On the Potential of Emerging Learning Technology Standards and Specifications to Enhance Learning Experience

By

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This master's thesis is carried out as a part of the education at the University of Agder and is therefore approved as a part of this education. However, this does not imply that the University answers for the methods that are used or the conclusions that are drawn.

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Abstract

Emerging educational technologies had a significant impact on the learning environment. Nowadays, classrooms are no longer as simple as it used to be, like using chalks and blackboards. Lots of technologies (e.g. video projectors, electronic boards) have been integrated to learning environments to better support students and teachers. eLearning is one the technologies that provided virtual classrooms environments on the Web. eLearning helped teachers and students to have a better control over courses and learning process respectively.

In this thesis, I had an investigation on the potential of some eLearning standards and specifications that enhance interoperability as well as learning experience. I studied xAPI specification in more details and the use of this specification in learning environments for tracking students' learning experience and mobile learning scenarios. I proposed a mobile learning solution that can help teachers to easily track their students' learning activities based on xAPI specification and give their students quick feedback.

For designing a mobile learning solution, first, I had a research on the existing mobile learning dashboards to find out how they are supporting teachers and students and to identify what are the existing lacks. Second, I followed the Human-centred Design activities. I specified the context of use, who are the users and how they are going to use this application. Then, I had interviews with teachers to specify their requirements for using a mobile learning dashboard. I evaluated a paper prototype and tested it with teachers. During the test, teachers gave me great comments and feedback. Finally, I designed a mobile learning dashboard prototype that met some of the teachers' requirements.

This study identified the use of eLearning technologies by teachers and how much they are engaged with these technologies and how they prefer to track their students' learning experience. The potential of the xAPI specification in tracking learning experiences were studied and how this specification is used in mobile learning scenarios.

Acknowledgement

I would like to express my regards to my supervisor, Dr. Ghislain Maurice Norbert Isabwe. I am really grateful to had him as my supervisor. He gave me helpful advice and support in every stage of this thesis. I am really thankful for his valuable comments and suggestions and being available during the way to discuss ideas and Thesis process.

I would like to offer my sincerest gratitude to my family for supporting me during my life. I specially thank my dear sister Parvaneh and her husband Dr. Alireza Borhani, for helping and supporting me to be here to study for Master. I thank them for their constant support and encouragement to find my way.

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Parisa Sarshar

List of Abbreviations and Acronyms

AC – Activity Consumer

ADL – Advanced Distributed Learning

AICC – Aviation Industry Computer-based Training Committee

AP – Activity Provider

API – Application Program Interface

CMI – Content Management Instruction

GBL – Game-Based Learning

HCD – Human-Centred Design

JSON – JavaScript Object Notation

LMS – Leaning Management System

LRS – Learning Record Store

LTI – Learning Tool Interoperability

LTSA – Learning Technology Standard Architecture

LTSC – Learning Technology Standard Committee

MOOCS – Massive Open Online Courses

PLE – Personal Learning Environment

QTI – Question and Test Interoperability

RTE – Run-Time Environment

SCO – Sharable Content Object

SCORM – Sharable Content Object Reference Model

VLE – Virtual Learning Environment

WBL – Web-Based Learning

xAPI – Experience API

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1. Introduction

During the last decades many things have changed around us due technology developments. By the development of technology, a new term added to the education area, the term electronic Learning (eLearning) and it is becoming more and more popular and playing an important role in the learning. eLearning can be defined in different ways depending on the context of use. In this thesis, eLearning refers to digital technology supported teaching and learning scenarios.

The aim of this master thesis is to investigate learning technology standards and specifications in order to suggest a new solution for supporting students in mobile learning scenarios based on learning analytics.

1.1 Background

In the recent years, web based learning had a huge impact on the students' learning. eLearning provides and supports students in a more personalized, flexible, portable, and on-demand manner. The author in [1] defines ELearning as a form education which includes self-motivation, communication, efficiency, and technology. Also, eLearning is about interaction of learners with information, education and training that covers area such as; web-based learning, computer-based learning, virtual classrooms and digital collaboration. Another author in paper [2] mentions that eLearning is a way of using the internet technology to increase knowledge and to improve the performance. A simple definition for eLearning can be defined as the use of electronic tools which are web-based, web-distributed, or web-capable in learning, training and educational programs.

By use of multimedia and eLearning technology the traditional way of teaching such as books, blackboard writing is changing into online and interactive forms. eLearning technologies helps students to access learning materials from anywhere and anytime via Internet. The new form of learning materials including video and/or audio can help students to learn effectively.

Based on the literature reviews for this thesis, eLearning can be divided into three categories [3], 1) Virtual Learning Environment (VLE) 2) Social networks 3) Games. VLE refers to any learning system that is able to deliver learning materials to the students through the internet. VLE allows teachers and students to interact via the internet. This web-based interaction can include video meetings, forum discussions, course activities, online exams, etc. The most important advantage of VLE is that it helps teachers and students to teach and learn even when they are not physically in a learning environment such as school or university. It means the learners are able to be engaged and have interaction with educational activities without having limitations to be in a certain physical location. This is defined as ubiquitous learning (u-learning). A complete definition for the u-learning has been written in [4]. In this paper the u-learning has been defined as an environment where “all students have access to a variety of digital devices and services, including computers connected to the Internet and mobile computing devices, whenever and wherever they need them”.

The second category explains the role of social media and its impact on the learning. By using the social network, learners are able to share the knowledge/information. Social media by sharing a supporting and powerful environment, motivates students and improve their learning experience which leads to achieve better learning performance. I think, learning experience is any interaction and activities that students gain some experience from. As illustrated in figure 1, a student can have an interaction with his teachers, with learning materials and with other students. Each of these interactions lead the student to learn something and this is called learning experience.

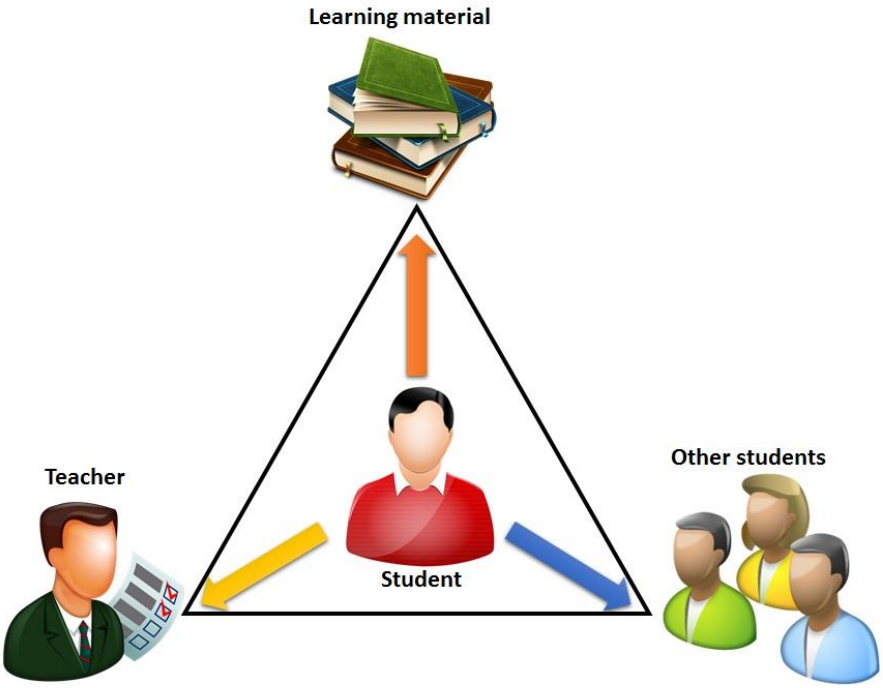


Figure 1 Learning Experience

Game based learning (GBL) refers to the use of game elements with the aim of teaching to its users. GBL does not only provide an environment for students to play games but also helps them to be engaged with the learning materials [5]. A deeper study on GBL has been done in [6].

ELearning comprise of applications, software and hardware that can be used as a learning tool. One of the most commonly used eLearning tool is a learning management system (LMS). LMSs are software application designed with specific abilities to help teachers to achieve their pedagogical goals to deliver required content to their students. LMS are able to manage learners, control and check their progress and performance based on their activity and tasks. LMS have the capability to record the learners' data and provide insight on their progress. Although a significant amount of LMS are running through internet, it seems that there have been some lacks [7]. For example, the LMS are not able to meet the users' requirements efficiently, e.g. dynamically create and control learning activities and processes, and efficiently describe and use the semantics of learning objects and content.

A schema-driven methodology has been proposed [7] to solve this problem. LMS are able to support interaction between learning environments and transfer course material and results over Internet. This ability helps the teachers to track their students' records and progress and monitor their performance.

The LMSs need to interoperate with other LMSs, then they need a common language to share the information by. For this purpose, eLearning standards are proposed. Without this standards and specifications, the systems are not able to share a structured data. There are different standards such as; Sharable Content Object Reference Model (SCORM) [8], Institute of Electrical and Electronics Engineers -Learning Object Metadata (IEEE-LOM)[1], Information Management System (IMS)[2], Dubline Core[3], Aviation Industry CBT Committee (AICC)[4], Ariadne MetaData[5]. Some of these existing standards and specifications are described in section 2.1 in more details.

As the use of mobile technologies is increasing every day, using mobile technologies for learning is becoming more and more wide-spread. The institutions and teachers have understood the potential of mobile technologies as a learning tool.

1.2 Problem Statement

As eLearning is becoming more and more adapted by teachers, students and educational institutions, there is a need to have an efficient mechanism to distribute the data between different LMSs based on eLearning standards. The standards are a documented agreement which contain specifications that will be used as rules and guidelines between LMSs to communicate with each other.

Standards allow for interoperability in a such way that a given LMS has the ability to work with other systems. The contents in the LMSs with the same eLearning standard can be transferred and received. Let's look at some issues that necessitate the development of standards; for example, teachers were not able to move course content between LMSs, they could not move hundreds of files between systems, students could not find the course they wanted easily, it was difficult for lecturers to combine courses and tools from different LMSs, the students with disabilities only could use the systems with custom-developed courses.

Data sharing is very important in learning environments. The advantages of sharing data between LMSs can be noted as tracking learning experience of the students by different educational institutions. No more paper work for assessing learning progress and performance of the students. Later in this thesis, there will be a detailed description about reasons why the data needs to be shared between learning systems.

[1] www.satndards.ieee.org
[2] www.imsglobal.org
[3] www.dublincore.org
[4] www.trainingindustry.com
[5] www.ariadne-eu.org

This thesis intends to find out the mechanism of the data sharing between LMSs based on standards. Also, to see how data sharing can enhance mobile learning and use of learning analytic tools in mobile learning for improving the progress and performance of the students.

For this purpose, the objectives of this study are to:

1. Present the state-of-the art of learning technology standards and specifications
2. Specify teachers' requirements for data which can be used to better support students within technology supported learning environments
3. Test and evaluate a virtual learning environment which supports the tracking, storing and analysis of student learning activities
4. Design a digital tool that uses learning analytics to support teachers in mobile learning scenarios

1.3 Research Questions

The focus of this research is about the tools and process of collecting data on students' learning experience with the intention of helping them to learn better. We are looking at learning analytics that analyze the collected data based on a certain standard in order to propose a design solution for teachers. The following research questions are addressed:

1. What type of information is required by teachers to support students within technology supported learning environments?
    a. How can TinCan specification be used to support tracking of students' learning experience in mobile learning environment?
2. How to design an xAPI based mobile solution that help teachers to enhance students' learning experience?

1.2 Thesis Outline

This thesis is structured in several chapters. First chapter covers introduction. Introduction of this thesis includes the aim of the thesis, background on the eLearning scope, problem statement and research questions. Chapter two covers the most commonly used standards, mobile learning setups and literature review on eLearning. In chapter three the methodologies used in this thesis are described. Chapter four contains description of existing learning dashboards. Also, the findings from interviews with teachers about their requirements as users can be found in chapter four. The experimental setups including interaction of LMS and Learning record stores, Human-centred design of the proposed solutions are presented in chapter five. Finally, the conclusion of the research and the future work can be found in chapter six.

2 Learning in a Digital Age

Learning in digital age, means the use of new technologies in learning environments. For example, replacing chalk and blackboards that teachers and students used to have in classroom with new digital boards. Developing variety of LMSs that help teachers and students to have a better control on the courses. The ubiquitous learning technologies such as mobile phones which allow students to learn regardless to the physical location. Learning technologies helps students to learn from face-to-face lecture, game-based application and virtual learning environments.

2.2 Learning Technology Standards and Specifications

Standards are defined as "document agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that material, products, processes and services are fit for their purpose" according to International Organization for Standardization (ISO) [9]. There are four purposes for development and use of standards: durability, interoperability, accessibility, reusability [10]. Durability refers to no need for correction for a new version of system. Interoperability is the functionality between different systems together. Accessibility is about searching and following according to the demand and finally reusability means making appropriate changes and use by other tools. Many different organizations tempted to develop standards to enable interoperability between learning technologies. Many features provided by these standards control interoperability and data sharing among learning tools (LT). In the following section, some of the most widely used standards in the educational environment are described.

2.2.1 Sharable Content Object Reference Model

The Sharable Content Object Reference Model (SCORM) standard and specification has been investigated and developed by Advanced Distributed Learning (ADL) organization. One of the most important feature of SCORM is easy portability of learning content between LMSs. The goal of this standard can be listed as; accessibility, adoptability, affordability, durability, interoperability and reusability. The smallest unit that can be shared between the LMSs under SCORM standard is called Sharable Content Object (SCO). SCO is a launchable learning resource that communicate with other LMSs through SCORM run-time environment. The SCO represent the lowest level of learning granularity that a LMS can track.

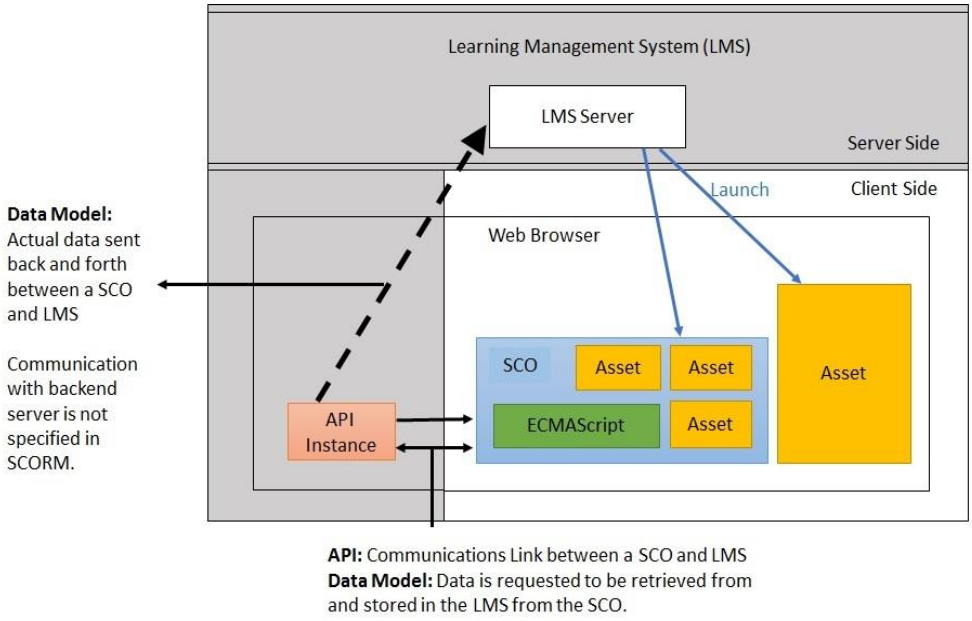


Figure 2 SCORM Conceptual Run-Time Environment [8]

Figure 2 shows SCORM conceptual run-time environment (RTE). SCORM developers made an Application Programming Interface (API) that helps developers to have a common language for sharing and communicating learning objects. APIs allows LMSs to retrieve, set and initialize information that are determined in the SCO. In general, RTE has three components; Launch, API and data model. Launch process refers to a common way to start web-based content object. Content object is any piece of information and content that can be launched to a learner (SCOs and assets). It defines the process of establishing a communication between the launch content and LMSs. API provides a communications mechanism that allows content object to communicate with LMS. Whenever a SCO is launched, then the information can be exchanged between the SCO and LMS. Therefore, an API is used for retrieving and storing data between LMS and SCO. Data model is a standard set of data elements which is used to define information that are known both for LMS and SCO. The information such as; status of a statement or score of quiz or a test.

2.2.2 IEEE Learning Technology System Architecture

The Aviation Industry Computer-Based Training Committee (AICC) developed many specifications for learning hardware and software. The most important ones are Content Management Instruction (CMI) specification and IEEE Learning Technology System architecture (LTSA). Both of them are used for interoperability between web courses and LMS. This data exchange model provides many fields to store different forms of students' interaction with LMS. The fields can be noted as; end state, state of success, interactions, objectives and finally comments from learners [11].

The IEEE (1484.1) Learning Technology Standard Committee (LTSC) has developed an architecture that can be used for all learning technology systems, Learning Technology Standard Architecture (LTSA). The LTSA specification advantages include making a framework

to understand existing and future systems, increasing interoperability and portability, 5 to 10 years' applicability while it is adapted to new technologies. In figure 3 the LTSA is illustrated.

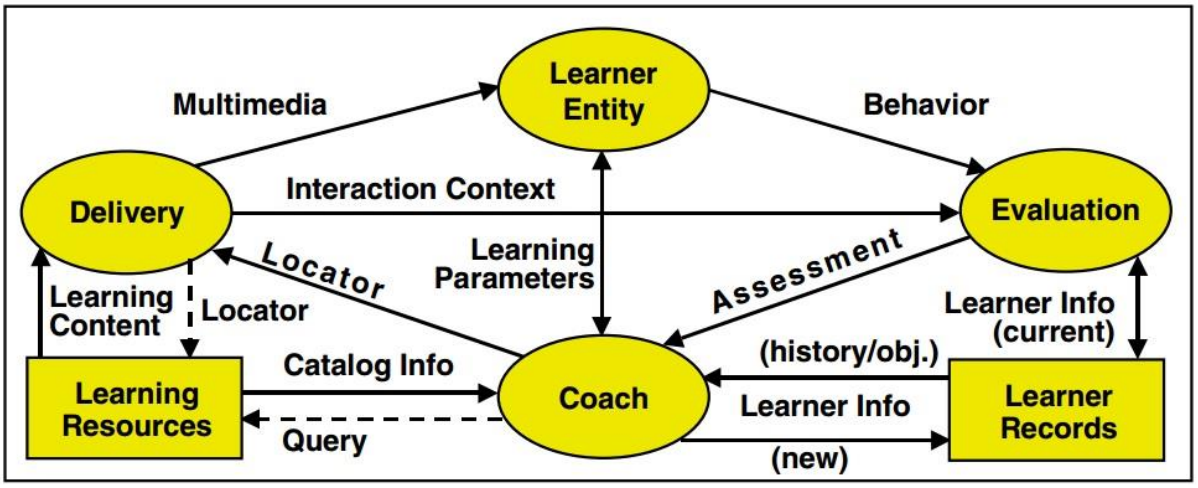


Figure 3 Learning Technology Systems Architecture (LTSA) by IEEE 1484.1 [12]

The learner entity presents a learner which can be a single learner or a group of learners. This entity receives multimedia presentation and the learner behavior is observed by the evaluation. Behavior flow contains behavior information like keyboards clicks, mouse clicks choices, etc. Also, there is a two-way communication between the learner and coach (mentor, teacher, employer, institution and etc.) which negotiate learning parameters. Accessibility requirements, cultural adaptation parameters, physical limitation and cognitive limitations are some of the information types for learning parameters.

The evaluation is an abstract process that may evaluate the assessments and performance information of a learner and then the assessment information is sent to the coach. Interaction context flow provides information about the learners' behavior and send these contexts to be evaluated.

On the other hand, the leaner information (past, current and future) is stored and retrieved by a two-way data flow between the evaluation process and learner records store. The "learner records" can receive data both from the evaluation process and the coach. The coach can send request to the learner records to get information about the learners' performance and/or preferences.

The information from learner stores and the evaluation assessments help the coach to decide and choose future learning experiences. For this purpose, coach sends queries to learning resources to search for appropriate learning materials. Then a catalog information is sent from the learning resources to the coach which contains list of locators (a lesson plan, pointers to content) based on the coach's search. Then, the coach may send these locators to delivery process. Learning resources include presentations, tutorials, tutors, tools, experiments, laboratories, and other learning materials as resources for learning experience. Finally, delivery process retrieves learning contents from learning recourses based on the locator that

receives from the coach. Then, the learning content is transformed into a multimedia learning experience by the delivery process and send to the learner entity.

2.2.3 Learning Tool Interoperability

LMSs should be open to be integrated with other learning tools while at the same time these systems should keep the balance between new tools and their stability. Service-oriented approach is one of the possible solutions for this integration. The service-oriented approach separates and distributes the functions of LMSs between multiple systems. This approach creates an environment which allows the learning tools to function with LMSs. Therefore, a new flexible way will be open that increases the amount of capabilities for LMSs to help teachers and learners.

The Information management system (IMS) organization develops standards to enhance learning. Learning tool interoperability (LTI) is one the standards developed by IMS. The main reason for developing LTI standard is providing an integration between learning applications and platforms like LMSs and VLEs. The LTI standard allows connection of externally hosted and web-based applications and tools (from simple applications like calendar to complex ones such as those for learning mathematics). For example, a teacher using an interactive assignment reporter application, can easily and securely connect the application to a LMS based on LTI standard. Figure 4, shows the advantages of LTI for people (developer, administrator, learners, teachers) who are involved in a learning environment.

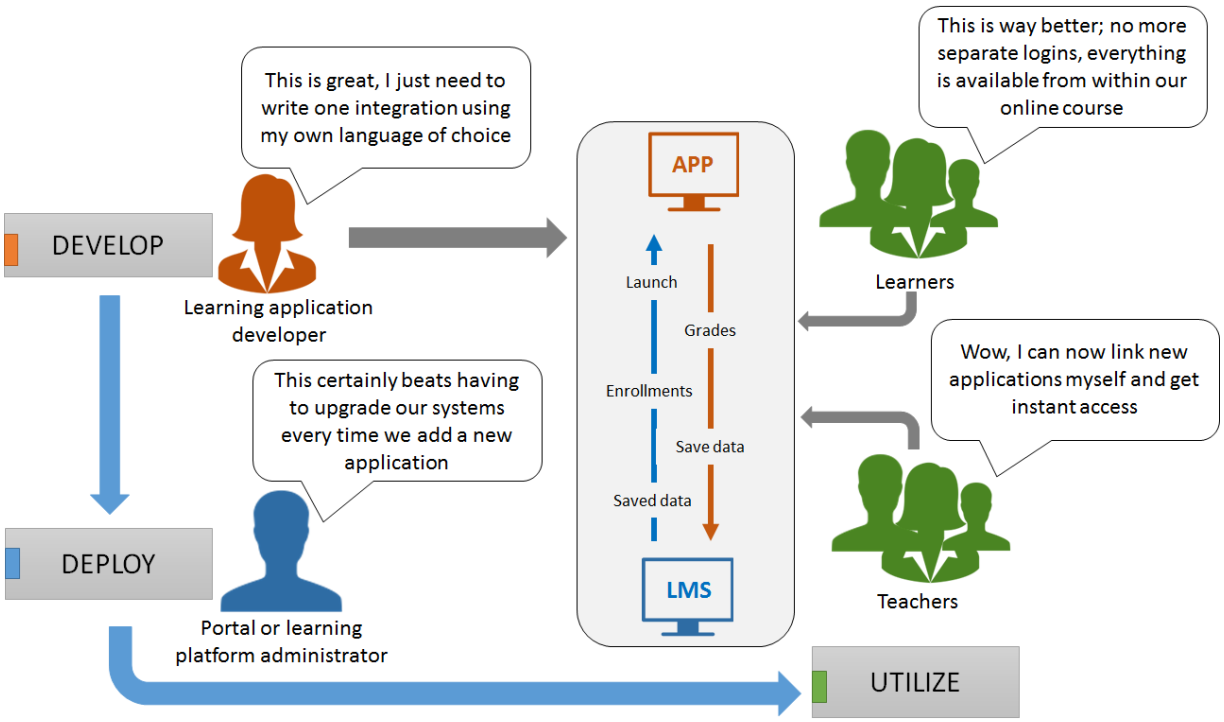


Figure 4 Advantages of LTI [13]

An outlook of IMS learning tools interoperability standard:

- Allows installing external tools to learning environments
- When user launches a new tool, this standard securely launches, course materials, users' identity etc.
- Allowing external tools to have both way communication with a LMS

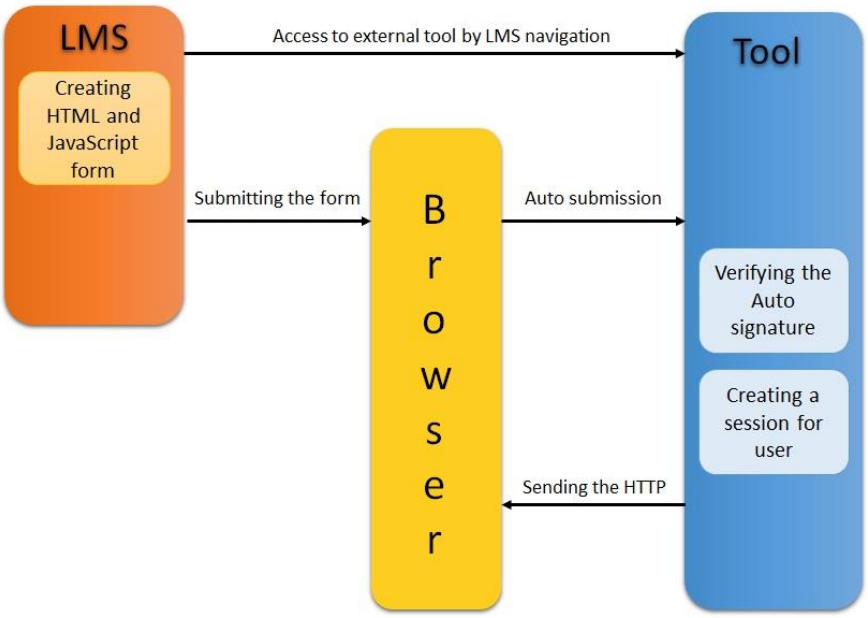


Figure 5 IMS LTI Launch Sequence

Figure 5 shows the LTI launch process [14]. Three components are involved in this process; LMS, external tool and browser. Users can have access to external tools using LMS navigation. Then, LMS generates a HTML and JavaScript file. The file will be signed by OAuth pattern for secure launch. The signature assures external tool that the file is coming from the LMS. First, LMS sends this file to the users' browser. When the user's browser receives the file, it is automatically submitted to the external tool. Some fields containing information such as user, course and any other necessary information are placed in the form by LMS. The form contains a signature signed by LMS using OAuth standard.

When external tool receives the form, it verifies the OAuth signature. Then, external tool creates a session for user and sends back the HTTP response containing a cookie to maintain the tool's session. After that user can interact with the external tool via their browser.

2.2.4 Question and Test Interoperability

Question and test interoperability (QTI) is another specification developed by IMS. QTI defines a standard format which is used for representing of learning materials evaluation and results.

Specifically, QTI is designed to:

- provide a well-document file to store and exchange information (question, test data and their results' reports). This file is different from the one that an authoring tool used to create
- provide content format to store and exchange information (tests). This format is different from the one that a construction tool used to create.
- Help develop item banks (a system that collects and manages assessment items) by using variety of learning and assessment delivery systems.
- Help develop items, item banks and tests from different sources.
- provide report for the test results based on a defined format.

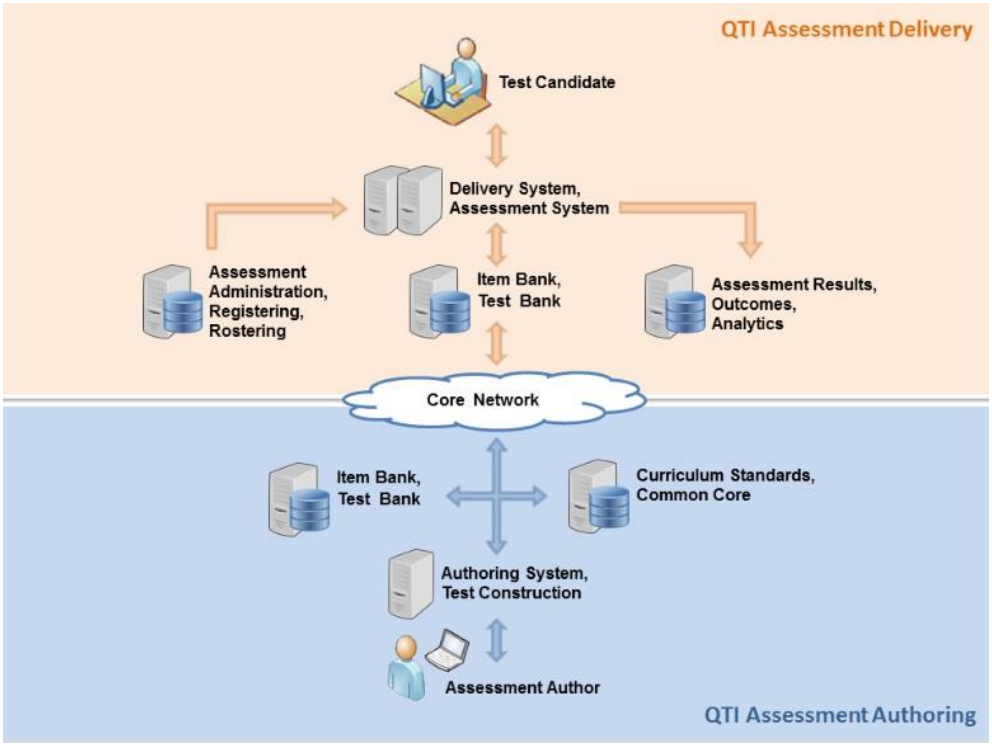


Figure 6 The Role of Assessment Tests and Assessment Items [13]

QTI specification is developed for the question (assessmentItem) and test (assessmentTest) data and providing the reports related to this information. Figure 6 shows exchange of item, test and results information between authoring tools, item banks, test building tools, learning platforms and assessment delivery systems. The assessment author uses authoring system to create assessment item and is able to apply any changes to this items. The author also interacts with the test construction tool which is used to assemble tests from individual items. Then, the assessment items are sent to item bank system for collection and management. Assessment delivery system is for delivering the assessment items to the candidates and score the responses automatically or send the answers to another scoring system.

2.2.5 TinCan (xAPI)

The Experience API (xAPI) also known as Tin Can is an eLearning specification developed by ADL [15]. The Experience API can be considered as a modified version of Sharable Content Object Reference Model (SCORM) specification and it goes beyond SCORM. SCORM has been a common language between learning systems for decades and a standard for online courses. A comparison between SCORM and xAPI is shown in Table 1.

Table 1 Comparison between SCORM and the xAPI

SCORM	xAPI
Track: completion, time, pass/fail **Report:** single score	Solid security and use mobile apps for learning **Track:** completion, time, pass/fail, serious games, simulations, informal learning, real-world performance, offline learning, interactive learning, blended learning, long-term learning, adaptive learning, team based learning **Report:** single and multiple score **Not required:** LMS, internet browser, cross-domain app for learning

The focus of the Experience API is on defining a data model for storing information about the students' learning experience and to share this information between systems. In other words, it is a standard to share information about the learning experience of students between the programs. xAPI is simple (activity statement) and flexible, and collects data that are quantifiable, sharable and trackable. xAPI can be used in a variety of area such as simulations, serious games, real-world activities, social and collaborative learning, mobile learning and experiential learning (xAPI can be used in interactive learning environment to help people to improve their skills experientially).

The xAPI collects data based on statements and a statement has a specific format based on JavaScript Object notation (JSON)[1]. JSON is a popular light-weight data format. The attributes (elements) of this format are: Actor, Verb, Object, Result, context, Authority, Timestamp, Attachments. Table 2 shows description about each attribute.

[1] www.json.org

Table 2 xAPI attributes' statement

Element	Description	Require
Actor	An identity of someone who did an action which can presented as an individual or a group.	Required
Verb	The action done by actor.	Required
Object	What the actor is acting on. It can be also another actor or group or even another statement.	Required
Result	The outcome of an activity e.g. grade, success etc.	Optional
Context	The context of the activity. Context is contextual information added to the statement. e.g. the instructor for an experience. When the experience happens as a part of a team.	Optional
Authority	A person or a group that asserts the truth of a statement. The agent who asserts that the experience happened. This is verified by the Learning record store.	Optional
Timestamp	Is about the time that the experience happens.	Optional
Attachment	Attached files can be attached to the statement.	optional

Some examples for xAPI statement are shown in Table 3:

Table 3 xAPI statement examples

Actor	Verb	Object	Result	Context
Sam Hoopes	watched	Security video	-----	-----
Paris Lakey	Viewed	PDF	-----	-----
Sara Baker	Passed	Midterm exam	With grade B	-----
John Snyder	Failed	Interaction exam	With score 20	-----
Daniel Caswell	attended	Interaction design course	-----	Maria Smith

First two rows in table 3 show the TinCan statement at the simplest level which is expressed as “Actor, Verb, Object”. Next two examples contain “Result” property. The last example contains also “Context”.

The JSON format for first statement is:

```
{
  "actor": {
    "name": "Daniel Caswell",
    "mbox": "mailto:danielCas-345@mail.com"
  },
  "verb": {
    "id": "http://adlnet.gov/expapi/verbs/attended ",
    "display": { "en-US": "attended" }
  },
  "object": {
    "id": "http://example.com/activities/interaction-design-
course ",
    "definition": {
      "name": { "en-US": "interaction design course" }
    }
  } ,
   "context": {
     "instructor": {
       "name": "Maria Smith",
       "mbox": "mailto:Maria23-sth@mail.com"
     }
   }
}
```

Let’s look at the code in more details. “name” and “mbox” are Actor object properties. Maybe there many people in the word with name “Daniel Caswell”. Therefore, there must be a property which is unique for this Daniel and that is “mbox” which only belong to this Daniel.

Vern property in the JSON statement is a Uniform Resource Locator (URL), it is aa address of a web page. This property also contains a short display string. Verb is an important element of the statement, because it shown the action done by the actor. TinCan registry[1], published by ADL contains initial verbs. In general, any full URL can be used as a verb in JSON statement based on TinCan specification.

[1] https://tincanapi.com/registry/

Object property can be presented as an activity, another actor or another statement. In our example the object is an activity. Each activity must be defined by a unique URL and have a clear definition.

Context property is about contextual information that can be added to the statement. This property contains information such as the instructor of the activity. In this example Daniel attends to interaction course, under the instruction of Maria Smith.

Figure 7 illustrates the general architecture of xAPI which contains three components. In the following a more detailed figure is presented (figure 8).

Figure 7 General xAPI architecture

- **Activity provider (AP):** is the software that communicates with a learning record store for recording the information about the activity of a learner.
- **Learning Record Store (LRS):** One of the key components of the xAPI architecture. LRS is an application interface that can safely (by validating the statement format) collect, store and exchange learning experience, activities and performance.
- **Activity consumer (AC):** an xAPI client that communicate with the LRS to access the data.

Figure 8 is presenting the experience tracking by the xAPI components in more details. Tracking learners' experience helps teachers to see the progress and performance of their students. Therefore, information on the learning experience needs to be stored somewhere. Every learner by interacting with a LMS achieves learning experiences. A learning record provider is responsible for receiving learning experience and creating learning records and sending them to other LRSs. A LRS is responsible for authentication and authorization with Other LRSs. Each learner has an account in one or more LRSs. A learning record consumer has access to the records by using the authentication of the learners.

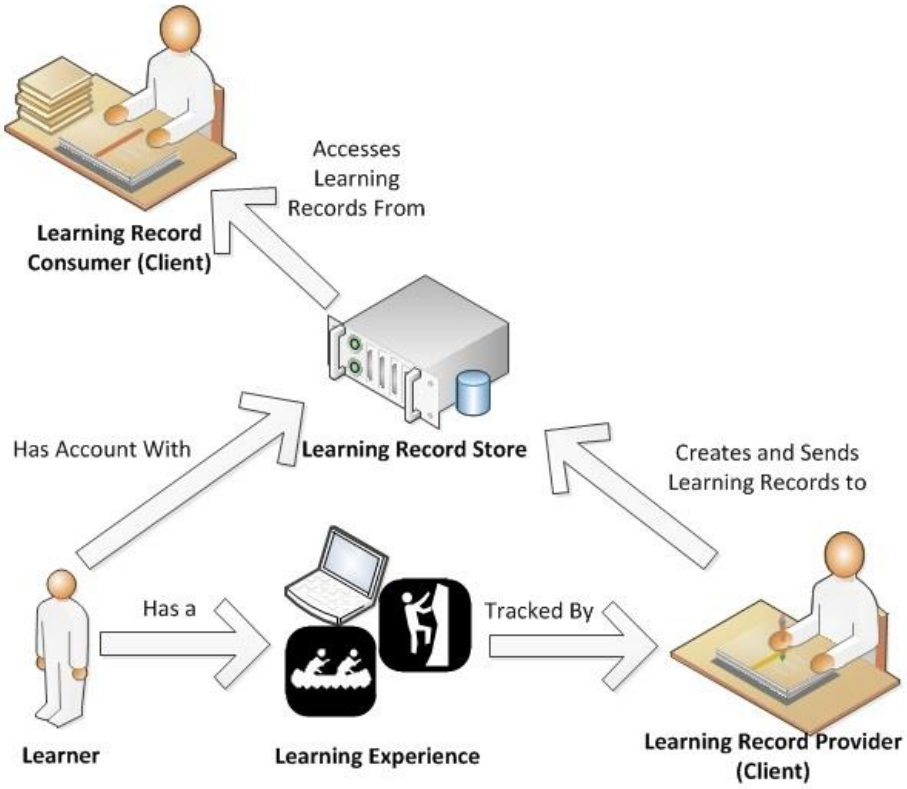


Figure 8 xAPI architecture for tracking the learning experience [15]

When the learning activities of a learner needs to be recorded, the LMS sends secure statement in the form of JSON to a LRS. The LRS records the statements that are made by the LMS. xAPI allows LRSs to communicate with each other and share the statements. A LRS can be combined with a LMS or it can exist on its own. Each LRS has an endpoint. The endpoint is an URL which is defined in the LRS system. Each leaning environment by having this endpoint is able to be connected to a specific LRS. Then, every learning activity that is done in the learning environment will be stored in a LRS based of xAPI statement.

Figure 9, shows why the statements need to be shared between LRSs and figure 10, shows how the statements can be shared between LRSs. Wax, Watershed and Learning Locker are different type of LRSs.

The learners' statements need to be portable and shareable. For example, if a learner wants to move from one university to another one (which is using a different LMS/LRS) the record should be transferred to the new university. Maybe it is needed that the statements to be shared with a new LRS. There are some other systems rather than LRSs which use statements in other ways. For example, a training delivery system may use the statements to deliver materials (various instructional materials such as; text, audio, video and diagrams) to support learners in their performance.

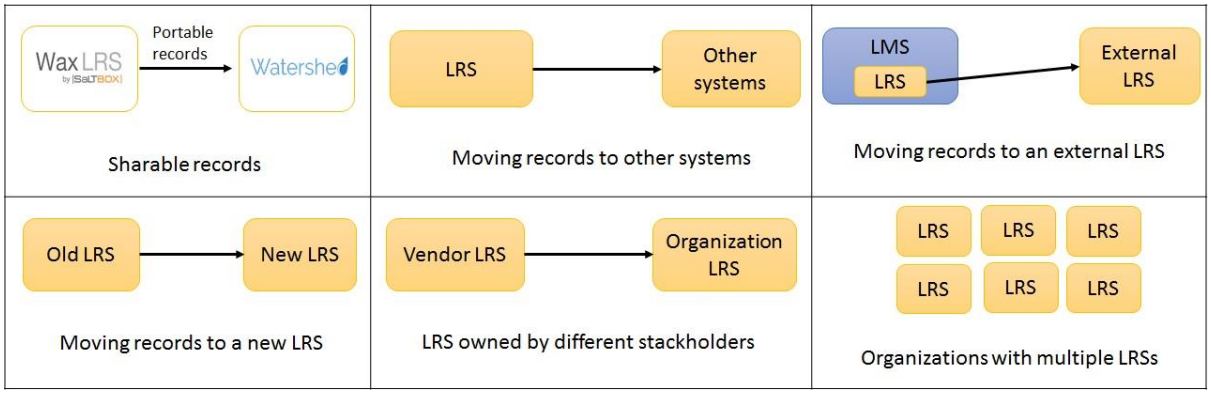


Figure 9 Why the statements need to be shared? Adapted from [15]

As it was mentioned the LRSs can be inside in a LMS or to be a separate application. Some organizations use both type of LRSs, in this case they need the data to be shared between their LRSs. There are some product vendors who develop their own LRS and also send the data to the customer's LRS. There is a possibility that an organization is using separate LRSs in different sections and maybe one section needs to have access to the information stored in another LRSs.

There are number of different ways which the statement can be shared:

- **One way Sharing:** in this approach only one LRS share its statement with another LRS. The second LRS only receives the statement. This can be achieved by first LRS sending statement to the second LRS or the second LRS quering the statements from the first LRS.

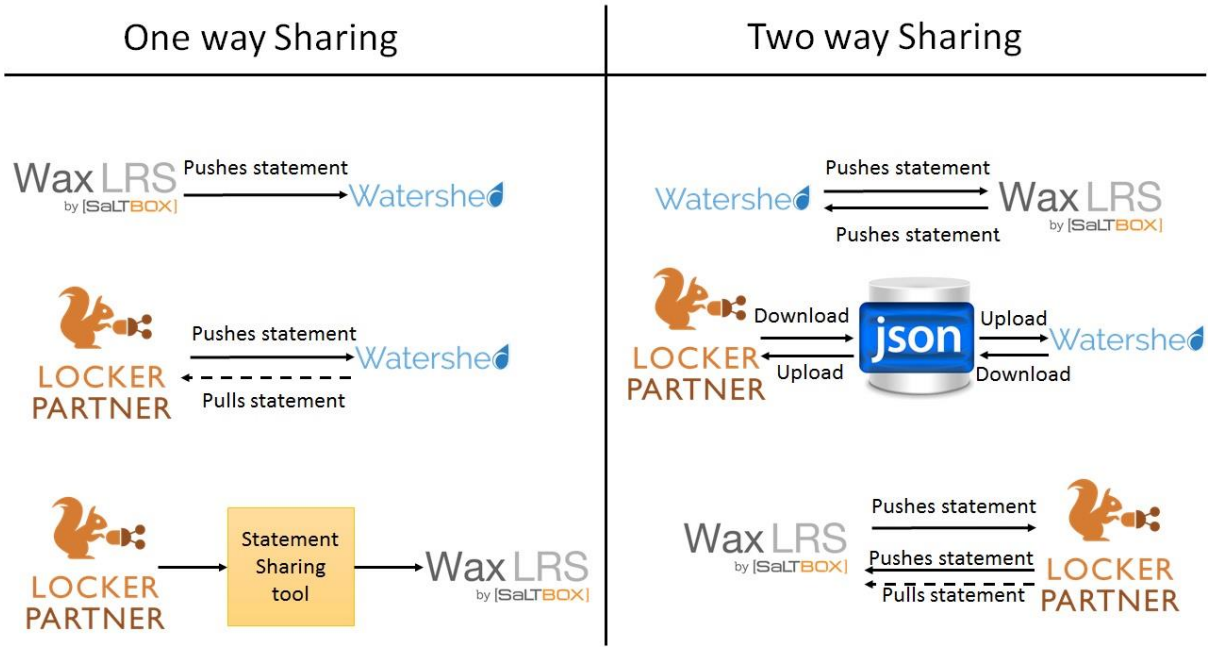


Figure 10 How the statements can be shared between LRSs Adopted from [15]

- **Two way sharing:** in this approach both LRSs send statements to or query statements from other LRSs. It is possible to share statemts by using a statement sharing tool. This approach is know as man-in-the-middle. These systems fetche statement from one LRS and pushe it to another LRS. These systems does not necessarily store the statements. They act as an interface between two LRS. When the two LRSs are not able to directly connect to eachother because of the connectivty issues or security restrictions, statements will be downloaded as a JSON file from one LRS and will be uploaded to another one.

2.3 On eLearning and Mobile Learning Concepts

The wide range use of mobile and communication technologies leads to new use of mobile devices for different purposes beyond making phone calls and sending text messages. The potential of mobile learning (m-learning) has been identified for the instructional designers and educators. This new way of learning encouraged teachers to use mobile technologies as a learning tool in their teaching. Mobile learning can be considered as a quick and easy access learning tool since almost every student and teacher has a mobile device in his pocket.

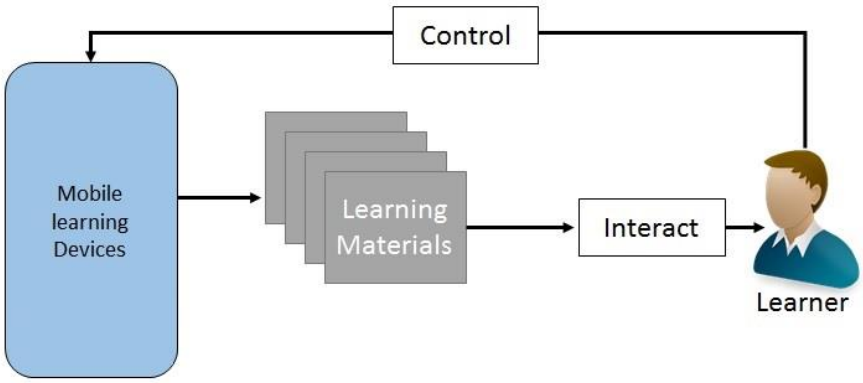


Figure 11 Mobile learning general scheme

A simple scheme for mobile learning is illustrated in figure 11. The figure shows the interaction of a learner with mobile learning device. The learner can select the appropriate learning materials (audio, video, e-books, assignments, etc.) from the learning application that is installed on the device to interact with. Also, the learner has control over the application; for example, there are some applications that can be used both online and offline. So, the learner is able to take the device anywhere. The learner can capture information for learning by using the camera, sound recording and note apps.

A mobile learning project [17] have been investigated by three European countries. The project took 4 years of planning, research, development and also the large-scale testing of mobile learning systems with learners in three European countries. The project developed learning materials to study about the enthusiasm of the students for using mobile learning in their education.

Some of the Key findings of the project about mobile learning are:

- Location independence
- Makes learning more entertaining and add diversity to courses or lessons
- Removes some formal disciplines in teaching and makes a fun and friendly environment for students.
- Help the students who may find the courses unattractive, the ones who are shy and frightened to interact with the learning materials easier.
- Enhance individual and collaborative learning experiences
- Helps distracted learners to stay more focused for longer periods
- It supports literacy, numeracy and language learning

There are different types scenarios which a mobile learning can be set up, in the following some of the mobile learning application setup are shown.

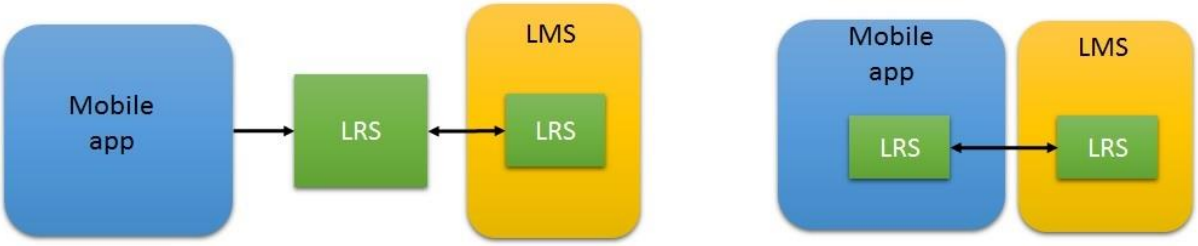


Figure 12 Mobile learning application scenario with internal and external LRS

Figure 12 shows two mobile learning implementation setup. In the left figure the mobile application may generates xAPI statement and send them to an external LRS. Then, the data can be shared between the external LRS and the LMS. In the right figure the mobile application generates the statements and then the statements will be saved in the internal LRS of the mobile application. In this way, the data can be shared directly from the mobile application LRS to other LMSs.

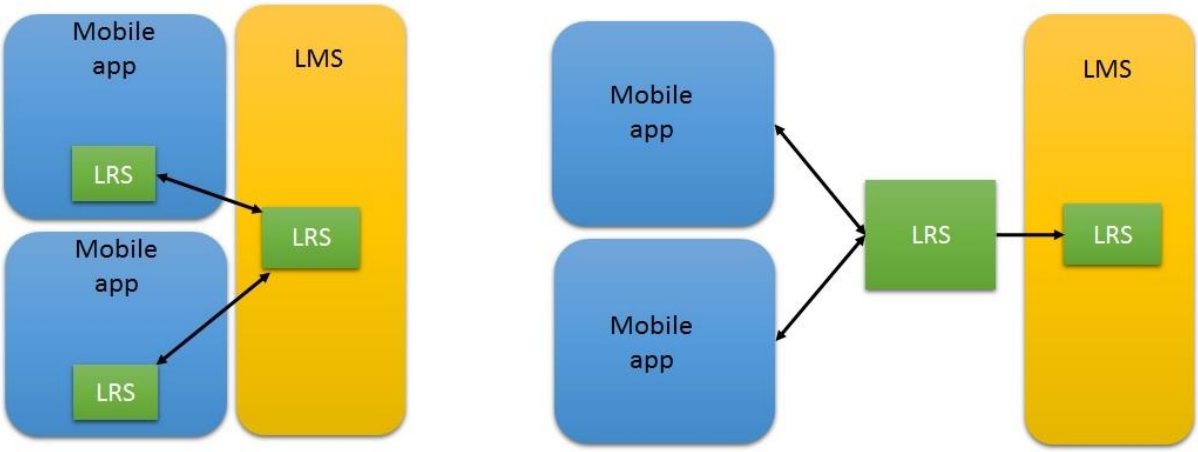


Figure 13 Simple mobile learning scenarios with internal and external LRS

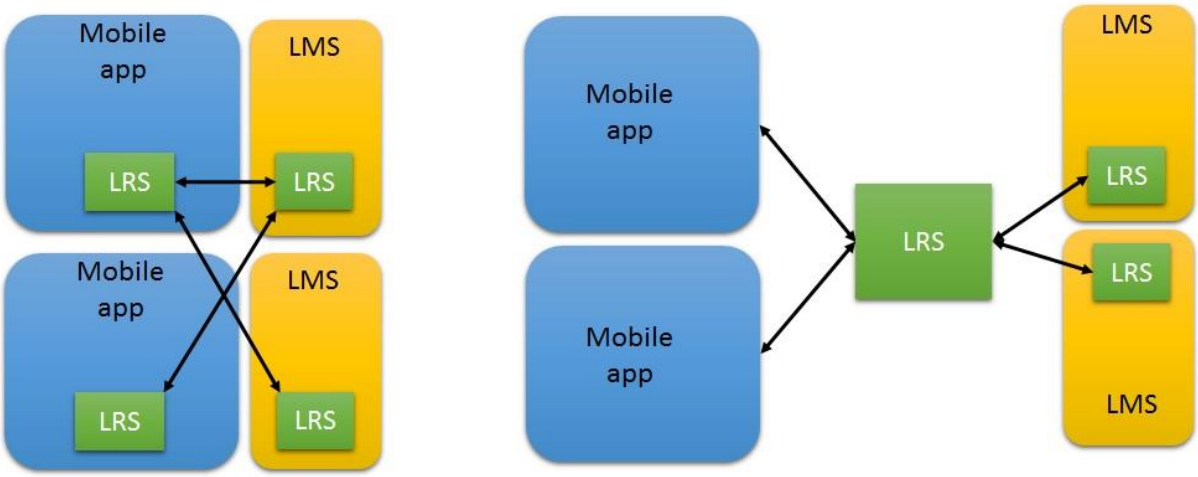


Figure 14 Multiple mobile learning scenarios with internal and external LRS

Figure 13 illustrate simple mobile learning setup using internal and external LRS. Figure 13 shows the interaction of two mobile apps with an LMS and how these mobile apps are connected to a LMS. As it is shown, the LRSs of each mobile app is connected to the LMS's LRS or just the data is send to an external LRS. The data is collected and stored in the LRSs by the xAPI standard. The connections show a two-way communication between the LMS's LRS and mobile apps LRS/ external LRS. It means the LRS and LMS are sending xAPI statements and querying data from each other. In learning scenarios, it is possible to add some external tools to learning environments. These external tools could be another LMS or any useful application that can help teachers and students to improve their performance.

Figure 14 shows a multiple mobile learning app setup with two LMSs. Also, in the multiple scenarios, the mobile applications can have internal LRS or just send the statements to an External LRS. In multiple setup an LRS can be connected to more than one LMS to forward and/or request statements.

2.4 Learning Analytics

The LMS are able to collect a huge amount of data on students' activities and results. In addition to the standard courses in LMS, there are other learning environments such as Khan Academy, Coursera, and Udacity which provide Massive Open Online Courses (MOOCs). These open courses also store a lot of data about the students' performance. Here there is a need of learning analytics (LA) tools to use data mining and analytics techniques to extract information from the LMS and MOOSCs data. LAs are used for measuring, collecting and analyzing learning experience of the students. The purpose of using the LAs is detection of the learning problems, evaluate the students and studying learning results. These analysis results can be used by the students as a motivation for self-assessment and teachers to see the problems and improvements. For example, students can use the learning analytic tools to monitor their progress and performance, compare their trend with other students etc. Teachers can use the learning analytics results to monitor their students learning process,

discover the problems, identify indicators for students' success and failure, improve their teaching, material, learning environments etc. [18].

There are some well-known LA tools, here there is short summary of their capabilities.

- SNAPP [19] – uses social network forums to categorize students into different groups such as engaged students, disconnected (or "at risk") students, or information brokers.
- LOCO-Analyst [20] – helps teachers about the web-based courses by providing course statistics and pointing the course most important parts.
- Course Signals [21] – analyses the students' performance to identify the students who are at risk. Two type of data will be analyzed: static (students' background and characteristic), dynamic (course grades, students' interaction with LMS)
- Desire2learn (Student Success System) [22] – by analyzing students' grades, login frequency, discussion posts, and results and number of attempts in quizzes, attempts to detect students at risk.
- Pittsburg Science of learning Center (PSLC) [23] – a data base of extracted data from different learning courses to help in development of standards.

Learning analytics are aimed to help the process of learning and its environment by analyzing the collected data and context of the learners. The learning analytics have the ability to estimate the learners' response time to course materials. Running data analytics on mobile devices may be a challenge due to limited computational power and storage size. Therefore, mobile devices may send the data to the cloud computing server (internet-based computing) and external LAs are able to access this data to create more advanced statistics and results.

2.5 eLearning Research

There has been lots of research on eLearning area. In one of the papers the concentration has been on the affective issue of learning technologies in collaborative systems [24]. It discusses the role of affective factors in three main areas of collaboration: 1) In collaborative learning where groups of people are sitting together (adults and children) 2) in online communities (adults) 3) in support and development of socio-emotional skills (children). Curiosity, control, confident, challenge as motivational aspects were briefly described in this paper. The literature review in this paper shows the important role of confident and control in collaborative learning.

In another paper the multimedia eLearning technologies were discussed and evaluated [3]. It has been mentioned that eLearning technologies have made it possible to create virtual environment classrooms on the web. eLearning technologies contains communications (mobile), social network (Internet) and game-based learning. This paper points some advantages of eLearning such that it can be reached from anywhere and anytime through internet by the students and it is very effective for the students with different learning style.

Another paper focuses on LMSs and personal learning environment (PLE). This paper studies the impact of some social media such as *Twitter, Flickr and Wordpress* on learning [25]. The idea of this paper was to facilitate carrying out external learning activities based on tools in the students' personal learning environment in order to improve their learning. The use of video games as learning tools, known as Game-Based Learning (GBL), has been gaining prominence in recent decades.

The main features and guidelines of the gamification framework on social learning environment has been presented in another paper. In one of the newest papers which has been released in January 2016 [26], online learning performance and behavior has been studied. In this paper, 12 papers have been analyzed. In the first paper, by Chen-Wei Hsieh and Sherry Y. Chen customized digital learning system (CDLS) and personalized digital learning system (PDLS) were studies. These two systems were implemented on the devices (e.g. Mobile phones and Tablets) of some students. The results show that students who are using CDLS and PDLS got similar scores, despite the students' differing cognitive styles. Second paper by Lai Hung, et al. used funny images as reward to encourage students to give answers to the questions. Students' observation showed positive emotions. In the third paper the authors think navigation and performance has a negative effect on the students' offline comprehension skills. On the other hand, the authors indicate that offline comprehension skills as a positive impact on digital reading. Online education has been studied in fourth paper by Cheng Xusen, et al. In this paper thinklets (scripted collaborative activity for group work based on collaboration patterns) was introduced to online collaborative learning. The results showed a great effect on students' satisfaction. Fifth paper studies the integration on OpenCourseWare with flipped classrooms and its effects on students' learning and students' interaction with their teachers. The results showed higher score for students who used integrated OpenCourseWare with flipped classrooms. In the sixth paper a new approach Effective Classroom Interactions (ECI) to help children teachers to design new methods to enhance their readiness was introduced. In the seventh paper, authors discuss about the implementation advantages and disadvantages of eLearning systems with learning objects (LOS). In the eighth paper the authors discovered the impact of students' emotional intelligence on online learning readiness. In the ninth paper the authors indicate that the students who had done at least one assignment or exam out of the course instruction had higher potential to go through self-paced distance courses. The tenth paper, by Piret Luik and Merle Taimalu studies the "blogging" effectiveness. The results showed that the students are very satisfied in using blogs and also the strength of social relationships was increased. The authors suggested that teachers can use blogs in their teaching. The eleventh paper studies the students' psychological and online behavior. The results showed that time online behavior has an impact on their psychological behavior and their learning process. Finally, the twelfth paper by Chin Lay Gan and Vimala Balakrishnan studies the mobile learning technology to improve students' interaction with their lectures and other students. The results showed that the students are satisfied about the ease of use and enjoyment in using mobile learning technology. The research helps the readers, educators, teachers, and schools who are looking

to implement online educations. Also for the ones who want to improve their students' learning performances and behaviors.

The relationship between different individual characteristics (gender, age, education, tenure and managerial level) and the success of the eLearning system has been discussed in another paper [27]. This study faces two limitations. The first was the small sample size and the second use of statistical techniques that detect only relationships. The major findings indicated that it is better to have homogenous groups of students and teachers to improve eLearning system effectiveness. Also, try to change the attitudes in eLearning systems which improves satisfaction and performance.

In the next paper [28] the extension of the eLearning into wireless/handheld (W/H) computing devices with the help of a mobile learning (m-learning) framework has been studied. In this framework a mobile learning application has been developed based on the requirements that were identified in the framework. The application that could be used to complement the classroom or distance learning was tested with potential users. The authors indicated that most of the learning pedagogies could be adapted to mobile learning environment. Finding the strength and weaknesses of the mobile learning was the key aim of the paper. The results provided the importance of mobile learning in higher education.

The impact of video in an eLearning system was discussed and analyzed in another paper [29]. Four different environments were examined (eLearning environments—with interactive video, with non-interactive video, and without video and traditional classroom environment). The results and finding showed the high effectiveness of video in eLearning environments.

In the [30] a Personalized Teaching and Learning (PETAL) eLearning system which is a personalized learning platform has been proposed. This system has been equipped with a learning analytics application which is able to detect learners' levels of attentiveness. Also the distance between the learners' eyes and the mobile phone. In an inappropriate situation, the learning analytics will alert he learners to keep the distance from the device. The PETAL has been used to develop an interactive video player application integrated with image processing techniques.

Self-regulated learning has been studied in another paper [31]. 36 students used their mobile phones to track how much time they spend on learning over four months. The result showed a positive effect of recording the learning time. It helps students to learn about time management skill. The results also helped to understand how mobile notifications should work to help students in learning online courses.

eLearning standards have been analyzed and defined in many different papers. For example, [32] studies the capabilities of eLearning standards (IEEE and xAPI) to improve data collection. In this paper, functionality of some well-known analytic tools was described (e.g. SNAPP, Course Signals, Desire2learn). The result of the analyzing of the two standards showed that the IEEE standard is extensively adopted. On the other hand, the API run-time model did not

allow other LMSs to access the data. So, the use of xAPI and LRS made sharing and accessing the data better and easier. It was occluded that the xAPI standard provides a better performance according to the LA tools requirements.

The use of xAPI in mobile learning environment is described in [33]. In this paper the capability of the xAPI for linking sensor networks to collect learning experience was studied. Different types of mobile learning implementations showed how the concept of xAPI is integrated in mobile learning environment. One mobile learning application called "The Mobler Cards" for supporting flashcard learning. This application shows the connection of the learning analytics functions with LRSs compatible to xAPI. These features have the ability to inform learners about their progress and performance and also help them to manage their activities.

A survey has been done on six different universities in the US to find the possibilities and potential of learning analytic tools within LMSs [34]. Data gathering methods in this paper were; interviews with IT directors and administrations, online survey instrument and also a case study in Embry-Riddle Aeronautical University. The investigation shows the universities' tendency for having a capable learning analytic tool in order to make better decisions. So, these universities are using the analytic tools that are able to collect data, analyze and measure the learning materials to improve students' progress.

Leaning dashboards enable learners to track their learning activities and enables them to have goal and follow the goals and track their progress. Also, improves awareness, reflection, and sense-making [35]. In this paper, performance of learning analytics that helps teachers and students through dashboard applications (Backstage, TinckerBoard, Slice 2.0, Classroom salon, Glass, Moodle[1], etc.) was presented. For this purpose, they designed and developed a package of tools to track learning activities and visualize them as learning dashboard. Learning analytics dashboard were categorized in three groups; "1) dashboards that support traditional face-to-face lectures, 2) dashboards that support face-to-face group work, and 3) dashboards that support awareness, reflection, sense-making, and behavior change in online or blended learning." Each of these groups where described in details. Then, some research issues for developing learning dashboards were outlined. For example; identifying relevant user actions, capturing data on relevant action, the impact of awareness, reflection, sense-making on different type of users and measuring the impact of learning dashboards. The results showed the advanced potential of these dashboard in improving the learning environment.

In [36] a portable learning analytics dashboard has been proposed. The study in this paper shows that existing dashboards are barely portable. When they are integrated with a learning environment, it need lots of efforts to be transferred to a new learning environment. Therefore, this paper proposes a new dashboard which is portable between learning environments (Moodle, Blackboard, Graaasp[2]) with lower costs by using open specifications

[1] www.moodle.org

[2] http://www.grasplink.com/

(OpenSocial and ActivityStreams) and widget APIs. In their proposed solution, the dashboard is assembled by several widgets as a metawidget. Then, this metawidget is added to a widget repository which allows teachers and students to easily add this dashboard to a learning environment. This feature helps students to use dashboards in distance education and to be aware of their personal leaning progress and performance.

A brief comparison between existing dashboards can be find in [37]. This paper briefly introduces learning dashboards such as; Moodle dashboard, LOCO-Analyst, SAM, StepUp! CourseVis, GLASS, OLI dashboard, Student Inspector, Tell Me More, etc. The study shows how these learning dashboards support teachers and students and the potential of these learning dashboards for improving.

All these dashboards are able to collect the data and by using learning analytic tools, analyze the data and provide statistic visualizations of the results for teachers. Also, based on my research there are a few mobile learning dashboards (described in chapter 4) that can be used by students and teachers. But none of them are not good enough to help teachers to track their students in learning, and allow teachers to give students quick feedback on their performance. As I realized in the research in this area, there are not any mobile learning dashboard that supports xAPI specification. Therefore, I am going to investigate on need of a mobile learning dashboard which supports xAPI specification. The reason that this thesis is focusing on xAPI is that, this standard in new and covers recording any learning experience anywhere and anytime it happens.

3 Research Methodology

In this section the methods that are used are explained. The first method that is used is documentary review which is collecting data about a particular subject for understanding its pattern, regularities and also used in investigating and categorizing physical sources [38] [39]. It is also used to analyze the documents that contains information about the subject that we are going to study. The main usage of documentary review and analysis is in the literature chapter were it helps to support and validate the facts founded in the research. Documentary review helps the researcher to understand the lacks and gaps in a particular area.

The next one is survey methodology. This method studies the sampling of individual units from a population. For data collection, some of the survey techniques used include questionnaires. In the survey methodology the data can be collected in different ways: 1) asking people questions 2) having interviews and recording the answers or people read the questions and record their own answer [40]. This method will be used in this project to see the teachers need and requirements in the mobile learning environment and how much they are engaged with the eLearning technologies. The use of learning technologies and its impact on teachers' teaching.

3.2 Data Gathering

On the most important part of the data gathering in this thesis is interview with teachers. As it was mentioned before the focus of this thesis is to investigate on the potential of learning technologies' standards to enhance learning experience. Therefore, in this thesis there will be an investigation on teachers' awareness of eLearning technologies with focus on possibilities to use data from digital learning environments to better support students. For this purpose, I have decided to have semi-structured interviews with teachers to find out, from teachers' perspective:

- Importance of students' learning experience
- The current use of eLearning technologies
- The use of learning analytics results in their teaching
- Their requirements of a learning technologies
- The kind of information that teachers would like to know about their students

3.3 eLearning Technology Experimental Setup

Another method which will be used in this thesis is experimental setup of eLearning technology to investigate:

- How the learning experience of the students can be shared between LMS and an external LRS.
- What kind of data can be shared between LMS and LRS?

A learning environment setup under consideration involves a LMS, an external LRS, and a mobile learning application. Figure 15 shows the idea of the setup. What we are looking for is to connect three learning technologies (LMS, an external LRS, a mobile learning application). The plan is:

- To create a course in a LMS which is supported by xAPI specification
- Connect the LMS to an external LRS by using the required plugins
- Manage the learning records in the external LRS
- Finding a mobile learning application like a dashboard for supporting the teachers
- Connect the mobile learning app's LRS to the External LRS
- Pushing and pulling the learning experience between the mobile learning app, LRS and LMS

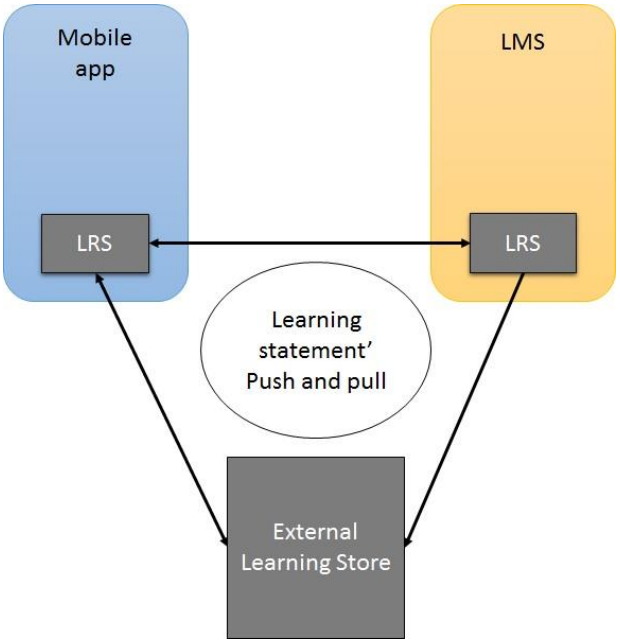


Figure 15 Experimental setup

The mobile learning application will be working as a dashboard to get the xAPI statements form the LRS and LMS. The dashboard has a set of tools which are able to show the process of learning activities. For example; the number of students' login, course schedule, students' time spend on a course etc. more details about the dashboard will be explained in the next chapter.

3.4 Designing Mobile Solution

3.4.1 Principles of Human-Centred Design

Human-centred design (HCD) [41] is based on the physical and psychological needs of the users. In HCD, researchers and designers attempt to cooperate with or learn from potential users of the products or services which they are developing. Their goal is to develop products or services that match users' practices, needs and preferences.

The International Organization for Standardization, ISO 9241-210 specifically recommends six characteristics of HCD:

1. **Explicit understanding of users, tasks and environments**

HCD requires understanding the reality: identifying all relevant users, stakeholders and other people who might be involved (directly or indirectly) and their needs. One of the reasons that cause systems failure is lack of understanding about the users and their needs. Context provide the scope where the products are used and accessible. Context of use is about identifying the characteristics of different types of users (different levels of experience), the tasks and the environments that the users are going to perform the tasks in. The environment includes hardware and software and any other materials that are used. It is important to understand and identify the details of this context in order to manage early design decisions, and to provide a basis for evaluation.

2. **Involvement of users throughout the design and development**

By involving the users in design and development of the system, lots of information will be provided about the context of use. People who are involved in the design should have the experience, capabilities and characteristics that can present a range of users that are going to use the system.

Users involvement in system design has many benefits: it improves the system quality arising from more accurate user requirements. The level of acceptance of the system will improve. It will prevent the costly system features that user do not use. Greater understanding of the system by the users' feedback.

3. **User-centred evaluation drive and refine the design**

Evaluation play a critical role in HCD. When the design problems are detected earlier, it is easier to correct them with a lower cost. Therefore, evaluating earlier protocols are highly recommended. By testing a prototype is possible to gain the effectiveness of each component of the complex system.

4. **Iterative process**

Iteration have to be implemented during the development of a system. In this way it is possible to eliminate serious mistakes and to reduce re-implementation time, since the first design is based on experimental knowledge of user behavior, needs, and expectations. When the potential solutions are implemented in a prototype and if it does not meet determined requirements, the process will be iterated again until the requirements are met.

5. **The whole user experience (UX) is addressed in the design**

The primary goal of any product is to provide useable functionalities to allow people to perform their tasks. We have to make sure that these tasks are pleasurable as well. UX involves the effectiveness, functionality, performance, etc. of a system. In designing a common system, the previous users' experiences have to be considered. Design decisions are based on numerous factors including relative capabilities and human restrictions against technology with respect to, e.g., speed, accuracy, and flexibility.

6. **Multidisciplinary skills and perspectives of design team**

It is not important how large the HCD team is, but the team should contain different types of designers with different skills and viewpoints, ranging from human factors and system design, over product design and marketing, and up to business analysis. There are some benefits for projects such as creativity and new ideas from collaboration of the team members, and their awareness of the constraints and disciplines.

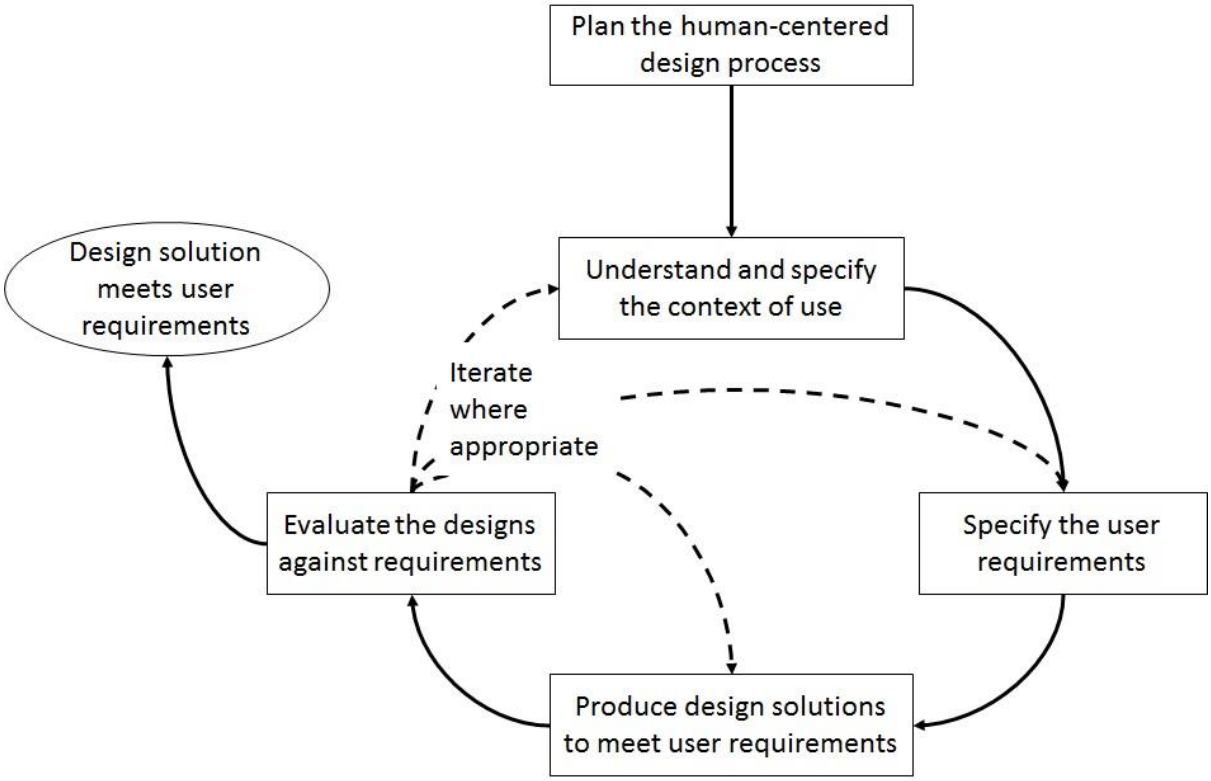


Figure 16 Human-centred design activities [41]

Figure 16 illustrates the HCD activities.

1. **Understanding and specifying the context of use:** in this stage the characteristic of the users, their actions and the environment that they are going to perform the actions must be identified. In this stage all the potential users must be identified (individuals and stakeholders). The characteristic of the users such as; their knowledge, skills, experiences, physical attributes etc. The goals and tasks of the users and the system. All the possibilities that might have a consequence for health and safety and any risks that might cause problems for the tasks. The environment that the users are going to perform their tasks and actions like; hardware and software.

2. **Specifying the user requirements:** in designing any application and systems identifying users' requirements is one of the major activities. Based on the HCD, there must be an explicit statement about the users' requirements according to the context of use. In this stage the designers must identify what the users want to achieve and also the users' functional and non-functional need.

3. **Producing design solutions:** design solutions have a great impact on the user experience. Based on HCD, the design solutions help designers to get a good user experience. The designer can identify the users' tasks, their interaction and interface.

4. **Evaluating the design:** evaluating the design is a required activity in HCD evaluation. In every stage of the design it can be evaluated to help designers to have a better understanding of the users' need. Designers by creating paper and clickable prototype can test the system with users to find out about the design strength and weaknesses. The designers can get positive and negative feedback from the users which helps them to improve their design as advanced as possible.

4 Testing and Evaluation on Integration of LMS and LRS

After all the research on the xAPI statement and knowing about its interoperability with LMS and how the data is collected and stored in LRS, it was time to see how this interoperability is working in practice. For testing the integration of the LMS and LRS, Moodle learning system and Wax LRS[1] have been used in our experiment.

Moodle is the world's most popular LMS, it is free to use, highly-flexible, feature-rich and open source. Based on Moodle statics written in Moodle website it has 86,239,422 users in 229 countries. For this thesis, the most important aspect is, its support for xAPI specification. Wax LRS is also based on the Experience API. There are other LRSs that are based on xAPI like; Watershed[2], ADL LRS[3], Learning Locker[4]. Wax LRS was chosen for this implementation because it is very easy to install and use.

In order to store xAPI statements in an external LRS a plugin called Logstore[5] was needed to be installed in the Moodle LMS. For connecting the LRS to Moodle three piece of information were required to be added to Logstore plugin configuration; LRS endpoint, username and password. This three information can be found in each LRS settings. LRS end point is a fixed URL (Uniform Resource Locator), but the username and password for every learning environment must be generated by LRS.

After connecting the Moodle to external LRS, I have created a course in Moodle and enrolled some students as it is shown in figure 17. Each time that the students, login to the systems

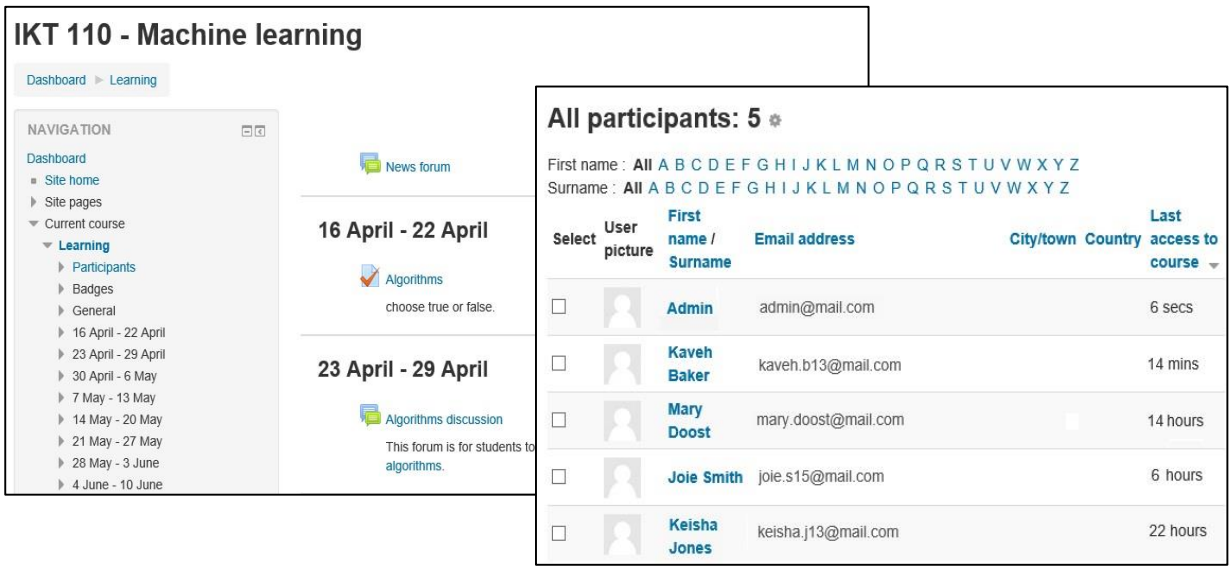


Figure 17 Moodle course and participations

[1] http://www.saltbox.com/
[2] https://www.watershedlrs.com/
[3] https://lrs.adlnet.gov/
[4] https://learninglocker.net/
[5] https://moodle.org/plugins/logstore_xapi

and they start taking actions like, viewing a document, watching a video or submitting an assignment, their activities are storing in LRS, based on xAPI standard.

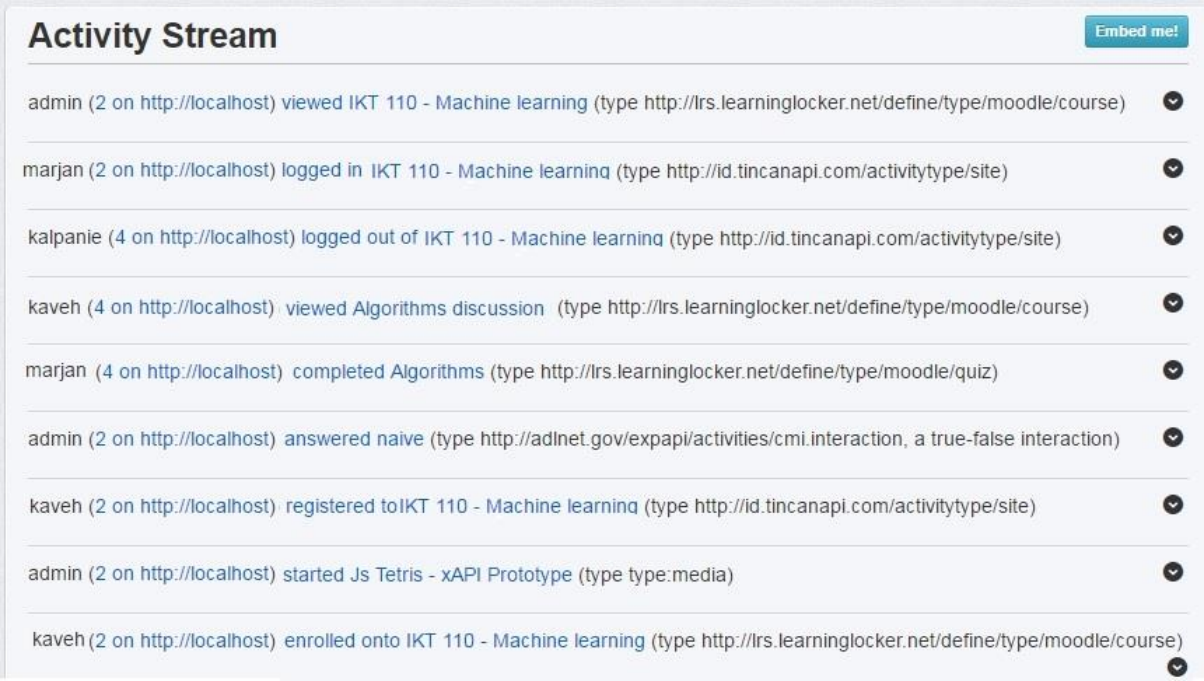


Figure 18 Activity Stream of the activities

On the other hand, the LRS provides some reports and analysis of the activities that it receives from the LMS or any other learning environment. Figure 18 shows the activity stream of the students. The activity stream presents enrolled students' activities done in the Moodle LMS. As it is illustrated the activities are based on simple xAPI statement, "Actor, Verb, Object" e.g. Kaveh registered to IKT 110 – Machine learning. let's look at one of the activities in more details.

As it is shown in Figure 19 every activity contains detail such as the time of activity, which language is used, where it is stored and from which learning environment the activity comes. Also, the JSON code can be seen in the details.

If we take a look to this experimental setup, we can see that all the students' activities can be collected based on xAPI specification, and can be stored in a LRS. All the data about students' activities are generated and displayed in the LRS. But how this information can be used by teachers, how this information can help teachers to know about their students' learning experience.

Here comes the mobile learning solution. Existence of a mobile learning dashboard which is able to be connected to this external LRS (which could have all the students' learning activities from different learning environments) is needed. The mobile learning dashboard is able to pull xAPI statements from a LRS and provide visual results of students' learning activities that help teachers to better follow their students' learning experience and give students quick feedback anywhere and anytime.

kaveh (5 on http://localhost) viewed Algorithms discussion (type http://lrs.learninglocker.net/define/type/moodle/forum)

grouped with testbed (type http://id.tincanapi.com/activitytype/site), IKT 110 - Machine learning (type http://lrs.learninglocker.net/define/type/moodle/course)

using the language en

taking place at 2016-04-25T15:19:46.000000Z

stored in this LRS at 2016-04-25T15:19:47.651587Z

(This statement's id is 47e09298-ac16-4443-84de-25f18a02f6ab)

Raw JSON


```
{
    "verb": {
        "id": "http://id.tincanapi.com/verb/viewed",
        "display": {
            "en": "viewed"
        }
    },
    "timestamp": "2016-04-25T15:19:46.000000Z",
    "object": {
        "definition": {
            "type": "http://lrs.learninglocker.net/define/type/moodle/forum",
            "extensions": {
                "http://lrs.learninglocker.net/define/extensions/moodle_module": {
                    "completiondiscussions": "0",
                    "course": "3",
                    "blockperiod": "0",
                    "assesstimefinish": "0",
                    "id": "3",
                    "introformat": "1",
                    "scale": "100",
                    "trackingtype": "1",
                    "completionreplies": "0",
                    "type": "forum",
                    "forcesubscribe": "0",
                    "displaywordcount": "0",
                    "assesstimestart": "0",
                    "warnafter": "0",
                    "rssarticles": "0",
                    "assessed": "0",
                    "name": "Algorithms discussion",
                    "url": "http://localhost/mod/forum/view.php?id=5",
                    "blockafter": "0",
                    "maxbytes": "512000",
                    "intro": "This forum is for students to discuss their findings about the machine learning alg
orithms.",
                    "maxattachments": "9",
                    "rsstype": "0",
                    "completionposts": "0",
                    "timemodified": "1461597002"
```


Figure 19 Activity stream details

5 Designing Mobile Dashboard

5.1 Portfolios and Learning Dashboards

A learning dashboard is a tool for supporting the teachers and students in virtual learning environment. Dashboards provide a visual graphical view of the students' learning activities. The visualization helps teachers to track the progress and performance of their students. Also, help the teachers to have a better overview of the course activities.

According to [37], learning dashboard are about awareness, reflection, and sense-making and impact, as illustrated in figure 20.

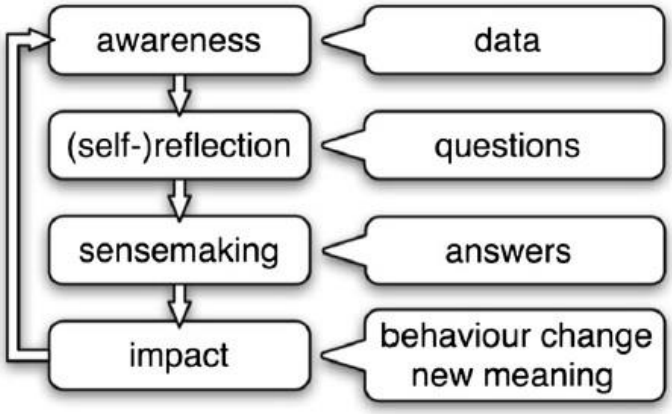


Figure 20 Learning analytics process model [37]

The awareness is about data visualization like, leaning activity statistics presented as tables and charts. The reflection is about users' asking questions and trying to understand how the data can be used. Sense-making is about the questions and answers in reflection stage which leads the users to come up with new ideas. Finally, the impact of the previous stages on users to change their attitude in learning if it is helping them to improve.

5.1.1 Dashboards that Support Face-to-Face Interactions

There are many different dashboard applications that support face-to-face lectures. These applications are designed to be used inside the class room to help teachers to know about the interactions of their students. For example, in [42] a new learning system has been developed and introduced. This learning system recognizes the behavior of students by tracking their movement and voice using the camera and microphone of the PC. It is able to get the social signals (stress, politeness, and disagreement) of the students inside a smart classroom. These signals can help teachers in their teaching process.

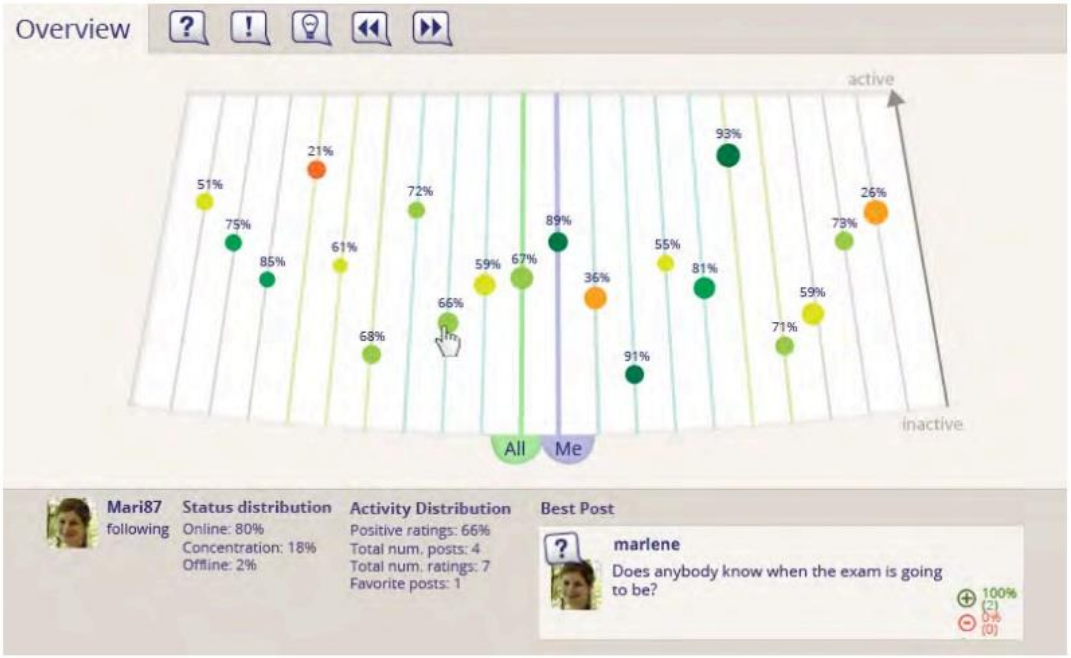


Figure 21 Backstage system [42]

Backstage [42] is another application which is used to visualize Twitter activities of the students during the class. Each student can see his/her own Twitter activity and compare it with its peer's activities. As shown in figure 21 the blue line shows the activity of the student who is using the system and other nodes are presenting the rest of the students in the class. Also, the green line which is labeled "All" shows the average activities in the class.

Another useful system is called Classroom Salon[1]. This system is developed to help teachers upload their course materials such as, documents and videos. When the students are joined to the salon, they can see the materials, comment on specific word, sentence or the documents and videos. Classroom Salon helps teachers and students in many ways. Teachers and students can assess their courses by using:

- Creative interface: Classroom Salon has a great tool to set and assess the courses.
- Workflows: Classroom Salon also helps students to build social discussions about their learning content and it allows them to learn from others. It allows students to communicate with their own self-organized networks
- Algorithms: Classroom Salon uses analytics more than similar platforms. It has the analytics to go through entire course and find out about the students' contributions for example; the analytic tools are able to find "hotspots" for discussions and videos for better understanding.

Another type of dashboards that are used by teachers are face-to-face group work dashboards. These systems are used to identify the group activities in the class. This allows teachers to see and manage real-time classroom activities. TinkerBoard [43], Collaid [44]

[1] www.classroomsalon.org

(collaborative learning aid) and Class-on [45] are the examples of face-to-face group work dashboards. These systems are able to track groups collaboration on tabletops and provide a visualization of the activities. Tabletops are computer interfaces that are placed on top of a table and it is able to capture several users' activities simultaneously. The results will be displayed in large screen to help teachers to be aware of the group work performance. This kind of dashboards are equipped with tabletop, microphone and a sensor to capture physical activity of students.

5.1.2 Dashboards that Support Online Interactions

This kind of systems are supported in learning management systems such as, Moodle, Canvas[1], Blackboard[2]. Moodle is a LMS that is known for its good features, flexibility and ease of use. In [46] a dashboard for Moodle Learning management system has been developed for lecturers. The dashboard designed for Moodle shows general data about the course, short and full name of the course, name of the students, an overview about students' current and predicted process.

Online or blended learning dashboards have many benefits for both students and teachers. Students can see their progress and performance during their learning process. Students can compare their progress with other students. They can see what they have done to achieve the goal that their teacher has defined for them. Teachers can see various analytics of the students' activities. There is a possibility that teachers could see the social activity of students to identify the students who are not very connected to other students. Dashboard analytics by providing hourly and daily reports can help teachers to track their students' activities. It gives teachers a good overview about what students know, how many of them logged in, watched the videos and participated in different learning activities.

An early interesting mobile dashboard for supporting students in learning forums is called iTree [47]. This dashboard is an early example of a mobile learning dashboard that visualize the progress and performance of students by a tree. The activities of the students lead to the growth of the tree, figure 22. The activities include, students' post, number of replies to the post, the number of times the posts are read, the total number of posts and replies.

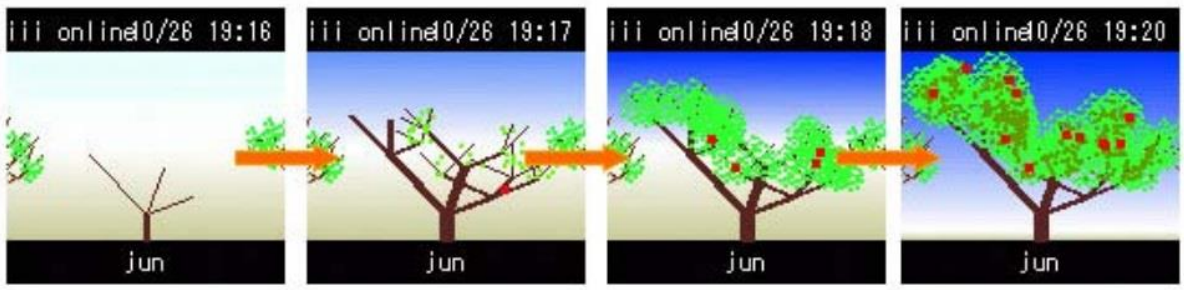


Figure 22 The growth of the tree based of students' activities [47]

[1] www.canvaslms.com
[2] www.blackboard.com

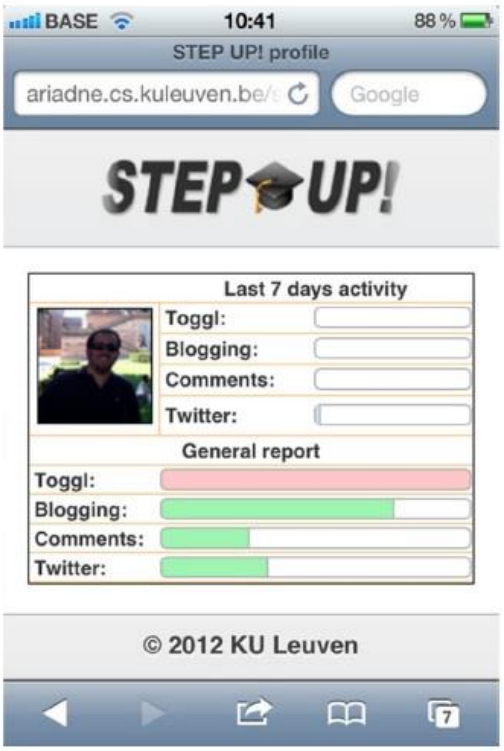


Figure 23 Student profile on StepUp! Mobile dashboard [48]

The StepUp! [48] is another learning dashboard which is in this category. StepUp! is an activity visualization tool for students. This mobile dashboard presents students' learning activities over a specific course. This dashboard provides information such as; students' comments about the course or replying to other peers, blogging and twitting the activities as shown in figure 23.

After investigation through existing learning dashboards and describing some of the dashboard in the thesis, I still could not find a mobile learning dashboard which supports xAPI specification. Through all these application, I only could find one application which supports xAPI specification. Some screen shots of this application is shown in figure 24. I tried to figure out how this application works. It seems that this application is only for creating the xAPI statement. When the user creates a xAPI statement, then the validity of the created statement will be checked. If the statement is based on xAPI requirements, then it will be stored inside the application LRS. After that, the statement details are available to see. It is a good application for making the xAPI statement. This application can be used by developers to create statements very easily, but this application cannot be used by teachers to enhance students' learning.

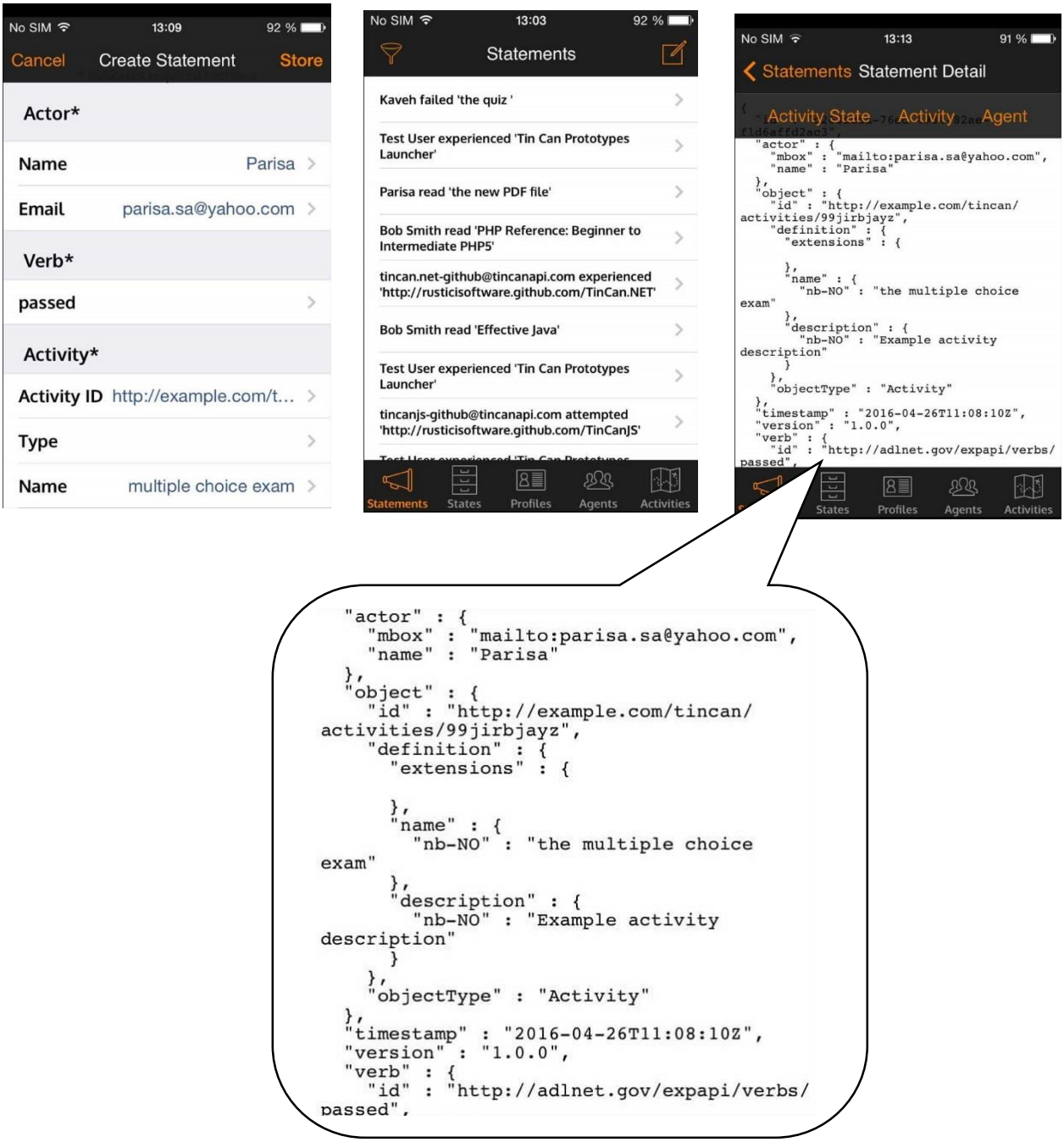


Figure 24 xAPI viewer application

5.2 Findings on Teachers´ Needs and Expectations

As it was mentioned in the methodology section of this thesis, semi-structured interviews have been carried out. The interviews include 10 teachers from different areas, 5 teachers in information and communication technology, 3 teachers in institute of global development and community planning, 1 teacher in engineering and science and 1 teacher in mathematics didactic. The interviews took place at University of Agder (Campus Grimstad and Kristiansand) figure 25shows two interview sessions in campus Grimstad. In total there were 20 interview questions. The questions were divided into four sections; LMS, learning experience, mobile learning and learning analytic tools, 5 questions per section.

Learning Experience

1. What the teachers know about learning experience?
    a. If they know, how they define the learning experience?
    b. If they do not know, what is the reason? Do they care about it?
2. What aspects of the learning experience do they care about more?
    a. Is it student's participation?
    b. Is it students' activity in reading notes?
    c. Is it students' answering questions?
3. What are the most interactions they care about more?
    a. Students' interaction with other students through forums?
    b. Students' interaction with learning materials?
    c. Students' interaction with the teacher?
4. What data the teachers would like to know about learning experience of the students?
    a. Their progress and performance?
    b. Identifying the students who are at risk?
    c. Evaluating the students according to their performance?
5. What they think can help to know in terms of learning experience/performance/progress?

Learning Management Systems

1. How teachers are interested to follow their students in learning?
2. What is the teachers' opinion about the learning management systems?
    a. What systems they have used?
3. What teachers know about the possibilities of the LMSs they are using?
    a. If they know, what the options?
    b. If they do not know, why they do not know?
    c. Would they like to know?
    d. How they would like to know?
4. How they use the LMSs?
5. What kind one LMSs they prefer to use?

Mobile Learning

1. What the teachers know about the mobile learning?
2. Have they ever used any mobile learning application?
    a. What was it?
    b. How was it?
3. What was its impact on student performance?
4. Do they like to use it?
5. Do they like to include mobile learning components to their teaching? Components such as:
    a. Prioritizing pedagogy over technology
    b. Easy-to-Use, Intuitive Navigation and User Interface
    c. Access to Multiple Content Types

Leaning Analytics

1. What teachers know about the leaning analytics?
2. How they think it may help their teaching?
3. What the data about the students they would like to be analyzed?
4. Are they willing to use the result of the learning analytics in their teaching?
5. Have they ever used any analytics system?
    a. What was the system?
    b. What was its impact on their teaching?

In each session I have used my mobile phone to record interview. Then I transcribed all the interviews and coded them for farther analyzes.

Figure 25 Interview with teachers

First section of the interview questions was about learning experience. Teachers were asked to give a definition about learning experience. They give different definitions about learning experience, but generally they all come up with the idea that learning experience is about activities that help students to learn something. Let's look at some definitions given by teachers:

- Learning experience is about engagement. They have to be engaged with all the materials and tools they use for learning

- The way of gaining knowledge and be able to use it
- Leaning experience means the satisfaction level, if the students are satisfied with the learning or not. If they do not get a good mark at the end, it is important that at least they have learnt something.
- Every activity that students do to learn something, like downloading a video to watch, asking from others, reading an article etc.
- Pedagogical approaches, social interactions, resources learners are using, physical and virtual environments.

According to the interview with teachers, they all mentioned their interest about following their students. Some of them think tracking students' activities is a key aspect of being a teacher and the aim of being a teacher is to make your students to learn something and then to be able to track their activities to make sure that they are learning. Figure 26 shows the most important aspects when it comes to tracking students' activities.

Figure 26 Aspects of tracking students' activities

Learning experience is about interaction, any interaction that help students to learn something. Based on the research for this thesis, I can consider interaction of the learners in

three parts; 1) interaction between learner and learning materials 2) interaction between learner and other learners 3) interaction between learner and teacher.

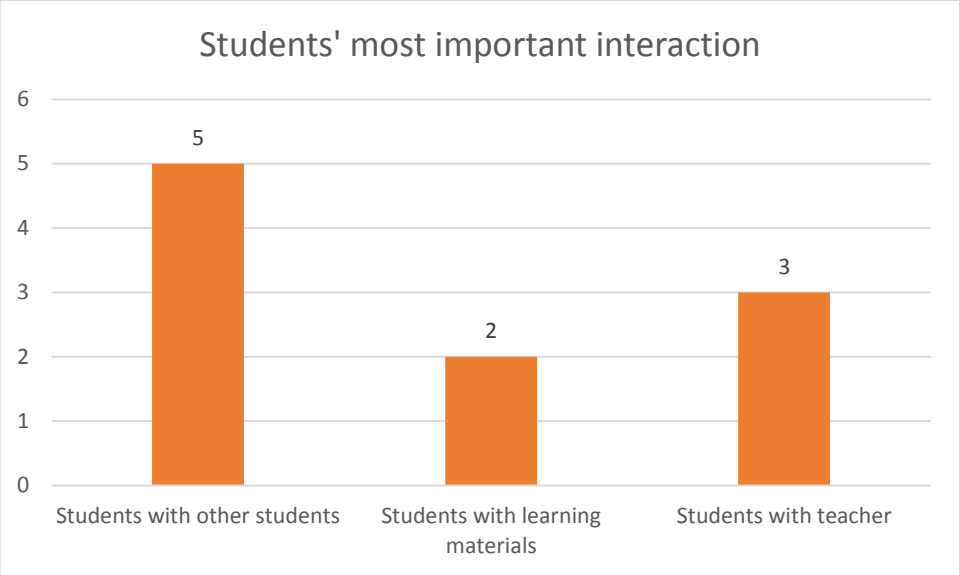


Figure 27 Students' most important interaction

The teachers were asked about the most important interaction that students have which helps them to gain more learning experience. Figure 27 shows the result of the question. 5 out of 10 teachers think that students learn more when they communicate with other students. 5 out of 10 teachers agree that, they as teacher provide every learning material for their students to help them understand things very well. But from their experience, maybe some of the students do not learn so much during the lectures. Therefore, these students try to ask for help from other students which is the most common way to understand course materials. 3 teachers think the interaction of students with teacher is very important. In their opinion, the interaction of the student with them as a teacher helps them to understand the difficulties of the course. Teachers can understand if the students are following them in course or not. Learning material was mentioned about the most important interaction with 2 out of 10 teachers. They believe that first of all students receive the learning materials and start to understand it. But when students face a problem or have any questions, they start communicating with their teachers and classmates.

eLearning is opening new ways in education and teaching. LMSs are one the most popular tools by the educational institutes, teachers and students. One of the most important features of these tools is in tracking students' activities, such as; the number of visiting the course, the number of comments, the number of downloading videos etc. I asked teachers about how they track their students in learning. As it shown in the figure 28, the results were really surprising. 4 out of 10 teachers were using LMS to follow their students. Among these 4 teachers only 2 of them knew about the possibilities of the LMS very well. 2 other teachers were not good at using LMSs and they were not familiar with the options of these tools. They just used LMS because they were asked to use it. 4 out of 10 teachers were not following their

students by LMSs. They preferred to have face-to-face interactions with students. For example, asking questions from students during the course to get some feedback about their learning or to check their exam papers to see their strength and weaknesses. 2 out of 10 teachers were tracking their students' activities by their own developed systems. The reason is that it gives them more control over the system and they can apply their requirements to these systems. Since the use of LMSs can make some of the tasks easier for teachers, they should be engaged with these systems to facilitate management of courses, exams, feedbacks and tracking their students' activities. But the results are showing the lack of knowledge among teachers about the potential of LMS.

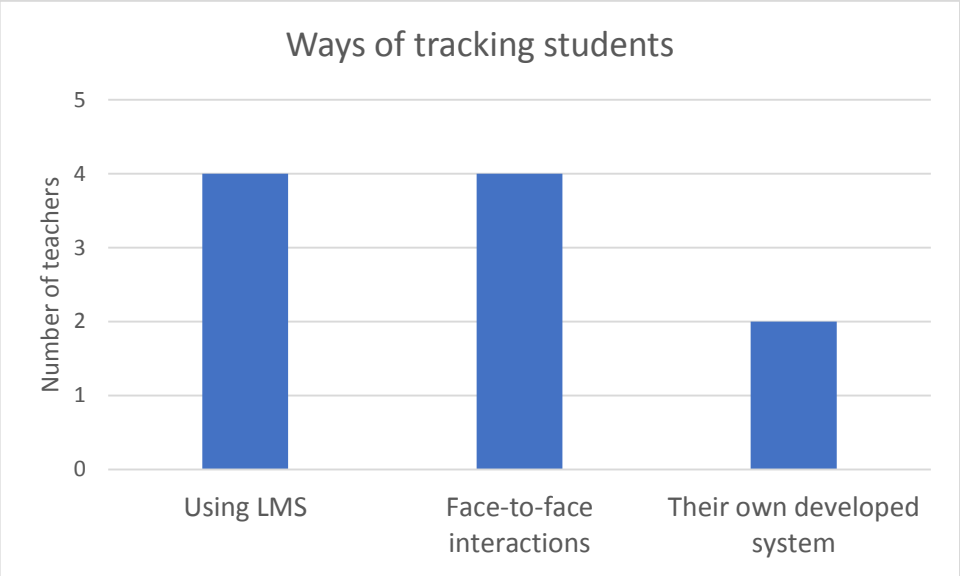


Figure 28 How teachers follow their students in learning?

Since one of the aims of this thesis is to investigate the potential of xAPI standard in mobile learning, the teachers were asked about mobile learning applications. First, they were asked about the opinion about mobile learning and how it can help them in their teaching. Teachers said their ideas about mobile learning. For example, they mentioned that it can be used by teachers and students anywhere and anytime. Mobile learning helps teachers to give feedback to students quicker. Mobile learning can help teachers to give feedback to students when the teacher is on travel or not in the office or when they are not near their computer. But maybe mobile learning is not a good idea for the areas with poor facilities and internet connection. One of the teachers said that mobile learning brings in some elements that are very close to the physical experience where you touch it. So mobile technology can be very useful in learning. Mobile learning may change in number of ways. Also they think there are developments toward mobility, there are attempts to establish mobile platforms in learning, but maybe it is not very advanced.

With all these comments and ideas about mobile learning, then I asked them if they have ever used a mobile learning application in their teaching. The answer of 8 out of 10 teachers were "No", they have never used a mobile learning application. 2 out of ten teachers said "Yes",

they have used mobile learning application on their teaching but it was just a small test. From the teachers' answers about mobile learning I understood that they have never used or seen any mobile application which they can use to follow their students' learning activities. Some of them have searched about mobile learning applications but none of them fulfilled their requirements. Here comes the fourth section of the interview questions. In this section, I asked the teachers about their requirements and the data that they want to know about their students.

- Composition of discussion threads
    - Number of posted messages, argumentations, help seeking or a question
- Students' activity trends during the whole course
- Level of competence between students
- Students' answers to the projects
- What materials students' use, what they skip, what they review again and again
- The time that students spend on each course
- How much help they get from other students
- The quality of their activities
- Students satisfaction level
- When students log in
- what documents they are looking for, what documents they have read
- A tool for managing the comments

5.3 xAPI Statement Design Based on Teachers' Need

Each xAPI statement is used to describe the tracked learning experience. After having the interviews, we find out the teachers' requirements and what data they need to be tracked about the students' learning experience. So, it is the time to design the xAPI statement. According to teachers' need, some of the required can be shown as xAPI statement in Table 4.

Table 4 xAPI statement examples based on teachers' requirements

Actor	Verb	object
Sara	Posted	30 messages to the forum
Nelly	Reviewed	Lectures on week 34
Sam	Logged in	To the room at 10 am
John	Looked for	Papers about graphic design
Kevin	Pressed	Satisfactory button level 5
Tom	Asked	Other students about exercise 1
Ashton	Reviewed	Video about security

In the following there are two JSON statements based on example in table 5.

1. **Sara posted 30 messages to forum**


```
{
  "actor": {
    "mbox": "mailto: sara@mail.com",
    "objectType": "Agent"
  },
  "verb": {
    "id": "http://adlnet.gov/expapi/verbs/posted",
    "display": {
      "en-US": "posted"
    }
  },
  "object": {
    "id": "http://localhost /activities/ ",
    "definition": {
      "name": {
        "en-US": "msg"
      },
      "description": {
        "en-US": "30 messages in the forum"
      }
    },
    "objectType": "Activity"
  }
}
```


2. **Ashton reviewed video about security**


```
{
  "actor": {
    "mbox": "mailto: ashton14@mail.com",
    "objectType": "Agent"
  },
  "verb": {
    "id": "http://adlnet.gov/expapi/verbs/reviewed",
    "display": {
      "en-US": "reviewed"
    }
  },
  "object": {
    "id": "http://localhost /activities/ ",
    "definition": {
      "name": {
        "en-US": "video"
      },
      "description": {
```

```
            "en-US": "video about security"
          }
        },
        "objectType": "Activity"
      }
    }
```


5.4 Conceptual Model

Conceptual model a is visual description of a system which shows how a system works, what would be the possibilities of the system. A conceptual model will help individuals to understand what a system is designed for and simulate the actions of the users and system. Usually the model contains blocks that presents the users' actions that they face while they use the systems and the corresponding actions from the system. Also, the conceptual model should present the relationship between actions. Figure 29 shows the conceptual model for the proposed mobile learning dashboard for the teachers.

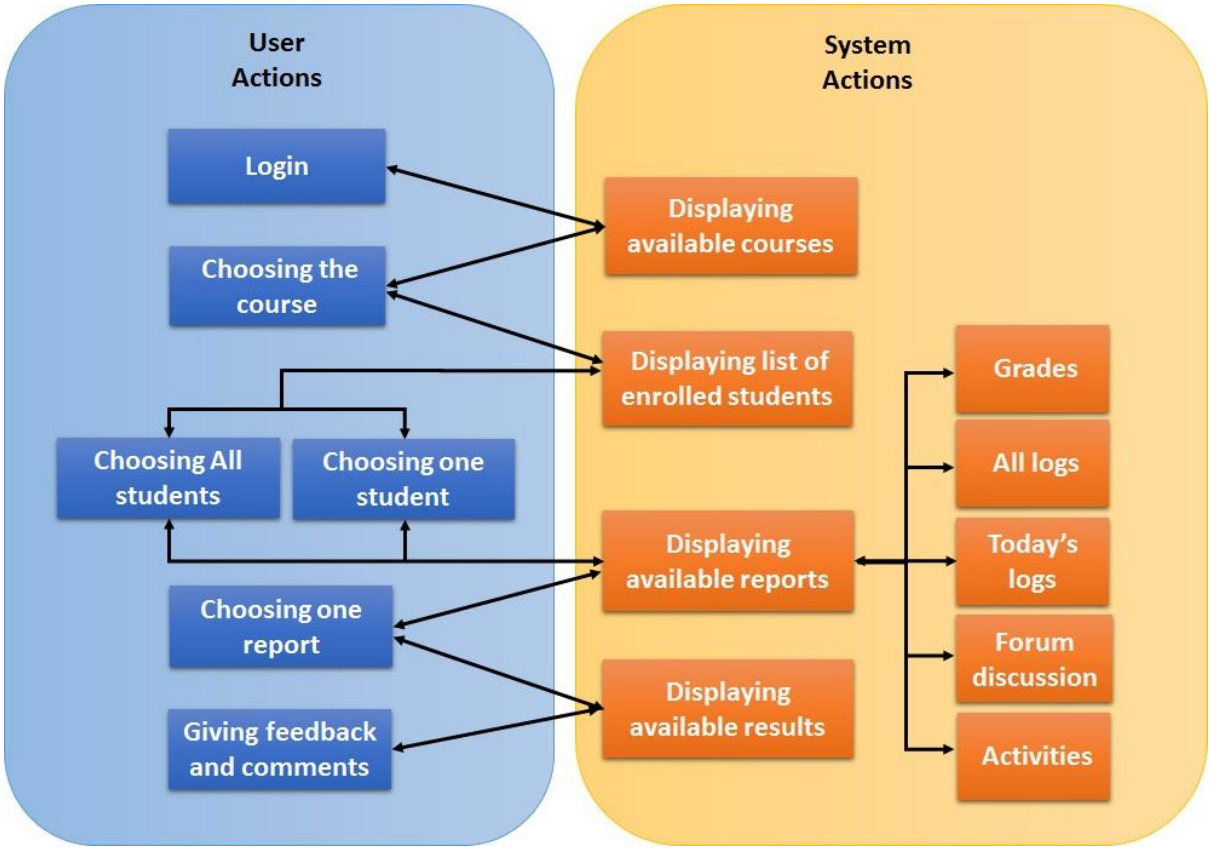


Figure 29 Conceptual Model

As it is illustrated in figure above first the users need to be logged in to the system. When the teachers, login they can see the list of available courses. The teachers who are teaching more than one course can choose a specific course and continue following their students' activities. After that, the teachers have two possibilities. They can choose to see the reports of all the students in the course or they can choose only one student and see individual results. Teachers can see the students' log activities during a day and during month. They can see

students' grades and for the assignments, quizzes, exams etc. and give students quick feedback on their results. Also, the teachers can see the students' verb activities, they can see what is the most used verb by the students. The teachers can go through the forum discussions posted by students to read about their ideas, comments and problem, other students' replies and the teacher can also reply to the students' comment. The teachers can see the number of posted discussion by each student. They can see students' activity trends during the whole course. In the student's verb activity result, teachers can see what students review and what they skip. What is students' preference, they prefer to watch a video or read a document. Teachers can see the for how long the students were logged in to the course room.

5.5 Scenario for Mobile Learning

I decided to design the dashboard as a mobile application because as far as I know there is no mobile learning solution which can help teachers to track their students' learning process. A mobile learning solution has some advantages like, it can be used anywhere at any time, the mobile device is portable, light-weighted, private, etc. Mobile learning is based on modern technologies that can help teachers to use it in their teaching.

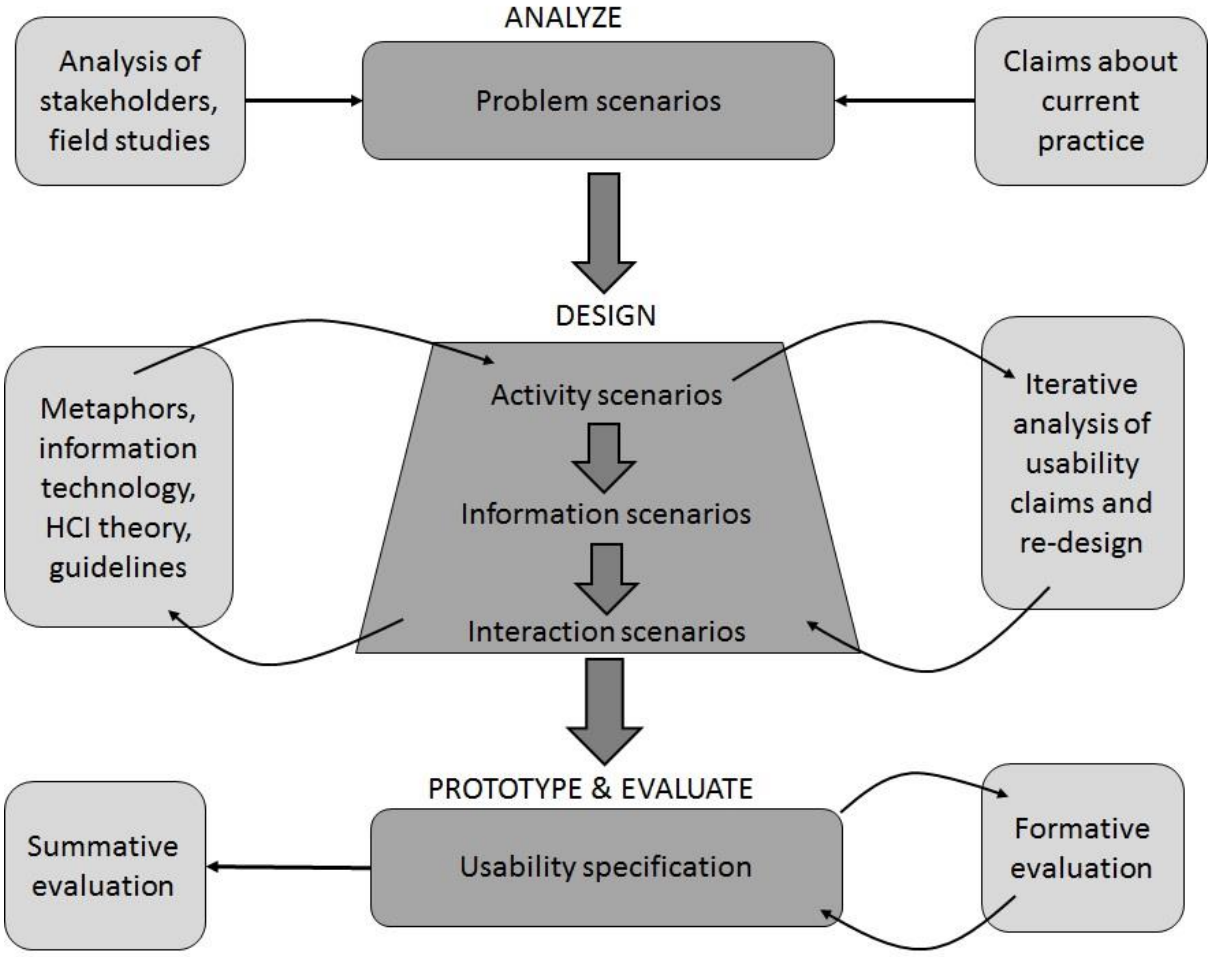


Figure 30 Scenario Design Based [49]

Scenario based design (SBD) [49] is one of the approaches in software design. SBD is a group of techniques that describe the use of a future system at an early point during the development process. SBD is a description of how a system is going to be used by users and how the system could be used to direct user's activities. An overview of the SBD is shown in figure 30.

First, the goal and the concerns of the current practice should be defined in the problem domain, then it goes to iterative design and evaluation process. A way to understand the analysis of the current situation is to communicate with the problem scenarios, such as; activity, interaction and information scenarios.

A Scenario is a hypothetical story to help designers to go through the application features and test system. In the following mobile learning dashboard scenario is presented and it highlights some of the application features and the way that it could be used by teachers.

Daniel is a 45-year-old teacher. He is very interested for new technologies to use in his teaching. Daniel was talking with one of his colleague about a mobile application which helps him to follow his students. Daniel's colleague suggested him to try Dashboard application for teachers. Daniel found the application in the university's website. Daniel installed the application on his phone and then he got a username and password from the IT section. He opened the application and inserted the username and password. After the login, Daniel could see the courses that he was teaching in the university. By clicking on each course he could see the enrolled students. In this page he could choose one specific student and then see all the reports generated for that student.

One they Daniel was in another university waiting for a conference to start. Daniel was checking his E-mail, then he saw an E-mail from one of his students, Joie in the graphic design course. In the E-mail, Joie mentioned that she is very surprised with her grade for the midterm exam and she thinks that there must be something wrong.

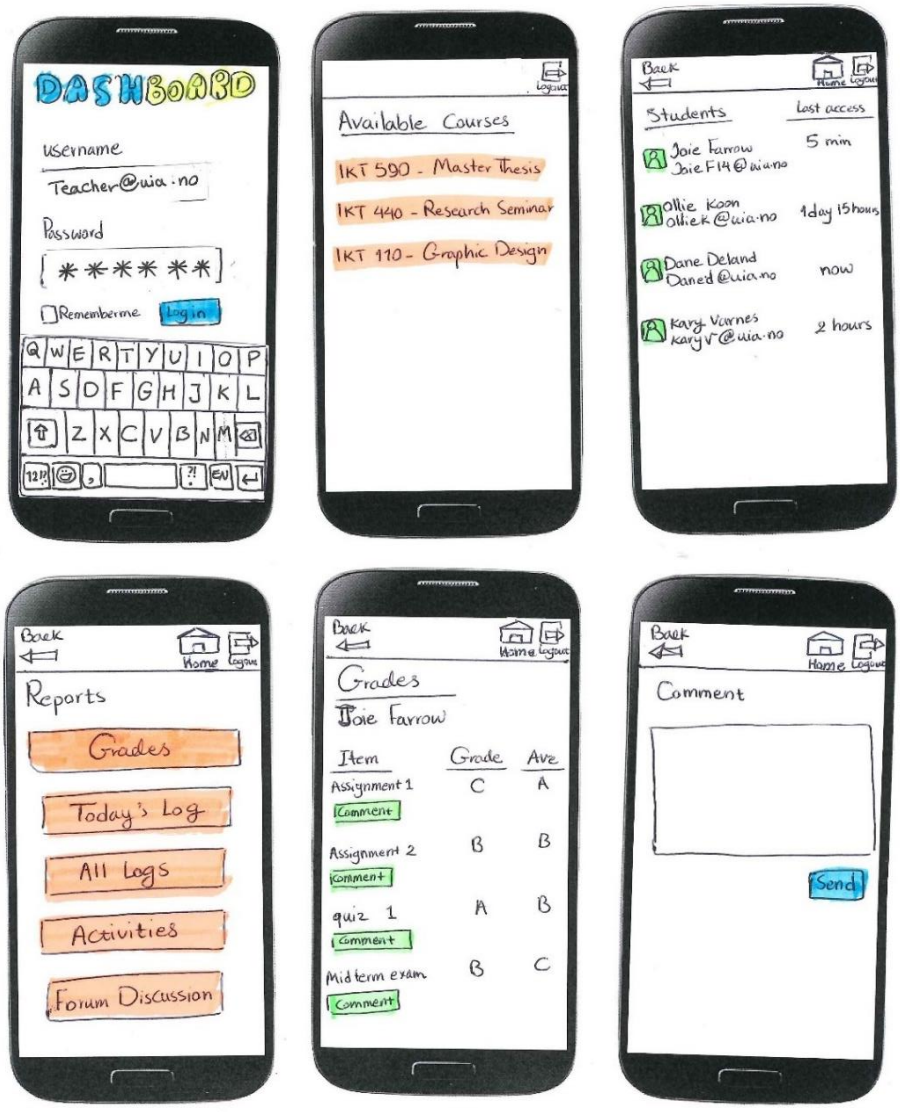
In that moment, Daniel open the dashboard application and in the enrolled students page chose Joie's name. Daniel was directed to the reports page of Joie. Daniel first checked Joie's midterm grade and the average grade for all the students. Joie got D for the midterm exam, while the average grade for this course was B. Comparing this two grades helped Daniel to understand that the rest of the students had a good understanding and performance on the midterm exam but Joie did not. Then, Daniel check Joie's activities for the previous month.

By looking at the Joie's activity chart, Daniel saw that she was very active and submitted all the assignments on time with a good grade. Daniel also checked the forums discussion of the Joie.

Daniel saw that Joie also was very active and she replied to her classmates many times and also she answered to their problems regarding to the midterm exam. By looking at Joie's answers, Daniel understood that she had a good concept over the course and maybe he made a mistake. Daniel pressed the comment button under the midterm exam in the Joie's grade page, then he directly sent her a comment. Daniel replied he will check her exam paper again when he is back to university.

5.6 Mobile Dashboard Design for Teachers

The designed dashboard contains pages, such as; log in, courses, enrolled students, reports students' grades, activities, forum discussions. First version of the paper prototype is shown in figure 31. A paper prototype is a usability testing technique. In this technique, designers create hand drawing of the application interface. It helps designers to test it with users and get new ideas and feedback before the interface development. Paper prototype is very cheap compare to developing and coding a prototype.



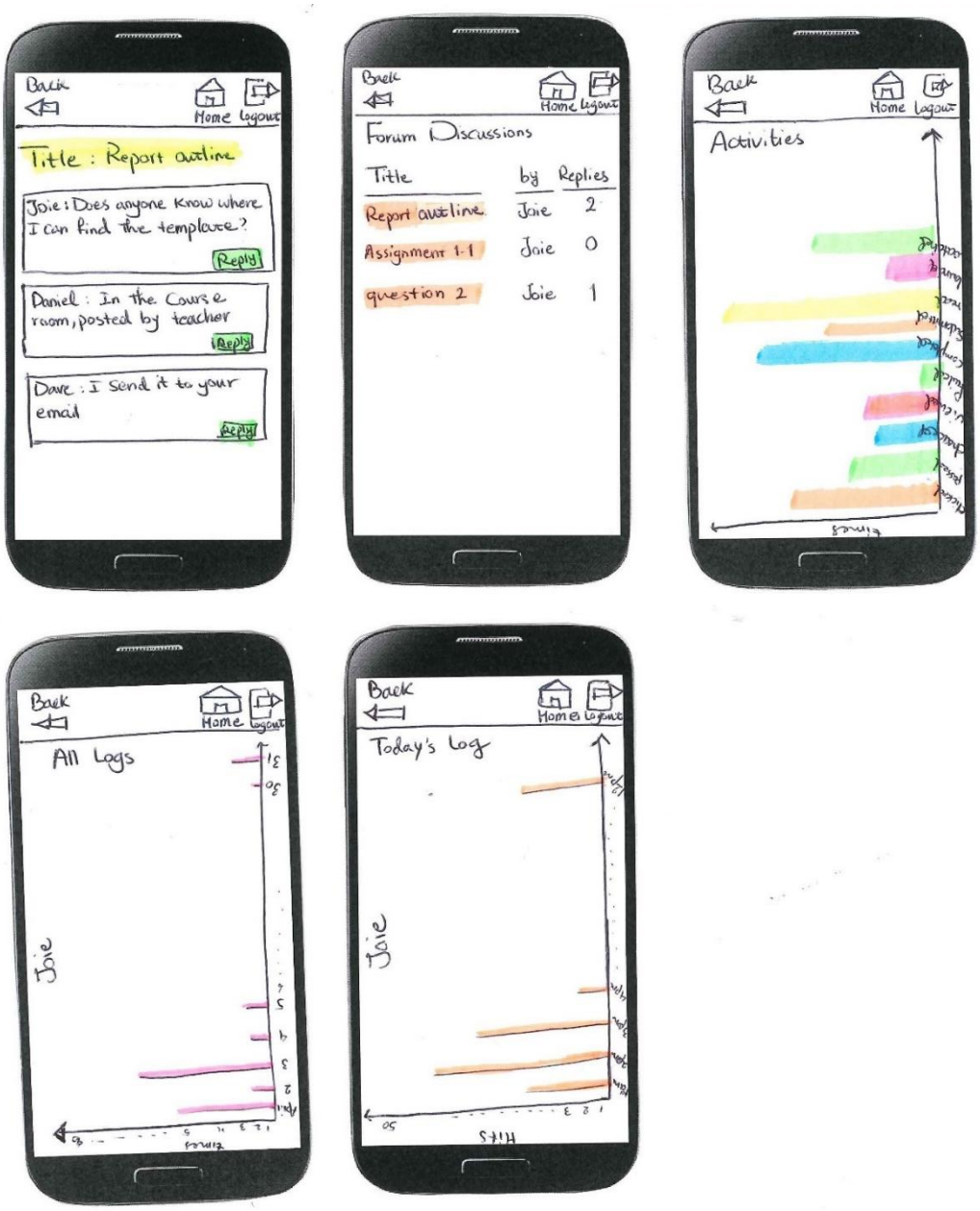


Figure 31 Application paper prototype

First teacher said, it is nicely designed and it is very good that teachers can see students' activities. He also mentioned that the students' activities help them to give students grade based on their effort during the course. He said that he is interested in a tool which is able to analyze the students' comments. For example, the system counts the number of words typed by the students, how many comments were short answers or how many comments were written in multiple line. The teacher also said that he would like to have a ranking algorithm for assignments in the application. Another option that the teacher wanted to have was students' feedback to other students. But he also mentioned that maybe the mobile phone is not a right device, because he would like to see the results on bigger screen.

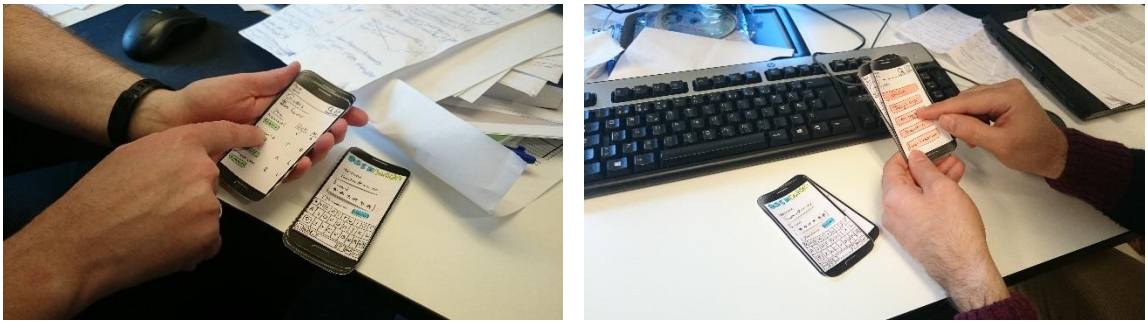


Figure 32 Prototype test by teachers

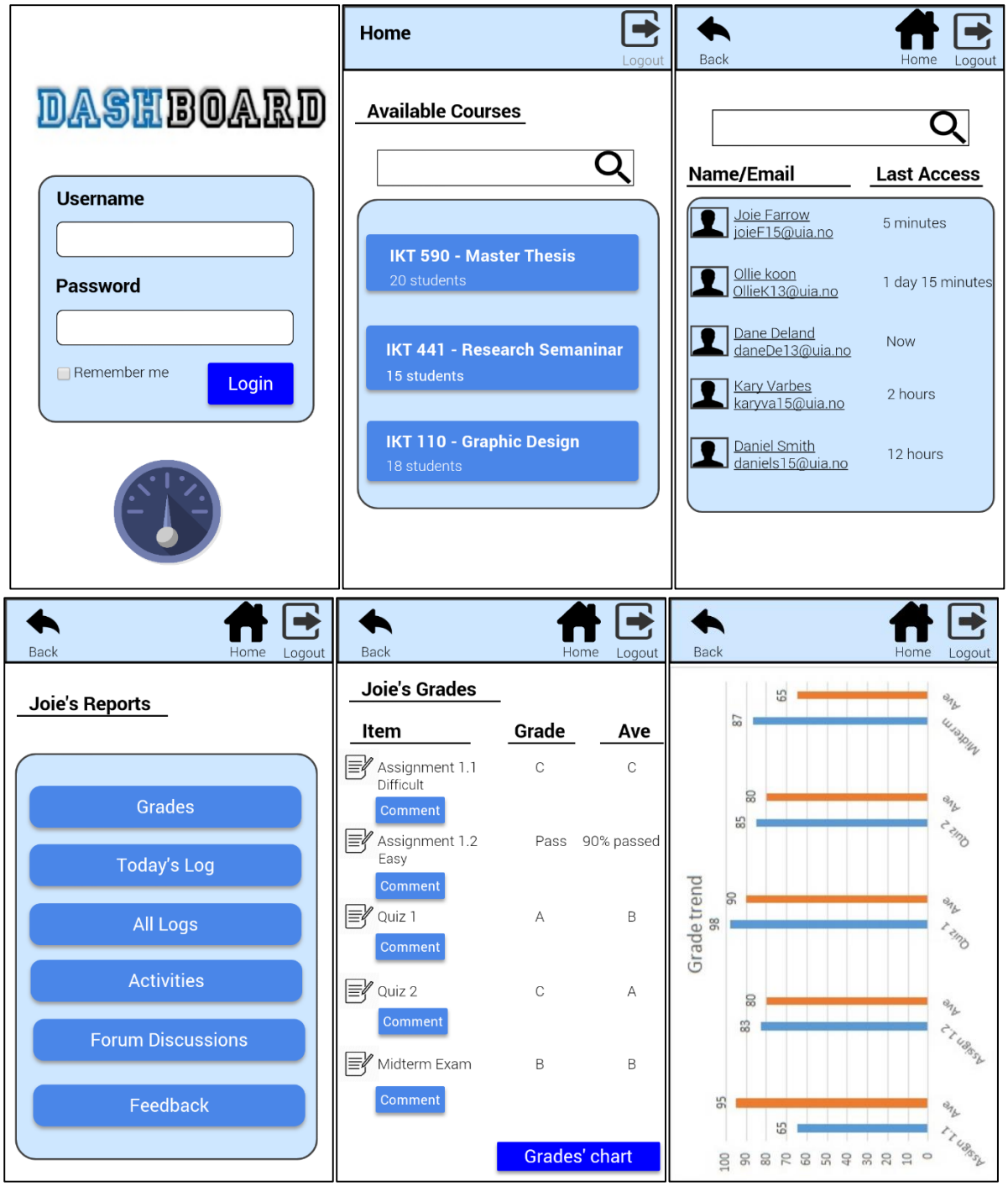
After designing the paper prototype, I have tested it with 5 teachers to get some comments about it. During the test, I observed teachers and take some notes. Figure 32 shows two prototype testing with the teachers. In the following there are teachers' comments on the paper prototype. Second teacher said it is a good application and he tried all directions of the paper prototype. The teachers suggested some comments, for example he said that it will be very nice to see the students' verb activities in pie chart. The teacher would like to see all his comments to a specific student by clicking on one button. The teacher also said he wants to see the students' grades trend in one chart. In this way the teacher can see the student progress in one semester. The teacher also suggested a search button inside the enrolled students' page to search for a specific student when there are a lot of students in the course. Another suggestion from this teacher was showing the number of enrolled students under each course in the home page.

Third teacher said that the prototype is well designed and he is interested to use such application. The teacher only had one suggestion, he said that it would be nice by clicking in the all logs activities to be able to see the details of each day. What has the student done in a specific day.

Fourth teacher said that this application is very useful and she would like to use it in her teaching. She said that the application has a clear and easy interface to work with. This teacher asked about the point of having today's log and all logs in the application. I explained to her that these charts can help her to see the students' activity during the semester. By looking at these charts the teacher can understand if the student was active during the whole course or s/he was only active near the deadlines and final exam. The teacher suggested that it is nice if they can see the difficulty level of the assignments in the grade page.

Fifth teacher perceived the ease of use and usefulness of the prototype. She was interested to have the application and use it in her courses. She mentioned that maybe some assignments are not graded with letters (A, B, C etc.), they are graded as "Pass" or "Fail". She said that she would like to send E-mail to students by clicking on their E-mail address.

After testing the paper prototype, I applied some of the teachers' comments to the medium fidelity prototype of the application. The medium fidelity prototype of the application has been created in Justinmind[1] software. The medium fidelity prototype is shown in figure 33.



[1] www.justinmind.com

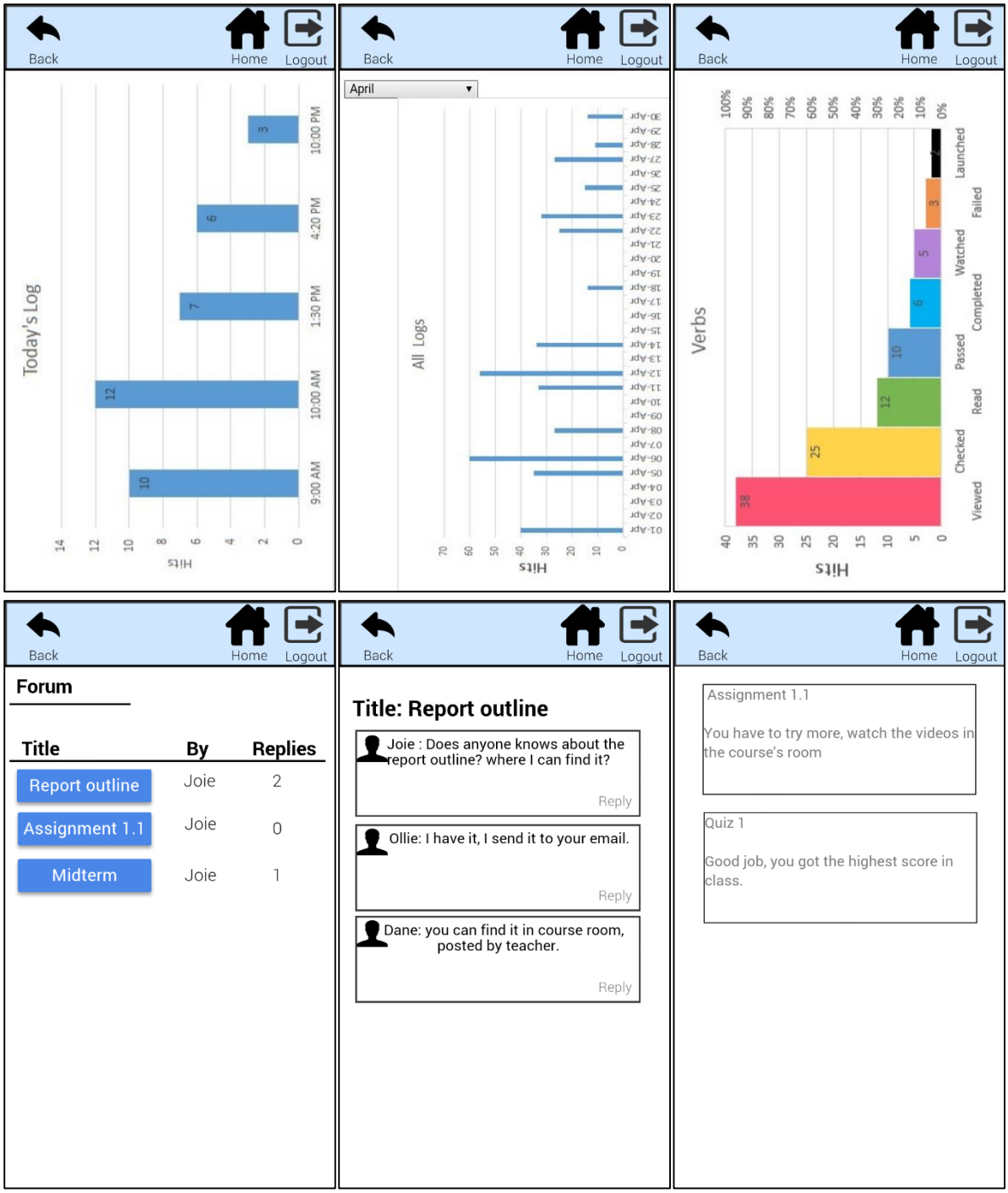


Figure 33 Application medium fidelity prototype

6 Conclusion and Future Work

In this master thesis I investigated on the potential of learning technology standards and specifications for enhancing learning experience. First I went through some of the mostly used standards and specifications in learning environments such as, SCORM, LTI, QTI, IEEE LTSA and xAPI. The potential of these standards and specifications and how these standards can be used in learning environments to help teachers, students and educational institutes were studied.

Then, I have done a test with Moodle LMS and Wax LRS to see how xAPI specification is used to capture and store the data in a LRS in practice. xAPI specification by a simple statement design can capture students' learning experience anytime and anywhere. Students' learning experience in the Moodle LMS was captured by the xAPI statement and the data was stored in external LRS. The LRS provided the students' activity stream and also the JSON format was generated. But how this information could be used by teachers, how these data could help teachers to know about their students' progress and performance. I proposed a mobile learning dashboard which is able to be connected to an external LRS and pull xAPI statement from it. This thesis proposes a mobile learning dashboard.

Mobile leaning dashboards are applications that can help students and teachers in many ways. By using these dashboards teachers have a better control over the courses and students' learning process and activities. Teachers can compare their students' progress with other students. Mobile learning dashboards by providing visualize data help teachers track their students' learning activities. Teachers can identify students who are at risk and evaluate their students based on their progress and performance.

for designing a mobile learning dashboard, I followed the HCD activities: Identifying the context of use, specifying user requirements, providing design solution, evaluating the design. Therefore, first I started to identify the context of use; who are the potential users, how and where they are going to use the application. Then, I had semi-structured interviews with teachers to identify their requirements for supporting their students in a learning environment. Teachers from different areas had different requirements and some of them mentioned about particular requirements based on the courses they had. Meeting all teachers' requirements was a challenge for me in designing a solution which could fulfill all the needs.

In the next step, I designed a paper prototype and I tested it with teachers. They gave me comments and feedback which helped me to understand the strengths and weaknesses of the design. By using this dashboard, teachers could be able to track their students' learning experience. For example, teachers can see their students hourly and monthly active logs. Teachers can see students' grades and give them quick feedback. Based on my research on mobile learning dashboards, to the best of my knowledge, there is no mobile learning solution that could help teachers in this way. So, I think this solution would be very helpful.

During this master thesis I found how much the teachers are interested to track their students' learning experience and use the results in their teaching, how they are interested to follow their students. Some of the teachers preferred face-to-face interactions a, some of them were engaged with eLearning technologies such as LMSs and leaning analytic tools. I figure out what are the teachers' requirements to support students in learning process. The use of xAPI specification in learning environments, how and what data can be collected by this specification. Finally, proposing a mobile learning solution that can help teachers to enhance tracking students' learning experience.

There were some limitations in this master thesis like, lack of literature about standards and specification used in mobile learning dashboards, how these standards are used in mobile learning environment to collect students' learning experience. Because of time limitation, it was not possible to have interviews with more teachers in order to identify more requirements. Also, because of the time limitations, the paper prototype and medium fidelity prototype were tested with a few number of teachers.

As future work, it would be useful to carry out a larger scale investigation, involving more teachers, to identify more requirements and improve the design of this mobile learning dashboard. Thereafter, develop further and integrate this mobile learning dashboard with a LMS and LRS which makes it possible to share data.

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