xAPI – New eLearning Standard for LMS – Simulations Integration

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***Abstract*— SCORM 2004 as a predominant e-learning standard does not satisfy educational and training needs anymore. Towards the intention that the new one (xAPI) is going to be accepted by IEEE as a commonly accepted standard, the research is performed to evaluate the pros and contras for replacing the actual with the new one. The research has a focus on experiments made to acquire the influence of xAPI on different eLearning processes such as learning, serious gaming, testing, reporting about results and measuring of real competences.**

I. Introduction

There is a real need to find a way to improve existing e-learning systems. The learning management systems (hereinafter LMS) are commonly used as an eLearning solution in educational institutions (mainly for delivering theoretical knowledge to the learners) as well as in the companies (for training of their employees). In both cases, achieved learners' results are not matching well with their realistic competencies.

Limitations of SCORM 2004 [1] are the one of the reasons that causes this gap. Therefore, the new project named Thin-Can [2] had started many years ago and as a result, the new standard named *Experience API* (hereinafter xAPI) proposed by Advanced Distributed Learning (ADL) Initiative [3] took a place for further considerations. Still in the standardization process, several commercial eLearning content production tools have already incorporated xAPI standard. The xAPI enables more opportunities than the previous one – including information from sources different of LMS. For instance, there is lot of useful information collected in simulation systems, VR systems and other kind of interactive multimedia systems. The engineers are struggling to find a way to incorporate new standard into such systems. It becomes obvious that the new standard needs the new eLearning architecture.

On the other hand, the learning effects can be improved by collected information and as well as a measurement of real learners' competences. The research describes different scenarios how to implement xAPI into realistic simulation, VR and interactive video systems. It uncovers the problems faced and proposes the solutions for overcoming them.

Next section describes the research problem – constraints of SCORM 2004 as actual eLearning standard and new requests that high educational institutions and vendors are expecting from eLearning. The third section describes the works related to LMS, xAPI and main streams in development of competency based frameworks. The forth section demonstrate the way to collect the learner data from different sources and formats. The last section contains the results and conclusions as well as the proposals for the further work.

II. Problem Description

What are the weaknesses of SCORM 2004 and what are the ways for solving them by using xAPI? SCORM 2004 is a commonly accepted eLearning standard focused on the e-content production and exchange. First, it is a content packaging standard (Sharable Content Object Reference Model - SCORM). The content published in SCORM format is LMS deployable as an activity. When the learner uses the SCORM packed e-content, it is emitting next information about learner's activity:

1. Pass / failed
2. Completed
3. Time
4. Single score

Implicitly, the LMS is collecting only these few types of data during the learner sessions under the SCORM formatted e-course. This is far away from the representative information needed for realistic evaluation of learner skills and knowledge. On the other hand, there are many other eLearning tools used for training and evaluation of learner's performances. The formats and evaluation criteria is different from one to another one eLearning tool. Consequently, these data are highly distributed and it is hard to collect them and make comparable relationship between them. Moreover, there are skills need to be checked in the teamwork (e.g. group trainings and exercises).

III. Related Works

The most of contemporary LMS are SCORM 2004 conformant systems: *Moodle, Ilias, ItsLearning, Sakai, Blackboard*, and many others [4]. Regardless the learning architecture is in the radically changing process, just few of them only partially support xAPI standard. By implementing xAPI, such systems become only one part of the wider eLearning ecosystem. Practically LMS are emitting the learners' data to the common registry (so-called LRS – Learner Record Store) for the further processing.

There are efforts for implementing xAPI in the educational and training. Kevan and Ryan in [5] discussed the relevance for learning, instruction and assessment of xAPI for LMS. Several implementations mentioned in research works: nurse training [6], teaching physics [7], learning project management [8], chemistry [9].

Some [10 and 11] authors proposed Interoperable Performance Assessment (IPA) as a method for defining and describing processes such as learning, experience and performance assessment. They found xAPI appropriate for communication among components of IPA. Practical examples [12] demonstrates how the air, ground and gunnery systems can share the data in order to create feedbacks for individuals, aggregated data for trainers, flexible data views for researchers and qualification data for evaluation purpose. The xAPI provided results prove the gains in learning and training efficiency [13]. Owing to enriched learner history, xAPI provides the better conditions for adaptation of learning content [14]. Moreover, xAPI is appropriate for recording of learning experiences in experimental environments for remote laboratories [15]. The command and control of unmanned autonomous vehicles training represents one more military implementation of xAPI [16].

Still now, there is no satisfactory solution for this purpose. For instance, the ADL Initiative (creator of both SCORM and xAPI standards) developed Learner Locker as a LRS open source solution [X]. Unfortunately, it acts more as a data collector than a data processor. On the other hand, there are many standalone successful data processing & visualizing (dashboard) solutions (*Scoro, Datapine, Inetsoft, Tableau, Vidi*, etc.).

There is no one solution for LRS – Dashboard coupling. The reasons are different: for instance, the row data are in various formats (non - normalized) and the amount of data needs advanced tools for data analytics. The visualization of row data is partially useful. On the other hand, there is no one reasoning tool for making conclusions on data incorporated. There are several solutions for rule based reasoning (e.g. Clips, Jess), fuzzy reasoning (e.g. *FuzzyJess Toolkit*), artificial neural network toolkit (e.g. *Neuroph*) that can be used as a part of solution [X]. The paper will show the performances of software solutions mentioned above. The comparison of data collected through different experiments (eLearning scenarios) will produce the arguments for the proposed solution.

The focus on experimentation is how to collect / analyze the data collected from simulations, VR and interactive videos and how to make conclusions on them, useful for competency measurement.

IV. Proposed Solution

Depending on heterogeneous tools, frameworks and existing solutions mentioned, the hybrid approach is necessary. The most of LMSs are modular solutions with many low-coupled components (often called plug-ins) connected with the core of the system (directly to database or/and through some proxy module) and with other components. Each component has specific purpose. Moreover, vendors provide to users the opportunity to build their own components and to extend the LMS database according to their needs (e.g. Moodle LMS). LMS administrator has to register such components in order to enable them to exchange the data with the rest of the system and with other systems.

For instance, there is a component named *Tin Can* (https://moodle.org/plugins/mod_tincanlaunch) – plug-in for emitting xAPI-formatted information about the learner activities in the Moodle LMS. Next illustration (Figure 1) shows the LMS and xAPI emitter (e.g. *Tin Can* plug-in) on the left hand side and *Learner Record Store* (hereinafter LRS) on the right hand side.

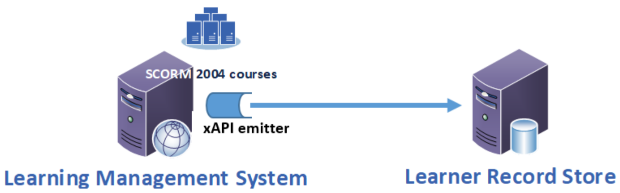

Figure 1. LMS is emitting learner data to the LRS

The xAPI emitter sends the data from LMS to LRS. LRS is the system designed for collecting the data from different sources and in different formats. In addition, its purpose is to provide the analysis and for making conclusions about the leaner activities. In the most of the cases, LMS xAPI emitters are specialized for concrete eLearning scenario. For instance, *Tin Can* plug-in is specialized just for built-in Moodle LMS events related to e-courses and quizzes.

Therefore we developed SGIQ (Serious Gaming based Interactive Questions) [17], designed as a plug-in for Moodle LMS, which provides using of interactive 3D space model for different purposes: learning, self-tests and assessment (Figure 2).

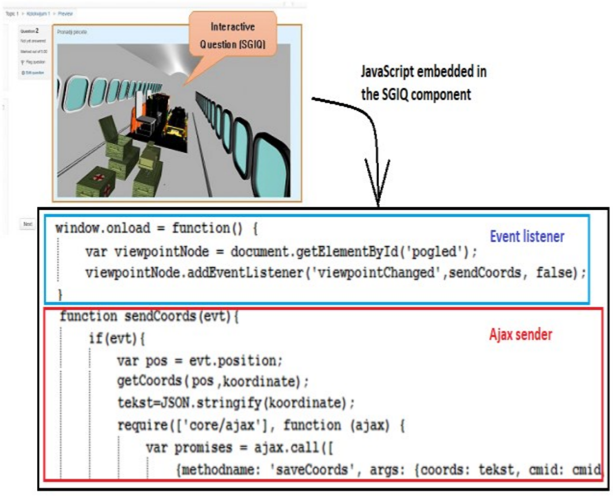

Figure 2: Example of SGIQ activity

During SGIQ activities, the intensive interaction happens on the client side. Delivered SGIQ page contains JavaScript code that browser uses for emitting the JSON formatted data (cursor coordinates and mouse events) to the Moodle LMS via Ajax requests. The overloading happened on the server side as the number of simultaneous SGIQ clients had grown. It produced the exponential dependency and therefore, we optimized the SGIQ code by additional algorithm:

1. Measure the distance *s* between mouse movement endpoints for each Δt interval,
2. If *s* is less than Δs OR Δt is not expired repeat #1,

3. Send current time and location to the server side and repeat #1,

Where:

1. *Δt* – the time interval that depends on the current link throughput and
2. *Δs* – (Meaningful) distance that depends on the display size of the client platform.

As the client side solution already contained the demanding Web GL code for graphical rendering, the SGIQ optimization module sometimes produced the decreasing of client performances (depending on level of interaction during activity and link capacity).

V. REASONING BEFORE XAPI EMITTING

The further research brought the improved solution implemented in (more demanding) flight simulator. Depending on aircraft type, the flight simulator produces values for approximately 20 different properties each tenth of second during the simulation (Figure 3). For instance, latitude, longitude, altitude, three velocity vectors, azimuth, elevators, flaps, rudders represent some of them. Each flight can last from few minutes to tens of minutes.

	Velocity	Altitutde	Course	Slope	the angle of ascent/descent	Power	AVG mark	Description
fhl002	7.00	5.00	9.00	5.00	5.00	8.50	6.58	ne zadovoljava zbog visine, nagiba
fhl003	6.00	7.50	5.00	5.00	5.00	8.00	6.08	ne zadovoljava zbog kursa, nagiba I
fhl004	5.00	8.00	9.00	5.00	5.00	5.00	6.17	ne zadovoljava zbog brzine, nagiba
fhl005	5.00	5.00	5.00	5.00	5.00	5.00	5.00	ne zadovoljava po svim elementim
pen001	10.00	10.00	9.00	9.00	9.50	9.00	9.42	
pen002	8.00	10.00	9.00	9.00	8.00	8.00	8.67	
pen003	6.00	10.00	10.00	10.00	7.00	7.00	8.33	

Figure 3: Flight simulator – xAPI solution

The solution makes the post-processing of the huge amount of data recorded by the simulation software and stored as a file on the local computer or some remote storage. As the flight–simulator row data are useless for building the final competency user profiles, the improved solution includes the reasoning module (hereinafter FSR – *FSReasoner*) that implements the expert knowledge of flight instructor (hereinafter SME – subject matter expert) as a rule based system. The module developed on JESS (*https://www.jessrules.com/jess/*) framework uses knowledge base scripted in CLIPS language (www.clipsrules.net/). There are seven criteria evaluated for giving final decision about the simulated flight: velocity, altitude, course, slope, power and angles of ascent / descent. The module produces the marks from five (worst) to ten (best) for each of criteria and the result of post-processing is in the form of recommendation – is candidate passed, or failed the simulation. The candidate that does not have any negative mark passes the simulation.

There are linear regression functions developed for the assessment of each criteria. As there are exceptions introduced by SME, the rules had to be used in order to handle the exceptions. For instance, there is a function for assessment of velocity criteria. Its value is depending on the values of velocity components (${}_{a}^{i}V$) normalized by predefined coefficients (k_{ij}):

$$f(V) = \begin{cases} K_V - k_{a0} \times {}_{a}^{0}V - k_{ax} \times {}_{a}^{x}V - k_{ay} \times {}_{a}^{y}V - k_{az} \times {}_{a}^{z}V, \left({}_{a}^{0,x,z}V \leq 10, {}_{a}^{y}V < 5\right) \\ 5, \left({}_{a}^{0,x,z}V \geq 10, {}_{a}^{y}V \leq 5\right) \end{cases} .$$

In the equation, *V* components represent average absolute deviation of velocity components while *k* coefficients represent normalized (weighting) factors for expert knowledge fine-tuning. The last parts of functional definition formalize the exceptions when instructor eliminate the candidate in the very beginning from further considerations.

The previous illustration (table in the bottom of figure 3) shows the assessment of seven candidates. The system eliminated four candidates. As a feedback, the system makes the arguments for its decision and the further processing; it sends each record as a single xAPI message to the LRS. This way, on-site post-processing eliminates sending of huge amount of row data to the LRS preserving it of data overload.

VI. CONCLUSIONS

The paper describes in-deep view of using xAPI – the new eLearning standard in different simulation scenarios. The commented (previous) works shows that in the last few years there is a growing interest how to implement the new standard in the already built eLearning systems. Still there are many challenges about that. Therefore, there are two scenarios developed in the presented research.

The first one represents the built-in solution in Moodle LMS: SGIQ plug-in module, designed to obtain high interactive 3D environment for different eLearning purposes. It is tracking the information about the user movements through the virtual space sending it to the LRS for further processing. Such an approach can produce the information overload on the LRS side if there are lot of clients and / or the given tasks requires lot of interactivity, or interactivity in a long time. Moreover, the number of users exponentially influences on the growth of system response time.

The efforts to optimize the link exploitation produced processing overload on the client side. Optimization algorithm (implemented on the client side) got a lot of processing time mostly used for generating of high interactive virtual environment. It resulted in development of second scenario where the simulator represents the stand-alone solution hosted on the client. The basic difference in this approach regarding the previous one is the reasoning module that enriches the xAPI emitter reducing the amount of information sent to the LRS. In other words, it implements the expert knowledge in order to perform assessment of candidates and to prepare this information for sending to the LRS.

Both cases shows that the operating level implementation of such systems represent a big challenge. Some of the component (frontend ones) should run in real time and synchronous. Such request is sometimes impossible and running mode should be changed (adapted). On the other hand, backend modules can work in batch mode, or on demand, what is necessary related to their purpose (e.g. data analytics, making conclusions).

TLA – Total Learning Architecture represents the recommended eLearning architecture, which supports the new standard. There are many challenges in its implementation. The presented content represents the contribution to these efforts.

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