Towards a Model of Learner-Directed Learning: An Approach Based on the Co-construction of the Learning Scenario by the Learner

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Abstract: To improve the learning process, the evolution of learner's characteristics (cognitive, affective, prior knowledge, workflow, organization, ...) must be taken into account during the personalization or adaptation. This requires generating several scenarios (a description of activities, their order and links in the learning sequence as well as the expected outcome for the learner) adapted to the identified profiles. We propose a model which aims at improving learners' learning processes by giving them control over two key aspects: (1) the steps of the learning scenario to be followed: after each learning goal is completed, the learner chooses the next one among several possible ones (in terms of their current knowledge) while respecting pedagogical constraints (time and quality of the solutions produced according to satisfaction thresholds); (2) the assessment mode: the learner chooses a mode corresponding to their own goals in terms of mastery, while respecting the minimum thresholds set by the teacher. We assess our approach with learners in terms of (a) adequacy of the model with learners' expectations and (b) usability of the system through self-report questionnaires and an analysis of the data collected over 16 learners who used an implementation of our system on the LMS (Learning Management System) in the context of a real computer course. The results reveal that our model is mostly well-received, that various scenarios are indeed followed by the learners and that the 3 assessment modes have been used by learners.

Keywords: Learner-directed learning, Co-construction of learning scenario, Technology Enhanced Learning, Multi-scenario design, Knowledge Space Theory, Support of learning

1. INTRODUCTION

According to the pedagogical triangle, learning is a process involving three components: the knowledge, the learner and the teacher (Friesen & Osguthorpe, 2018). The integration of the social dimension, with the notion of learners group, makes this process even more complex (Ruthven, 2012). At best, the teacher creates a knowledge-based course with well-defined learning goals. The course is then organized in a scenario which is used to guide both the teaching and the learning (Mbatchou, 2016). However, this standard scenario, as envisioned by the teacher, can be inappropriate or at least suboptimal for some learners, because the learning also depends on their personal characteristics (*e.g.* pace of work, cognitive styles, emotional factors, prior knowledge, …). To improve the learning process, it is therefore ideal for each learner to have their own personalized scenario. Moreover, while learning, some characteristics of the learner may change (*e.g.* more motivation to learn about a topic than another, less time because of personal issues), making the initially defined scenario less and less appropriate. It would be difficult and time-consuming for the teacher, particularly in an online context, to detect the change in the learners' characteristics in order to propose a new better suited scenario. However, this detection may be more achievable by using computer-based methods relying on the use of learning traces, learner modeling (Greer & McCalla, 2013) and intelligent tutoring systems (Ma, Adesope, Nesbit, & Liu, 2014). A limit of these methods though, is that they usually require a large volume of traces (which can be challenging for courses with only a few students enrolled), and when new profiles are detected the system may need reengineering or a refinement of some parameters to take them into account. Thus, there can be

issues relative to the real-time detection of changes in learner profiles to assign them an appropriate scenario. Involving the learner in the construction of their learning scenario can be a way to tackle this issue. Moreover, more fundamentally, various works on metacognition and self-regulation show that involving the learner, for instance by making them choose their learning goals, can lead to deeper learning and increased motivation (Harley, Taub, Azevedo, & Bouchet, 2018), compared to a linear more passive way predefined by the teacher. This approach forces the learners to re-evaluate their decision if they realize they have chosen an activity for which they do not master yet all the required skills. Therefore, it seems that involving the learner in the choice of their learning scenario is not only a solution to a technical issue, but also a pedagogical choice that can have additional benefits for their learning.

Following these observations, this paper focuses on the co-construction of the learning scenario by the learners, as they learn, to make the learning process or acquisition of knowledge more efficient. We use the term "co-construction" because although the next learning goal depends on the learner, the range of their choice is constrained by the teacher, to prevent them from making illogical choices (*e.g.* trying to acquire a competence before its prerequisite). In this context, our research questions are: (RQ1) Can we set up a model allowing each learner to co-construct his or her scenario during the learning process? (RQ2) Is such a model understandable and acceptable to learners? (RQ3) How do learners use the possibilities of co-construction made available to them? Our contribution is to provide learners with conceptual and technological tools to build their learning scenario in a learning context imposed by the teacher and supported by technology.

The remainder of this paper is organized as follows. In section 2, we present a brief overview of related works on personalization and adaptation of learning. Section 3 presents the core concepts of our model. Section 4 presents our model of co-construction of the learning scenario. Section 5 presents our implementation of the model in a LMS. Finally, section 6 presents results of an evaluation of our approach in terms of acceptability of the model by learners, but also an evaluation of the system usability through an analysis of data collected in a preliminary experiment conducted in real situation with a class of students.

2. RELATED WORK

The description of a learning scenario can be formalized with the Educational Modeling Language (EML) (Koper & Manderveld, 2004) which offers the modeling of reusable, interoperable, rich and customizable learning units. Through personalization and reuse, it is possible to design several scenarios, but the EML language does not provide ways to switch from one scenario to another during the learning. This is because the scenario design is generally based on the intentions of teachers (Emin, Pernin, & Aguirre, 2010) (teacher-centered pedagogy) and on pedagogical goals (Dalziel, 2008) (content-centered pedagogy). Some works have tried to be closer to a learner-centered pedagogy, for instance by taking into account teachers' intentions, activities to follow by learners and learner interactions (Mariais, Michau, & Pernin, 2010).

To design a pedagogical scenario, (Esnault & Daele, 2003) defined 17 dimensions of question, taking into account learners' individual differences. However, to take this personalization into account, the scenario designer must know the learners' profiles in advance. Even if new scenarios can be designed by reuse and adaptation of existing ones (Riad, Mourad, Nourredine, & Hamid, 2012), profiles can evolve during the learning process and no personalized path corresponds to the new profile. (Marne & Labat, 2014) proposed a scenario based on activities with several input and output states. The links between activities based on prerequisite relationships among them makes it possible to have several learning paths. However, their model, defined in the context of serious games, does not give the learner the possibility to choose the scenario to follow.

The Competence-based Knowledge Space Theory (CbKST) offers a model for structuring competences-based learning for personalization (Heller, Steiner, Hockemeyer, & Albert, 2006). From the relationship of prerequisite among competences, the model constructs several recommended learning paths (Kopeinik, Nussbaumer, Bedek, & Alber, 2012). Each path is composed of knowledge states (set of competences acquired in a particular field). From a knowledge state, the learner progresses in their learning by choosing a competence to acquire that will bring them into a new higher knowledge state. The learning is complete when the learner is in the terminal knowledge state (state with all acquired competences). Although the CbKST offers several learning paths, it does not consider learning constraints (temporal and qualitative related to satisfaction threshold of activities) in choices of paths, nor multi-goal activities (*e.g.* case studies),

nor the conditions to change paths (*e.g.* a change can take place after a certain number of failures or the incapability to reach a fixed goal or a temporal constraint non-respected).

3. CORE CONCEPTS OF THE MODEL

There is not a single path to knowledge acquisition: there are many ways to do it, depending on the learning goal. But to build multiple scenarios, the course design model must allow it. We proposed a multi-scenario model of learning relying on five concepts (*cf.* Figure 1):

1. **Decomposition of knowledge by learning goal to be achieved.**

The learning or teaching is decomposed by learning goals where each of them is defined by the tuple of 5 elements detailed below.

Considering a course with **N** learning goals, a learning goal $\mathbf{G_i}$ ($\mathbf{i \in [1, N]}$) is defined by the following elements:

- A minimum duration ($\mathbf{T_i^{Min}}$) to achieve a goal; it is a recommended minimum deadline
- A maximum duration ($\mathbf{T_i^{Max}}$) to achieve a goal; it is a recommended maximum deadline
- A satisfaction thresholds ($\mathbf{S_i}$) that determines the minimum expected achievement of the goal
- A set of $\mathbf{M_i}$ learning resources ($\mathbf{R_i^j}$; $1 \leq j \leq M_i$) for knowledge acquisition
- A set of $\mathbf{N_i}$ learning activities ($\mathbf{A_i^j}$; $1 \leq j \leq N_i$) for validating acquired knowledge

$$\mathbf{G_i = \{T_i^{Min}, T_i^{Max}, S_i, \{R_i^1, R_i^2, \ldots, R_i^{Mi}\}, \{A_i^1, A_i^2, \ldots, A_i^{Ni}\}\}}$$

$(M_i, N_i) \in IN^2 - \{(0, 0)\}$ are respectively the number of learning resources and the number of learning activities

Definition of learning goal

To achieve a goal, we have a time range $[\mathbf{T_i^{Min}} - \mathbf{T_i^{Max}}]$ for the following reasons:

- There are learners qualified as "last minute" who only work intensively towards the end of allocated time to be on time. To allow them to work frequently, the system will propose them a minimal duration (T_i^{Min}) to achieve a learning goal. If a learner is not able to achieve the goal in a time inferior to T_i^{Min}, the system will give him gradually an extra time up to the maximum duration (T_i^{Max}).
- There are learners who are not able to reach their goal in the time initially defined or chosen, for instance if they have had exterior events reducing their exepcted availability. The system will allow them to go beyond the maximum duration if their progress to achieve goal are satisfactory. Otherwise, the system recommends changing this learning goal.
- A learner who achieves a goal with a grade not satisfactory for him, has the possibility to keep on improving it until the maximum duration (T_i^{Max}).
- Before the end of course duration, a learner who finished his learning can come back on the aspects he wants to improve.

2. **Prerequisite relationship between knowledge component.**

There can be many ways to learn a course, but there are nevertheless order constraints, taken into account in our model by a prerequisites graph between the goals. Let G_1 and G_2 be 2 goals. If G_1 is a prerequisite to G_2, it is represented by $G_1 \rightarrow G_2$ and means that : to master the goal G_2, it is necessary to master the goal G_1. Conversely, if a learner has the mastery of goal G_2, it means that they must already have the mastery of goal G_1. The prerequisite relations must be transitive and asymmetric.

3. **Encapsulation of knowledge in learning resources for learning goals.**

This encapsulation guarantees modularity in a course since a resource is reusable in another course without modification. The resource can be a file, a video, a web site, …

4. **Assessment of acquired knowledge.**

We define activities to assess the learning. To prevent assessment from depending on only a single activity, we define for each activity ($\mathbf{A_i^j}$) a percentage of participation ($\mathbf{P_i^j}$) in knowledge validation. Each activity ($\mathbf{A_i^j}$) contributes to the validation of goal G_i with the rate $\mathbf{P_i^j}$ where $\sum_{j} P_i^j \geq \mathbf{100\%}$. The sum of

the percentages must be greater than or equal to 100 so that the learner has a flexibility in the choice of activities to achieve his goal. An activity can also contribute to the validation of several knowledge components.

When a learner performs an activity A_i^j, he obtains a grade $\mathbf{V_i^j}$. A_i^j has also a satisfaction threshold $\mathbf{S_i^j}$ which determinates if it is validated or not.

An activity A_i^j is validated if $\mathbf{V_i^j \geq S_i^j}$

An goal G_i is validated if $\sum_{j=1}^{N^i} P_i^j V_i^j \geq \mathbf{S_i}$

Acquisition conditions of knowledge

To prevent a learner from validating all activities N_i of goal G_i and not to be able to validate the associated goal, the rates participation (P_i^j) of activities (A_i^j, $1 \leq j \leq N_i$) at the achievement of a goal ($\mathbf{G_i}$) will respect this condition $\sum P_i^j V_i^j \geq Si$

5. **Grouping learning goals into learning units.** To be close to the teachers' practice, the goals are grouped into learning units (generally parts, chapters, sections, ...).

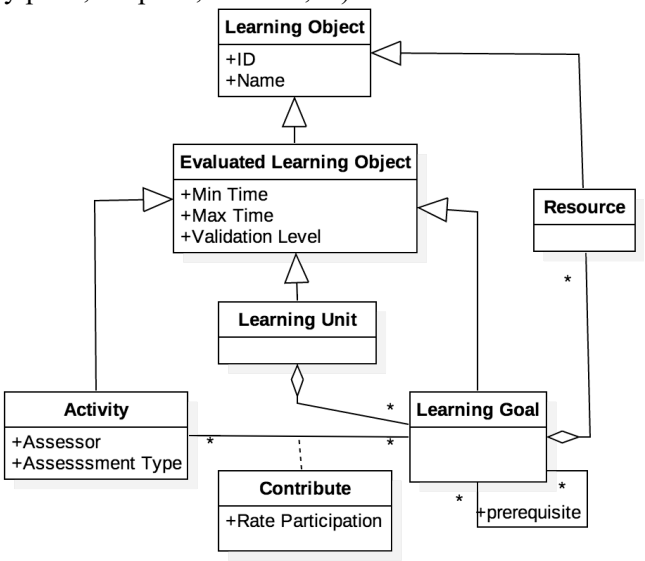

Figure 1. Class diagram of learning objects for course design

Our model allows to create several learning scenarios by articulating the learning objects.

4. CO-CONSTRUCTION MODEL OF LEARNING SCENARIO BY LEARNERS

4.1 Hypothesis, goal and theoretical grounding

Our approach of co-constructing knowledge with learners, relies on two observations and one hypothesis.

The first observation is that we do not have a priori learner profiles due to lack of appropriated data for profiling. The second one is without necessarily being able to choose the adapted scenario for learners, giving them the choice in scenario building involves them more as an actor of their training than when there is a linear sequence of activities predefined by the teacher. This approach forces the learners to make decisions and eventually to re-evaluate them if they realize that they have been too ambitious either in their level of requirement for an activity or in their choice of an activity for which they do not yet master all the required competences.

The hypothesis of our work is that each learner is aware of the new skills they acquired and able to detect their behavioural changes. This is a strong hypothesis, as it basically means that the learner is able to properly self-regulate their learning, which is certainly not the case of every learner. There are nonetheless dedicated tools based on trace analysis that can help in raising students' self-awareness (Sambe, Bouchet, & Labat, 2018), which could be used complementarily with our work to ensure this hypothesis is realistic. Under this assumption, we believe the learner is able to define or construct the adapted scenario.

The model is meant to provide learners with an environment allowing them to learn the way they want while respecting the rules and constraints of learning. This should enable them to make the learning process or acquisition of knowledge more effective. Thus, the learning scenario to be followed by learners has to be built by them.

The pedagogical reasons behind of our model rely on various works on metacognition and self-regulation that show that involving learner in his learning (for example by giving him a choice of his learning goals or competences to acquire) can lead to deep learning and increased motivation (Harley, Taub, Azevedo, & Bouchet, 2018), compared to a linear and passive method predefined by the teacher.

The model is based on knowledge states to enable each learner to situate themselves in their learning and to progress. A knowledge state is a state that describes acquired and validated knowledge by a learner; it is composed by achieved learning goals (Mbatchou, Bouchet, & Carron, 2018). The knowledge states are produced and associated according to the Knowledge Spaces Theory to obtain different learning paths (Falmagne, Albert, Doble, Eppstein, & Hu, 2013).

4.2 Learning process

The co-construction of the learning scenario is based on the notion of knowledge state. At each stage of learning, the learner chooses the goal to achieve. The system provides learning resources to acquire knowledge and learning activities to evaluate the knowledge acquired. The learning process is to guide the learner from initial state to final state. The learning constraints defined by the teacher when designing learning objects is an implicit guidance contributing to co-construction. Learning is supervised by a human tutor as a learning facilitator (role not detailed in this chapter).

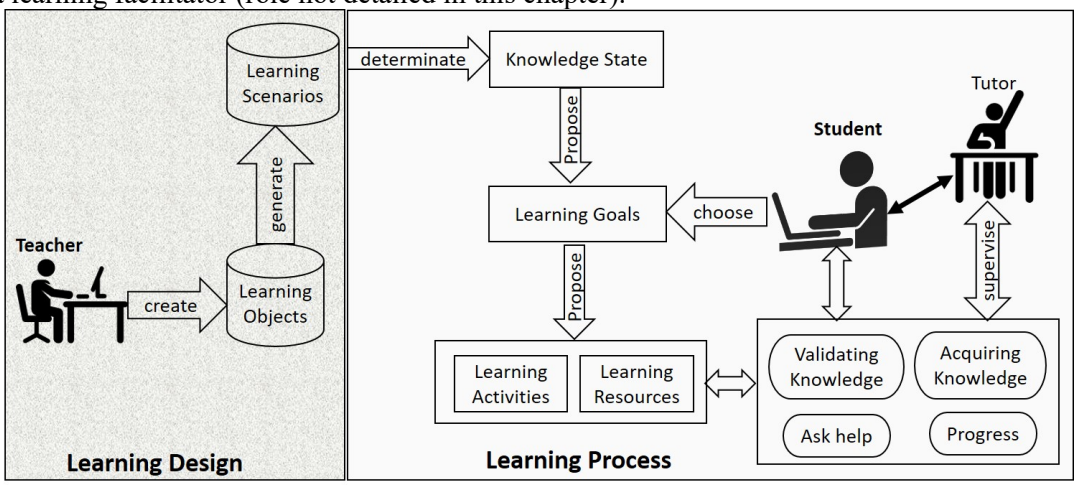

Figure 2. Learning process

4.3 Decision during co-construction

To allow co-construction to happen, there needs to be moment during the learning process in which the learner is asked to take decisions about his learning, *i.e.* to enter into a more metacognitive mode. During the learning, the system determines the learner's knowledge state and offers them a set of goals to achieve. Then for the chosen goal, the system proposes a set of resources and activities that will allow them to reach it. After an assessment that the knowledge is acquired, the system determines their new knowledge state. If they are unable to perform a given activity (resp. progress in a chosen scenario), the learner can abandon it and choose another activity (resp. scenario) offered by the system in the same scenario (resp. according to the learning goals).

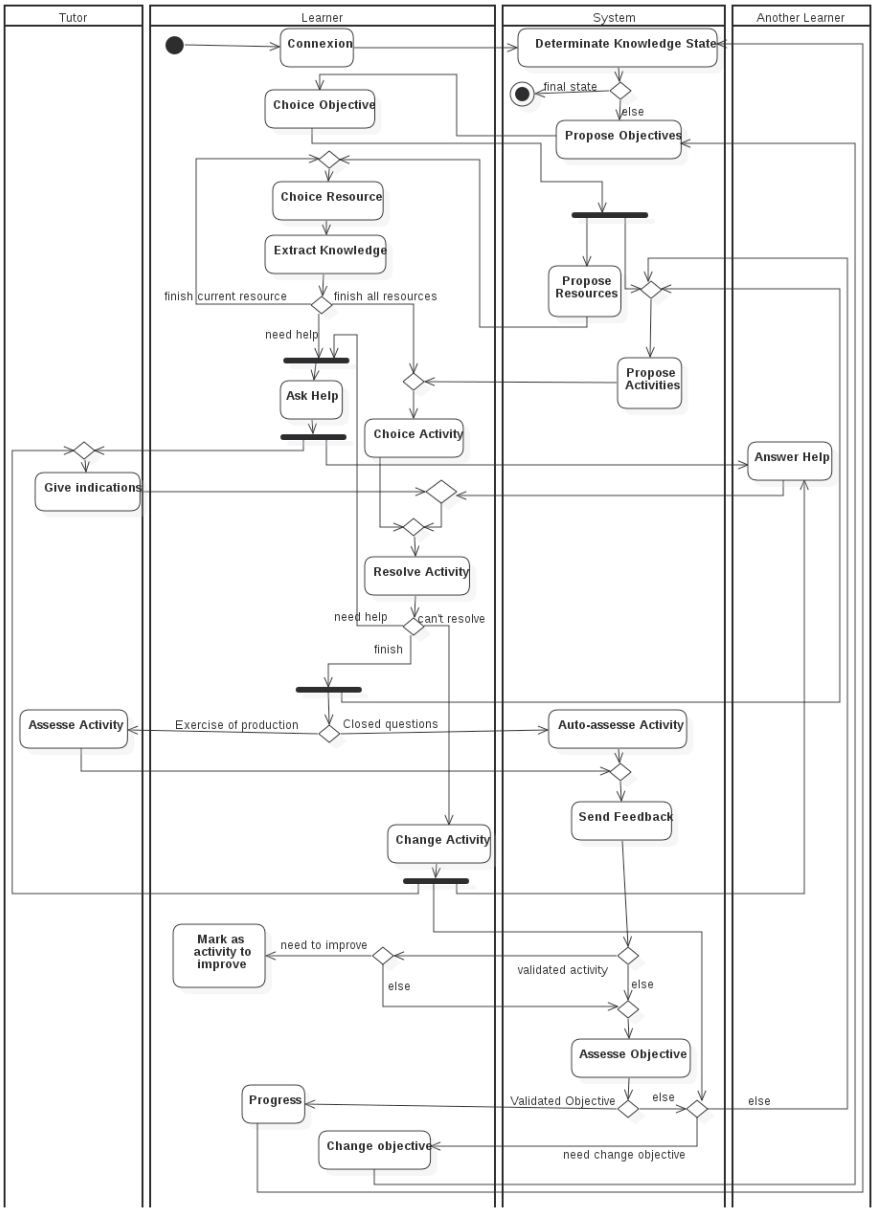

Figure 3: Activities diagram of learning

4.4 Quality of the co-constructed scenario

The model integrates knowledge assessment modes to progress in learning. The choice of the mode depends on the challenge that the learner sets for themselves at any moment. Since the learner is situated in learning by their knowledge state, suppose a state with N goals $\{G_1, G_2, \ldots, G_N\}$. Each G_i has a set of learning activities $\{A^1_i, A^2_i, \ldots, A^{Ni}_i\}$ for validating the acquired knowledge. Each activity A^j_i has a percentage of participation P^j_i to achieve the goal G_i. When a learner chooses to perform the activity A^j_i we keep the obtained value V^j_i to compute the score obtained for this goal. The validation of each goal (G_i) is constrained by a threshold (S_i). To validate his state with N goals, the learner has the following modes:

Assessment mode by flexible compensation. The state is validated if $\sum_{i=1}^{N} \sum_{j=1}^{Ni} P_i^j V_i^j \geq \sum_{i=1}^{N} S_i$. So, learner can progress without validating certain goals because he can obtain them by compensation.

Assessment mode by restrictive compensation. With the previous mode, a learner can validate a state even with one goal with a very low level of satisfaction. To avoid this case, in compensation mode, the learner must make minimum efforts for each goal. The state is validated if $\prod_{i=1}^{N} \sum_{j=1}^{Ni} P_i^j V_i^j \geq \prod_{i=1}^{N} S_i$.

Strict assessment mode. This mode allows challengers learners to master all goals of a state before progressing. The state is validated if **∀ i, 1 ≤ i ≤ N,** $\sum_{j=1}^{Ni} P_i^j V_i^j \geq S_i$. The quality of the built scenario is better if the strict mode is used throughout the learning.

4.5 Progression in learning

During the co-construction of the scenario, it is necessary to ensure the progression of the learner and to be able to anticipate failure (non-progression). To progress in learning is to move from the current knowledge state to one of higher knowledge states. Progression can be sequential or not. In our model, to allow non-sequential progressions, we introduced the notion of fast progression. To anticipate failure, we have also introduced the notion of blocked progression when the learner is blocked in a knowledge state.

Sequential progression. A progression is sequential when the learner moves from a current knowledge state to a knowledge state immediately superior. This progression is made by mastering only one goal not in the current knowledge state.

Fast progression. A progression is fast when the learner uses an augmented link (Mbatchou, Bouchet, & Carron, 2018) to progress. An augmented link allows the learner to skip some intermediates states. It is possible when the learner chooses an activity with multiples goals without master all goals of activity. This possibility allows to take into account learners who have knowledge about the goals of course.

Blocked progression (no-progression) A blocked progression is the inability of learner to move from a current knowledge state to a higher knowledge state at the given time. A goal of our model is to help each learner to achieve their goals by anticipating failure and offering appropriate suggestions.

Example: Considering a learner in a knowledge state where he has 3 goals A, B and C to achieve. The precedence relationships between these goals are A→B and B→C. In sequential progression, the learner must achieve the goal A, then B and finally C. In fast progression (if there is an activity with multiple goals aiming to achieve both the goals A, B and C), the learner can attempt to achieve goal C. If he succeeds, then goals A and B are also achieved since they are prerequisites for C. In case of blocking situation, the system suggests sequential progression. If it is blocked in a sequential progression, the system will propose to him to change goal. In a blocking situation, the system sends an alert to the human tutor who can help the learner.

In conclusion, from the previous points, we answered positively to our first research question (RQ1) by proposing a theoretical model which embeds several features that we think would help learners in co-constructing their learning scenario.

5. SYSTEM OVERVIEW

We chose to implement our model as a plugin in MOODLE (Modular-Object Oriented Dynamic Learning Environment), which is the LMS used in our test university (the model being platform-independent). The plugin, named EGbKST (Educational Goal based Knowledge Space Theory), provides a dynamic interface to be used while learning (*cf.* Figure 4) as well as an on-demand interface allowing the learner to see a summary of their results so far (not presented here). The learning interface is organized in several dynamic blocks (Communication, Statistics, Resource, Goal and Activities) which content and visibility depend on each learner and their knowledge state.

5.1 System used for the first experiment

The learner initially chooses a goal to achieve (block in green). As soon as it is reached, the system offers them a new set of goals they can achieve and so on. During the procedure of achievement of the current goal, the system shows the relevant resources (block in yellow) that allows to acquire the necessary knowledge. The assessment of acquired knowledge is done by choosing activities to do (block in blue). The learning ends when the learner has achieved all the goals. The goals and the order in which they are chosen represent the scenario built by learner. The system allows to change current goal to choose another one if necessary. To progress in learning, the learner has a list of assessment modes (block in red) to choose from to express their desired degree of challenge. The efforts made and the chosen mode allow them to progress at a higher knowledge state.

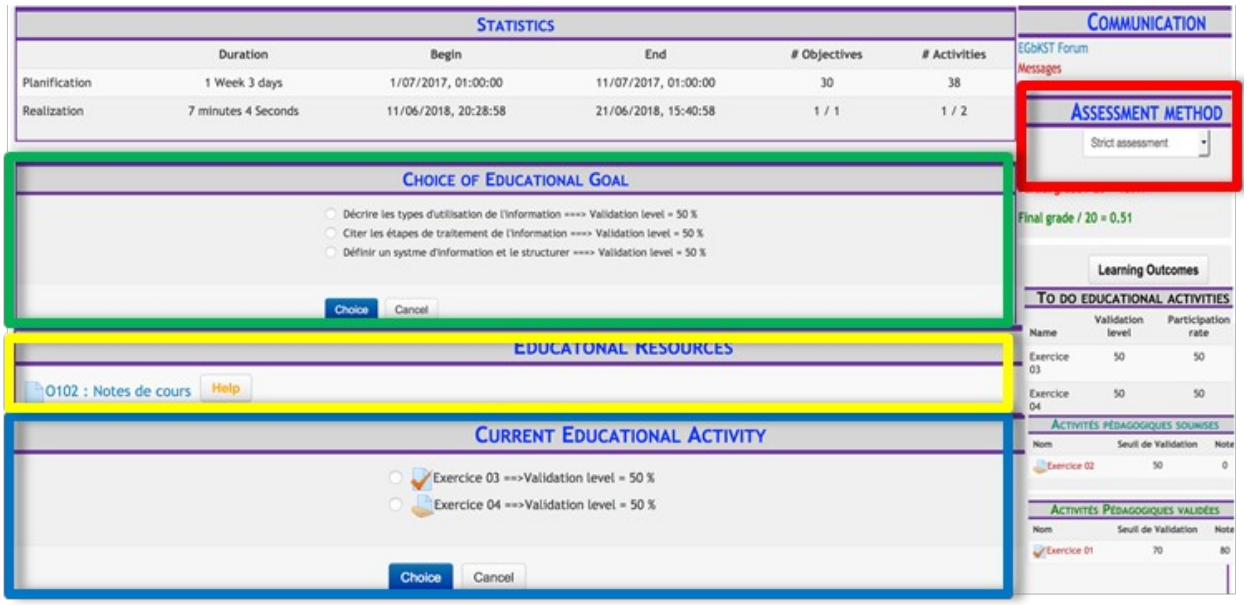

Figure 4. Learning interface

The acceptability of our model by the learners is made during the first experiment. The results presented in (Mbatchou, Bouchet, Carron, & Pernelle, 2018) reveal that our model is understandable and acceptable by learners. This result allows us to be optimistic that our model will improve the learning process of each learner. But this experiment revealed some bias during the learning process which were related to some system weaknesses that need to be corrected not to misinterpret the learners' behaviours. Some recommendations were thus made during the analysis, and adaptation of the model as well as system reengineering were necessary.

In a previous work, we have also assessed our model acceptability (https://goo.gl/forms/ne1Uua4UeYPW3EeO2) from the teacher's point of view (Mbatchou, Bouchet, & Carron, 2018b), showing their willingness to use it. An experiment with 16 teachers from 8 specialties also allowed us to (1) detect and correct the inconsistencies in their educational productions; (2) find that certain goals of their course are not related to others; (3) find that there is little prerequisite relationship between goals; and (4) note the multiplicity of scenarios in their course.

5.2 Reengineering for the second experiment

At the end of the first experiment, we revealed system weaknesses to correct in order to avoid bias in the analysis of learners' behaviors. For example, a bias during the construction of a scenario due to the presentation of goals with numbers which could suggest an order between the goals.

Before the second experiment, we made the reengineering of our model and system. We added to the model (1) strategies to ensure learning progression and (2) the guarantee of learning to be sure that learner acquired knowledge during its progression.

5.2.1 Strategies to ensure learning progression

Each goal (G_i) has minimal (T_i^{Min}) and maximal (T_i^{Max}) durations recommended by teacher to achieve a satisfaction threshold (S_i). To ensure the learners' progression, retroactions (feedbacks) are proposed to guide him (*cf.* Table 1). The retroactions are based on duration (T_i) and grade (V_i) obtained at goal (G_i). To encourage learner to achieve the current learning goal, extra-time are granted, defined according to the following formula:

$$ExtraTime = (T_i^{Max} - T_i^{Min})/2$$

Table 1: Table of suggestions to ensure the progression and to anticipate failure

Condition on T_i	**Condition on V_i**	**Action**
$T_i \geq 50\%$ of T_i^{Min}	$V_i \leq 10\%$ of S_i	Be careful! You have consumed more than 50% of allocated time for educational goal. Your grade for this goal is very poor because it does not exceed 10% of the required score
$T_i \geq 75\%$ of T_i^{Min}	$V_i \leq 20\%$ of S_i	We suggest that you change the educational goal because you have consumed more than 75% of allocated time to educational goal while your grade is less than 20% of required score
$T_i \geq 75\%$ of T_i^{Min}	$V_i \leq 50\%$ of S_i	Be careful! You have consumed more than 75% of allocated time for educational goal. Your grade for this goal is insufficient because it does not exceed 50% of the required score
$T_i \geq T_i^{Min}$	$V_i \leq 25\%$ of S_i	We suggest that you change the educational goal because you have consumed more than 100% of allocated time to educational goal while your grade is less than 25% of required score
$T_i \geq T_i^{Min}$	$V_i \leq S_i$	To offer you opportunity to validate this educational goal, we offer you an extra-time.
$T_i \geq T_i^{Min}$ + ExtraTime	$V_i \leq S_i$	Despite the extra-time, you could not validate the educational goal. We give you a last extra-time. On the other hand, we advise you to change your educational goal if you can't progress.
$T_i \geq T_i^{Max}$	$V_i \leq S_i$	Your grade does not allow you to validate the educational goal. Change your assessment method which allow you to progress in your learning. If no method allows you, change immediately your educational goal.

5.2.2 Guarantee of learning

To be sure that learners acquire knowledge during their progression, it can seem reasonable to impose to learners the sequential progression because at least it is a path that is known to help in acquiring knowledge progressively. However, by not proposing the fast progression, we penalize some learners (challengers, learners with acquired knowledge before, …), preventing them from choosing activities with multiples goals where several of them are not yet acquired. To find a right balance, we chose to suggest to learners who uses fast progression, the strict mode acquisition of knowledge. Additionally, for a learner who uses the sequential progression, when he is in a knowledge state greater than an augmented knowledge state, the activities with multiples goals of that augmented knowledge state will be systematically proposed. The success of these activities helps in strengthening the competence level of learner in the different goals of the activities. In case of failure, the learner is free to progress but, these non-validated activities will be notified to them as weak points to work on. They then have opportunity to redo each of them when he wants. Once an activity has been validated, it is no longer considered as a weak point.

5.2.3 Reengineering of system

During the first experiment, we have strict mode as default assessment mode. To avoid this bias, we designed an interface (Figure 5) allowing learners to explicitly choose its initial assessment mode. This mode can be changed at any time during the learning.

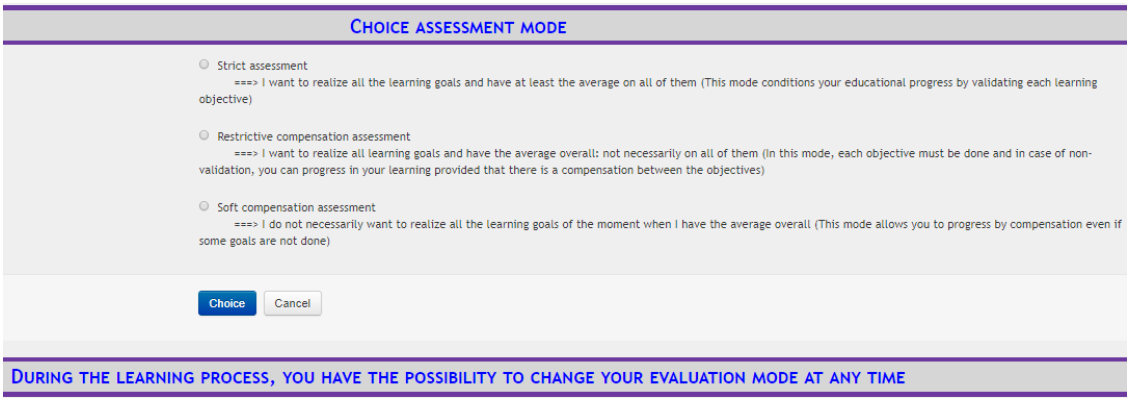

Figure 5: Interface to choose the assessment mode at the beginning of learning

Another bias of previous system was the numbering of goals, which indirectly reflected the original sequential approach followed by the teacher. Instead, in the reengineered version, we decide to show each goal with its metadata like satisfaction threshold, recommended time, number of resources and activities (Figure 6).

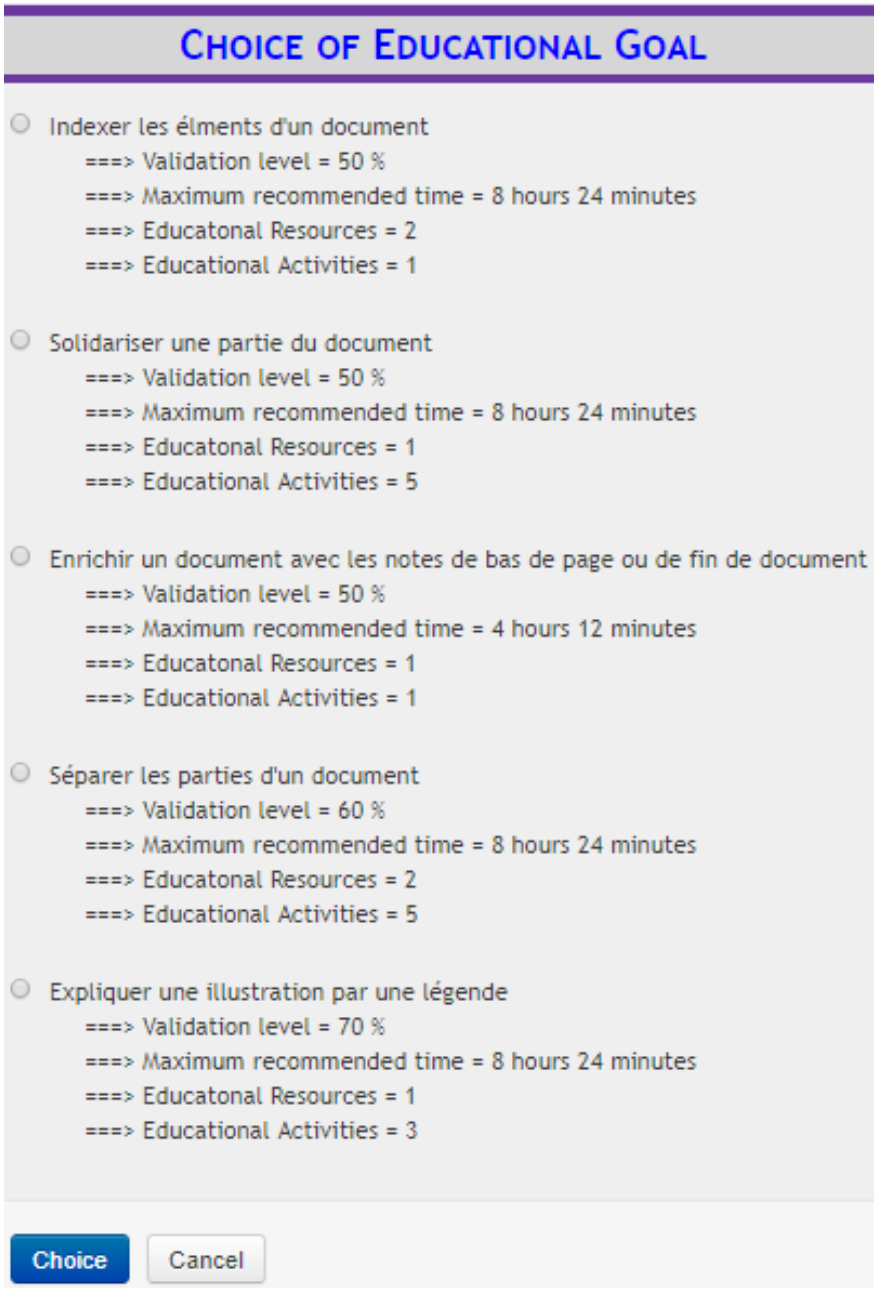

Figure 6: Interface to choose learning goal

To help a learner to choose an activity, we present the activities with their satisfaction threshold, number of targeted goals and a message to prevent the learner if they do not yet have all the skills to complete it (Figure 7). We randomized the order of activities to prevent a learner from having the same list in the same order every time.

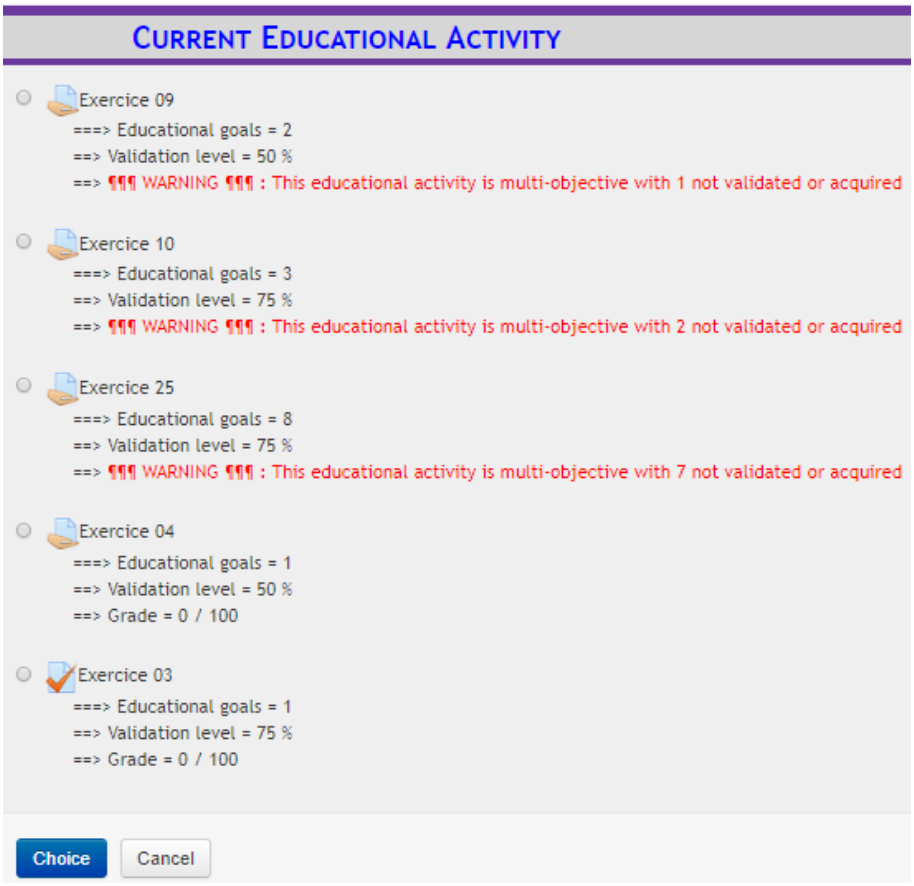

Figure 7: Interface to choose learning activity

The other interfaces can be found in (Mbatchou, 2019).

6. ASSESSING CO-CONSTRUCTION OF SCENARIO BY LEARNERS

6.1 Methodology

6.1.1 Experimental protocol

The experiment was realized in 3 phases in a public university in sub-Saharan Africa, with nearly 3500 students enrolled in 21 academic sections and 120 teachers in 15 specialties (from bachelor to doctorate).

Phase 1: Assessing the acceptability of the model by the learners. To answer our second research question, we submitted a survey[1] to students. The survey questions are in affirmative form with responses on a 4-point Likert scale extending from "strongly disagree" to "strongly agree". The survey collected student opinion on the following aspects: (1) Current educational model: the question is to find if they find that (a) the courses have clearly defined and identifiable educational goals, (b) for the defined goals, do they have learning resources and activities to evaluate them? (c) can the learning be done in a different order than the teacher's? (2) Interests for a goal-based educational model: the question is to know if they think that a such model would facilitate their learning and success. The questionnaire was sent to all 3500 students, but we received only 85 responses[2]. This can be explained by the fact very few students are trained to take online courses (around 250 students have access to online training platform). Participants come from 14 academic

1 https://goo.gl/forms/EgiVdEgE1z8mfFQr1

2 Consulted at 11-24-2017

sections and 3 teaching cycles. Their age varying between under 18 years to over 45 (M = 21.60, SD = 6.46). 80% of survey responses are from learners who have been trained in the use of online learning platform.

In view of the response rate, these results should be taken with caution, because it probably over represents certain categories of students (*e.g.* motivated, technophiles). To counter this potential bias, we also asked those questions[3] to the 11 students who tested the system (*cf.* below) in the first experiment.

Phase 2: Assessing the usability of the system. The first experiment conducted on the "General Political Economy 1" teaching unit with 11 learners (Mbatchou, Bouchet, Carron, & Pernelle, 2018) revealed weaknesses in the system that must be corrected to avoid bias in the analysis of the results. After having done a reengineering of the model and the system (*cf.* section 5.2), we carried out a second experiment on a different computer science course in continuing training with the students of the professional license in Renewable Energies. This course has 20 objectives, 32 resources, 25 activities, and a known predefined scenario recommended by the teacher. The resources are a mix of files, webpages and videos. The activities are of the production type (open-ended questions) and quizzes (true/false, yes/no, matching, single choice and multiple choice). The students (N = 16) are those of the initial training who have chosen to continue Renewable Energies in continuing training with a level of license 2 in physics. The learning lasted 2 months and was performed in blended learning alternating online sessions and face-to-face sessions. Learning was done more online because work instructions, resources and learning activities are available online. A forum has been created for discussions among students on the one hand and between students and the teacher on the other. To break the isolation effect of students, face-to-face sessions were organized to allow students to meet in a classroom once a week to discuss the difficulties encountered. A face-to-face session lasted an average of 1 hour and is led by the teacher. Forum questions with unsatisfactory answers are processed again. New questions about resources and activities are addressed and guidance is provided for successful learning activities.

6.1.2 Data collection protocol

Assessment of the model acceptability (phase 1) is done with the Google Forms tool, with data saved in a CSV (Comma-Separated Values) file. During learning (phase 2), learner interactions with the system are recorded in a plain text log file in which each line contains a 7-uplets (date, action, grade, type of learning object, learning object, learner identification on Moodle, learner identification on EGbKST plugin), corresponding to the action done by a learner on a learning object.

6.1.3 Data analysis protocol

To validate our third research question, we considered 2 indicators: diversity of scenarios and of assessment modes. We considered only 14 students because 2 of them did not participate in the training.

The diversity of scenarios allows to determine if co-constructed scenarios are different. For each learner, we extract successive learning goals followed in chronological order. For those who have not completed their learning, we compare their learning sequence with the corresponding sequence in the reference teacher-recommended scenario (*e.g.* the first 5 steps for a learner who dropped out after 5 steps). The diversity of scenarios is represented by the number of different scenarios and the distance between alternative scenarios (distance based on the Levenshtein distance - when computing distances between scenarios, we only consider sequences of identical length).

The diversity of assessment modes allows to determine the willingness of each learner to progress according to the mode chosen at each learning stage. This indicator is broken down into 2 sub-indicators: the percentage of time that each assessment mode is used to progress, and for each mode, the number of learners who used it and the number of times used.

3 http://foad.uasz.gouv.sn/mod/questionnaire/view.php?id=5273

6.2 Results and discussion

6.2.1 Acceptability of the model by the learners

The acceptance of the model is assessed in the general framework with all 85 respondents. We present below the results and then contrast them with the results obtained with the 11 students involved in the experiment.

Current educational model. The survey shows that the courses are organized mainly in chapters (81.2%) and often in parts (32.9%). 27% of participants estimate that certain learning goals do not have learning resources clearly associated to them. 3.5% of participants believe that in some courses, goals are not announced. Results are more concerning for exercises, for which 50.7% learners estimate that educational goals are not assessed. This finding justifies our approach to associate resources and exercises with each goal to better structure and facilitate learning. 70.6% of participants' estimate that the course could be better learned with a different scenario than the one imposed by the teacher. We conclude that current educational model contains weaknesses identified by learners and their wish reinforces our approach of co-construction.

Interests of pedagogical model based on goals. 81.2% of learners estimate that learning would be easier if it is organized and presented by goals and not by chapter. 91.8% of them believe they would obtain better results if they were assessed by goal. The results obtained from the 11 students of our first experiment are similar to those obtained on the larger sample. The only difference is the availability (online) of resources and activities for the goals. This difference is justified by the fact that online course procedure requires the availability of resources and activities for each learning sequence.

We thus can respond positively to our RQ2: our approach seems in agreement with learners' expectations.

6.2.2 Scenarios diversity

To visualize different scenarios followed by the learners, we represented each stage of the scenario of each learner with a different color (*cf.* Figure 8). We can see each student has built its own scenario.

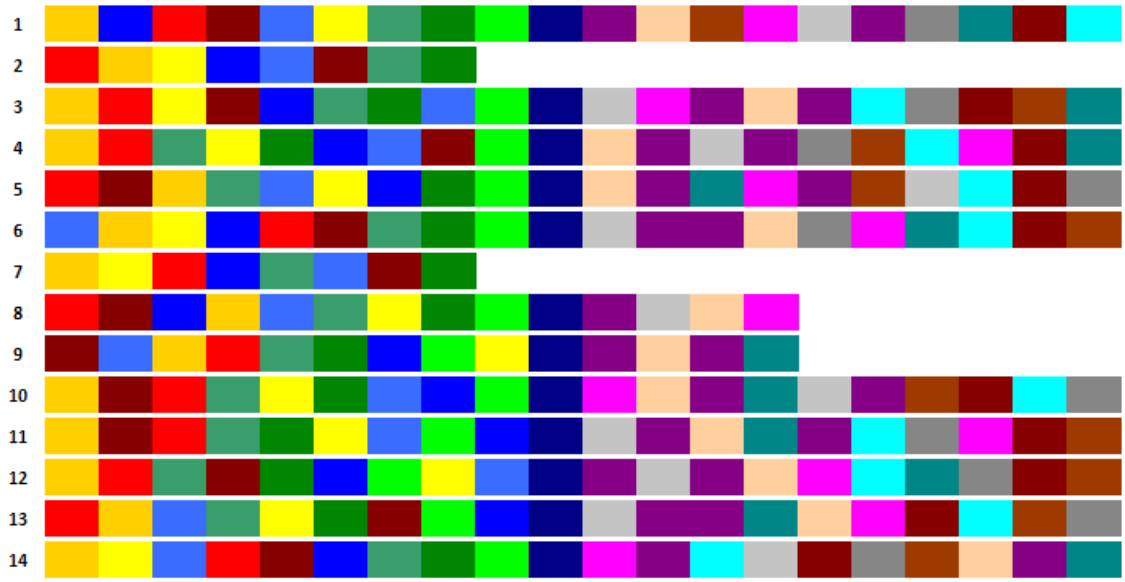

Figure 8. Visualization of 14 scenarios built by learners

By computing the Levenshtein distance between the scenarios, we see that the scenarios are different from each other (*cf. Table 2*). The maximum distance is 20 and we find that the majority of the scenarios have a distance of more than 10 of the others. Despite the possible interactions between students and weekly meetings, each student has chosen different goals to achieve.

Table 2. Levenshtein distance between different scenarios

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	0	5	14	15	13	12	5	8	9	13	14	14	16	13
2	5	0	6	5	5	2	4	5	8	7	8	8	6	4
3	14	6	0	12	15	12	5	10	11	13	11	11	14	11
4	15	5	12	0	13	14	5	11	9	10	12	12	13	13
5	13	5	15	13	0	14	6	7	9	10	13	16	13	15
6	12	2	12	14	14	0	5	10	10	16	12	13	13	13
7	5	4	5	5	6	5	0	6	7	6	6	6	7	4
8	8	5	10	11	7	10	6	0	9	10	10	10	8	10
9	9	8	11	9	9	10	7	9	0	7	9	6	9	11
10	13	7	13	10	10	16	6	10	7	0	13	14	13	15
11	14	8	11	12	13	12	6	10	9	13	0	11	12	17
12	14	8	11	12	16	13	6	10	6	14	11	0	13	17
13	16	6	14	13	13	13	7	8	9	13	12	13	0	17
14	13	4	11	13	15	13	4	10	11	15	17	17	17	0

We wanted to know if the scenarios were also as distant from the one recommended by the teacher. This, we calculated the distance between each scenario and the recommended one. We realized that no scenario is similar or close to that recommended by the teacher (*cf. Figure 9*) except for scenarios 2 and 7 where students only completed 8 steps out of 20.

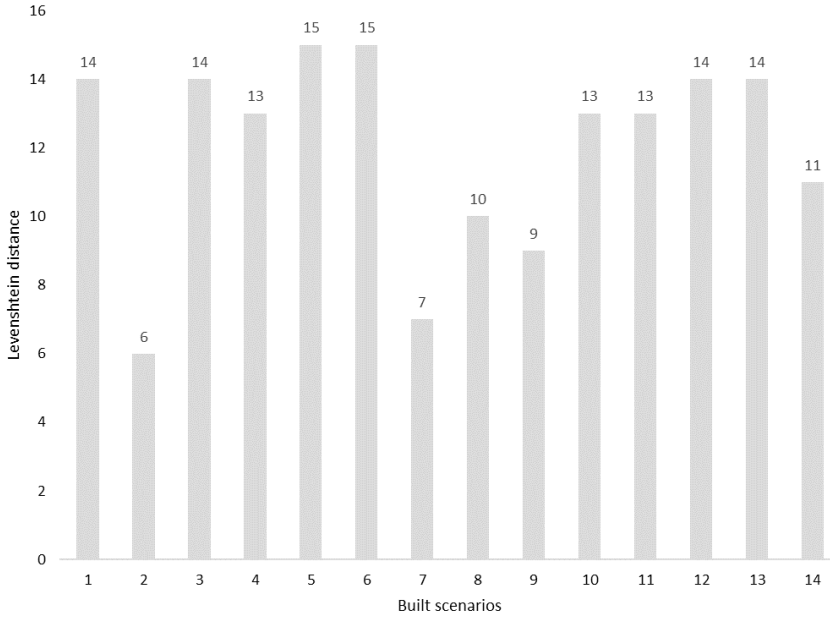

Figure 9. Levenshtein distance between students' scenarios and the teacher's recommended scenario

These results show that when giving choice to the learners to build their own scenario, they can build a variety of logical scenarios while respecting to pedagogical constraints.

6.2.3 Assessment modes diversity

At the beginning of the learning, the assessment mode is chosen by each learner and we note (except learner L07) that all the learners started with the strict mode (*cf.* Figure 10). Unlike the first experiment, the percentage of use of the strict mode decreased from 75% to 29.1% (*cf. Figure 11*) because the system (*cf.* Table 1) suggested to learners the appropriate mode of evaluation for each learning stage (*cf.* section 5.2.1). Nevertheless, we observe some learners (L12 and L13 in Figure 10) who decided not to follow the suggestions of the system because they wanted to keep on using the strict mode. There are learners (L10 and L12 in Figure 10) who have chosen to improve certain learning activities to return to the strict mode. We think that once the learners have changed the assessment mode, they want to progress quickly and therefore preferred the flexible mode over the restrictive one. We find that all learners who prematurely stopped learning changed their assessment mode for the flexible mode. This could mean that changing to flexible mode indicates future dropout, and that could be brought to the teacher's attention.

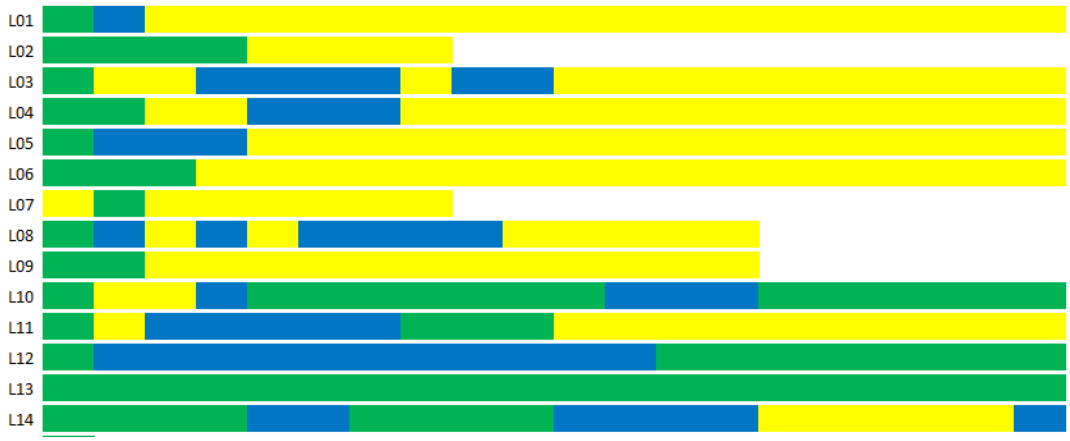

Figure 10. Scenario representation of each learner by assessment mode (Strict mode in green; Restrictive mode in blue; Flexible mode in yellow)

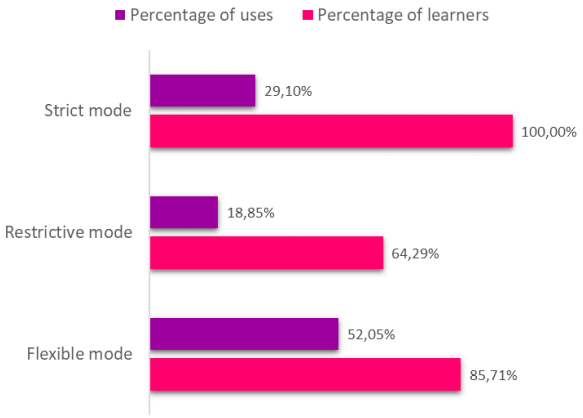

Figure 11. Representation of learners and progress number by assessment mode

7. CONCLUSION

Giving learners the opportunity to build their scenario while learning, making them a main actor of its co-construction, is not really considered in recent research in TEL. Our model shows that it is possible, and that the built scenarios respect educational constraints defined by the teacher. Experiments led with teachers and learners show their satisfaction and the ability of the model to improve both the learning and teaching processes. The diversity of scenarios built by learners revealed that some learners seem to prefer a different approach than the teacher's default one. Moreover, the model offers learners to modify their assessment mode at any time. Their desire to be challenged is a sign that our model offers a motivating framework to better acquire competences. This is confirmed by the fact some learners returned on previous activities to improve their score to remain in a strict assessment mode.

Among the limits of this work, the context of our experimentation (few online learners in sub-Saharan Africa) does not allow us to fully validate our approach – integration to a MOOC could help reaching a more reliable conclusion. Moreover, our model is only applicable for learning by competences or educational goals.

In future work, we will integrate into the model the analysis of the chosen scenario and present it to the learner. When they face difficulties while diverging from the reference scenario, we may redirect them towards the reference scenario. Moreover, traces analysis over several courses could help in identifying patterns and thus learner profiles and learning indicators that will help us to guide or redirect future learners.

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