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RESEARCH ARTICLE

Studying Learner's Player Learning Style for Generating Adaptive Learning Game

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This work involved human subjects or animals in its research. The authors confirm that all human/animal subject research procedures and protocols are exempt from review board approval.

ABSTRACT Several studies have been conducted in the field of Technology Enhanced Learning (TEL) have shown that the adaptation to learner's learning styles is a task that must be taken into account during the design phase of the educational sequences in order to increase the student's motivation. Cognitive psychologists have proposed various models of style, which it's often represented by using multiple dimensions statistically estimated, each model suggests an instrument for measuring an individual's learning style. Most of them use questionnaires such as (Honey and Mumford (1992), Kolb (1984), Index of Learning Styles (ILS)). This paper shows the results of a study that was addressed to doctoral students. The sample of the population was made up of 300 persons. The purpose of this study is to illustrate the effectiveness of the French version of the Index Learning Styles (ILS) and uses factor analysis for investigation into various dimensions to help students decrease the time spent on this test. The main finding of this paper is: 1) the integration of the French version of the ILS into eAdventure and 2) the generation of an adaptable learning game (LG) and the development of a new version of the eAdventure authoring tool based on Eadventure Index of Learning Style (E-ILS), capable of fixing learners' preferences (desires, habits, etc.).

INDEX TERMS Learning game (LG), personalization, information and communication technologies (ICTs), index of learning style (ILS), Felder-Silverman learning style model (FSLSM), technology enhanced learning.

I. INTRODUCTION

Information and communication technologies (ICTs), such as video games, social media platforms, and online marketplace platforms, are causing profound changes in society at multiple levels, including technological, economic, and social. These innovations have an impact on how people receive and process information. In the context of education, the immediacy with which content is transmitted, as well as the availability of content in multiple audiovisual formats, means that educators must adapt their methodologies to meet not only society's new demands, but also their students' new characteristics and interests. In this regard, there has

been a shift in the usage of traditional approaches during the previous decade, and the use of ICTs in education has become increasingly accepted [1]. This adaptative process has included games as well. The use of resources such as Virtual Worlds (VM), normal or educational video games, and the gamification of education Learning Games (also known as serious games, educational games, or applied games) have recently become popular [2], [3]. While each form of game has a different application method and certain rules should be addressed depending on the unique situation [36], research has proven that they all have an impact on learning. Indeed, recent studies have shown that serious video games are at least as good as, if not better than, traditional learning methods like master classes or video-based learning in specific settings [4] [3]. Serious games are those that are used for

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business, treatment, medicine, education, health, advertising, and military training, as well as for fun. Serious games, in addition to offering amusement, are primarily used to train and educate players [5]. Learning tools, prompting a variety of research and application initiatives in this area [6]. Serious games provide a new way to increase learning interest, coaching, and user performance evaluation. Serious games, for example, can be created to solve complicated problems collaboratively, improve learning efficiency, achieve predictive modeling and real-time visualization, and increase information retention when compared to traditional techniques [7]. Researchers, instructors, and educational practitioners are increasingly focusing on gamification, specifically the topic of employing digital games in education, their impact on learning and teaching, and the effectiveness of game-based learning [8]. "Digital gaming" as a concept can be used to a wide range of games, including action games, adventure games, simulation games, sports games, strategy games, and puzzle games. Games can be classified based on content, aims, style, or interactivity. Students can move and act freely in the teaching-learning environment generated by games, while honing their problem-solving skills, commitment to learning, and desire to learn more. The games contribute to the cognitive knowledge development (perception, comprehension, opinion formation, drawing conclusions), help to develop higher cognitive abilities, strategic thinking, group decision-making, and enable the creation of a realistic and diverse learning environment [8]. On the other hand Developing Game-Based Learning (GBL), presents new and varied problems in terms of flexibility to learner characteristics. As a result, adaptation is a necessary component of educational systems as long as learners differ in terms of knowledge, abilities, preferences, and motivation. Although many scholars insist on the personalization of information based on the learner's characteristics and including the range of opinions on customized and adaptive learning, one way to achieving adaptation in learning environments is based on learning styles [9].

A. PERSONALIZED GAME BASED LEARNING AND LEARNING STYLE

Personalized learning, particularly digital personalized learning with pre-packaged curricula, testing, and continuous data collecting, has emerged as a definite area of student learning growth [10]. As long as there are substantial differences amongst learners in terms of knowledge, abilities, and preferences, personalization is an important aspect of educational systems. Many individuals are aware that different learning styles and strategies are preferred by different people. The learner's learning style is one of the techniques to attaining adaptability in learning environments and Game Based Learning (figurative, symbolic and semantic...), we can recommend strategies that are more suited to the learner if we recognize and comprehend the learner's learning styles. This speeds up and increases the quality of our learning. Despite

the fact that many academics insist on personalizing data based on learner characteristics [11]. Personality-based learning styles are supposed to aid students with diverse talents and habits in monitoring learning settings in order to develop their cognitive capacities [12]. Learning styles are defined as the proclivity or manner in which pupils absorb and share information efficiently, as manifested in speaking patterns, learning methods, how to complete tasks, how to respond to others, and other favored activities [12]. The learning style can predict a student's behavior and, as a result, can be used as a good indicator of effective distance learning. Because learning styles are more dynamic and offer higher results when properly addressed, the majority of research in this field has focused on them [13]. For example, Felder points out that learners with a specific learning style can have learning problems if the teaching style does not match their own style [14], [15]. Students in a given classroom environment have varying levels of motivation, perspectives, and responses to the learning process [14]. Learning procedures that are incompatible with how a student learns are unsuccessful and unpleasant for the student [16]. This problem with learning styles has prompted educational scholars to investigate and construct learning type models. The David A. Kolb Learning Style (See Figure1) [26], The Learning Style of Peter Honey and Alan Mumford (See Figure2) [25], and the Felder-Silverman Learning Styles Model (FSLSM) are examples of learning style theories that have been developed [17]. The FSLSM is used as a learning style reference in this study. The FSLSM is the most appropriate learning-style model for analyzing the learning styles of e-learning users, according to Deborah *et al.* in 2014 [18]. The FSLSM can also be used to examine learning item preferences and e-learning system interaction designs [17]. In this section, we will look at different learning style models, specifically the Felder-Silverman Learning Style Model (FSLSM) 1988, to recognize learners' learning styles in order to build an adjustable GBL and thus deliver successful learning. Learning style models are grouped into three types [19]:

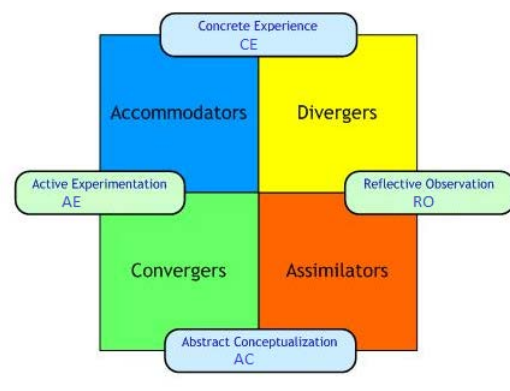


FIGURE 1. The David A. Kolb learning style.



FIGURE 2. The learning style of Peter Honey and Alan Mumford.

- Models of learning style that concentrate on teaching and learning goals.
- Learning style models are concerned with how the learner processes information.
- Learning style models that take into account the learner’s personality.

1) THE FELDER-SILVERMAN LEARNING STYLE MODEL (FSLSM)

The Felder-Silverman model designates four personality parts that make up a gift for learning. According to this model, there are four dimensions of learning styles: Active or reflective, visual or verbal, inductive or deductive, and sequential or global”. The four dimensions are detailed in the following discussion (See Figure3):

- **Dimension 1: Information processing (Active or reflective)**
The first dimension represents the dimension of reflection and information processing by the learner. It varies from reflective to active. Active learners prefer to get information by doing something. active thing by arguing or applying it or clarifying it toothers, they work well in groups. As reflective learners they prefer to work alone and want to think quietly first.
- **Dimension 2: Perception (Sensing or Intuitive)**
This second dimension represents perception. It varies from Sensing to Intuitive. Sensing learners prefer to learn from facts, such as solving problems by fixed means and revelations, they like courses that have an apparent connection to the real world. Intuitive learners, on the other hand, prefer innovation. And they often feel

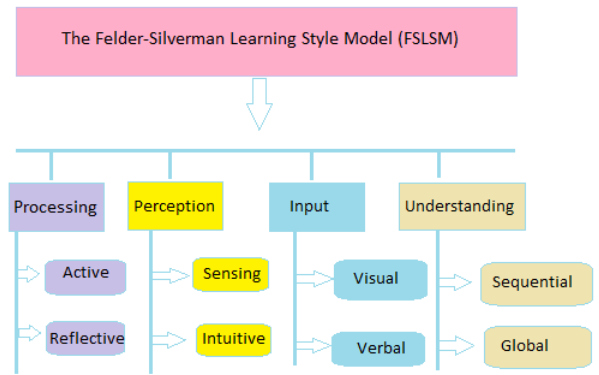


FIGURE 3. The Felder-Silverman learning style model (FSLSM).

more comfortable than sensing ones, with abstractions and mathematical formulations.

- **Dimension 3: Input (visual or verbal)**
The third dimension consists in representing the way in which the learner prefers to perceive information. It is the size sensory. It varies from visual to verbal. Visual Learners recall visual information and demonstrations such as: diagrams, flowcharts, timelines, while verbal learners get a lot out of spoken explanations and promote visual discussion, for example in the form of a presentation. Good learners are able to learn the information presented both visually or verbally.
- **Dimension 4: Progress towards understanding (sequential or global)**
this dimension varies between global and sequential. Sequential students learn in small steps whereas global learners tend to to study in a big leap, for example before starting to study the first unit of a chapter in a text, they search through the entire chapter.

B. FELDER-SILVERMAN LEARNING STYLE INDEX (ILS)

Based on the Felder-Silverman Learning Style Model (FSLSM), a psychometric assessment tool correspondent has been created. It has been called the Learning Style Index of Felder-Solomon (ILS). This is a 44-point questionnaire, where the preferences personalities of the learners for each dimension, are expressed with values between +11 to -11 (See Figure 4 and 5). The purpose of ILS is not to match the teaching style to the learning style, but to “achieve a balance by ensuring that each style preference is expressed to a reasonable extent through teaching” [20] and further instruction can occur when training styles match styles of learning. Students want skills related to both extremes of each learning style dimension work effectively,so that the perfect teaching approach is the well-suited method in which all learners are sometimes trained in a method that corresponds to their preferences and therefore they are not too uncomfortable to study effectively, and sometimes the reverse, to encourage them to develop and improve their learning abilities [21].

Index of Learning Styles Questionnaire

Barbara A. Solomon
Richard M. Felder

North Carolina State University

Directions

Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name
lanyae bennis

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
 - (a) try it out.
 - (b) think it through.
2. I would rather be considered
 - (a) realistic.
 - (b) innovative.
3. When I think about what I did yesterday, I am most likely to get
 - (a) a picture.
 - (b) words.
4. I tend to
 - (a) understand details of a subject but may be fuzzy about its overall structure.
 - (b) understand the overall structure but may be fuzzy about details.

FIGURE 4. Felder-Silverman learning styles index questionnaire.

Learning Styles Results

Results for: lanyae bennis

ACT	X	11	9	7	5	3	1	1	3	5	7	9	11			REF	
							<-- -->										
SEN		11	9	7	5	3	1	1	3	5	7	9	11				INT
							<-- -->										
VIS	X	11	9	7	5	3	1	1	3	5	7	9	11				WRB
							<-- -->										
SEQ		11	9	7	5	3	1	1	3	5	7	9	11				GLO
							<-- -->										

FIGURE 5. Learning styles outcome.

C. eAdventure AND ITS CURRENT DESIGN MODEL

eAdventure (formerly “e-Adventure”) is an open source advanced game author written in Java. It was conceived as a research project of “e-UCM” (e-learning research group at the Complutense University of Madrid). With eAdventure,

anyone can create a point-and-click conversational 2D adventure game. This type of game is generally considered to be more suited to instructive contexts due to the emphasis on exploration and reflection as opposed to time stress or fast-paced action [22].

eAdventure is developed to be easily used by novice users, among which we can generate an LG supported by all universal operating systems, such as MAC OS, Windows and Linux. The eAdventure architecture contains two main applications the eAdventure Editor and the eAdventure Engine Core [23] (See Figure 6). Through the eAdventure editor (the game description) the novice user can design his own LG by choosing the game components. This includes not only characters, objects, game scenarios, but also the effects triggered in the game. game(see Figure 6).

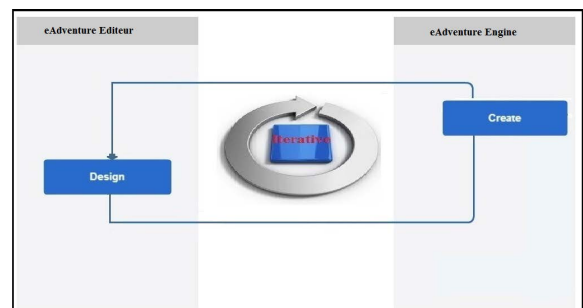


FIGURE 6. The current game design of eAdventure.

II. OUR APPROACH BASED ON INTEGRATING THE FELDER-SOLOMON LEARNING STYLE INDEX (ILS)

In this section we briefly introduce our approach concentrating especially on the use of Felder-Silverman learning style model (FSLSM), as shown in this article most other learning style models categorize learners in limited groups, while Felder and Silverman define the learning style of a student in more feature, differentiating among preferences on four dimensions. Litzinger *et al.* [21], reports that the Felder Model is the greatest suitable for hypermedia courseware and shows also that FSLSM is utilized frequently in research linked to learning styles in innovative learning technologies. Our approach to provide an effective learning allowing teacher designer to control their learning environment and select the options best suited for their learners learning style preferences based on the Felder-Silverman Learning Style.

A. LEARNING STYLE MEASUREMENT: ILS QUESTIONNAIRE

This measure is based on the ILS Learning Styles Index compiled by Felder *et al.* [16] and Solomon. ILS considers that people’s approaches to perceiving and mentally processing information can be classified according to four dimensions. We have translated into French, with the help of doctoral students, the original Felder-Soloman questionnaire in English consisting of 44 modal questions. The new questions have been adapted according to the language of higher education

in Morocco to stay close to Educational Obsessions. A study was made to verify whether the new French version of the ILS questionnaire allow to properly measure the learning style of doctoral students from the Meknes Faculty of Science according to the model proposed by Felder in using the statistical analysis tool SPSS (Statistical Package for Social Science).

B. STATISTICAL ANALYSIS TOOLS: SPSS

Data analysis is the process of examining and interpreting data to develop answers to questions and draw conclusions. There are many methods for this purpose. Among these and the most popular, we cite SPSS (Statistical Package for Social Sciences). SPSS is software specially designed for statistical analysis (Carricano and Bertrandias, 2010) [27]. The first version of SPSS was released in 1968 and one of the most widely used programs for statistical analysis in social Sciences. It is used by researchers belonging to various persuasions scientific (economics, health science, national education, etc.). This software can use data from almost any type of file to generate reports put in tables, diagrams of distributions and trends, statistics descriptions and complex statistical analyzes (Levesque, 2005) [28]. It contains several modules: basic system, regression models, advanced models, tables, exact tests, categories, trends and other specialized modules. SPSS is more accessible to beginners and more convenient for seasoned users. It is for this reason that we have chosen to use it as an analysis tool contributions of our approaches.

C. SAMPLE OF THE POPULATION FOR THE STUDY

The study we conducted was aimed at doctoral students. The sample of the population was finally composed of 300 people. The primary goal of this study was to show that the French version of the ILS questionnaire provides a good measure of a student’s learning style.

D. RETAINED FROM THE STUDY

In this study, we adopted a single measurement instrument: the French version of the ILS questionnaire adapted for students from the Faculty of Science Meknes. The questionnaire contains 44 closed questions with two modalities (a and b) which form 4 groups of 11 questions. Each group of questions develops a dimension for the cognitive model of the student which is therefore composed of 4 dimensions (See Table 1).

To determine the dimension of a student, simply count the number of answers a and answers b on the 11 corresponding questions and make them subtraction to get a positive number. Let A and B respectively be these numbers. The A-B difference helps to situate the student’s style (see Figure 7). A negative number indicates that the pupil is close to end b and vice versa. We attributes to this style a degree of confidence calculated by $d = |A-B|$. Table 2 gives the semantics of this measure.

TABLE 1. Distribution of the index learning style questionnaire according to the FSLM learning style dimensions.

Dimensions	Extremity Lower (a)	Upper End (b)	Questions(ILS)
D1: Reasoning	Deductive(a)	Intuitive(b)	Q2, Q6, Q10, Q14, Q18, Q22,Q26, Q30, Q34, Q38, Q42
D2: Sensory	Visual(a)	Verbal(b)	Q3, Q7, Q11, Q15, Q19, Q23, Q27, Q31, Q35, Q39, Q43
D3: Reflection	Asset(a)	Reflexive(b)	Q1,Q5,Q9,Q13,Q17,Q21, Q25,Q29,Q33,Q37,Q41
D4: progress	Sequential(a)	Global(b)	Q4, Q8, Q12, Q16, Q20, Q24,Q28, Q32, Q36, Q40, Q44



FIGURE 7. Dimension of learning style.

TABLE 2. Confidence of the learning style measure.

Degree of confidence	Signification
1-3	Uncertain
5-7	moderate
9-11	strong

E. RELIABILITY OF THE FRENCH QUESTIONNAIRE VERSION

After entering and analyzing the responses to the French version of the questionnaire FSLSM by SPSS software, We calculated Cronbach’s α coefficient for assess the reliability of this questionnaire. The authors point out that in the case of a questionnaire that measures a level of knowledge, the acceptance threshold is set at 0.75 and in the case of a measure of preferences or attitude at 0.5. The French version of the 44-question ILS questionnaire presented to the target population obtained a Cronbach’s α coefficient = 0.64. Which indicates a reliability rate suitable for measuring learning style.

F. REDUCTION OF THE LEARNING STYLE MEASUREMENT QUESTIONNAIRE

After this state of the art on ILS and the study we conducted on the population target (PhD students from the Faculty of Sciences of Meknes) it was found that the number of question 44 is too high, therefore the level of concentration and motivation of the player learner decreases. Using factor analysis, we reduced the questionnaire to only these 25 questions. The weak number of questions reduces the time taken. This having necessarily have a consequence on the reliability of the measurement. This new questionnaire we have named E-ILS (See Figure3) and (See Figure8).

TABLE 3. Reduction of the learning style measurement questionnaire.

Old Learning Game Style Index	Factor 1	Factor 2	Factor 3	Factor 4
	D1: Reasoning	D2: Sensory	D3: Reflection	D4: Progress
	Q2, Q6, Q10, Q14, Q22, Q26, Q30, Q38, Q42	Q3, Q7, Q11, Q15, Q19, Q23, Q27, Q31, Q35, Q39, Q43	Q1, Q5, Q9, Q13, Q17, Q21, Q25, Q29, Q33, Q37, Q41	Q4, Q8, Q12, Q16, Q20, Q24, Q28, Q32, Q36, Q40, Q44
New E-ILS	Q2, Q6, Q10, Q14, Q19	Q3, Q7, Q11, Q15, Q19	Q1, Q5, Q9, Q13, Q17	Q4, Q8, Q12, Q16, Q20

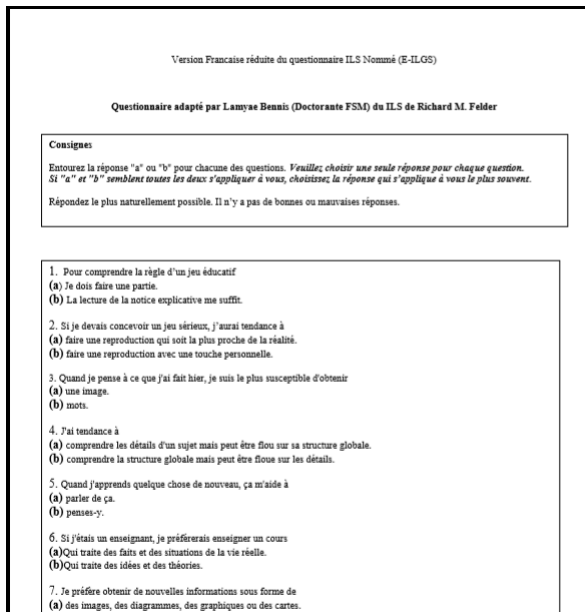


FIGURE 8. French version of the questionnaire (E-ILS) reduced to 20.

TABLE 4. Distribution of the e-Adventure index learning Style(E-ILS) questionnaire according to the FSLM learning style dimensions.

Dimensions	Extremity Lower (a)	Upper End (b)	Questions(ILS)
D1: Reasoning	Deductive(a)	Intuitive(b)	Q2, Q6, Q10, Q14, Q18
D2: Sensory	Visual(a)	Verbal(b)	Q3, Q7, Q11, Q15, Q19
D3: Reflection	Asset(a)	Reflexive(b)	Q1, Q5, Q9, Q13, Q17
D4: Progress	Sequential(a)	Global(b)	Q4, Q8, Q12, Q16, Q20

We used the French version of the E-ILS questionnaire reduced to 20 issues. The reduced number of questions requires a change in the scale of coding [-5, -1, 1, 5] on the four axes (See Figure 4).

G. THE NEW eAdventure ARCHITECTURE USING E-ILS

Our approach to the new eAdventure Architecture using E-ILS to provide effective learning that enables teacher designers to control their learning environment and select

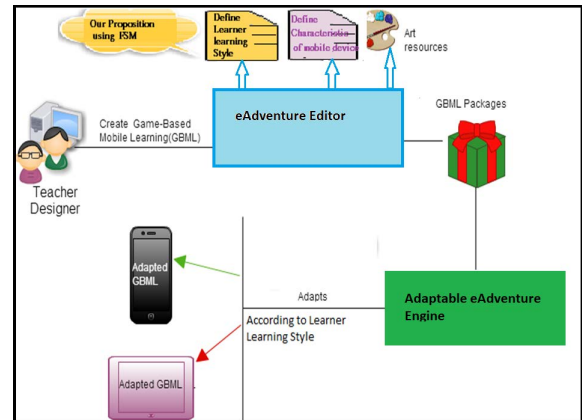


FIGURE 9. The New eAdventure architecture’s based on adaptation according to the learner’s learning style.

options that are most better suited to the learning style preferences of their learners based on the FSLSM learning style model, after perfecting the automatic adaptations generated by the “eAdventure” tool. Applying this approach to adapting GBL to different styles learning is a significant challenge for different reasons. As a result, the eAdventure platform contains two applications: an “eAdventure” editor which supports the involvement of novice trainers in the process of design of GBL, keeping them focused on delivering value (See Figure 9) and an “eAdventure Engine”, which facilitates the deployment and dissemination of GBL adaptable to students [24].

H. ADAPTATION ALGORITHM ACCORDING TO LEARNER’S LEARNING STYLE

We can summarize the mechanism of adapting educational content according to the learning style of the learner in six steps (See Figure 10):

- Step 1: The system collects and records all information personal information, including username and password.
- Step 2: The player learner is faced with two distinct choices: choice 1: answer the E-ILS questionnaire and go to the fourth step. This questionnaire is a set of questions of psychological aspect whose aim is to easily detect the learning style, preferences and learner attitudes. Choice 2: Proceed to step three.
- Step 3: In case the user surpasses the questionnaire, the system must assign it a default learning style defined in step 1, and proceed to the fifth step.
- Step 4: The system defines the learning style of the learners through the learner’s response set.
- Step 5: This step measures the adaptation parameters of the content according to degrees of preference.
- Step 6: The eAdventure system will generate Game Based Mobile Learning (GBML) based on the results of measurement of adaptation parameters.

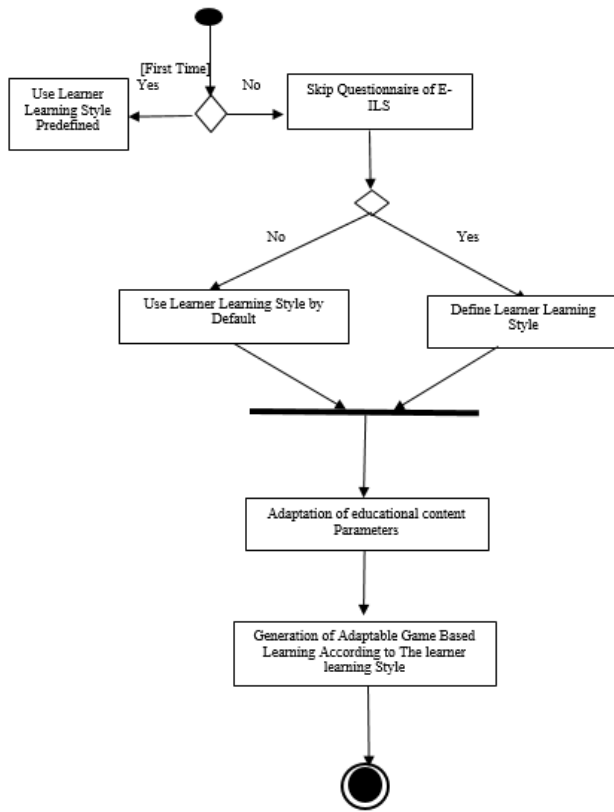


FIGURE 10. Adaptation algorithm according to the learner learning style.

III. CONCLUSION

In this paper, we have presented the different learning style models and the proposed French version of the Index of Learning Styles (ILS) reduce it, using the factor analysis in order to decrease the time spent by student via this test. We have also presented the new version of eAdventure authoring tool based on E-ILS, which is able to determine the preferences of the learner, his desires, and habits, and its complete architecture based on the overall architecture of dynamic adaptive hypermedia. In the near future we look forward to make a system running perfectly and allows a dynamic learning adaptation centered on learning style and cognitive status of the learner in order to meet their needs and expectations as its characteristics.

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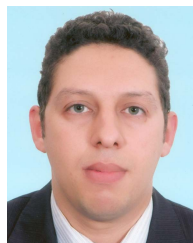
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