject of debate among researchers and practitioners as to their ambiguities, their points of convergence and divergence, and their contributions to academic success [1].

In this paragraph, we analyse these two types of educational approaches that are very often opposed and whose theoretical

principles are different. Our objective is to deduce a teaching model that articulates the two attitudes "teacher activator" and "teacher facilitator", and which can be used for teaching in e-learning mode.

A. The pedagogy or the explicit teaching process

The pedagogy or the explicit teaching approach does not date from today. By examining the literature published between 1966 and 2016, Jean Stockard and his collaborators on explicit teaching, raised the effectiveness of this type of teaching and its strong contribution to the success of students in several disciplines [2].

In his book, Visible Learning, a synthesis of more than 800 meta-analyses of academic achievement, Hattie highlights the importance of explicit instruction in developing deep learning in learners of different ages and backgrounds. capacities [3].

A result that will be confirmed by the work of Steve Bissonnette and his collaborators on effective strategies promoting fundamental learning among pupils in difficulty at elementary level [4].

Very recently, the interdisciplinary educational council of Quebec published a special issue of its journal, under the title "Explicit teaching: an effective pedagogical approach to promote the success of the greatest number." This testifies to the interest that we continue to bring to this method of teaching [5]. It contains brief studies and analyses of the nature and origins of explicit teaching, as well as an account of experiences and practices of this type of teaching.

In his article entitled "Explicit Instruction: A model elaborated from research on classroom instruction and validated by research on human cognitive processing" Barak Rosenshine, indicates that explicit teaching is an educational model resulting from mainly North American research on effectiveness. of teaching in the 60s and 70s, carried out in particular by Medley and Mitzel in 1963, Flannders in 1960, Bellak in 1966 and Gage in 1963. These researchers attempted to highlight the observable characteristics of effective teaching [6].

On the basis of these characteristics, Mac Donald and Elias in 1976, were able to demonstrate a direct and effective teaching model. Such a model which will be developed subsequently by Barak. Rosenshine in 1976, in which formalizes explicit teaching procedures (present content, revise frequently, guide students, provide models, check understanding…).

He gives it a more meaningful name, which is explicit teaching, to remove the ambiguity with the "direct teaching" model, while giving it the following characteristics:

- Present and explain what has been learned;
- Promote interactions and involvement of learners;
- Gradually structure learning, going from simple to complex, to aim for comprehension;
- Value efforts and strategies for success.

Explicit teaching has its foundational foundations in pragmatic educational research and cognitive science research, including cognitive load theory and the concept of competence building. Explicit teaching is then defined as a structured and systematic teaching approach that is part of the family of so-called "instructionists" models based on teaching strategies structured in sequenced and highly integrated steps. This is an approach that emphasizes planning and facilitating information from the teacher to the students; characterized in particular by modelling, the organization of numerous guided practices and the communication of numerous feedbacks to support the learning process. Explicit pedagogy offers teaching whose contents are determined, organized and presented according to cognitive processes.

Explicit teaching is a teaching model that emphasizes well-developed and carefully planned lessons, designed around small levels of learning and clearly defined and prescribed teaching tasks. It is based on the theory that clear instruction eliminating misinterpretation can greatly improve and speed up learning [1].

There are several patterns in designing an explicit lesson, depending on the learners' levels of integration into the lesson construction. We expose in this article a more evolutionary model proposed by Gauthier and his collaborators, in which we clearly distinguish the fundamental stages [7].

- Scenario or opening: aims to approach the topic to the learner and to prepare him cognitively. In this phase the teacher explains the objectives to his learners and tries to reactivate their previous prior knowledge;
- The learning experience: composed of 3 linear phases:
  - Modelling phase: The teacher performs the tasks in front of his learners, asking himself questions and explaining his strategy aloud as if he were in their place;
  - Guided practice phase: Learners carry out instructions and tasks by explaining their strategies aloud;
  - Autonomous practice phase: The learners repeat several successes independently.
- Objectivation: Synthesis and deduction of knowledge and skills to be retained.

B. Pedagogy or the discovery learning process

Bruner introduced the principle of discovery learning in the 1960s. It is an investigative learning approach that encourages the learner to seek information on their own [8]. Instead of simply being given the solution to a problem, the learner must use the pre-existing knowledge and resources at his disposal to arrive at his own conclusions. Rather, according to Bruner, instructors have a facilitating role and

create lessons and educational resources that provide basic structure and information.

Thus, discovery learning in the field of e-Learning is seen as a form of constructivism where the learner has an active role in the educational process and interprets concepts and ideas autonomously.

Still according to Bruner, there are two main goals that teachers want to practice this type of learning with their learners:

- This method should serve as an extension of constructivism theory, which focuses on experiences targeted to the learner;
- Discovery learning should provide learners with the structure to explore the topic of the course on their own. Thus, it serves as a guide that learners can follow to expand their knowledge.

Essentially, discovery learning is that the material to be learned is not presented to the learner in its final form or as a finished product, but in a form such that the learner must rearrange or transform it beforehand. to incorporate it into its cognitive structure.

Discovery learning ranges, in complexity (taxonomic), from the formation of concepts and generalizations (principles) to problem solving and creativity. At the level of these last two types of learning, that is to say of creativity, learning by discovery is indicated; so that on this subject there is no controversy between the proponents of discovery learning and those of receptive learning.

In classroom practices, the research identifies different approaches in the practice of teaching based on discovery learning that can be summarized in the figure below.

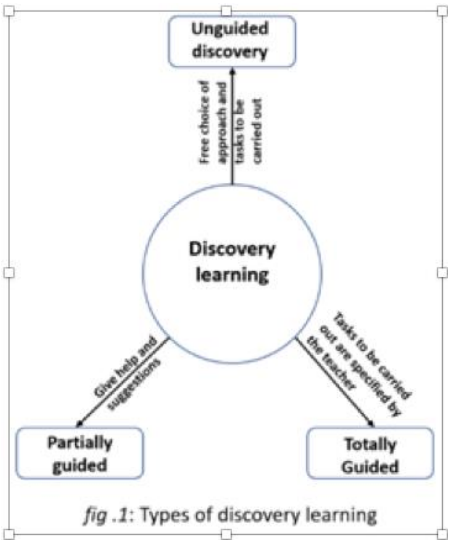

fig .1: Types of discovery learning

In learning by guided discovery, sometimes called direct and directed discovery, the subject is placed in a situation where he is allowed to discover the principles and the regularity of learning.

In guided discovery learning, teachers provide learners with specific resources one by one, difficult questions and clear outcomes. As much as possible, learners should always be given the opportunity to interact independently with each resource; however, specific resources, as well as the order in which learners interact with them, are prescribed by the teacher.

The guided rediscovery strategy is characterized by the discovery, through guided induction mechanisms, of the rules, principles and concepts that are the object of learning. It is about, through a more or less guided progression, to bring the learner to discover for himself the principles which are the object of the learning.

The use of simulations, modelling, demonstration video, animation and still images are very popular in this type of learning, especially in e-learning mode.

C. Combine explicit teaching and guided discovery learning in e-learning mode

The explicit approach and the discovery approach are different, of course, in their assumptions, characteristics and approaches. In the explicit approach, the teacher is an "activator", while in a discovery approach, his role is a facilitator.

Glaser points out that the fact that the two modes explicit (or even deductive) and discovery (or even implicit and inductive) have often been treated separately in research, and that these two modes are often confused, teaching practices of learning n 'have not been able to benefit greatly from the integration of these two modes [9].

Moreover, recent research on the performance and effectiveness of the two approaches to teaching and learning is no longer interested in comparing the two approaches, but rather in their combinations and their integrations. In addition, much research has shown the effectiveness of mixing these two teaching methods: learning both in the development of critical thinking, the appropriation of scientific approaches as well as in performance and academic success.

In this context, explicit teaching is not equivalent to a didactic exhibition with passive reception, any more than inquiry is equivalent to hands-on [1]. Efficient use of either mode requires consistency.

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However, in recent years there have been different effective direct-discovery teaching models that describe the components, stages and active tasks of learners. We will refer

more particularly to the studies carried out by Sweller and his collaborators, Archer and Hughes, Haak and his collaborators, Hassar, Lawson, Peterson, Rosenshine and Wright among others [10; 11; 12; 13; 14; 15; 16; 17].

Recently, Ku and colleagues examined in their study three modes of teaching, featuring the direct teaching approach and the discovery-based approach in different sequences and proportions, to improve the performance of thoughts. reviews of Chinese secondary school learners [18]. They showed that the performance of learners who benefited from hybrid instruction combining explicit mode and discovery mode was better.

In a context of teaching biology through experimentation in the laboratory, Adimoto and his collaborators on the one hand and Erika on the other hand, show through their studies on the use and impact of a model teaching learning combining explicit mode and discovery mode, that this hybrid model improves the performance of learners in learning and develops in them a series of skills and scientific skills such as the appropriation of the process and experimental techniques [19; 20]. According to the authors, the combination of the two teaching-learning modes leads learners to formulate hypotheses, to propose experimental protocols, but also to encourage them to actively participate in the construction of their knowledge and know-how.

For their part, Holyoak and Morisson have pointed out that the teaching-blended learning strategy, coupling explicit mode and discovery mode, has proven to be one of the most effective strategies in the teaching of science learning [21].

But we can disagree on what types of mixtures are most effective educationally for achieving different goals (learning ideas, acquiring skills, ...) in different contexts (in labs, conferences, discussions , computer courses, ...).

By way of conclusion, the teaching model that we propose in e-learning mode is a hybrid model, articulating the organization of content and learning tasks made explicit by the teacher around discovery situations guided by the learners with the aim of to achieve learning objectives from a perspective of developing transferable skills in problem-solving situations.

In this model, the teacher must set up a hybrid pedagogical scenario, in which he plays the role of activator (in the background) by specifying the skills to be worked on by his learners, the objectives allowing the development of these skills, the learning activities, the tasks to be carried out by the learner independently, the various learning resources. In the foreground, the learner is constantly placed in a situation of reflection, questioning, proposition of hypothesis, restitution of his various knowledge, confrontation, observation, analysis and deduction ..., which can be translated into a model of pedagogical scenario by the use of action verbs sweeping the different cognitive and metacognitive levels.

In this article, we present a lesson model combining explicit teaching and discovery learning, consisting of 4 steps stated previously but undergoing major modifications to give more possibilities to learners to interact with the lesson.

Table: Pedagogical Scenario Steps

Steps	Actions
Situation	The teacher offers his learners an authentic situation in relation to the theme such that it will encourage learners to call on their previous knowledge and their daily experiences, to ask themselves questions, to make assumptions. The teacher, by accepting all the proposals, clearly declares the objectives and the procedure to be followed to build together the knowledge and skills likely to validate the hypotheses.
Guided practice	The teacher offers his learners activities to be carried out in a linear manner, by specifying the objective of each activity, the tasks to be carried out independently, and by providing them with the various knowledge and skills resources. Tout en sachant l'objectif et en suivant la démarche proposée par l'enseignant, les apprenants réalisent les différentes activités en mode individuel ou en groupe. They explain aloud how they think, reason, observe, extract information, analysed it and draw conclusions.
Objectivation	Learners organize and structure the knowledge and procedures acquired, and use them to validate their hypotheses or to adapt their responses to the initial questions.
Evaluation	The teacher offers his learners a series of evaluation situations, in particular a situation allowing them to enhance the skills associated with the lesson: problem situation, situation of complex tasks or integration situation, etc.

In this hybrid model, the performance of the teacher in the explicit design of the lesson is joined to the performance of the learners in the execution of the tasks by adopting a scientific approach (figure opposite).

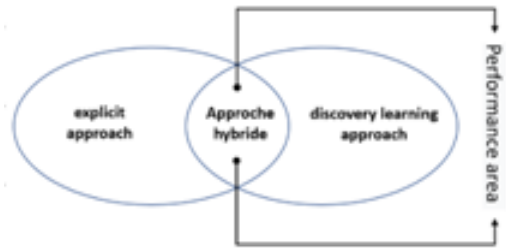


fig.2. delimitation, of the hybrid approach

III. MODELING OF EDUCATIONAL SCENARIOS

The Educational Modeling Language (EML) is used to design, implement, describe ... learning scenarios. Typically, this involves Modelling learning activities.

A learning scenario represents the description, carried out a priori or a posterior, of the progress of a learning situation aimed at the appropriation of a specific set of knowledge, specifying the roles, activities and handling resources. Knowledge, tools and services needed to implement activities.

There are several tools to model an educational scenario. Some of these tools are inspired by software engineering. We are interested in three types of diagrams that will be used to model the structure of the contents, the learning activities and the learning situation, namely the DS structure diagrams, the DA activity diagram and the diagram Vee.

A. The structure diagram: the scripting of the didactic unit

The structure diagram is a development tool used to model the different parts of a system, from previewing how the individual parts interact to create the whole, to modelling the details of the smaller parts themselves, such as the various objects and classes used in system programming.

The structure diagram visualizes the operation of a system from initial input to processing and, finally, to the desired output. It is especially useful in determining all the interfaces involved between the different parts and helps developers to agree on how each part should be connected based on the models displayed on the structure diagram.

In pedagogy the SD diagram, in accordance with the trends of an explicit pedagogy can be used to represent or model the structuring of the contents of the teaching modules or units and the underlying learning sequences (fig. 3)

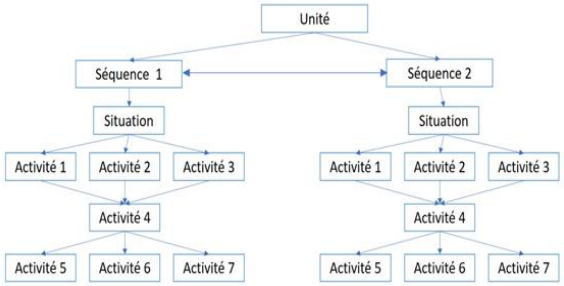


Fig.3. Educational structure diagram of teaching unit

The figures below illustrate respectively the application of the use of the SD diagram in the modelling of the pedagogical scenario of a concrete didactic unit of teaching of the chapter "electricity" for the 3rd grade class of middle school in Morocco, and of a didactic sequence on the notion of electrical energy in a hybrid educational context coupling explicit teaching and guided discovery learning.

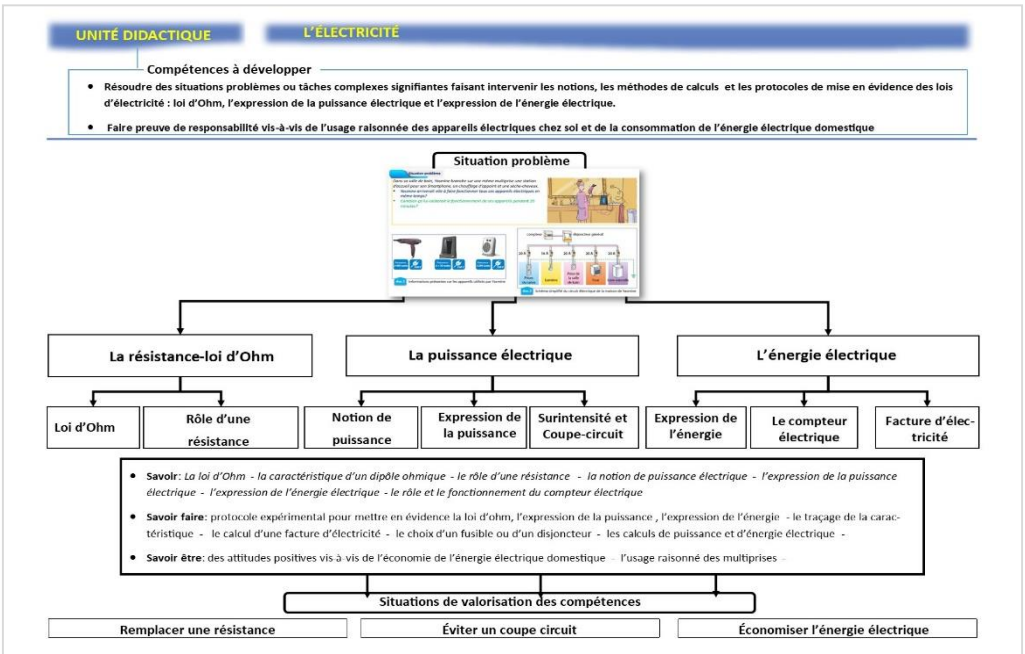


Fig.3a. Educational structure diagram of unit « electricity »

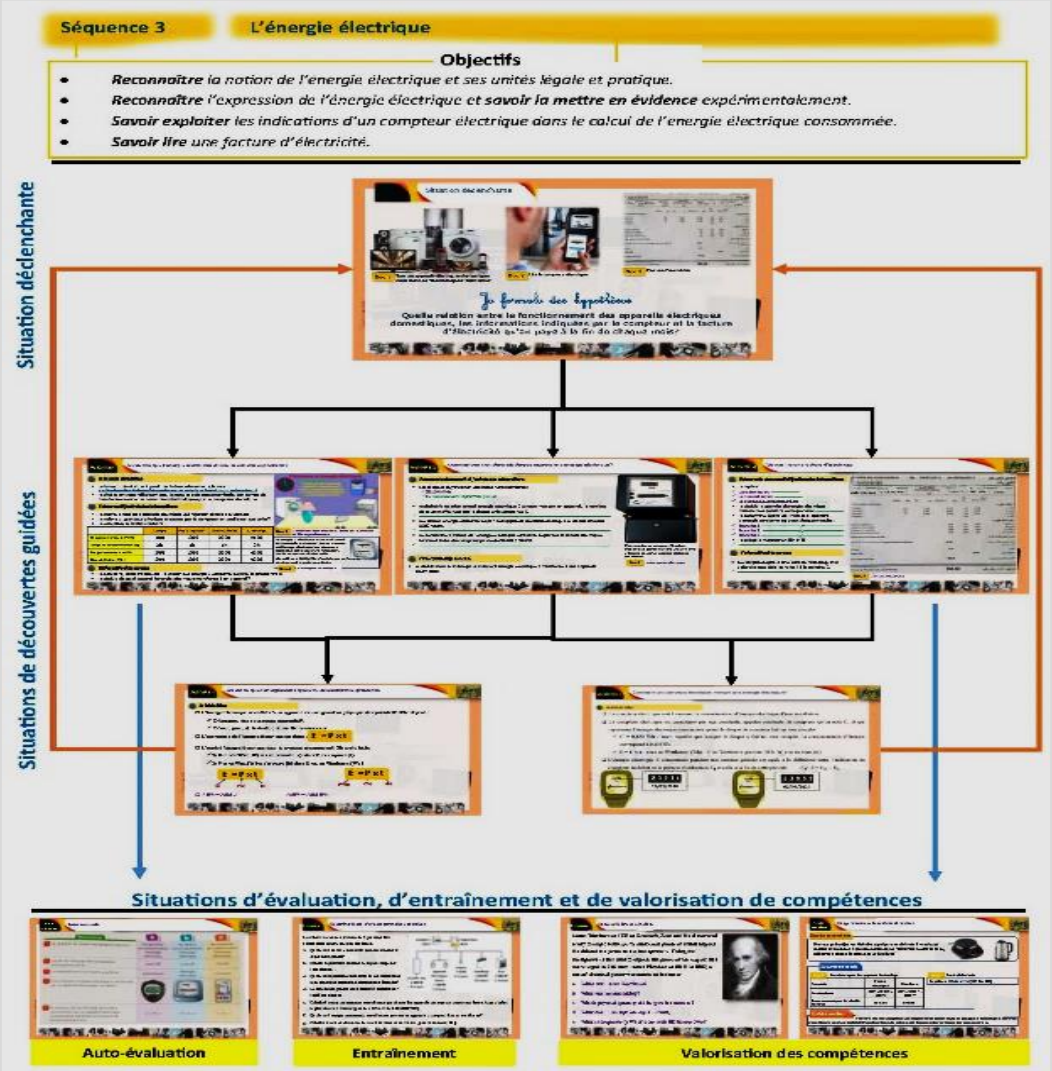


Fig.3b. Educational structure diagram of electrical energy sequence

B. The activity diagram: scripting the learning activities

In the field of software engineering, activity diagrams make it possible to focus on processing. They are therefore particularly suitable for modeling the routing of control flows and data flows. They thus make it possible to graphically represent the behaviour of a method or the course of a use case.

The similarity with the field of pedagogy is that the learner in a learning situation, in a cognitivist context, is always put in a situation of processing data from the learning situation, his memory and the processing of different data.

The use of these diagrams in the field of pedagogy, in particular in the design phase of learning situations can prove to be of great use for the teacher insofar as it will help him enormously to explain with specify the tasks to be performed by the learner in the face of a learning situation and quickly see if his tasks are relevant with the hybrid explicit-discovery approach.

Using an activity diagram to script a learning activity will allow you to specify the different transformations and interactions between the two information blocks and therefore the quality of the cognitive transformations generated.

The figure below shows one way to use the activity diagram to model the learning scenario in an explicit hybrid mode - by discovery.

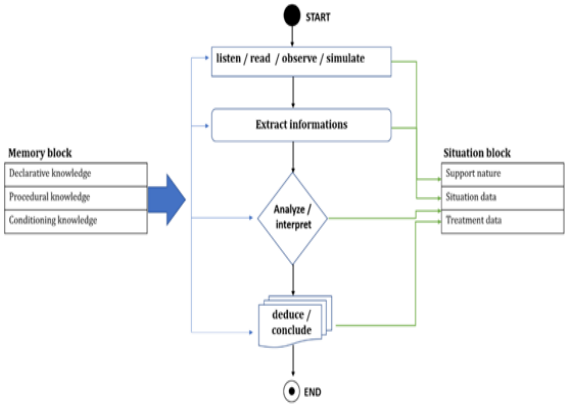


Fig.4. Educational activity diagram

The learning activity explicitly designed and structured by the teacher leads the learner to reconstruct his learning by adopting an inductive guided discovery approach comprising the 4 phases of the scientific process starting from watching a video or carrying out a video. " a simulation or quite simply the observation of images or the reading of a text until the deduction in autonomy of a definition, a rule, a procedure while passing by the extraction of the relevant information and their analyzes and interpretations.

The figure below is a concrete illustration of the application of the activity diagram to script a learning activity in "electricity" based on the use of simulation as a tool to help the discovery of a physical law.

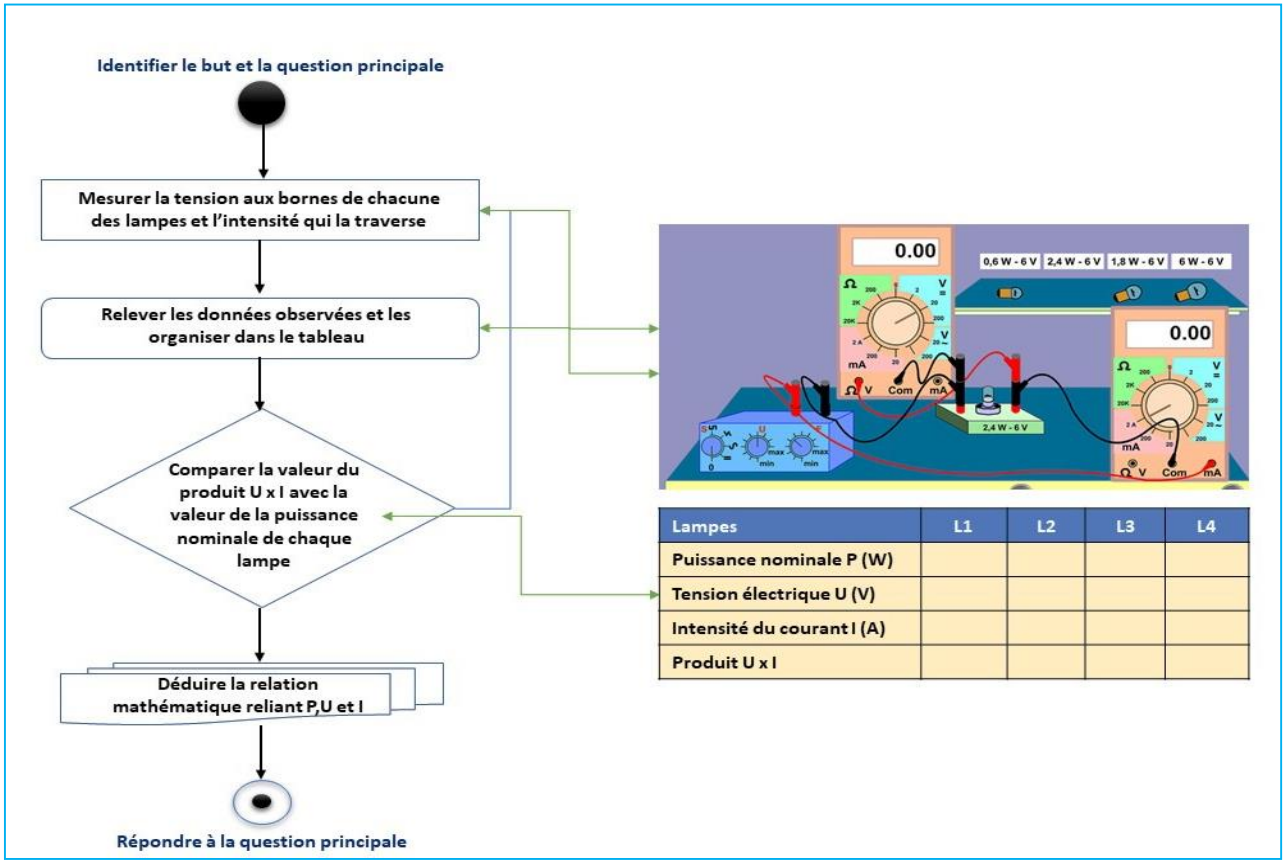


Figure 5: Example of an activity diagram to script a learning activity in physics

C. The Vee diagram: Modelling a learning situation

In the case of distance education, more particularly in e-learning mode, the learning situation, whether it is an autonomous learning or directed by a tutor (teacher), is now central and decisive. from an explicit perspective / guided discovery. Its design and implementation requires a precise analysis of its relevance to the objectives and the skills to be developed, the precision of the nature and types of knowledge likely to generate, and the learning tasks to be conveyed.

The Vee diagram is one of the effective tools in the design and implementation of learning situations oriented towards the development of competences as pointed out by the studies carried out by Ausubel and his collaborators, Novak and Gowin, Alvarez and Risco, and finally Novak [22; 23; 24; 25]. The Vee diagram was developed by Bob Gowin in 1970. It is a metacognitive thinking tool that helps instructional designers plan meaningful and constructive learning situations [26].

In learning mode, the Vee diagram is a tool that can be used in teaching situations to boost the thinking skills in learners and to inspire them to develop deep learning.

The use of the Vee diagram is widespread in cognitive science research. Alvarez, et al. Point out that using the Vee diagram greatly helps learners to construct and structure their knowledge. Very recently, Kurniasih and Irpan show that the use of Vee diagrams helps to develop comprehension processes in science [27]. Other research highlights the effectiveness of Vee diagrams in problem-solving performance [28].

Evrena and his collaborators show that the use of the Vee diagram in the teaching of experimental and technological practices allows the development of critical and scientific thinking, therefore suitable for the scripting of a learning situation by guided discovery [29].

Novak and Gowin in 1984 and Alvarez in 2005 let it be known that the Vee diagram works with the "thinking" and "doing" principle. We start by drawing a big "V", we place

on the left, the conceptual knowledge or the pre-acquired knowledge of the learners to be put in place vis-à-vis the learning situation in question, on the right we write the data of the situation and what the learner must do to reach the goal or to answer the main question, located elsewhere at the bottom of the diagram. The achievement of the objective or the answer to the key question arises from the interaction and interrelation between what the learner has to restore from his memory and the data of the learning situation. The figures below respectively represent the upstream modeling of the didactic situation of learning which aims to discover the expression of electrical energy, using the Vee diagram (fig. 5a), and its educational design in the explicit hybrid pedagogical context - by guided discovery.

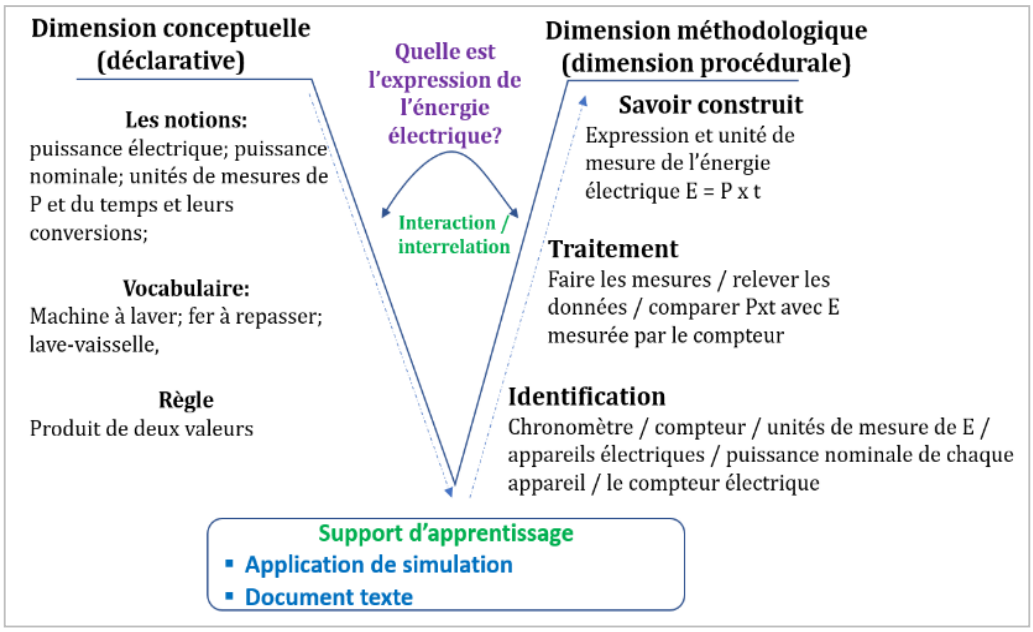
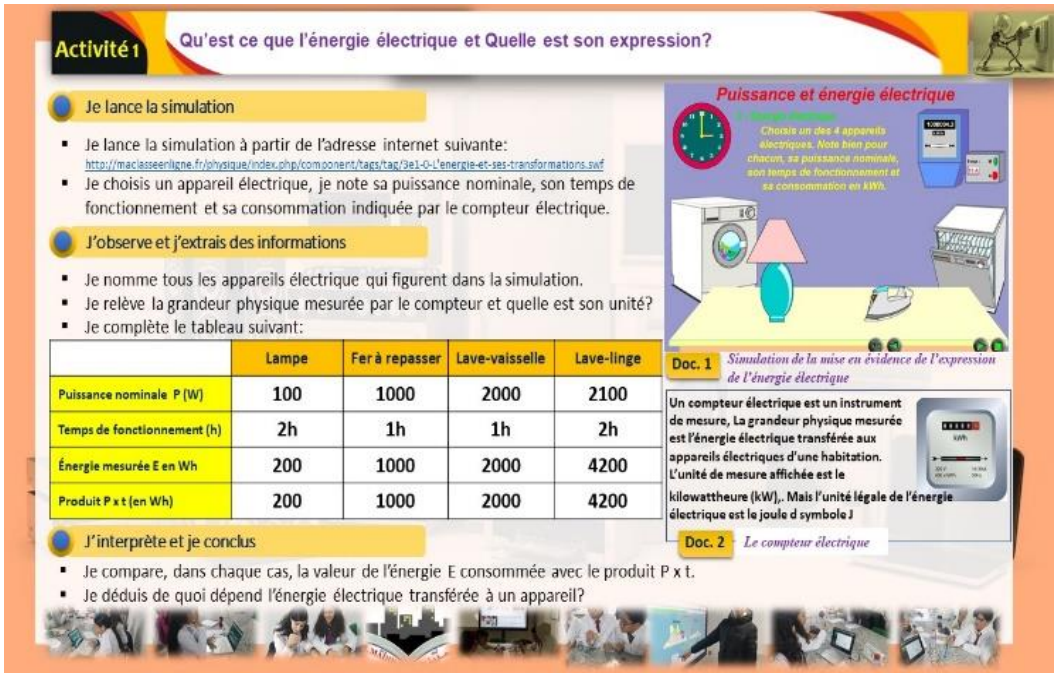


Fig. 5a: Example of the use of the Vee diagram to model a learning situation by guided discovery



	Lampe	Fer à repasser	Lave-vaisselle	Lave-linge
Puissance nominale P (W)	100	1000	2000	2100
Temps de fonctionnement (h)	2h	1h	1h	2h
Énergie mesurée E en Wh	200	1000	2000	4200
Produit P x t (en Wh)	200	1000	2000	4200

Fig. 5b: Design of the learning situation by guided discovery

IV. CONCLUSION

In electronic education (e-learning), the presence of the teacher or trainer is not always obvious. The learner, on the other hand, must feel this presence and this personality through the way in which the teacher easily explained his intentions, his ways of doing and carrying out, his thoughts, his approach and his reasoning to pass on to his learners. While giving a helping

hand to its learners to perform the different tasks and to appropriate the different cognitive and metacognitive skills.
The use of pedagogical engineering by these principles, its techniques and its tools can help the teacher enormously to make available to his learners a coherent and effective electronic teaching.

In this sense, the use of certain UML diagrams can be of great use in helping the teacher to model and set up appropriate pedagogical scenarios with the teaching / learning approach, in particular when it is necessary to 'is an approach combining explicit and discovery.
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REFERENCES

1. Schuster D., William W., Cobern B., Adams A J., Undreiu A., &Pleasants B,. 2017,. Learning of CoreDisciplinaryIdeas:EfficacyComparison of TwoContrasting Modes of Science Instruction. Research in Science Education.
2. Stockard, J., Wood T., Coughlin C., &RasplicaKh C., 2018,. The Effectiveness of Direct Instruction Curricula: A Meta-Analysis of a Half Century of Research. Review of Educational Research, 88 (4), 479-507
3. Hattie, J. A. C., 2009,. Visible learning: A synthesis of over 800 meta-analyses relating to achievement. London, UK: Routledge.
4. Bissonnette, Steve, Gauthier, Clermont, Richard, Mario, Bouchard, Carl., (2010). « Quelles sont les stratégies d'enseignement efficaces favorisant les apprentissages fondamentaux auprès des élèves en difficulté de niveau élémentaire ? Résultats d'une méga-analyse », Revue de recherche appliquée sur l'apprentissage, vol. 3, no 1, p. 1-35.
5. Apprendre et enseigner aujourd'hui. Revue du conseil pédagogique interdisciplinaire du Québec. Volume 8. N°2. Septembre 2019. www.conseil-cpiq.qc.ca
6. Rosenshine B(2012). Explicit Instruction : a model elaborated from research on classroom instruction and validited by research on human cognitive processing. In Apprendre et enseigneraujourd'hui: L'enseignementexplicite. La revue du conseil pédagogique interdisciplinaire du Québec. Volume (2) , N(8). 2019.
7. Gauthier, C., Bissonnette, S., & Richard, M. (2013). Enseignement explicite et réussite des élèves, Montréal : E.R.P.I.
8. Barth Britt-Mari. Jérôme Bruner et l'innovationpédagogique. In: Communication et langages, n°66, 4ème trimestre 1985. pp. 46-58.
9. Glaser K., 2013,.The Neglected Combination: A Case for Explicit-Inductive Instruction in Teaching Pragmatics revue tesl du cana da. 163 (30), special issue 7.
10. Sweller J., Kirschner P A., & Clark R. E., 2007,. Why minimally guided teaching techniques do not work: a reply to commentaries. Educational Psychologist, 42(2), 115–121.
11. Archer A L., A. Hughes C A., 2011. Explicit instruction: effective and efficient teaching. Karen R.Harris and Steve Graham, Series Editors.
12. Hake R R., 1998,. Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics,. 66 (1), 64–74.
13. Hassard J., 2003,. Direct-interactive teaching model., https://www.jackhassard.org/mos/di9.html
14. Lawson A E., 2010,. Teaching inquiry science in middle and secondary schools,. Washington, DC: SAGE.
15. Peterson P E., 2011,. Eighth-grade students learn more through direct instruction. Education Next, 11(3).
16. Rosenshine B., 2008,. Five Meanings of Direct Instruction. Center on Innovation &Improvement, Academic Development Institute.
17. Wright J., 2013,. Introducing Academic Strategies to Students: A Direct-Instruction Approach,. http://www. interventioncentral.org/academic-interventions/general-academic/introducing-academic-strategies-studentsdirect. Consulté le 11 mars 2020.
18. Kelly Y L Ku., Irene T Ho., Kit-Tai Hau., & Eva C M Lai., 2014,.Integrating direct and inquiry-based instruction in the teaching of critical thinking: an intervention study. Instructional Science volume 42. 251–269
19. Adimoto A., Goodyear P., Bliuc A M., &Ellis,R.A., 2013,. Inquiry-based learning in higher education: principal forms, educational objectives, and disciplinary variations. Studies in Higher Education, 38, 1239-1258.
20. Erika T M., 2014,. Using a combined Approach of Guided Inquiry& Direct instruction to Explore How

Physiology Affects Behavior. The American Biology Teacher. Vol.76, N°9.

21. Holyoak K J., Morrison R G., 2005,. The Cambridge Handbook of Thinking and Reasoning. Cambridge University Press.
22. Ausubel D P., Novak J D., and Hanesian H., 1978,. Educational psychology: a cognitive view (Second Edition). New York: Holt, Rinehart, and Winston.
23. Novak D J., &Gowin B., 1984,. Learning how to learn. New York: Cambridge University Press.
24. Alvarez M C., and Risco V J., 1987a,. Veediagrams: helping students underst and the structure of knowledge. Washington, DC.: Paper presented at meetings of the American Educational Research Association.
25. Novak J D., 1990,. Concept maps and Veediagrams: two metacognitive tools to facilitate meaning full earning. InstrSci 19, 29–52.
26. Novak D J., &Gowin B., 1984,. Learning how to learn. New York: Cambridge University Press.
27. Kurniasih S., and Irpan A M., 2019,. Diagram Vee and mind mapping application to develop conceptual understanding of plant reproduction. J. Phys.: Conf. Ser.
28. Thiessen R., 1993,. The Vee Diagram : A quide for Problem solving. Aims Newsletter.
29. Aysegul E., Kaan B., Serkan Y., 2012,. The effect of using v-diagrams in science and technology laboratory teaching on preservice teacher's critical thinking disposition. Procedia - Social and Behavioral Sciences 46 (2012) 2267 – 2272