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Educational Data Mining on Learning Management Systems using Experience API

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***Abstract*— Educational data mining is an application of data mining to derive meaningful patterns from educational systems which in turn can be used to improve the learning experience of students. The emphasis of this paper will be to explore educational data mining in the context of Learning Management Systems (LMS). In this paper, we explore the possibilities of using Experience API to extract patterns from Learning Management Systems. The possible inferences that can be derived from the patterns are also discussed in the paper. This paper has been developed using real time data that is gathered from the public Learning Management System, SCORM Cloud.**

Keywords- Learning Management System, Experience API, Educational Data Mining

I. INTRODUCTION

Information and Communication Technology (ICT) has a big role to play in education. The concept of L3 i.e. Life Long Learning and A3 i.e. Anybody, Anytime, Anywhere is possible through ICT. One of the key components that enable L3 and A3 is the concept of e-learning. E-learning refers to web-based educational delivery mechanism where the students can access the trainings anytime anywhere through the use of internet. One of the key enablers of e-learning is Learning Management System. Learning Management systems are specialized software applications that are custom made to for managing and delivering different types of educational trainings. Apart from just offering the training programs, they have many capabilities to provide rich learning experience to the learners[4]. Learning Management Systems have now become an inevitable component of every organization in order to facilitate lifelong learning which increases the productivity of its employees.

Learning Management Systems have the capability to track and accumulate huge amounts of information pertaining to the learners. They can record learner activities such as time taken to read specific content, answer specific assessment questions, perform various tasks provided in the course and so on. The logs present in the LMSs track many types of activities performed by the learners. This in turn will serve as a rich reserve of educational data. The standards used for the design of e-learning play a major role in deciding the amount of learner data that can be tracked.

Sharable Content Object Reference Model (SCORM) is the most common standard used nowadays for the creation of web based trainings or e-learning that can be hosted on a LMS. Though SCORM supports interoperability between the various Learning Management System vendors and provides some amount of learner experience information, it has its own set of shortfalls. The main shortfall is that SCORM has not been designed to provide extensive retention and sharing of learner interaction and result data. Though it can track learner interaction to some extent, it is not enough to meet the present day requirements where all systems are becoming more and more user-centric and user experience is the key goal. The following types of interaction / learning requirements cannot be tracked by SCORM: [1]

- Detailed test results
- Use of mobile applications for learning
- Tracking of simulations
- Tracking of off-line learning
- Tracking of interactive learning
- Tracking of blended learning
- Tracking of team based learning

Because of these shortfalls, SCORM has become outdated, as it is not able to cater to the present day learning requirements [3]. The next major transformation in LMS is the evolution of Experience API, which is the future of e-learning and is the next major step that will revolutionize the field of educational data mining as it provides many features which will help to track learner experience. In the next few sections, we explore the capabilities of Experience API to track learner activities and how they can be used to derive useful inferences in educational data mining.

II. LEARNING MANAGEMENT SYSTEM AND LEARNING RECORD STORE

In order to best understand the working of Experience API, it is necessary to understand the concept of Learning Record Store in the contest of LMS. Learning Record Store (LRS) is a data storage system, or repository, that stores data generated by the content delivered from LMS. The LRS can be a part of the LMS or it can be an external component that passes the data it receives from the content to the LMS for further processing such as generating a report.

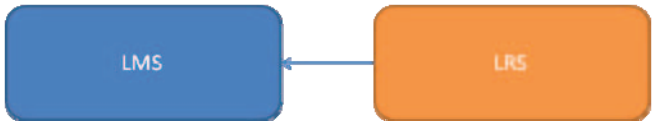

Figure 1. Integration of Learning Management System and Learning Record Store.

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Organizations can configure the LRS to share its data with a single LMS, multiple LMSes, other LRSes, or reporting tools within the organization or across organizations. Further, the LRS data can be selectively or wholly used to generate detailed reports.

III. Introduction to Experience API

Learning delivery modes can be broadly categorized as Formal Learning and Informal Learning. Formal learning is the conventional method of learning, where the learner attends classroom trainings, conferences and seminars, participates in group discussions, etc. Generally, in this mode, there is a direct interaction between the learners and the instructors or the facilitators. The instructors can be at the same location as the learners or they can be available virtually through video conference or web-based meeting.

Informal learning modes include learning by reading online, participating in discussions on social networks, listening to a podcast, playing games and simulations, etc. Considering the cost, demography of the learner base, and advent of cost-effective technology, informal learning modes have gained huge popularity and have been as effective as Formal Learning modes in several cases. Experience API can be used to track both informal and formal learning. The Experience API is a service that allows for statements of experience to be delivered to and stored securely in a Learning Record Store (LRS). [2]

One of the advantages of Experience API is that it can work offline as well. The content stores data in a temporary location when the learning occurs offline and shares it with the LRS or reporting tools when the learner connects to the internet.

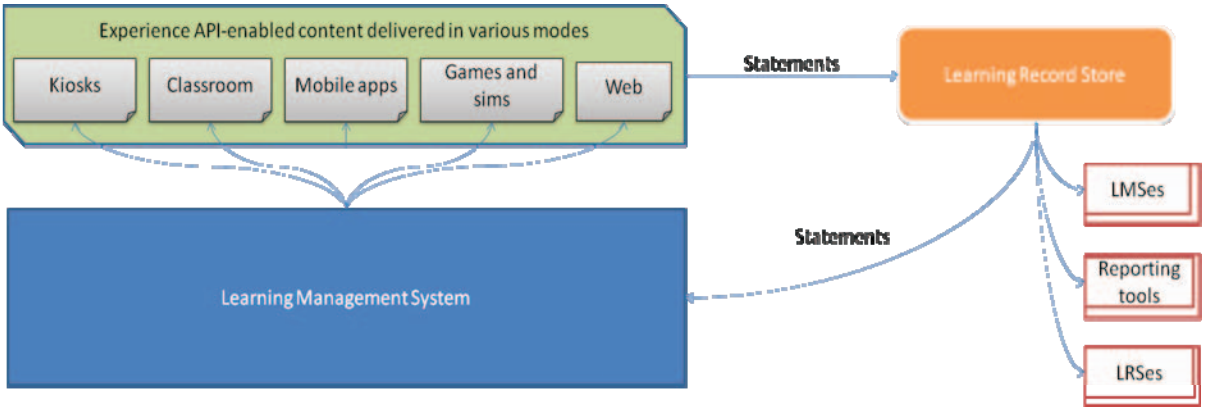

Figure 1. High-level Architecture of Experience API Implementation

IV. Application of Experience API in EDM

The core of Experience API is the statements. Experience API tracks the learner's activities, generates statements, and stores them in LRS using the RESTful API methods. These statements contain learner's identity, roles, action performed, the object of action, etc. For team activities, the statements can contain identity of the team. For mandatory courses, the statement can contain the identity of authority who certifies that the learner has completed the learning unit. If the learner is expected to attach a screenshot as the proof of completion, the statement can contain that information as well. Content authoring tool developers, known as Activity Providers, include support for generating statements. Organizations that want granular reporting must choose the appropriate tool as per their requirement. The data thus generated and stored in LRS can be used for various purposes.

The statements generated by the tool contain three main components.

- **Actor:** An actor is any agent that initiates the action. It can be the learner, the group's identity, or even a software application. This is the first and foremost data you can use to associate with any activity.
- **Verb:** Verb is the most useful part of a statement. Statement creators can use the verbs readily available in the Experience API Registry or they can create their own as per their requirement.
- **Object:** Object is the object on which the learner acts.

In addition to this, statements also contain the time at which the statement is stored in the LRS.

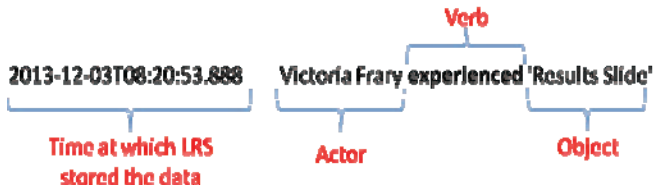

Figure 2. Sample statement

A. Simple statements

A simple statement is in the "Actor-Verb-Object" format. Simple statements can be used to track activities such as:

- Learner watched a video.
- Learner visited a webpage.
- Learner attended a conference.
- Learner completed a game.
- Learner shared a blog post.

B. *Complex statements*

A complex statement contains more components than a simple statement. It can contain the information about context, authority, location of the attachment, etc. Some examples where complex statements can be used are:

- Learner paused a video at a specific point
- Learner passed the activity with the score "n".
- Learner correctly answered the activity with the response of "xxxxxx" with score of "n".

The data generated from statements can be used in various ways. In the next section, we will examine some types of data generated using Experience API and the types of inferences which can be derived using them.

V. DATA CAPTURE USING EXPERIENCE API

There are many course examples which are used to track the types of data captured using Experience API. Each set of courses is used to derive specific inferences using the screenshots/ statement excerpts of the data captured using Experience API. Each set of courses is treated as a separate example to derive a specific inference that is given below it. This is a real time data that is obtained from sample courses tested on SCORM Cloud LMS. The following were the sets of sample users created for this testing:

- Keira Edwards
- Matteo Milanesi
- Mandel Pelletier
- Jason Money
- Walter Kelley
- Billy Martinez
- Evelyn Rhodes
- Claudia Mueller
- Victoria Frary
- Kuodo Nishi

The following are the details of the courses used as samples:

- Articulate 101: Articulate Storyline: Foundation
- Articulate 201: Designing Courses with Articulate Storyline
- Articulate 301: Customization and programming with variables
- Articulate 401: Workshop

A. *Example1*

The learning path for Articulate Storyline courses is:

Articulate 101 > Articulate 201 > Articulate 301 > Articulate 401.

Each course is a prerequisite for the subsequent course in the learning path as the complexity of the course increases in that order.

TABLE I. KEIRA EDWARDS' ARTICULATE 201 COURSE DATA

2013-12-03T11:59:08.749 with score 100%	Keira Edwards passed 'Articulate201'
2013-12-03T11:58:30.035	Keira Edwards attempted 'Articulate201'

Figure 3. Keira Edwards' Course Registration Information

TABLE II. MATTEO MILANESI'S ARTICULATE 201 COURSE DATA

2013-12-03T11:41:02.604 with score 100%	Matteo Milanesi passed 'Articulate201'
2013-12-03T11:40:17.459	Matteo Milanesi attempted 'Articulate201'

Figure 4. Matteo Milanesi's Course Registration Information

TABLE III. MANDEL PELLETIER'S ARTICULATE 201 COURSE DATA

2013-12-03T11:04:09.025 with score 100%	Mandel Pelletier passed 'Articulate201'
2013-12-03T11:03:19.024	Mandel Pelletier attempted 'Articulate201'

Figure 5. Mandel Pelletier's Course Registration Information

Conclusion: Learners were able to pass the intermediate-level course, Articulate 201, without completing the foundation-level course, Articulate 101. The intermediate course was probably too easy for the target audience.

B. *Example 2*

Learners are expected to complete the Articulate 301 course by going through the course content and passing the quiz.

TABLE IV. LEARNER DATA FOR THE ARTICULATE 301 COURSE

2013-12-03T13:09:40.219	Jason Money experienced 'Select True.'
2013-12-03T13:06:52.690	Jason Money experienced 'Slide 3'
2013-12-03T13:06:48.763	Jason Money experienced 'Slide 2'
2013-12-03T13:06:45.390	Jason Money experienced 'Slide 1'
2013-12-03T13:06:41.002	Jason Money attempted 'Articulate301-1'
2013-12-03T13:05:40.219	Walter Kelley experienced 'Select True.'
2013-12-03T13:04:43.838	Walter Kelley experienced 'Slide 3'
2013-12-03T13:04:39.821	Walter Kelley experienced 'Slide 2'
2013-12-03T13:04:25.753	Walter Kelley experienced 'Slide 1'
2013-12-03T13:04:25.086	Walter Kelley attempted 'Articulate301-1'
2013-12-03T12:56:24.781	Billy Martinez experienced 'Select True.'
2013-12-03T12:55:23.542	Billy Martinez experienced 'Slide 3'
2013-12-03T12:55:20.079	Billy Martinez experienced 'Slide 2'
2013-12-03T12:52:42.754	Billy Martinez experienced 'Slide 1'
2013-12-03T12:52:42.469	Billy Martinez attempted 'Articulate301-1'

Conclusion: Learners stopped at the quiz slide. Probably the quiz was too tough or it was irrelevant for them.

C. *Example 3*

Learners who enrolled for the Articulate 401 course are expected to answer all quiz questions correctly to pass the course.

TABLE V. LEARNER DATA FOR THE ARTICULATE 401 COURSE

2013-12-03T14:40:55.707	Keira Edwards incorrectly answered 'Select True.' with response 'False' with score 0
2013-12-03T14:39:30.400	Keira Edwards experienced 'Select True.'
2013-12-03T14:39:05.942	Keira Edwards attempted 'Articulate401-1'
2013-12-03T14:36:20.074	Mandel Pelletier incorrectly answered 'Select True.' with response 'False' with score 0
2013-12-03T14:36:15.560	Mandel Pelletier experienced 'Select True.'
2013-12-03T14:36:00.179	Mandel Pelletier attempted 'Articulate401-1'
2013-12-03T14:32:23.362	Evelyn Rhodes incorrectly answered 'Select True.' with response 'False' with score 0
2013-12-03T14:32:11.986	Evelyn Rhodes experienced 'Select True.'
2013-12-03T14:32:00.850	Evelyn Rhodes attempted 'Articulate401-1'
2013-12-03T14:20:47.143	Claudia Mueller incorrectly answered 'Select True.' with response 'False' with score 0
2013-12-03T14:20:39.128	Claudia Mueller experienced 'Select True.'
2013-12-03T14:20:31.096	Claudia Mueller attempted 'Articulate401-1'

Conclusion: Learners answered a specific question incorrectly. The question might be too tough for them or the answer identified as correct by the learning designer might actually be incorrect.

D. *Example 4*

Learners are expected to go through the course content completely before attempting the quiz that tests their knowledge about the concepts covered in the course. The course has 26 slides.

TABLE VI. LEARNER DATA FOR THE ARTICULATE 101 COURSE

2013-12-03T08:20:57.979	Victoria Frary passed 'Articulate101-1' with score 100%
2013-12-03T08:20:13.095	Victoria Frary experienced 'Slide 2'
2013-12-03T08:20:01.370	Victoria Frary experienced 'Slide 1'
2013-12-03T08:20:00.849	Victoria Frary attempted 'Articulate101-1'
2013-12-03T07:58:53.178	Evelyn Rhodes passed 'Articulate101-1' with score 100%
2013-12-03T07:58:07.742	Evelyn Rhodes experienced 'Slide 2'
2013-12-03T07:58:07.680	Evelyn Rhodes experienced 'Slide 1'
2013-12-03T07:58:07.555	Evelyn Rhodes attempted 'Articulate101-1'
2013-12-03T07:55:39.757	Kuodo Nishi passed 'Articulate101-1' with score 100%
2013-12-03T07:54:59.798	Kuodo Nishi experienced 'Slide 2'
2013-12-03T07:54:59.412	Kuodo Nishi experienced ' Slide 1'
2013-12-03T07:53:01.017	Kuodo Nishi attempted 'Articulate101-1'
2013-12-03T07:36:20.009	Claudia Mueller passed 'Articulate101-1' with score 100%
2013-12-03T07:35:32.514	Claudia Mueller experienced 'Slide 2'
2013-12-03T07:35:29.300	Claudia Mueller experienced ' Slide 1'
2013-12-03T07:35:29.099	Claudia Mueller attempted 'Articulate101-1'

Conclusion: The quiz was easy enough to be completed without going through the course content.

VI. SUMMARY

In this paper, we explored the use of Experience API in LMS to track learner patterns. We have used several real time examples to demonstrate the data capture and tracking capability of Experience API. Experience API was launched only in April 2013. In spite of that, it has a good traction with various leading companies such as Articulate, iSpring Solutions, Inc., Blackboard, Docebo, Float Mobile Learning, Epic, City & Guilds Kineo, Metrix Group, etc., adopting it. Experience API undoubtedly has opened a new era in educational data mining history by providing a wide gamut of opportunities to both the researchers and the e-learning developers to do a deep dive into learner experiences.

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