

Learning Patterns: Towards the Personalization of E-Learning

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Abstract

E-learning through the web began as a service, by publishing some educational materials at websites. At the early stages, the learning process was carried out by browsing such a collection of educational materials and its effectiveness was based on the presentation of content in those materials. Customizing the presentation and interactivity of an e-learning application based on the users (which we call here personalization), should be done based on each learner's knowledge and learning experience. A learning pattern, presented in this paper, is a meta-level piece of information that can be used to achieve low coupling personalization in an e-learning courseware. A learning pattern, which is modeled on different levels of abstraction, is constructed based on the interaction of a learner with relevant materials and it is depreciated when he/she stops accessing them. In this paper, we also present how a learning pattern can be used to identify the appropriate learning path in an e-learning courseware. A collection of learning patterns is used to describe one's learning experience.

1. Introduction

Learning is the only thing next to breathing that we do continuously from the day we were born to the day we will die. By everything you do, say or think, you learn something. People have different definitions and views on learning but ultimately you will have to end up with a common phrase, "You cannot live a single moment without learning something."

The methods of learning have evolved over time and they have come a long journey from the exercise book to the palm top computer with the advancement of technology. However, the basics still remain the same.

E-learning is a process of learning that takes place through a network, usually over the Internet or an intranet of an educational institute or a company. It has its roots in the not-so-attractive world of computer-based training (CBT), which appeared in the early '80s

and used CD-ROMs to teach mostly technical skills to technical people. Lately, e-learning has evolved into a tool widely used in both the corporate and academic worlds. With the rapid expansion of the World Wide Web and other Internet based services, e-learning is becoming a tool for everyone's lifelong learning.

Learning is a highly personalized activity which varies based on the background knowledge of the subject, previous experiences (general and specific), motivation, preferences, context and other activities in which the user is engaged. Personalization is a process which would affect the learning of an individual at different levels [11]. First, it should identify specific skills and knowledge gaps and direct learners to the appropriate lessons or modules. Once a particular learning activity is started, it is possible to customize the presentation of learning materials according to factors given earlier in order to maintain an effective, efficient and continuous process of knowledge transformation. When the learner undergoes this change due to the knowledge acquisition, the values of all influencing factors of learning activity are also modified and such variations should be communicated to maintain an effective personalization process.

In this paper, the authors discuss a metadata based description which they name as a learning pattern, and how it can be built and utilized to achieve low coupling personalization while protecting the learner's privacy. In many traditional applications, personalization is considered as a tightly bound process which undertakes monitoring the user's activity and maintaining the user's profile. But if the learning service is provided by an unknown third party the learner will probably refuse to provide personal information that is simply needed for the personalized service described earlier.

Generally, the personalization is provided as an interface service to the user in a circular process. The success of this service depends on the corporation of three parties namely, the learner, author and facilitator. The author, who defines the sequencing order of lessons, should include enough metadata with each lesson in order to provide multiple sequences of presentation. The facilitator, who is the publisher of the copyrighted learning materials, will have to interpret

the learner's learning pattern in order to decide the most effective sequence of the presentation in an e-learning course.

This paper is organized as follows. Section two describes issues with respect to learning content and packaging. In section three, we define learning patterns and section four illustrates how learning patterns can be used to realize personalization in an e-learning package. Section five briefly covers about an intermediate website "Learning Home" to maintain learning patterns. We discuss details of relevant standards and related user models for personalization in section six. Finally, we conclude the paper stating benefits, limitations and the future of learning patterns in section seven. There are also several diagrams used to illustrate some of the important facts described in this paper.

2. Learning Content and Packaging

If the content of a particular entity/object is supposed to provide learning to the people who will access or interact with that, it should provide information that could generate new knowledge in the learner's mind. However, this process is more complicated than what we anticipate, since the process of transforming information into knowledge heavily depends on the learner's personal status and the form of communication.

The learning content in a particular courseware should be structured according to learning objectives specified at the very beginning of the course [10]. Number of modules in a courseware is determined based on these overall objectives and each module is specified with number of sub-objectives. The advantage of these objectives is that the author can modify the courseware to add/delete new content when he/she wants to create a different version of the courseware for a new offering. Based on the sub-objectives of each module, the relevant number of lessons is determined. Generally, a sequence should be specified when lessons in a module are combined.

According to the instructional design principles [12], a lesson should not communicate many ideas in a single visual display. A single visual display is referred as a page in the e-learning courseware and a lesson may consist of one or more pages depending on what extent the author wants to present the relevant materials to the learner.

2.1 Learning Styles

A learning style is a mechanism to deliver a particular content in a lesson, based on the user's preferences and/or the most effective way to do so. This can be

based on the learner's background knowledge and skills. In some other works, the personalization is discussed as the selection of a suitable learning style [12]. However, personalization should go beyond the mere selection of a suitable learning style.

Identifying and categorizing learning styles into a common set of styles have been done by a number of studies. The process of personalization can be started by selecting an appropriate learning style in a lesson. Following four categories of learning styles are widely used to design the presentation of e-learning courseware.

Style	Description
Visual/Verbal	Prefers to read information
Visual/Nonverbal	Prefers graphics or diagrams to represent information
Auditory/Verbal	Prefers to listen to information
Tactile/Kinesthetic	Prefers physical hands-on experiences

2.2 Learning Path

The structuring of learning content based on different levels of objectives, which is known as packaging is usually done by the course author. A package, which is the technical representation of an e-learning course, usually contains additional information about how amalgamated learning content should be sequenced in a presentation and some additional metadata to describe related learning resources. The learning path is a specific sequence of learning content [9][10]. Hence, a package may contain a number of learning paths depending on the author's metadata specification.

Figure 1 shows a simple course structure in a package. It has a number of learning paths and the browser which presents the e-learning courses, will select a relevant path depending on the meta information given in the learner's profile and his/her performance at different quizzes.

Sometimes, a particular learning path could be considered as a version of the course defined for a specific user group while still supporting common learning objectives. A simple knowledge pre-test could be used to determine which learning path is the most suitable at the beginning.

The size and scope of learning content that are combined to form an e-learning course is also a key consideration. For example, if a package is comprised

of only a few learning assets, then it may not make any sense to define different learning paths. This issue is also very important in the reuse of learning content [6].

3.0 Learning Patterns for Personalization

When you go to your shoe dealer you try to find a pair of shoes that perfectly matches your needs. The shoe manufacturer produces shoes in different sizes, colors and styles so that people with different preferences can find their matches. You select the best matching pair for you. Sometimes this best match is not the perfect match based on your requirements. We can think of the personalization as the perfect match for you. However, achieving the personalization is not easy as one would imagine. Therefore, when there is no alternative, you are forced to accept what seems to be the best match.

A pattern is an abstract representation of knowledge in a particular context. It could be used to document a group of entities/objects at different levels of abstraction. At the same time, it could be used to identify a solution in a particular context. A learning pattern corresponds to such a representation with respect to an individual in the domain of his/her e-learning space. A learning pattern which has an XML type representation, carries all information required for the personalization of the learning experience.

Since learning, which takes place with the interaction in the e-learning space, modifies the learner's knowledge, the corresponding learning pattern will also grow. This learning pattern is different from the static representation of the user's profile which just gathers metadata with respect to a pre-defined structure.

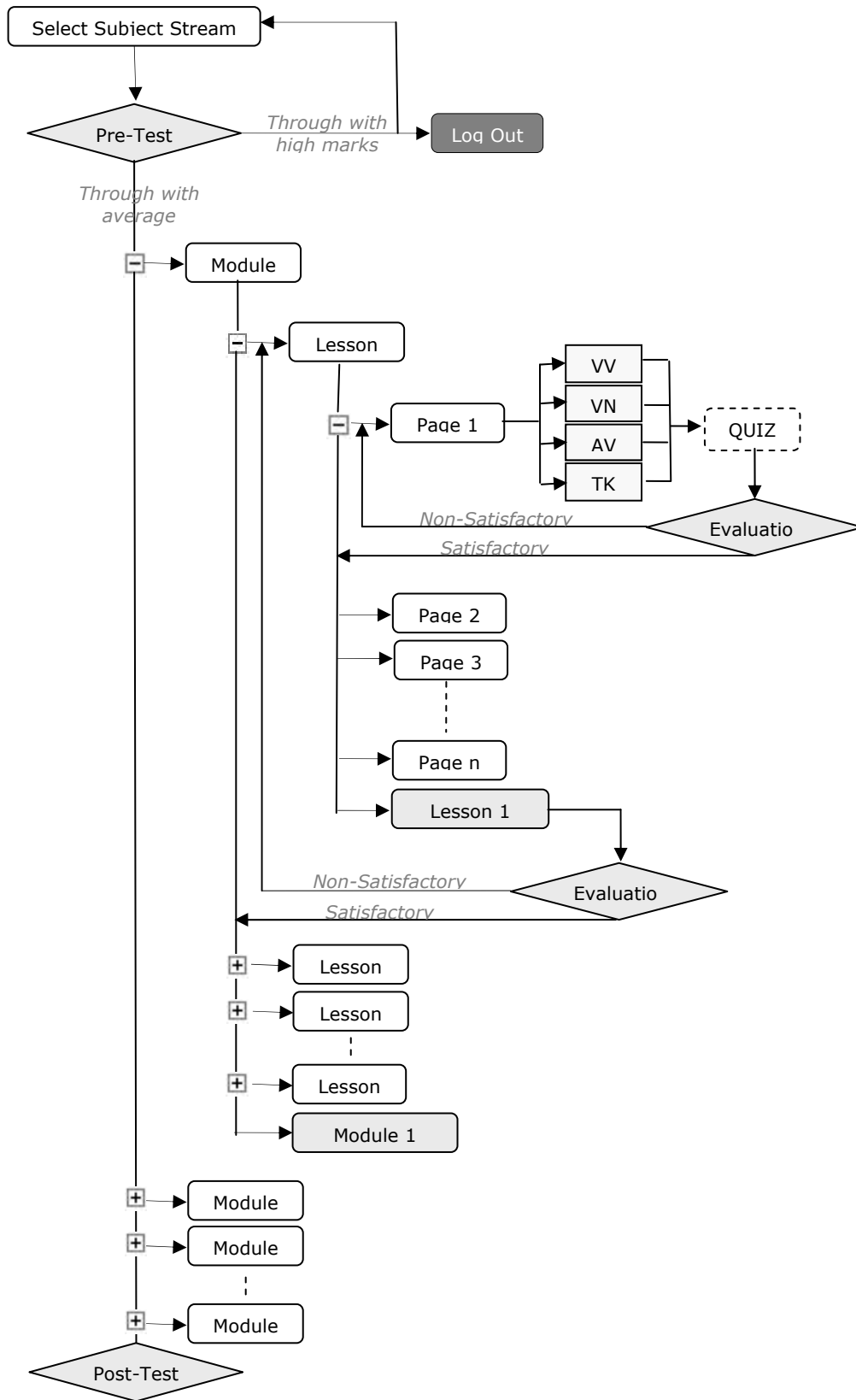


Figure 1: The course structure in an e-learning package.

At the same time, it could provide information at different levels when required. In addition, the learning experience is interpreted to specify its content.

A single user may have a lot of learning patterns with respect to the stream of subjects he/she is learning. This categorization can be done with respect to the scope of subject or classified interests of the learner. Hence, a learning pattern would be initiated whenever he/she takes the first course in a classified area of study/interest. The level of abstraction in learning patterns will be high at one end and it gives more details at other end.

Whenever the learner takes a related course in those classified areas, the corresponding learning pattern will be updated. But, with time it will be depreciated, since people usually forget what they know with the pass of time. Generally, someone's learning experience can be described as a collection of such learning patterns organized in a triangular model as shown in Figure 2. It divides a learning pattern into three meaningful sections.

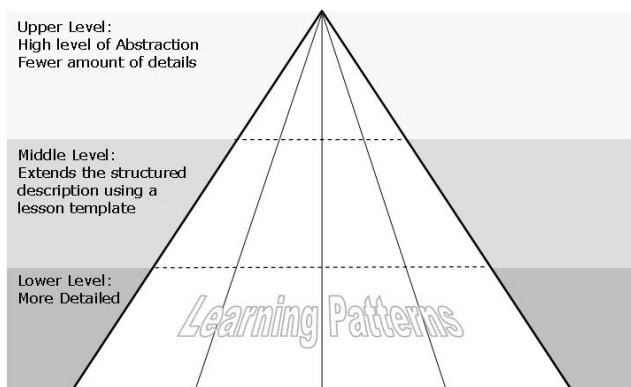


Figure 2: *The triangle represents a collection of learning patterns to show one's learning experience.*

A learning pattern has three levels, namely upper, middle and lower levels. In the upper level, the abstraction is very high and it describes a particular learning experience in a summarized way. The middle level of a learning pattern extends the previous abstract definition using a structured description. The lower level organizes the user's learning experience captured based on his/her active learning [8] activities.

3.1 Upper Level

The upper level includes some abstract details about the subject area using keywords and phrases. Usually main titles and other sub headings of the courses followed are used as phrases in the upper level. Author specified metadata or a sampling technique [7] could be used to identify relevant keywords. The upper level also defines the user's learning experience using a statistical counter (tag named 'success factor') and a classification based on the possible modules. When a learning pattern is initiated, modules are inherited from the first course but later they are split, merged or expanded based on the user's interaction with related other e-learning packages.

When a learner follows a course, he/she has to take multiple choice questions or other interactive assignments for which he will be given marks. The success factor is calculated by amalgamating these marks using a weighted average scheme with respect to the whole course as well as in module level.

3.2 Middle Level

The middle level further extends the description of modules given in the upper level. A module is described as a collection of lessons. Then a number of lessons simply specifies the scope of a particular module and it is a useful heuristic when two packages are compared. A lesson is defined using keywords, phrases and success factors.

3.3 Lower Level

This is the level which describes the user's interaction with respect to each lesson given in the upper level. A single lesson could be presented in different styles (Section 2.1) in order to provide the most suitable way for each individual learner to absorb the content of the lesson. Passive reading, watching and listening could hardly deposit a new knowledge in a learner's mind. The success factor is a good quantitative measure to evaluate the level of absorption but it doesn't depict the knowledge structure. The actual knowledge structure in a learner's mind is not visible but the user's activities such as underlining, highlighting and commenting could be used to approximate the outline of a structure. Some other applications can use the lower level to provide a quick revision to refresh the learning experience.

Figure 3 illustrates a fraction of the learning pattern for a course in mathematics. Such a pattern will be depreciated with time if the learner does not engage in the learning activities of the corresponding subject.

4. Realizing e-Learning Personalization

In the previous section, we discussed how to build learning patterns and their technical infrastructure. As we have described, these learning patterns are used to provide low coupling based personalization. In this paper, we are only discussing how these learning

patterns could be used to provide a customized learning sequence.

By matching relevant keywords and phrases, the system that facilitates browsing e-learning packages, first tries to identify whether a relevant learning pattern exists whenever the user selects a new course. If such a pattern is identified, it calculates a depreciation considering the date the learning pattern was created, the last date pattern was updated, and the current date of the system.

$$Depreciation = \frac{LastDate - CreateDate}{CurrentDate - CreateDate}$$

```

<?xml version="1.0" encoding="ISO8859-1" standalone="yes"?>
<abstract level>
<title phrases>
  <phrase> University 1st year Mathematics </phrase>
  <phrase> e-maths, online mathematics home page </phrase>
  <phrase> Applied Mathematics </phrase>
  .....
<keywords definition>
  <keyword> Differential Equations </keyword>
  <keyword> Integration </keyword>
  <keyword> Statistics </keyword>
  .....
<keywords definition>
<meta details>
  <user status> satisfactory </user status>
  <last visited> 12-oct-2003</last visited>
  .....
</meta details>
<success factor> 65% </success factor>
<module structure>
  <module 1>
    <title> Motion </title>
    <keywords definition>
      <keyword> Motion in a Straight Line </keyword>
      <keyword> Motion in a Circle </keyword>
      .....
    </keywords definition>
    <success factor> 77% </success factor>
    <number of lessons>10</number of lessons>
  </module 1>
  <module 2>.....</module2>
  .....
  <module n>.....</module n>
</module structure>
</abstract level>
<middle level>
  <module 1>
    <lesson 1>
      <title> Motion in a Straight Line </title>
      <keywords definition>
        <keyword> Velocity </keyword>
        <keyword> Acceleration </keyword>
        <keyword> Distance </keyword>
        <keyword> Height </keyword>
      </keywords definition>
      <success factor> 90% </success factor>
    </lesson 1>
    <lesson 2> ..... </lesson 2>
    .....
    <lesson 10> .....</lesson 2>
  </module 1>

```

```

</module 1>
<module 2>.....</module 2>
.....
<module n>.....</module n>
</middle level>
</lower level>
  <module 1>
    <lesson 1>
      <page 1>
        <learning style 1>
          <time> 3:35:05 </time>
          <success factor> 55% </success factor>
        </learning style 1>
        <interactivity>
          <underline> .....</underline>
          <highlighted> .....</highlighted>
        </interactivity>
      </page 1>
      .....
    </lesson 1>
    .....
    <lesson 10> ..... </lesson 10>
  </module 1>
  .....
  <module n> ..... </module 10>
</lower level>

```

Figure 3: A sample learning pattern for a course in Mathematics.

The depreciation value can be used to approximate the current value of the success factor. Rules are defined for different levels of personalization based on the current value of success factor. The common rule is that if the value is less than 45, then there will be no personalization of learning sequence in the new e-learning course. If it is less than 75 and greater than or equal to 45, then a medium level personalization will be considered. A higher level personalization is applied, if it is greater than 75. These common rules can be modified according to the learner's preferences by specifying different levels of personalization.

The next step is to identify matching modules in the learning pattern and e-learning courseware. This is done by matching the most relevant keywords and phrases used to define each module in the learning pattern with modules in the e-learning package. If a module in the package can be matched with a module in the pattern, the scope of these two modules are compared considering the number of lessons. Hence, three possibilities are identified "less than", "equal" and "larger than". The success factor is calculated considering the depreciation of the pattern and the recorded success factor for the module. Rules for the sequence modification are as follows.

Module Current Success Factor (msf) = Depreciation * (Recorded Success Factor for the module)

IF ($msf < 45\%$) **THEN** {no_sequence_modification}

IF ($msf \geq 45\%$ **AND** $msf < 75\%$) **THEN**
 { **CASE OF** "ModuleScope"
 "less": learning path discarded in whole module
 "equal" **OR** "large": obtain user's direct response }

IF ($msf \geq 75\%$) **THEN**
 { **CASE OF** "ModuleScope"
 "less" **OR** "equal": learning path discarded
 "large": only advanced lessons considered }

In the comparison of keywords and phrases declared between modules in the pattern and modules in the package, if there is a mismatch, then it is investigated considering the following possible cases. In case of such a mismatch, the module is considered to be a new module and is inserted into the pattern. If only a subset of keywords is matched, then it would be considered as a module with the less scope and the same rules will be applied to determine its personalization in the learning path. On the other hand, if it is verified that the scope is covered by two modules in the pattern, then the personalization is carried out at the lesson levels.

5. “LEARNING HOME”: The Place to Maintain Learning Experience

As we know, there are many websites which host e-learning courses on both paid and unpaid basis, and the number is increasing daily. Most of the packages available in those services are not integrated with a learning management system (LMS). Hence, it is sometimes hard to provide personalization facilities since the user is not willing to share his/her learning experience with a third party just for an additional facility.

As a solution, we propose an intermediate website which acts like the learning portal of the user. All learning patterns, which belong to a particular user, are stored at this website called *Learning Home*. It provides an interactive interface for all these patterns and when it is required, the user can also open and edit any learning patterns.

In a prototype system, the browser retrieves information from Learning Home to identify the correct pattern when the user opens a learning package. The system can also update learning patterns with new information or can insert new patterns when the browser interprets the current package as a new course. This pattern is updated as and when the learner takes lessons from this course.

6. Related Standards and Work

As we mentioned earlier, the personalization can be realized only through the cooperation of three parties; the learner, author and facilitator. In order to achieve such cooperation, e-learning standards play an important role.

IMS Content Packaging [1] is an interoperability specification to allow content creation tools, learning management systems and run-time environments to share content in a standardized set of structures. The purpose of this specification is to provide a mechanism that will allow content to be exported between systems with minimum effort.

In 1997, US Government initiated to push development plans for standardization of learning resources. As a result, Sharable Content Object Reference Model (SCORM) [2] was established by linking a number of other standards. The ADL SCORM constitutes three key components:

- The Content Aggregation Model (CAM),
- The Run-Time Environment (RTE), and
- Content Packaging.

Through these components the ADL aims to meet the following high-level requirements.

- **Reusability:** the content persistence over different LEs using a unified method of content markup.
- **Accessibility:** the globally accessible content repositories using metadata search facilities.
- **Durability:** the persistence of learning resources and system components over time.
- **Interoperability:** the platform independence of learning systems and learning resources.

“Learning Pattern” is a concept defined by combining interaction patterns and user profiles. There are some other similar models that have been described in the literature [3] [4] but learning patterns use the abstraction to model the complexity and carry the user’s manipulation interaction to provide personalization in different learning environments.

Creating fixed stereotypes is one of simple ways of user modeling [3]. New students are categorized and the system will customize its performance based on the category that has been set for each student. For example users could be categorized into novice, intermediate and expert levels within a system. This approach is useful when a quick, but not necessarily accurate assessment of the user’s background knowledge is required [4].

The overlay model is widely used in the adaptive hypermedia systems in the educational domain. A model of the student’s knowledge is constructed on a concept-by-concept basis and updated as the user progresses through the system. This allows a flexible model of the student’s knowledge for each topic [5]. For this model, the knowledge domain must be modularized into specific topics or concepts, similar to learning pattern concept given in this paper.

7. Conclusion

In this paper, authors presented a model for personalization, named learning patterns, for e-learning courses. This model is defined by extending the conventional approach of user-profile which is usually used in personalization of many applications, by especially considering the structured learning process.

Learning is a highly varying process from person to person depending on the individual skills and abilities. As a result of this process, the learner’s level of knowledge grows giving him more power to interact with a learning environment. We introduced the learning pattern concept to depict such changes in learning environment. A learning pattern is supposed to grow, freeze or die with time depending on the learner’s interaction with corresponding learning materials.

A learning pattern corresponds to a particular subject or interest in a learner's learning space. It is initiated when the learner starts the first e-learning course in a particular subject or interest. A learning pattern is updated every time the learner follows a similar learning content. In the scope of the work discussed in this paper, we only presented how it could be utilized to customize the learning path which is defined by the sequence of modules, lessons and pages in an e-learning courseware. However, it has more potential to provide fully fledged personalization. For example, it is possible to customize the visual appearance in a page using information recorded in the lower level of a learning pattern.

A learning pattern is depreciated with time when there is no interaction with relevant materials. This value is used to determine the learning sequence while the user interacts with corresponding packages. This sequence could vary in the same package at different times since the calculated values could be different.

One of the main limitations of the approach is that these learning patterns heavily depend on the keyword matching algorithms and metadata provided by the author. A learning pattern is initiated when the user takes his/her first relevant course. If the first package doesn't provide a suitable structure, it could badly affect the maintenance of the pattern. In this case, a learner can modify the pattern by accessing it at the "Learning Home" which maintains his/her learning experience using these patterns.

In the future, we will work to extend the functionality of learning patterns to provide different types of personalization. We emphasize personalization as not only providing what the user wants but also providing it just in the way he/she wants. Hence, we hope to integrate active learning and learning patterns while adhering to immersing standards for e-learning such as ADL SCORM.

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