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Learning Analytics Cockpit for MOOC environment

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Affidavit

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I dedicate this work to my late father.

Abstract

In recent years, learning has changed considerably through the use of new technologies. Online learning, the new and innovative way of learning, is not yet sufficiently explored due to its concept and the enormous amount of data. The way of data analysis is based on the use of different techniques for data collection, transformation and the drawing of visualization-based conclusions.

One of the most popular forms of knowledge transfer in online learning is the video format. Within the framework of this work, an analysis tool was developed that captures, processes and stores the behaviour of learners during the use of video content. The LA Cockpit, a Learning Analytics Dashboard, was already developed in an earlier project as a plugin for the Austrian MOOC platform iMooX and serves as a basis for this work.

In addition, this work deals with gamification to increase the motivation of learners. The GamifyBat was developed, an element in form of a battery, which can be recharged by combining the collected data of the learners and should increase the play instinct of the participants.

Kurzfassung

In den letzten Jahren hat sich Lernen durch den Einsatz von neuen Technologien erheblich verändert. Online-Lernen, der neue und innovative Weg des Lernens, und die dabei auftretenden enormen Datenmengen sind noch nicht ausreichend untersucht. Die Art und Weise der Datenanalyse basiert auf dem Einsatz verschiedener Techniken zur Datenerhebung, Transformation und dem Treffen von visualisierungsbasierten Schlussfolgerungen.

Eine der beliebtesten Formen des Wissenstransfers beim Online-Lernen ist das Videoformat. Im Rahmen dieser Arbeit wurde ein Analysetool entwickelt, welches das Verhalten der Lernenden während der Nutzung von Videoinhalten erfasst, aufbereitet und speichert. Das LA Cockpit, ein Learning Analytics Dashboard, wurde bereits in einem früheren Projekt als Plugin für die österreichische MOOC Plattform iMooX entwickelt und stellt die Basis für diese Arbeit dar.

Zusätzlich beschäftigt sich diese Arbeit mit Gamification um die Motivation von Lernenden zu erhöhen. Dabei wurde die GamifyBat entwickelt, ein Element in Form einer Batterie, welches durch die Kombination der gesammelten Daten der Lernenden aufgeladen werden kann und so den Spieltrieb der TeilnehmerInnen steigern soll.

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1 Introduction

Chatting with friends over the Internet, watching videos, downloading material from the Internet, posting on social media platforms and many other activities in the digital environment create traces of data that are interesting for different stakeholders. These stakeholders can be either an online retailer, who wants to know or try to understand the purchasing of their customers, or a betting platform that wants to improve advertising information or to understand customer spending pattern.

This trail of data is also known as digital footprint. Everything that is connected to the Internet whether it is on a smartphone or another device creates a digital footprint that is of interest to someone. Digital footprints can be characterized as every action and communication online, that a user leaves intentionally or not. Generally mentioned in comments or actions left by others that user does not online, can connect digital footprints to that user¹. This accumulation of data can start even before the user is born, for example, if someone shares user sonogram picture in the womb per email to the closest relatives or between doctors². The main issue is not how to store this generated data or if it has enough space to store these digital footprints, but how to sort these data. For example, to sort it in categories or to understand what that data means, also they contain some various key preferences that can be very valuable for subsequent process analysis.

¹https://techterms.com/definition/digital_footprint, 2019.

²<http://youthandmedia.org/publications/videos/borndigital/>, 2019.

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In educational organizations these trails of data, which are generated from teachers and learners can also be very helpful in the educational environment. Over the last couple of years, Learning Analytics have paid a considerably increased attention to educational organizations. Nowadays it is evident that information technology has increasingly influenced on every form of teaching and learning models in educational society (Beer, Clark, Jones, et al., 2010). What are positive and negative implications of teachers on users' commitment to the new educational concept, and how users react on new learning methods, for example virtual classrooms or online courses? These are topics that are continuously attracting attention in the online learning system, as well these large amounts of data being generated between online learning platforms and their users which should be analysed. This dataset holds generally answers to these new online teaching and learning models and their implications on educational learning process, as well as how upcoming teaching and learning methods in educational environment should be composed and guided.

In most cases in learning context data goes unrevealed and educational institutions try to improve performance to better understand current learning processes. The first definition mentioned at the First International Conference on Learning Analytics and Knowledge and engaged in diverse papers, describes Learning Analytics as "... measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" (Siemens and Long, 2011).

With the availability of new technological possibilities, it is a lot easier to manage the demands of Learning Analytics. When it comes to the application of Learning Analytics in the context of this thesis, we discuss the effects and analysis of online video learning. Through thought and the human awareness is capable in different ways of processing and accepting the displayed data, to recognize the relationship, order, and existence of connection depending on the way in which the infor-

mation is visualized and presented to the consumer. Another form of data representation is the visualization of the information suitable for manipulation and wrong interpretation. This misinterpretation of the information could be caused intentional or by a random selection of the wrong display mode. When presenting information, it is essential to identify the most relevant parameters of the information in order to simplify its presentation and make it more understandable to the user. Subsequently, the information should be selected in order to know what is relevant for later management.

In Learning Analytics, one of the primary tools used to present and visualize data in the correct way is a learning dashboard. Learning Analytics would not get increased attention of an educational society without clearly presenting data to the stakeholders, because the collected data during learning cannot speak for themselves. Information should be quickly and easily readable in the dashboard, which is not a typical characteristic of text-based tables. The main advantage of the dashboard is that it generates quickly recognizable reports, which can be quickly read and understood by its users with the help of dashboard visualizations.

Today's technologies have a vital role in analysing and using video learning content when it comes to storage, editing and transmission of data between two parties. The development of one of these tools to collect student online video activities as digital footprints and visualize these digital datasets in a dashboard of the iMooX³, is one of the subjects discussed in this thesis.

The developed Learning Analytics dashboard on iMooX platform is called LA Cockpit. The primary goal of this dashboard is to visualize user's commitments on the platform with a focus on various metrics. When these metrics are applied at the quiz aspects, then they could be used to measure quiz attempts at the course level, or or at the login

³<https://imoox.at/mooc/theme/imoox/views/about.php>, 2019.

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aspect to determine active logins at the platform level over a period of time.

The second subject this work deals with the development of one motivation tool to increase students' engagement in a course. The tool is based on a weekly basis through the users leave digital footprints on a course basis in the online learning platform. The purpose of this tool is to select from the collected data the specific data that are collected and then to use these data to motivate the user.

Every task that needs to be done in life requires motivation, or a willingness and desire to find out the background of the story. Thus, hiding some story is another very strong method to increase engagement. Human motivation and participation are very high for activities that correspond to their desires and passions. In other words, personal satisfaction is the best motivational driver. However, people are often faced with the tasks that they have to perform, where the process and even the result do not bring personal happiness. Therefore, improving motivation is the answer to many important questions as to how to reach a positive result, or how to remain happy and satisfied doing some tasks. In particular, learning as a school task is not the happiest word for most students. Although most people are not aware of the process of gathering knowledge and have pleasure in learning throughout their lives.(Boehm and Lyubomirsky, 2008)

Motivating people to learn is not an easy task, and in addition to traditional learning is added the new form of online learning, then it becomes even more challenging task. In comparison to traditional learning, online learning is using new technology and availability of the Internet to provide learners with new forms of learning. It reduces social interaction between participants and changes the way people interact; therefore, learners manage their time, decide the place where to learn and how fast they learn (Muljo, Perbangsa, and Pardamean, 2017). At the same time, reducing and changing social communication

can also have some negative impacts because the participants want to have direct communication with other learners, a relationship, and they want to receive feedback. Though with the revolution called e-learning, education through new technology causes learners to feel isolated and alone during online learning (Clayton, Blumberg, and Auld, 2010). This problem can lead to the loss of learners' motivation and make the learning processes more difficult (Bolliger, Supanakorn, and Boggs, 2010).

The difficulty to maintain motivation among learners and to avoid high dropout percentage are usually challenges in the online learning platform. The idea of using Learning Analytics datasets and offering alternative tools on the basis of these massive stored datasets should be encouraging for the learner's motivation. The users need to be pleased by using these motivating learning methods which online learning environment provides and to increase their engagement.

Xie and Ke, 2011 mentioned that learners' motivation ranges from an intrinsic motivation, where a student takes an action for the fun or challenge involved in the task, to an extrinsic motivation where the motive for a student to take an action includes searching for external stimuli or rewards. The advantages of online learning is the personal freedom that each user has when creating their own schedule or choosing topics. For more autonomous users, the free choice between subjects can play a strong role in their choice of learning.

The intrinsic motivation is essential in our everyday lives, and in the e-learning, the learner's attention is driven by the independence of the place and free choice of the content, so they are intrinsically motivated. The same case can be applied to students' intrinsic motivation by the freedom and autonomy that online learning environment offers. Many studies show that learning effectiveness depends on the learner's motivation. In other words, if the level of motivation was high, then the learners would better perform in learning challenges (Clayton,

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Blumberg, and Auld, 2010). When the learner starts to increase performance and change behaviours at e-learning platform influenced by an external source, it is the external motivational driver called extrinsic motivation.

Deci, 1972 provides a study showing one group, which is intrinsically motivated at the beginning of one learning process, and the influence of extrinsic motivation, how it would affect user motivation. The effect of engaging extrinsic motivation shows how intrinsic motivation increases and can be strengthened, and it increases the learners' participation in the learning process. But attention must be paid to the design of these extrinsic methods because not every method leads to increased motivation and participation of learners. Deci, Koestner, and Ryan, 2001 provide a study that shows how extrinsic methods could have a negative impact on the learners' intrinsic motivation if they are designed and provided to the learners in the wrong way.

There is a possibility to motivate students extrinsically if they lack motivation to learn (Hamari, 2017). Gamification describes the usage of game elements in the non-game environment. This motivation tool in education can be a very valuable advantage in education in order to increase learners' online activities such as quiz activity, login activity, videos viewing and forum reading and writing posts (Deterding, Khaled, et al., 2011).

The idea of applying gamification elements in an online learning environment to improve learners' engagement in online courses is a very young method and teachers have recently begun to examine the opportunity of using game elements in their online classrooms (Hanus and Fox, 2015). Gamification can not be seen as a game to achieve some single goal. It is a mixed system, which contains some motivational activities, features, and it can reflect some computer game elements. These elements encourage learners' desire for communication, collaboration and a regulated exchange of information to achieve course

targets (Schönen, 2014). These motivational elements can be evaluated depending on the design of the tool and on the intrinsic or extrinsic motivation of the user.

The rest of this thesis is constructed as follows. Chapter 2 presents theoretical background of Massive Open Online Courses, which impacts MOOCs have in educational society, the impact of Learning Analytics, how users' behaviours can be monitored and identified in the online learning environment, a brief overview of the dashboard and its effect on teachers' learning methods and learners' behaviours. The last part of this chapter consists of the background of gamification and provides some examples for further development. In Chapter 3, the major technologies used to develop required tools in iMooX environment will be presented. Afterwards Chapter 4 describes implemented tasks and their design, as well as the analysis of implemented tools and proof-of-work of requirements, while the last Chapter 5 concludes the work and presents possible future improvements.

2 Background

2.1 MOOCs

The traditional learning has not changed for decades, where students were sitting in lecture rooms, gaining new knowledge through a presentation by lecturers and expressing their opinions in open discussions with other students and lecturers. The new technological possibilities and WEB 2.0 empowers new movements in digital learning and replaces a traditional learning approach, see Figure 2.1. This new learning concept is called e-learning and it can be divided into two categories: synchronous and asynchronous teaching (Hrastinski, 2008). In e-learning, students and participants are doing their tasks and activities of enrolled courses in an online format. For instance, learning content is posted digitally on some platform, the students can review the content with a device connected to the Internet, they don't need to sit in lecture rooms and listen to the presentation, they can access to online learning content at any time, they can share their opinion in forums with other students and lecturers (Robbins, 2019). The goal of the section is not to discuss traditional versus online learning, but to provide a theoretical meaning of the word MOOCs and to show in which learning concept it falls.

Synchronous learning concept enables the students to directly express their opinion in real time or ask the teacher or other students various questions about content which they did not understand properly. For

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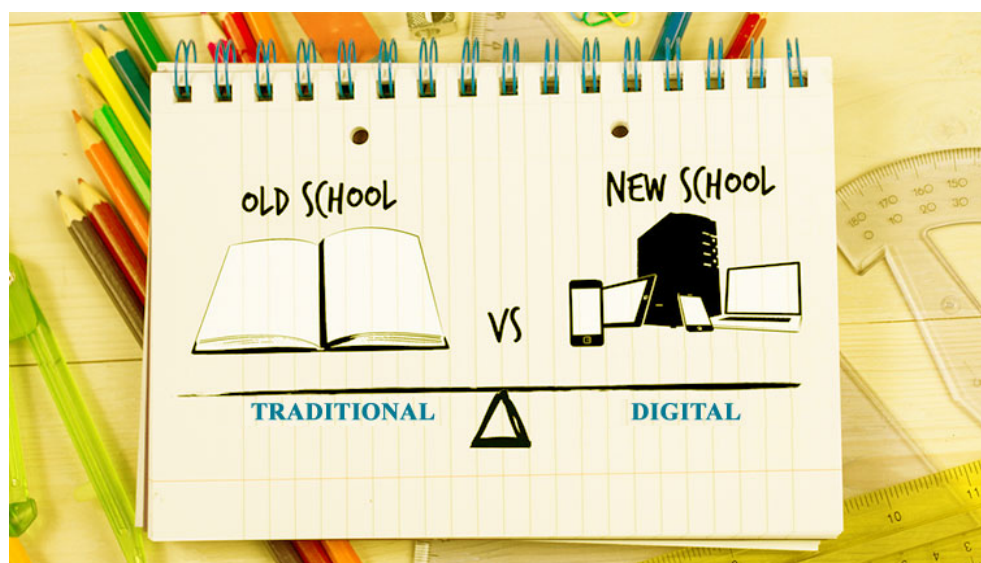


Figure 2.1: Traditional Learning vs Online Learning, from Education, 2017

example, synchronous learning performed in online learning environment via the chat. This type of learning can only happen online. Being online in this context means that contact with course instructors and other students occurs simultaneously. The term isolation mentioned in Introduction can be reduced remarkably by using synchronous learning approach.

In contrast, asynchronous learning can be achieved off- as well as online. Asynchronous learning supports course work done through the Internet, via email or message boards and then posted to online forums. Students do not need to use instant online communication and do not have to be available online at the forum. A benefit of asynchronous learning is that students were allowed to learn a subject at their own pace at home (Hrastinski, 2008).

Both categories can be supported through the term “MOOC”. MOOCs are online courses that provide usage of digital learning environments

to thousands of students to enrol and learn from it. MOOC is the abbreviation of four words:

- **Massive:** The number of participants in MOOC can be enormous but also very few MOOCs have very big size of enrolments. In the practice condition the average size of MOOC on less famous platforms is estimated to have a few thousand enrolments (Jordan, 2015). In a technological view, there is no limit to the number of learners per MOOC.
- **Open:** It provides anyone with Internet free access at no cost to learning courses and reading materials. In some cases, open-access of the course content of some MOOCs are not offered, there are copyrighted and learning materials are not generally open licensed (Hollands and Tirthali, 2014).
- **Online:** All the learning participants that get through MOOCs are usually provided completely via the Internet connection. In practice of MOOCs, there is often an example where learners can learn part of a course face-to-face and other parts online (Jordan, 2015).
- **Course:** The term course is represented as a unit of learning objects within a given structure. A MOOC course should have a beginning and an ending point, where learners go through teaching objects and afterwards receive credits for completing the course¹.

The first MOOC was offered in 2008 by George Siemens and Stephen Downes at the University of Manitoba, Canada. They designed a twelve-week online course and had 25 matriculated students paying the fee for credits and 2,200 non-paying participants from all of the world without possibility to get credits after finishing the course. The whole course material was available on the Internet, discussions and exchange of views between participants were realized via Internet forums, blogs

¹<http://desarrolloweb.dlsi.ua.es/moocs/what-is-a-mooc>, 2019.

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and other social networking tools. The idea was to present the teacher as the node between participants and to see the teacher as a connector and being part of social online learning system. (Waks, 2016)

In accordance with the term and meaning from 2008, the term MOOC was defined as "... an online course with the option of free and open registration, a publicly shared curriculum, and open-ended outcomes. MOOCs integrate social networking, accessible online resources, and are facilitated by leading practitioners in the field of study. Most significantly, MOOCs build on the engagement of learners who self-organize their participation according to learning goals, prior knowledge and skills, and common interests." (McAuley et al., 2010).

At the end of 2011, Stanford University offered three online courses, which were designed and consisted of short video sequences followed by multiple-choice questions. These three courses had a great number of participants and quickly attracted the attention of the technology and education society. Nowadays, after following these high number course enrolments they have emerged within months to three most famous platforms Udacity, Coursera and edX. They provided hundreds of courses with different topics, and the focus was to offer another way of learning and teaching which was different from the traditional learning. (Yousef et al., 2014)

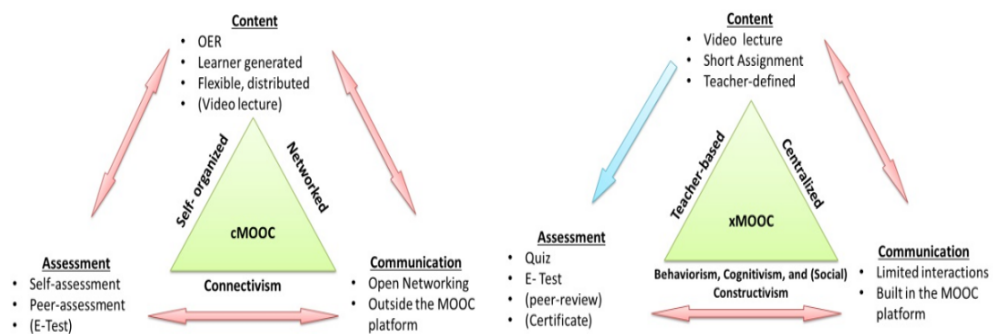


Figure 2.2: cMOOC vs xMOOC, from Yousef et al., 2014

2.1 MOOCs

A MOOC usually consists of content delivery via video sequence and learning status. The learning status is regularly monitored through self-assessments. An additional element is a connective opportunity of MOOCs, which is often illustrated via forums and chats where the participants can exchange ideas or build learning groups. The intensity of interaction and connectivity depends on the type of MOOCs, and this has also an influence on the self-defined objectives, views, learning group, the content of the course and the way the participants interact with each other. In this way, a classification is traditionally determined between two types of MOOCs: learning through participant interactions and creating his own objectives and views with a focus on connectivism (cMOOC) and more traditional learning approach through pre-defined learning objectives created by an external resource (xMOOC) (Yousef et al., 2014).

The first MOOC that was developed by George Siemens and Stephan Downes had most identical properties that nowadays is defined as cMOOC. This type of course is based on the principle of getting knowledge through merging with other participants. The requirement for qualitative learning experience and outcome is that participants have some foreknowledge of the subject they want to learn and they are ready to share their knowledge with other participants (Waks, 2016). Furthermore, the quality and speed of learning in the cMOOC courses depend not only on the participant itself, but it depends on the group motivation, activities and how they are willing to share their opinions and knowledge within this type of course. The purpose of the instructors in cMOOC is not to evaluate participants but to merge, motivate and activate the student to communicate and share their knowledge (Hollands and Tirthali, 2014). The results and content of cMOOC course are mostly determined by participants assessment and how they had discussed and thought within the learning group.

xMOOC represents a popular and traditional form of learning. In general, it consists of the week's video presentations and the learning

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process complements through short quizzes after short video presentations, various tasks, participation and interaction in forums (Chang, Gütl, and Ebner, 2018). Today, most educational institutions have started to use these sorts of courses to educate their students.

The traditional form of learning where students go to lectures, interact with instructors, do some tasks and take the exam can succeed and change the way of learning by xMOOC courses. The teaching system of xMOOC is designed on the properties of a traditional university course, where students gain knowledge through presentations, audio and videos lessons and some other online aids. The student is evaluated online and can participate in discussions and interact with instructors and college students through forums of registered courses. The main difference to cMOOC courses are in term content defining and delivery. The content is predefined by instructors of the course, the evaluation of students is done by instructors or by the system automatically (Yousef et al., 2014).

2.2 Learning behaviour patterns in MOOCS

In the last few years, MOOCs have become a very popular learning concept (DAAD, 2014), because the tools that are offered to the learners enable them to learn through the Internet anywhere and at any time. Additionally, MOOCs make things easier for teachers to improve their lectures through analysing the data, which are generated and saved in the background by various tools in online learning platform (Jülicher, 2015). The traditional form of learning has been increasingly supported and optimized through different types of MOOCs that were described in section 2.1.

The educational society is using more and more data generated through online learning platform to understand more effectively the learning

2.2 Learning behaviour patterns in MOOCS

processes of learners and design strategies to improve learning concept and share easier findings through the Internet afterwards (Huang et al., 2017). These generated data can be easily gained from various datasets on the online learning platform. In traditional course forms, it is much harder to collect and track student behaviours, which are generated through student activities in a lecture hall or some different places, where a student has done some activities related to the attended course.

For example, by observing the course attendance where the number of participants is high, one can see how difficult it is to store such dataset in the traditional learning environment. At the beginning of the session, the lecturer should mark individually every person who is attending the course. Also, after a few sessions, it will be difficult for the lecturer to notice if the same people are always coming to a session, or whether the attendance rate was higher or approximately constant at every session. In practice this example is feasible at a smaller number of participants, but in the case of MOOCs mentioned in 2.1, where the number of visitors is often enormous, it is almost unimaginable to monitor the presence. Looking at this example, it becomes clear that in a traditional form of learning it is hard to collect datasets, as well as to analyse user activities on the basis these datasets and to recognize some learning behaviour pattern.

It is clear that in traditional learning, it is a very difficult task to provide and centralize user behaviour datasets (Ebner, 2011) and then discover learning behaviour pattern. At the same time, on e-learning platforms, new technologies enable the easy generation and collection of large amounts of user behaviour datasets (Catropa, 2013). In general, it is carried out automatically by the Learning Management System. Khalil and Ebner, 2015 identify several factors that contribute to aspects analysing learning behaviour and these are: dissemination of technologies in education, the vast data generated by learning platforms, the possibility to manage and analyse data more easily, a demand to recognize learners'

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behaviour, improve the content and its accessibility and increase the quality of learning environment. MOOCs itself collects a huge amount of data, for instance, login activities, video watching timestamp, quiz completion and others. It just needs to be activated to track user activities in learning management system. The two popular providers of college-level MOOCs edX and Coursera have developed tools that track students' every click as they are learning on these platforms (Breslow et al., 2013). The remaining step of analysing the collected data that needed to clearly see visible learning behaviour pattern is by illustrating data through Learning Analytics approach.

There are many research papers in which different analytical techniques are used to present users' activity records in more understandable reports that represents learning behaviours in MOOCs. Sunar et al., 2018 classified learning behaviours into three categories:

- understanding users' participation in courses
- users' participation intention in course
- motivate users when it is necessary

A number of studies fall into one of these categories and try to explain user behaviours and increase learning content quality through various approaches. The drop-out behaviour of users has remained one of the biggest challenges facing MOOCs providers since "The year of the MOOC"². About 95 per cent of people who enrol in MOOCs courses drop out before completing them. It can be seen in almost every MOOC (Lackner, Ebner, and Khalil, 2015) that the percentages of active participants continue to decline by approaching the end of the course (Reich and Ruipérez-Valiente, 2019). Various studies based their research models on analysing learners' interactions with resources in course (A. Coleman, Seaton, and Chuang, 2015). It is therefore necessary to determine in advance what resources exist and would be

²<https://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html>, 2012.

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useful for analysis in order to discover the behaviour pattern. To analyse learners' engagement behaviours, (Kizilcec, Piech, and Schneider, 2013) used students' weekly activities. For each week the student was assigned to one label, labels were defined as: "on track" (completed weekly requirements on time), "behind" (did not complete weekly requirements on time), "auditing" (not completed weekly requirements but actively participated in one weekly activity) or "out"(drop out from course). Using these characterizations, researchers used machine learning technique to describe learners' engagements into four patterns: completing, auditing, disengaging and sampling. Additionally, these four patterns were used to analyse learners' geographical location, experience, intention, forum and video activities.

Another classification of learners presented by Khalil, Kastl, and Ebner, 2016, they categorized the participants by comparing their overall course effort with their certificate achievement. The course was mandatory for the students of university student but also opened for external participants. Since MOOCs are "open", provide free access 2.1 and various types of human personality are enrolled, they classify participants as internal and external participants. In the case of internal participants (the students), researchers found two types of participants with high certificate rate. While activities such as reading and writing in the forum and completing weekly quizzes were the same, video consumption rates differ. The group with low video activities and high completion rate was called "Gamblers", the participants wanted to get an accomplishment certificate as another group without watching weekly videos.

Using classification approach, (Hu, Lo, and Shih, 2014) has developed a warning system to predict online learning performance by tracking the progress of students. They chose a course, which lasted a full year, divided into two semesters and held by the same lecturer. The requirements of course were weekly online attendance and watching videos in specific time periods, they used these two requirements to create be-

2 Background

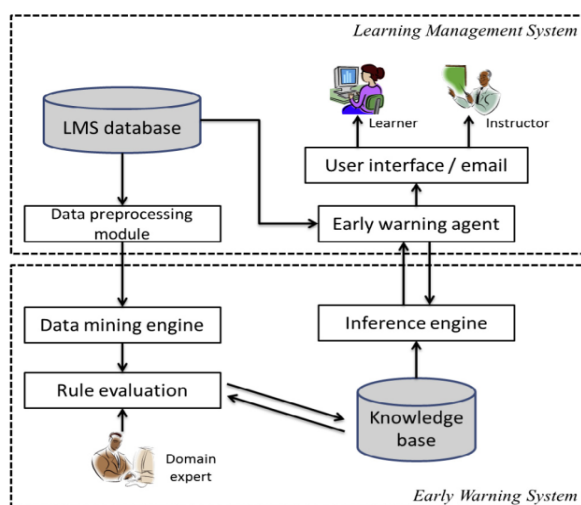


Figure 2.3: The early warning model from Hu, Lo, and Shih, 2014

havioural pattern, provided learning performance while the course was in progress. The LMS generated a record in the database for every user activity on a platform. The series of data preprocessing tasks must be executed to create and store a record in the LMS database. Each stored record was defined as one of the four types: login activity, the use of online course contents, assignment status, or activities in the forum. In their model they classify a student to either pass or fail label. The most valuable stored activities to perform this classification were: total time logged, average time per session, total time content viewed and course content viewed by course category. Using this announcement system shown in Figure 2.3, it can notify related parties such as teachers, and thereby, prevent poor learning rate. It is important here to mention that this model has difficulties to provide an accurate classification for a selected course at the beginning of a course because analysing previous students' datasets from other courses does not provide accurate estimation by learning performance. It is very likely that participants who are active in the courses after the first week will visit the course

2.2 Learning behaviour patterns in MOOCs

in the upcoming weeks as well (Ho et al., 2014). Dodge, Whitmer, and P. Frazee, 2015 showed that sending messages (interventions) via e-mail only leads to a limited results for the participant's success and that other learning methods such as one-to-one lessons, additional teaching content, and other methods should be applied.

A concept by Ferschke et al., 2015 demonstrates how synchronous learning approach already discussed in section 2.1 exemplify user behaviours in MOOCs on social basis. Every user has his own interest and the goal to enrol for a course. Once the user has enrolled for a course, the motivation of the users is a crucial factor to be active in the course. To keep the motivation of the users at the level at which they actively participate in the course, researches provide users a tool that reinforces their motivation through conversation with each other. In this study, they analysed students who had used the conversation tool at least once. The results of this study showed, that the attrition rate in a course would be lower while including an additional social mechanism in MOOCs. Yang et al., 2013 used a different model to show students' drop-out during a course. They analysed drop-out behaviour on the basis of the time when the students entered to the course and their interactions within the discussion forums. The students who had participated earlier in course, were more engaged in discussion forums, accomplished more tasks and the attrition rate was lower. In both cases the social factor had an impact on the drop-out rate and visible increase in students' engagement and motivation in MOOCs over time.

Khalil and Ebner, 2016 show influence using data of social activities in the discussion forums and quiz attendance. Their work has focused on these two MOOCs activities variables to reveal drop-out point. In order to define the drop-out point of a course, they compute the number of quiz attempts per week and the number of writings and readings post per week. The result showed that the total number of both activities was in the first four weeks evidently more decreasing; from the fifth week to the end of course a decreasing rate was quite lower. They

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defined a drop-out point in the week where the decreasing rate was not more affected as in the first four weeks of course.

Another interesting point covered in study was classification of the participants and determine a drop-out point of each category (Khalil, Kastl, and Ebner, 2016). Classification of participants is based on their video and forum activities, quiz attempts and finishing the course. Through classification, participants can be characterized as: registrants, active learners, completers and certified learners. The drop-out rate was absolutely lower when registrants type of learners were excluded from the total attrition rate. Further, when comparing the drop-out rate between active and certified learners, it was on a more acceptable level in contrast to Reich and Ruipérez-Valiente, 2019 study.

Juho Kim et al., 2014 examine video lecture interactions to form behaviour pattern of how students are using videos in their online learning process. In the current generation of MOOCs, video lectures are a crucial part of MOOC design (Sinha et al., 2014) and used as a form of knowledge communication (Reutemann, 2016). Learners spent most time throughout the online course on videos lecture (Breslow et al., 2013).

In this paper, researchers studied click-level interactions (playing, pausing, replying and quitting) within videos. The average drop-out rate of all videos was about 55,2%

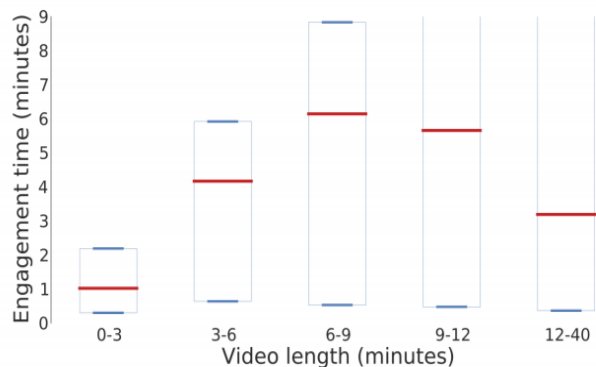


Figure 2.4: Engagement times vs video's length from J. Guo, Juho Kim, and Rubin, 2014. Bottom blue bar 25%, top blue bar 75% and red bar median rate.

2.3 Impacts of Learning Analytics dashboard

before the video ends. About a third of all drop-outs appear during the first few seconds, and that the video length shaped generally drop-out rates. With longer videos, the drop-out rate increased. A study by J. Guo, Juho Kim, and Rubin, 2014 demonstrates also that shorter videos are more interesting. In Figure 2.4 researchers divide videos into five categories according to video length and they found out that drop-out rate increases obviously if the video is longer than six to nine minutes.

Another interesting fact about drop-out behaviour in video lecture was showing instructor's head and the slides on the single screen. The drop-out rate was lower with videos where instructors face is recorded sitting at a desk in some video studio than recorded classroom lectures, especially when the video lecture is longer than 6-9 minutes.

2.3 Impacts of Learning Analytics dashboard

The need to understand how the learning process occurs throughout online learning platforms and influences further decisions in the learning context are factors that make learning analytics more important. Learning dashboards are aimed to visualize these processes in an easier and faster way to stakeholders.

The term dashboard is derived from a control panel in front of the driver in a car, which provides the driver information about the current status of the car. It gives important parameters such as fuel gauge, a speedometer, engine temperature, revolutions per minute (RPM) in the engine and more (EDMONDS, 2009). The dashboard brings together numbers, metrics and sometimes also rating systems, such as traffic light or scale-based systems on a single screen (Rouse, 2015). Dashboards can be designed to specific roles and display metrics that

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are focused on a specific point of view or group. The valuable components of a dashboard are therefore a customizable user interface and the ability to deliver data from multiple sources in a single screen section.

There are dashboards which take time to understand, and dashboards that seem to be understood immediately. In both scenarios, it strains the human brain and it needs to absorb information in order to be able to understand it. The information is processed with each visualization change. It can be compared to some executed computer task: when a request is performed in the system, the CPU unit is busy to handle and deliver the requested task as fast as possible (Suleymanova, 2018). The visualization that is displayed in a dashboard should work in the same way. It should provide an easily understandable overview of requested tasks to the stakeholders. In practice, the developed dashboards and their visualizations do not meet this requirement, it often takes longer to get an overview than it should (Few, 2006). There are many developed dashboards in practice that are visually presented as a dashboard but they do not seem to meet the fundamental function of a traditional dashboard (Sarikaya et al., 2018).

(Few, 2004) defined a dashboard as “...visual display of the most important information needed to achieve one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance”. Following these definitions, a dashboard is a tool that allows a consumer to view and analyse gathered data in different ways and offers a faster explanation of some objective. There are many visualization dashboards available depending on the purpose of its use. From the perspective of the features that a dashboard should contain, (Few, 2004) the following features are mentioned: the dashboard displayed on a single screen, information on the dashboard is displayed visually not as text, dashboards are modifiable and provide information clearly and without distraction. Usually, several items are placed on dashboards that are easily reachable from different devices. Section 2.2

2.3 Impacts of Learning Analytics dashboard

covered user behaviours in MOOCs, but it is important to develop a meaningful visualization that presents these learning behaviours to the stakeholders in faster and more efficient way than the text itself. (Podgorelec and Kuhar, 2011)

Learning Analytics dashboard should provide information in different ways to various stakeholders groups. These stakeholders can be learners, teachers, teaching assistants or researchers. This visual information from dashboard could be used to increase the quality of teaching, reveal the obstacles that participants were faced during online learning, solve these unpredictable difficulties in further course topics, as motivational tools to enhance the engagement of students and increase the quality of technologies that are used for teaching and learning (Podgorelec and Kuhar, 2011). In their study Park and Jo, 2015 classified Learning Analytics dashboards by analysing previously developed dashboards into three categories:

- dashboards for teachers
- dashboards for teachers and students
- dashboards for students

Dashboards for teachers provide information about student's engagement and their achievements in courses, student activities in discussions forums, support teachers in course management, present and visualize student's feedback, see average usage of the content and other objectives. Student dashboard provides information about the parts of the course that they have completed, support the student through guidance in order to know what to do next and their activities in course. Furthermore, dashboard identifies where the student is behind in comparison to other students in terms of learning performance and motivate students through dashboard visualization. In their paper, Verbert et al., 2014 analyse numerous deployed Learning Analytics dashboard and classify them into three categories: 1) the traditional face to face lectures dashboard, 2) face-to-face group work and classroom

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orchestration dashboard, and 3) online learning dashboard. This classification can be further divided into sub-categories by a stakeholder group presented in the paper by Park and Jo, 2015.

In the research study Govaerts et al., 2012 develop Student Activity Meter (SAM) visualization that displays students activities during the course. They used time spent and content usage as input variables to measure student engagement in a course. The goal of this tool was to provide teachers and students with information about the activities that were performed by the students. The participants were offered a dashboard in which they could choose between three different visualizations, but all three visualizations display the same objectives only in a different way. Figure 2.5 shows the line chart visualization in the SAM dashboard, which was the most used among the participants. The

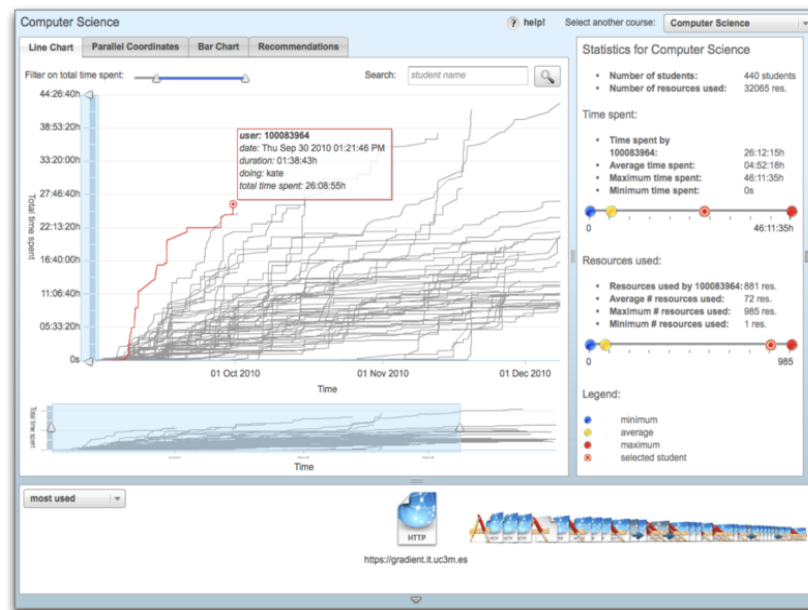


Figure 2.5: The Student Activity Meter, from Verbert et al., 2014

evaluation results of the study showed that SAM can assist teachers as

2.3 Impacts of Learning Analytics dashboard

well as students. Students could see their time spent and engagement in the course and compare with other participants. They could see time spent averages, where participants invest more or less time and this observation could serve them as a guide in order to know how to spend and manage their time in course. Another objective that the student could reveal from SAM was resource usage. Students could see which resource has a higher rate of usage and what was used by other participants in the course to achieve course goals, and they can compare their work with other participants. In contrast to students, teachers could see the participants' overall time spent in course, its average values and compare with their estimates. They could easily classify student, whether their course progress is good or not, they could also see which content is attractive and helps students in their course success. Teachers could compose future course content on these findings by SAM dashboard and have an influence on participants behaviour.

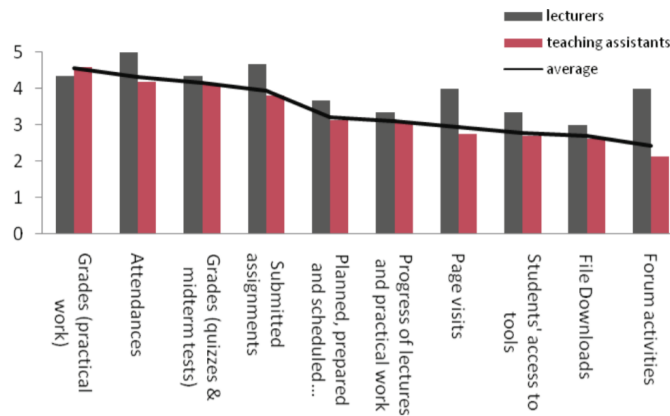


Figure 2.6: Favored teachers and tutors needs, it should display in dashboard, from Podgorelec and Kuhar, 2011

The authors in Podgorelec and Kuhar, 2011 worked together with

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teachers and tutors to develop a dashboard that will be applicable to their needs. They wanted to know which objectives were important to supervise the course, and which properties were interesting from the side of the participant behaviours in courses that they held. Researchers offered a survey to teachers and tutors, in which they express their wishes when it comes to useful information about participants in the courses. In overall, 183 educators participated in this survey, 34% of which were teachers and the remaining 66% were tutors. Figure 2.6 presents teachers and tutors' needs, and average values of these needs. After the survey, the researchers realized that tutors and teachers had different needs about knowing participants' activities in courses. Researchers applied Malik, 2005 dashboard definition that dashboards should be adopted to user needs, so they decided to create two different dashboards - one for each side one. These two developed dashboards in this study offered enhanced and deeper understanding of current learning status to both teachers and to tutors.

Using some advanced machine learning techniques could reveal some valuable learning outcomes: classify student in groups by their behaviours, characterize learners by their motivation, analyse drop-out rates and react at the right time to improve these rates through offering some new online learning methods, improve learning processes, change and adapt learning strategy in further course topics. Another interesting model discovered by authors is presented in Figure 2.7. They obtain that good exam results depend on whether the students are highly motivated to accomplish the course. If they are motivated, they will pass the exam, and in case that students are not motivated, their success will depend on average grade, so the students with higher average grade will pass the exam.

The authors in Verbert et al., 2014 attempt to demonstrate the meaning and influence of data, and which of these data is valuable for dashboards and visualization. Their focus was on different data, such as social behaviours of the learners, learners' interaction with resources,

2.3 Impacts of Learning Analytics dashboard

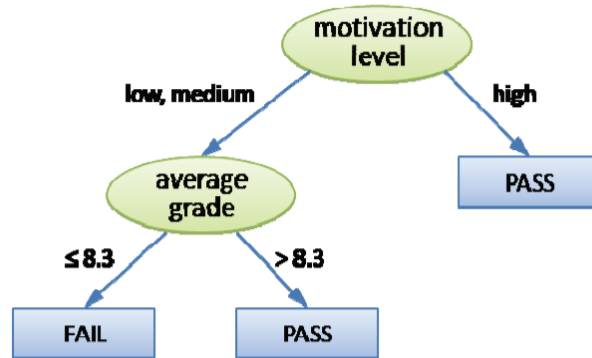


Figure 2.7: Simple prediction tree from Podgorelec and Kuhar, 2011, the success at the exam of a student is conditional on their motivation and average grade

learners' engagement through time spent in the course and stakeholders' satisfaction with learning dashboards. Therefore, the authors analysed these data in seven case studies and with a total of 100 participants, 59 were learners and 41 were teachers. Firstly, for each case study, the researchers sent a survey to the participants to rate how relevant the learning dashboard is to each single data aforementioned. In order to evaluate the participants' feedbacks of all case studies, the authors separate the feedbacks on teachers' and students' results. Teachers found all four visualizations useful for determining students' behaviours and for identifying students at risk. For instance, from a social interaction dashboard, teachers could classify participants who are working together and those who are working individually. From the learners' perspective, they considered the dashboard to be useful but not as much as teachers. They were mostly of the opinion that the dashboard does not reflect all their contribution throughout the course. Learners considered learners' interaction with resources as the most useful dashboard, because they use it as a recommendation to see which resource is popular among other peers.

In their paper Jeonghyun Kim, Il-Hyun Jo, and Park, 2016, the authors

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analysed the frequency of using a learning dashboard, if it had different effects on learning achievement and which properties are associated with dashboard usage frequency, dashboard satisfaction and learning achievement. They used three variables to calculate; dashboard usage frequency was calculated by the total number of opening learning dashboard by each user, learning achievement by summarizing the results of quizzes and exam, and dashboard satisfaction by sending a survey to participants to evaluate dashboard and whether it met their needs. The results of the research showed that learners who used the dashboard had greater success throughout the course. From the satisfaction perspective, the results of this study showed over time that the learning dashboard satisfaction rate was higher by learners who used the learning dashboard only a few times than those who often used learning dashboard. They also compare satisfaction between high and low achievers who used the dashboard often, and the result showed that low achievers were more satisfied with the dashboard than high achievers.

With the need to understand and analyse the goals of the dashboards, the authors of study Jivet et al., 2017 focused their work on analysing various papers that describe the design of dashboards and their goals for educational purposes. The findings in the study showed that most dashboards are intended to make learners aware of their learning process, and that these dashboards are mostly developed to support learners with self-regulated learning skills. The authors also stated that by designing a dashboard, it should be kept in mind that it has a broad use purpose, for example, the dashboard should help learners with planning, setting and monitoring aims.

2.4 Gamification effect

One of the major recognized issues that has been mentioned in various papers and already discussed in section 2.2 is the high rate of drop-outs of MOOCs learners (Onah, Sinclair, and Boyatt, 2014; Reich and Ruipérez-Valiente, 2019). One of the promising techniques in an online learning environment to prevent students from dropping out of courses before completing them is gamification (Pfeiffer, 2018).

Elements of computer games are an area of research that is often mentioned in the business society and other related non-computer games fields. Each computer game can be analysed in term of its dynamics, mechanics, aesthetics and the components of how the game is displayed to the player. The term gamification is used an academic discourse to describe applying elements of a computer game in non-computer games fields and using it to make real-world activities more attractive. Previous gamification research papers put their focus on the business, educational and psychological impact on the user. Numerous scientific and educational institutions demonstrated that the effects of gamification are positive. The response and feedback of customers are very good. (Hamari, Koivisto, and Sarsa, 2014)

The term gamification was already mentioned in the business world at the beginning of 2000, but the concept gamification did not get much attention until the second half of 2010 (Deterding, Dixon, et al., 2011). Gamification finds uses as multiple applications in different areas, including health, education, marketing and finance environment. Nick Pelling was first to coin the word gamification in 2002 (Pelling, 2011), and described it as: “applying game-like accelerated user interface design to make electronic transactions both enjoyable and fast” (Pelling, 2011). Deterding, Dixon, et al., 2011 raised gamification as a trending topic and it was involved in many commercial and noncommercial services. The authors also stated that gamification refers to “**the use**

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(rather than the extension) **of design** (rather than game-based technology or other game related practices) **elements** (rather than full-fledged games) **characteristic for games** (rather than play or playfulness) **in non-game contexts** (regardless of specific usage intentions, contexts, or media of implementation)". Gamification can also be defined from a different perspective, according to Burke, 2014, who redefined and provided the following definition of Gamification: "the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals". The basic elements of this definition are:

- Mechanics of computer games - layout, rules, tools that guide users through the game system
- User Interface - a user uses elements to interact with the game system
- Digital Engagement - where the user prefers to interact with digital devices than with another user
- Motivation - change user's behaviours, innovative thinking, developing skills
- Achieving the goals - aligning the users goals with organizational goals, receive indirectly the fulfilment of goal as soon as the user reaches his goals.

There are concepts that are similar to the gamification, including the term "serious game", which is based on the elements and activities represented by the computer game environment and perspective of a game designer. These tasks are mostly engaged by playing computer-related game to achieve non-entertainment goals (Sawyer, 2007).

Figure 2.8 presents the difference between these similar concepts provided by Deterding, Dixon, et al., 2011. The diagram displays that gamification contains parts of the game and the learners act as the game players. For instance, it contains facets from a game and adds them to learners' work area, learners can consume points, badges,

2.4 Gamification effect

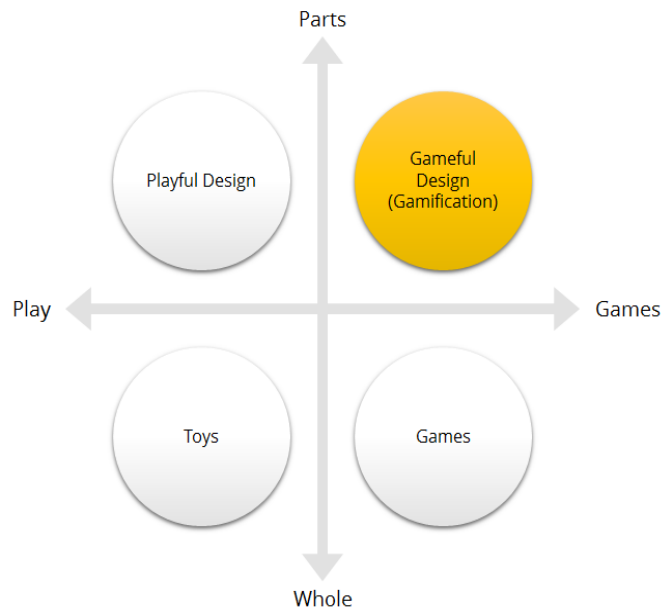


Figure 2.8: Simple game classification by Deterding, Dixon, et al., 2011, gamification contains parts of a game

leaderboards, task and interact with other peers, so the elements of the game are linked with non-game elements to fulfil some business goal.

In contrast to gamification, in a serious game, the reality of the situation is realistically simulated, for example in the form of game videos, simulation of game-playing elements. It contains the properties of a game, but the purpose of a serious game is to be useful not just for fun. Use cases of the serious game are the most widespread in educational environments, for example, as a training tool in military simulators, in the fields of health, arts and sport. The main difference between gamification and the serious game is that gamification can not imitate reality. It transforms reality in a game through representing game-related elements to learners and motivates them to accomplish further goals in the course (Berg, 2014).

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Looking at the pedagogical and psychological aspects of implementing computer game elements for educational purpose, many research papers report about positive impact on learning outcome (Duchon, 2018), users develop skills to think critically and problem-oriented, they get the feeling of belonging, of being a part of the community, and the ability to understand the content more deeply.

The gamification approach has an influence on the user learning behaviours, encourages participants communication activities, interaction, collaboration and competition with other peers (Lam et al., 2004), gets immediate feedback about user learning status, and failure is countered with new encouragements and automatically generated learning guidelines (Busch, 2014).

Khalil and Ebner, 2017 focused on the gamification component to improve students' engagement. They attempt to motivate students to increase their activities through the course and decrease the drop-out rate. Firstly, they developed Activity-Motivation framework, which used Learning Analytics concept to provide feedback by using traffic light system (Course Signals by E. Arnold and Pistilli, 2012). This system has three cases, the green light means that the student is on track, and other two cases the orange and the red light suggested at-risk student, and it requires some external intervention, such as by teacher or an institution. Authors attempt to detect at-risk students using the following MOOCs variable: login frequency, video watching actions, forum and quiz activities. They developed a gamification element displayed in Figure 2.9. The authors decide to use the battery as a gamification element, this element was animation, which reflected learners behaviour in MOOC. The element was updated on a weekly basis and depends on learners activities from the previous week. They utilized the Learning Analytics as a transforming tool to collect data and then generate proper traces of learner's behaviour in the previous week. Afterwards, the generated traces made possible to display learners' previous week behaviour as gamification icon. The evolution result

2.4 Gamification effect

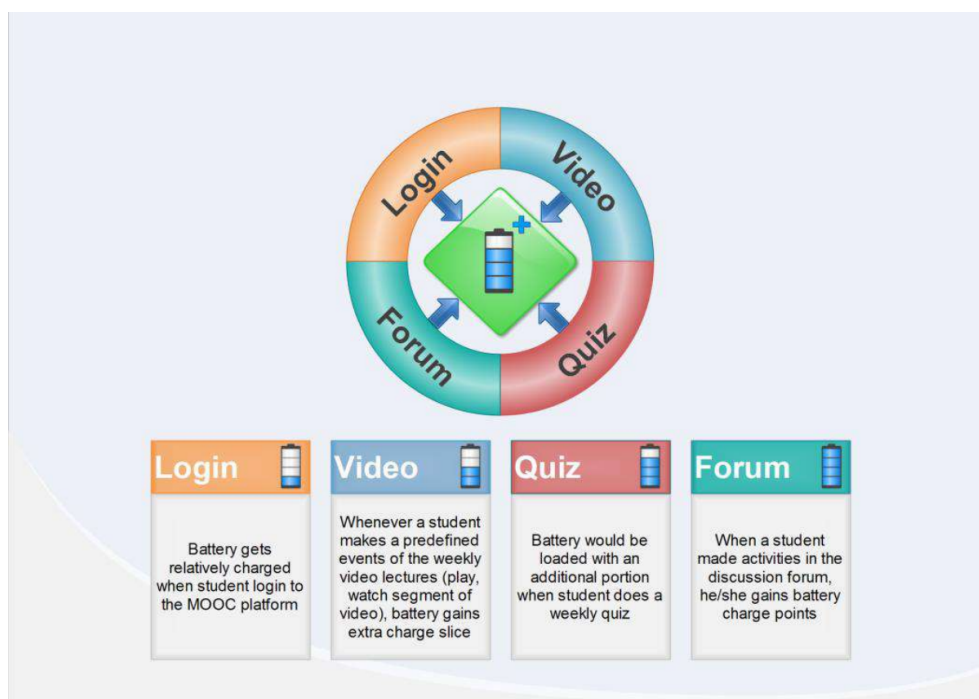


Figure 2.9: The Activity-Motivation framework

of the study showed that students carried out more activities and the attention of students was increased by the gamification element (Khalil, 2018). It is interesting that the highest number of students with full battery gamification icon was in week 2. Their explanation was that students change their behaviours and increase their engagement level to improve their battery icon status. The presented gamification icon and case study was implemented in iMooX 1.0³ platform.

In D. Hanus and Fox, 2015, the authors examined using gamification elements and their impact on student properties such as: motivation, satisfaction and engagement. They used two game mechanics to study the effect of gamification elements; a student could earn the badge

³<https://elearningblog.tugraz.at/archives/9853>, 2019.

2 Background

by doing some course tasks and the second was that students could track their progress on the leaderboard that presents their contribution compared to other peers. The participants were separated into two different courses. The requirement of one course was to use these two game mechanics and another course did not require the use of the game mechanism. The content of course was the same in both courses. The research results showed that using these two game mechanics can have a negative effect on student's performance. The students in a course that used game mechanics element were less motivated, satisfied and empowered in relation to students in the course that did not contain gamified elements. The final exam scores and intrinsic motivation of students in gamified-course were lower. The authors illustrated in this case study that offering badges and providing a ranking system can harm student's motivation for learning and engagement in online courses.

The authors in Christy and Fox, 2014 analysed the effects of leaderboards on female participants in the course. They tested female participants across three different leaderboards. One leaderboard was developed to present men at the top position, the second one presented women at the position and the third leaderboard had no leaderboard concept. The evolution result of this study showed that the female participants in female-dominated leaderboard achieved worse quiz results in relation to the male-dominated leaderboard and no-leaderboard concept. Researchers presented how the gamified element leaderboard could have a negative effects on student's performance, and which impact has a social comparison on student's interest, settlement and commitment.

Jayasinghe and Dharmaratne, 2013 explored two different types of game techniques and their impact in education. Authors analysed the differences between game based learning and gamification, and which of these two concepts increases learning and engagement rate. In the study 60 students were divided into 4 groups, groups being

2.4 Gamification effect

distinguished by sorting algorithms and game techniques. Two groups apply the different game method to learn Bubble sort⁴ and the other two groups to learn Bucket sort⁵. The result showed that the groups which used the gamified concept to learn algorithms, were more successful. Participants who used the gamified concept to learn Bubble sort had about 22% higher average mark compared to another group which used game based learning approach. In the case of Bucket Sort, the average mark using gamified concept was about 25% higher. The authors also presented an average time to learn sorting algorithms. Both groups that used the gamified element needed almost twice less time to learn the provided algorithms. Overall, the study shows that students are more concentrated and efficient following gamified approach.

⁴<https://www.geeksforgeeks.org/bubble-sort/>, 2019.

⁵<https://www.geeksforgeeks.org/bucket-sort-2/n/>, 2019.

3 Technologies

This chapter describes the different technologies that are relevant for practical implementation. The following sections explain the tools used to provide learning content to the user. It also explains the format in which user activities are recorded, where they are stored, and the technologies used to implement a tool that displays users' activities.

3.1 Moodle

Distance learning, also labelled as online learning or e-learning, is one of increasingly popular educational methods. It provides a less stressful learning process since the pupils do not have to be at a specific place at a certain time, which enables them to self-organize their time and to learn more easily and efficiently. One of the most used LMS for online learning is Moodle, a form that supports learning process. It is one of the most important software platforms available for this purpose. Moodle is a web-based system for the management of learning courses, which enables teachers to create a high-quality online courses. It is widely spread all over the world, at universities, schools, companies and used by many teachers.

The platform is designed in such a way that teachers and participants do not need to possess any advanced knowledge skills, but only

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basic computer and Internet skills. Moodle stands for **Modular Object-Oriented Dynamic Learning Environment**¹ and is an Open-Source. In the education environment, LMS delivers, handles, tracks and analyses various learning content (Sharma, 2015). LMS servers provide core functionality and record the user activity and important learning actions so that the required statistical data can be derived in a later period. These data provide information on the progress of the learning and give a view of the effectiveness of the teaching material.

Moodle is an open source learning management system². It is an open source software that can be downloaded from moodle.org. The first version was released in August 2002³. It was developed to support social and distance learning approach in education. It is free of charge, open source software and managed under the GNU General Public License, and suitable for use on PC, tablet or smartphone.

Implementing an electronic course is very practical in one of the LMS. The Moodle platform is a virtual LMS where one or more courses can be set up. It differs from a variety of such systems, both commercial and open source, by its good features. The organization and design of the Moodle user interface is completely customized to students' needs (Poulová, Šimonová, and Maněnová, 2015). Moodle provides all the characteristics of standard LMS platforms that offer a content-oriented learning model (tools for structuring the course, presenting text, multimedia and interactive content, tests and assignments). In addition, Moodle provides helpful interaction and networking concept for a student to share their ideas, collaborate and discuss in small groups.

Two types of users that occur mostly in Moodle are administrators and normal users. An administrator has all the rights to manage the

¹<https://techterms.com/definition/moodle>, 2018.

²https://docs.moodle.org/37/en/Managing_content, 2019.

³<https://docs.moodle.org/37/en/History>, 2019.

3.1 Moodle

platform, for instance, create new courses, edit existing ones, add new users and many other similar actions. Normal users can have different roles depending on the course they are accessing. A role is defined as a collection of permissions that it gives predefined responsibilities to a selected user in specific contexts⁴. There are in most cases three standard predefined user roles in a course: teachers (can edit their courses, add teaching materials, grade students, view course statistics), students (can view courses, post at a forum, use collaboration tools) and guest (a user without a profile, username, password, can view course information and also some teaching materials if it is approved by teachers).

Moodle is a system, which is constructed from multiple modules (small parts grouped form a single unit), and these modules can be separately added or modified. The course is structured from various resources⁵ and activities⁶ such as teaching content, video and audio materials, quizzes, tasks and so on. Standard predefined activities resources are shown in Figure 3.1. Moodle activities and resources are also visually displayed by icons; the name of activities and resources are constant; it does not change with new version of Moodle, the icons are changeable; it changes with a new theme or version of Moodle. Gogan, Sirbu, and Draghici, 2015 stated that Moodle is popular among students and teachers, as a tool for creating dynamic web-based online content where the focus is on managing and monitoring the learning processes. It is designed to provide teachers and students with a more engaging and effective distance learning, through resources and activities, which forms the basis for online learning.

⁴https://docs.moodle.org/37/en/Roles_and_permissions, 2019.

⁵<https://docs.moodle.org/37/en/Resources>, 2019.

⁶<https://docs.moodle.org/37/en/Activities>, 2019.

3 Technologies

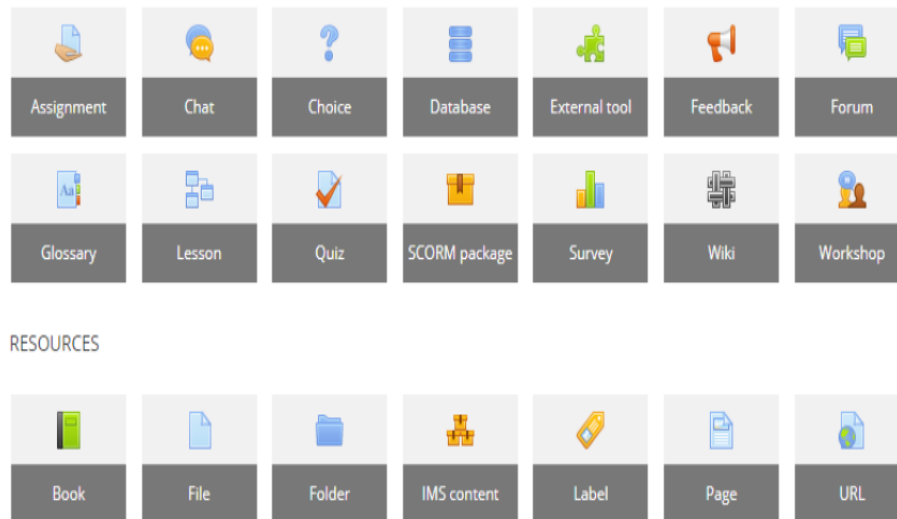


Figure 3.1: Moodle resources and activities

3.2 Learning record store

The use of e-learning technologies is becoming an alternative solution to improve, and in some cases, replace traditional education. Systems that offer distance learning collect data that is generated through student and teacher activities. Later, this data can be used to analyse the success of electronic content for learning and improve it. The database of these distance learning systems archive all student activities such as the use of learning content, attempts and scores of online tests, completion of various tasks, communication with other students, and group collaboration (Dimić et al., 2011). These archived data are essential in the assessment of a course content and users' activities.

Learning Record Store (LRS) is labelled as the database, where learning events and learning experiences are stored and documented in different learning environments. Although the data in the LRS present a detailed

3.2 Learning record store

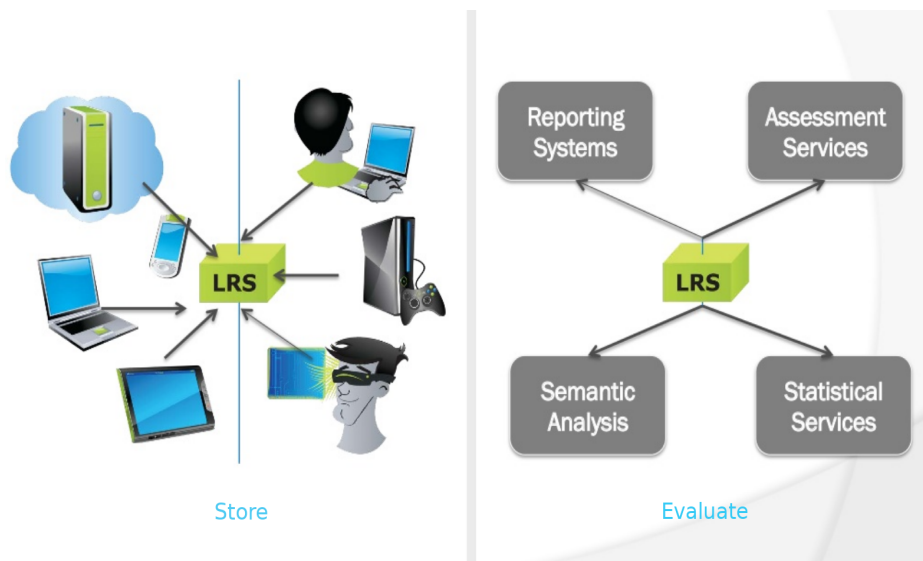


Figure 3.2: Learning Record Store (LRS), from Initiative, 2015

picture of the learning process, they are not easy for consumers to interpret, and these cannot simply be utilised to shape learning processes (Ionel et al., 2018). Figure 3.2 presents common purpose of LRS as online systems. The datasets stored in LRS demonstrating the tracking of learner progress from a variety of context including mobile devices, virtual gaming worlds, simulations, and standard e-learning concept. From the administrator's point of view, the LRS enables management of archived data and delivers them to a third party app for analysis. Third party app can obtain valuable information from the collected data⁷. Initiative, 2013 defined LRS as "a server (i.e. system capable of receiving and processing web requests) that is responsible for receiving, storing, and providing access to Learning Records".

⁷<https://www.webcampus.de/blog/105/xapi-der-learning-record-store-wieso-weshalb-warum>, 2017.

3.3 xAPI - Experience API

The Tin Can API, which was developed by Advanced Distributed Learning (ADL)⁸ as a project to collect data and support e-learning concept, and later renamed into the Experience API (xAPI)⁹. The xAPI closes the gap between users and applications, which was not explicitly related to e-learning. The common concept is to provide connectivity between the reporting system (e.g. in an LMS) and various learning content or interactivities (social learning independent of e-learning content). For

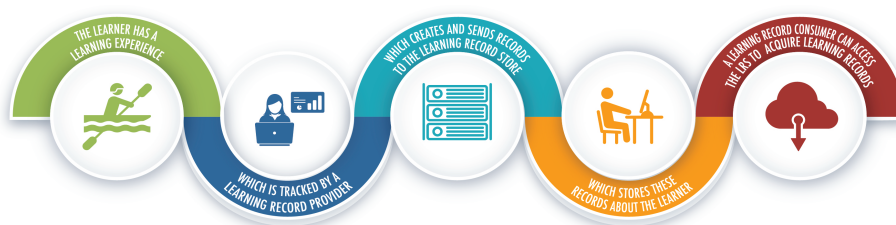


Figure 3.3: Data flow in xAPI, from Initiative, 2013

instance, various PC Applications, mobile apps and social networks can be integrated with xAPI, archive informal learning activities, and evaluate them later¹⁰.

The main part of xAPI is LRS, which was presented in section 3.2. All the data collected by xAPI is being stored in one or more LRS. How the data are generated, stored and returned to some party is presented in Figure 3.3. Initiative, 2013 defined xAPI as “collection of rules articulated in this document which determines how learning

⁸<https://adlnet.gov/about>, 2019.

⁹<https://xapi.com/tin-can-evolution/>, 2019.

¹⁰<https://www.checkpoint-elearning.de/corporate-elearning/xapi-als-bindeglied-im-vernetzten-learning-ecosystem>, 2019.

experiences are defined, formatted, and exchanged so that independent software programs can exchange and make use of this information”.

3.4 H5P - Interactive content

The H5P plugin allows users to create and share interactive content via different publishing system such as Moodle, backboard, drupal and others. The plugin contains many elements related to the game and the animation of the learning process. It can be used as a great presentation tool, but it is also great for interactive teaching and learning. Interactive H5P teaching tool involves the use of different visual contents (presentations, games, interactive videos, quizzes, feedbacks and more) that stimulate student’s response.

The plugin framework has been developed in HTML and based on JavaScript. It is distributed as free and open-source software and provides support for different devices and platforms. The usage of the plugin is very simple and supported by a graphical user interface. By creating some interactive content, a user does not need to have some advanced programming skills.

H5P offers a more dynamic learning experience, provides teachers useful techniques to create interactive content and resource, shares them with students, engages more students activities, and records their activities and scores.

3.5 JavaScript

JavaScript is nowadays used in almost all websites. In 1995, JavaScript was developed at Netscape Communications by Brendan Eich¹¹. It was developed as a tool for adding dynamic and interactive elements to the web pages and was inspired by Java. JavaScript is a client-side scripting language, which means that the source code is executed on a visitor side (user's device), not on the web-server side. This implies JavaScript functions can be executed after the page is loaded without communicating with the server (Kolarević, 2018). For instance, the JavaScript function can check the web form before it is submitted in order to ensure that all required fields were filled. JavaScript code can generate error message before the information is passed to the server. As well as server-side scripting languages such as PHP and JavaScript, code can be placed at any point in the HTML source code. The source code of JavaScript does not have to be compiled, it just needs to be interpreted¹².

The functions in JavaScript can be called within `<script>` elements or when certain events occur such as `onClick`, `onMouseDown`, `onMouseUp`, `onKeyDown`, `onKeyUp`, `onSubmit` and many others (Pereša, 2015). The standard use of JavaScript is to handle basic client-side tasks.

Like every other computer language, JavaScript has its benefits and weaknesses¹³. Some of the advantages of JavaScript are:

- Speed - JavaScript is a client-side scripting language, which is very fast because any key function can perform immediately, rather than being sent to a server and waiting on a response

¹¹<https://brendaneich.com/2008/04/popularity/>, 2019.

¹²<http://www.computerwoche.de/a/skriptsprachen-einfach-und-doch-sehr-maechtig>, 2019.

¹³<https://data-flair.training/blogs/advantages-disadvantages-javascript/>, 2019.

- Simplicity - JavaScript is relatively easy to learn and use
- Versatility - can be used in front-end as well as back-end development
- Popularity - is used by all famous companies and modern browsers

Some of the disadvantages of JavaScript are:

- Client-side security - since the code is executed on the client side, in some cases, this can be used for malicious purposes
- Simplicity - JavaScript source code is sometimes interpreted in different way by different browsers

Many web designers prefer to use JavaScript libraries such as jQuery for the development of more advanced and dynamic elements in web pages (Jain, Bhansali, and Mehta, 2015). The used libraries in this thesis are presented in the following subsections.

3.5.1 jquery

jQuery is a JavaScript library specifically designed to support the execution and development of scripts on the client side. In 2005, jQuery was developed by John Resig¹⁴. The jQuery syntax makes it easier for developers to navigate through documents, select individual HTML document elements (called DOM elements), create animations, manage events, and create Ajax applications that communicate with the server. With the constant updates, the current jQuery has become a basic script for the creation of the web pages.

The main advantage of the jQuery is its effectiveness on the complexity of the code. The motto of the jQuery-Library is "write less, do more"¹⁵. In jQuery can be a certain code in a smaller number of lines than

¹⁴<http://ejohn.org/blog/selectors-in-javascript/>, 2019.

¹⁵<https://jquery.com/>, 2019.

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written in JavaScript. There are several ways to create a jQuery library within the website. The two most common options are:

- download the library from the official jQuery website and include in *head* tag of HTML file
- the library is hosted by Google and can be included in *head* tag as follows:

```
<script src="https://ajax.googleapis.com/ajax/libs/jquery/3.4.1/jquery.min.js"></script>
```

The functionality of the jQuery library can be expanded with a number of add-ons that users develop by themselves, or it is developed by other users. Another great advantage of jQuery is that the functions have been tested and adapted for the most common web browsers¹⁶. This is a great benefit because it avoids the tedious task of adapting scripts to all web browsers that are used today. Therefore jQuery is one of the most used JavaScript libraries (Buckler, 2018).

3.5.2 D3.js

D3.js (Data Driven Documents or d3) is a JavaScript open source library. It simplifies the creation and transformation of objects in web applications that produce some form of data visualization. D3.js was written by Mike Bostock (Dewar, 2012). It uses pre-built JavaScript functions for element selection, creating SVG Objects, adding and modifying transitions, dynamic effects or tooltips. Newly created objects can be edited and applied by CSS. Large amounts of data can be easily linked to SVG objects using D3.js to create diagrams and graphs (Bostock, Ogievetsky, and Heer, 2011). Input data can be provided in various formats such as JSON, CSV, TSV and others filetypes¹⁷.

¹⁶<https://jquery.com/browser-support/>, 2019.

¹⁷http://learnjsdata.com/read_data.html, 2019.

3.6 JSON

JSON (JavaScript Object Notation) is a data-exchange format. The benefit of JSON is that it is readable for humans and is also easy to analyse and to generate. JSON is actually a text format that does not depend on any programming languages, but it uses C programming language conventions and other similar languages¹⁸.

```
{
  "firstName": "John",
  "lastName": "Doe",
  "isActive": true,
  "age": 30,
  "accountValue": 1234.56,
  "Contact": [
    { "city": "Anytown", "street": "Main St.", "st.number": 1, "tel": "+123 555-1234" },
    { "city": "Capital City", "street": "Main St.", "st.number": 101, "tel": null }
  ]
}
```

Figure 3.4: JSON example

The use of the JSON format has increased with usage of the AJAX technique for creating web applications, where data are retrieved quickly and asynchronously. Figure 3.4 illustrates one simple declared JSON object with values. In JSON format, values must be declared as one of the following types¹⁹:

- Number - support integer and decimal numbers
- String - sequence of characters
- Boolean - true or false values
- Array - ordered sequence values

¹⁸<https://www.json.org/>, 2019.

¹⁹<https://json-schema.org/understanding-json-schema/reference/type.html>, 2019.

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- Object - unordered sequence values, where keys must be declared as string
- null - empty value declared with word *null*

3.7 SVG Object

SVG (Scalable Vector Graphics) is a vector graphics storage format, based on Extensible Markup Language (XML) standard. Unlike raster graphics such as .png, .jpg, .bmp and others, in which an image is stored as a rectangular pixel grid, vector graphics consist of a few basic shapes grouped with each other. These shapes are two-dimensional geometric bodies defined by attributes²⁰. The main advantage of such images is that they can be zoomed without loss of image quality because raster graphics is built out of pixels where every pixel contains a certain amount of bits. In contrast to raster graphics, an SVG is built out from shapes, and by zooming, these shapes are instantly recalculated to fit at any screen resolution (Mangialardi, 2018).

SVG files usually have the extension .svg. Because they are XML-based, they can be read and edited in text format. An additional advantage of using XML is that it can be edited using JavaScript, which allows you to draw an SVG image as dynamic or interactive content as with an HTML document; it can represent a complete HTML site^{21, 22}. Images in SVG format are usually smaller than raster images (.jpg, .png, .bmp) and can be compressed like text effectively lossless (compressed .svg image uses the .svgz extension and the size of compressed file is typically 50-80% smaller than original file)²³.

²⁰<https://www.smashingmagazine.com/2019/05/svg-design-tools-practical-guide/>, 2019.

²¹<https://www.grin.com/document/195495>, 2002.

²²<https://www.awwwards.com/websites/svg/>, 2019.

²³<https://www.moxio.com/blog/6/serving-compressed-svg-files>, 2016.

4 Tracker plugin

This chapter describes the design and implementation of xAPI to capture the H5P video activities of users in Moodle courses and visualizations of these activities in the LA Cockpit. The practical goal of this chapter is to provide a tool that observes, captures and visualizes users' video behaviour. At the same time, the new visualizations should be integrated with the existing dashboard and its techniques to display users' video behaviours. The first section focuses on monitoring user interactions with H5P video activities. It explains the predefined JSON object structure and the meaning of each element in the JSON object. It then captures the users' video activities and stores essential properties of these activities in JSON form. The following shows how JSON objects are delivered and archived in the LRS. The second part of this chapter provides a data presentation of the collected H5P video activities by using developed xAPI. Three different visualizations are developed to display users' video behaviours. The purpose of this visualization is to facilitate user tracking H5P video activities, for example, to see how often a video is viewed, which part of the video is the most viewed, how many video activities was performed in a week, compare video activities between weeks and other useful information about H5P video content.

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4.1 H5P video tracker

The H5P video tracker needs to collect the video interactions of the users that occur with the H5P plugin. The H5P plugin provides students with interactive content that can be displayed with the H5P video player. With the H5P iframe player API, it is also possible to embed video content into Moodle page. The iframe player offers various events such as playback, playback speed, pause time and others. JavaScript allows you to control the player and its events. In fact, the focus is on the H5P tracker API's capabilities to capture user activity in the player and record it as log data. This log data is then transmitted to LRS, which can later be analysed to understand video learning processes, improve future video content and improve user learning success.

4.1.1 Architecture and JSON structure

The iMooX platform uses Moodle as an LMS to provide learning content. The H5P plugin was installed on the Moodle platform, where the interactive H5P content is made available to learners as Moodle activity. Since each video on iMooX is provided by the YouTube platform, the H5P plugin used YouTube as a resource to upload a video and then create interactive video content from that uploaded video.

As part of the H5P plugin, the tracker uses JavaScript technologies and its jQuery library to collect learners' interaction with H5P video content. In combination with the JavaScript events, the learners' activities are collected as statements and then serialized in JSON format. As in most programming languages, JSON describes a data exchange format that is structured in a simple and understandable way, already explained in section (3.6).

In this paper, the JSON structure contains the properties of the simplest form of JSON. It could report from JSON objects who performs

an activity, what the object of the activity was, and what action is performed on an object. Additional properties have also been captured as JSON elements such as timing, video length, video title, and others. Figure 4.1 shows a statement collected with the developed tracker. When using AJAX technologies, these statements are stored in a JSON file. These JSON files are created in the temporary storage. The temporary storage folder is located in the Moodle data directory, where the data is not accessible via the web. JSON's file names are unique and are created using the value *userid*, so each user has their own JSON file in which their H5P video activities are stored. The developed tracker is shown in Figure 4.2 and is divided into three levels: a frontend for delivering video content to the user, a backend for capturing user video activity, and a temporary memory where each user's activity is stored in a separate JSON file.

```
{
  "courseid": 3,
  "section": 1,
  "mobile": false,
  "platform": "linux",
  "videoid": "2oFwq0MiSh2",
  "videotitle": "[Test Video] 01 Einleitung",
  "videoduration": 594,
  "activityexecuted": 1563269643.624,
  "start": 373,
  "stop": 378,
  "type": "watched"
},
```

Figure 4.1: The H5P video activity presented as JSON object

The statements provided by elements of the JSON object contain valuable information about the use of video content, such as current information, whether it is a mobile device or the desktop PC to view video content, the start time of the video where the learner starts watching videos, did learners drag the seek bar forward and not viewed the entire video content, how learners ended viewing the video content. This data is captured through an developed xAPI called an H5P video tracker.

The last part of the tracker is formed by a temporary LRS that is used to accept and temporarily store information about users' video activities

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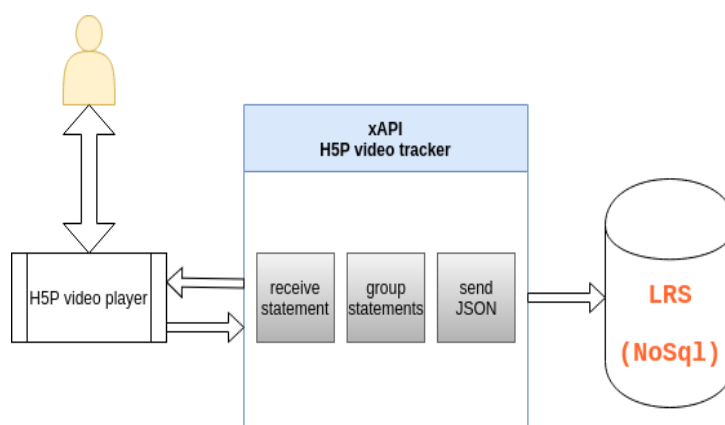


Figure 4.2: H5P video tracker architecture

during the learning process. Collected data stored as JSON files can be further shared with other systems. In this research study, it is referred to as intermediate storage because the collected data is deleted after a certain period of time for the purpose of further distribution.

This JSON file contains array elements. Each element in this array consists of a JSON object. The structure of the JSON object and the description of each element is shown in the table 4.1. The JSON statement is structured according to a simple form of expression consisting of actor, verb, and object¹.

4.1.2 Implementation

To find a compatible position for the video tracker xAPI implementation in the H5P plugin, the components of using the H5P plugin in Moodle must first be investigated. In the standard form, the H5P plugin makes learning content available to learners by selecting the Interactive Content option in the Moodle activity-resource menu. The

¹<https://xapi.com/statements-101/>, 2019.

4.1 H5P video tracker

JSON Object structure		
Field name	Type	Description
courseid	number	course is represented by unique course number
section	number	each course consist of several week, every week is presented by auto-increment number
mobile	boolean	assign true value when learners used a mobile device to watch H5P video content, and false otherwise
platform	string	identifies users' digital platform which is used to execute activity
videoid	string	identifier of a video on YouTube
videotitle	string	titel of a video on YouTube
videoduration	number	video length in seconds
activityexecuted	number	present the time(unix timestamp) when activity is executed
start	number	the starting point(in seconds) of activity in video
stop	number	the end point(in seconds) of activity in video
type	string	how the video activity is executed

Table 4.1: The fields in JSON object

learning content is uploaded as a resource and can be accessed by users via the H5P link on the course page. Clicking on the link opens the H5P main content page². The iMooX platform uses a different technique to provide H5P content to students, the learning content is provided by embedded code and inserted into the course page. As a source, they use YouTube to upload content as interactive content using the H5P plugin. If the student wants to view H5P content, it is automatically displayed to the student. The problem of automatically loading content

²<https://h5p.org/node/258172>, 2019.

4 Tracker plugin

to a consumer when multiple embedded H5P content is presented on the course page as the speed of loading and delivering H5P content will often be slow. The developers of the iMooX platform provided a technique where the H5P content is presented to the user as a YouTube video thumbnail³ combined with the play icon. Playback of the H5P video content begins after the student has clicked on the play icon.

Since video content is delivered via embedded code on the iMooX platform, in the H5P plugin directory `embed.php` file is used to deliver content to the user. The `embed.php` file contains all the JavaScript files required to provide all the HTML and DOM elements that are necessary for users to view the video learning content. The JavaScript file is also included in the `embed.php`, which is implemented as an H5P video tracker to capture user activity. This JavaScript file is loaded with video player and content when the user clicks on the YouTube video thumbnail aforementioned.

The Implemented file waits JavaScript event `window.onload()` to create an object that stores the activities of users. This event occurs when the browser has loaded an HTML object⁴, in our case it will wait until the user clicks on the play icon. When `onLoad` occurs, all content is loaded (including video player API, H5P integrated YouTube content, CSS styles of H5P players and content, integrated H5P tracker). Any video content presented in iMooX as H5P content is displayed in the course page as `iframe`. Using the HTML element `<iframe>`, it delivers and integrates all contents of another HTML page into the current HTML page⁵.

First, Tracker API creates the array of JSON objects (see 4.1). Each object contains all user behaviours in the `iframe` object and additional information such as a course, a week of course, a device used and

³<https://creatoracademy.youtube.com/page/lesson/thumbnails?hl=en>, 2019.

⁴https://www.w3schools.com/jsref/event_onload.asp, 2019.

⁵<https://developer.mozilla.org/de/docs/Web/HTML/Element/iframe>, 2019.

others. The created object stores *courseid* and *week number* at the beginning of tracker execution. These two variables are stored in the object with the implemented *getURLParameter* function. The purpose of this function is to get the value of the *iframe link* as a string and to split this string based on the parameters of the input function. The input parameters are defined as *id* or *section*. The other two variables declared and captured at the beginning of the tracker's execution are *mobile* and *device*. The two variables like *courseid* and *section* are the identical for all objects until the course page is updated. The reason these variables are stored for each object is because it is easier to provide this information to an LMS, and it required less effort to query records in the Nosql database.

All activities performed by users with the H5P video player are collected using the *setListener()* function. Any embedded *iframe* of H5P plugin in Moodle is labeled *H5P-iframe*. The *getElementsByClassName* function collects H5P video content and supplies it as a parameter in the *setListener()* function. The *setListener()* function appends an event listener as a message to get *iframe* updates. Each time an update is retrieved from *H5P-iframe*, it contains all the information about the currently playing interactive content. This information also includes additional data from the YouTube player API, since all provided video content on the iMooX platform uses YouTube as its source, where all videos are uploaded to one channel. To find out information when the user plays, pauses, seeks forwards or backwards, it is important to find out the status of the YouTube player API. The ability to distinguish between different player types is realized by checking current YouTube player statuses. The possible YouTube states are⁶:

- **-1** - unstarted
- **0** - ended
- **1** - playing

⁶https://developers.google.com/youtube/iframe_api_reference?hl=en, 2019.

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- 2 - paused
- 3 - buffering
- 5 - video cued

The H5P Player API is shown in Figure 4.3. When the user starts playing the video content, the H5P player's video navigation bar appears at the bottom of the iframe field. Clicking on the video screen pauses the video. The main controls in the navigation bar of the implemented H5P tracker are the Play/Pause button, clicking the video area, and using time-shifted sliders. With these three elements in the Video Player navigation bar and clicking on the screen, the user interacts with the video player that is of interest to the tracker and captures the current states of the player. Basically, the listener receives the updated



Figure 4.3: H5P video player interface, player minimized screen standard controls, play/pause button, playing time, time-shifting slider, additional options(video quality, captions settings), enter fullscreen icon

message from the attached event (Player API), it provides the current playback data. This data includes the current YouTube playback state, the current playback time, and other information about the currently playing content. This data is collected by the tracker and sorted by type.

4.1 H5P video tracker

The type depends on the user's interaction with the player, current playback time, and previous playback states. The following playing types are defined and classified in H5P tracker api:

- watched - when the user plays video content from a one point and pauses at a specific position.
- closed - it occurs when the user views video content and then updates or closes the course page without stopping the video.
- finished - when the user sees the last 10 seconds of the video or more.
- playforwardseeking - if the previous state of the YouTube player was playing and then the user seeks forward without interrupting the playback
- playbackseeking - if the previous state of the YouTube player was playing and then the user seeks backward without interrupting the playback
- pauseforwardseeking - when the previous state of the YouTube player was paused and then the user seeks forward
- pausebackseeking - when the previous state of the YouTube player was paused and then the user seeks backward

After collecting a user interaction and classifying it by type, the tracker api collects other information such as playing start time, stopping time, video title, YouTube video ID, video duration, and the time the interactivity was performed. All this information is stored in a JavaScript object. The *insertActivity()* function is executed after each player state change which takes this JavaScript object as a parameter and stores it as a JSON object in the above mentioned declared array.

The second event that occurs with the *setListener()* function is waiting for the refresh or close of the course page. This event is registered and executed with the jQuery *one()* method and the JavaScript event '*beforeunload*'. When the user refreshes or closes the page, the *uploadActivities()* function is performed before the page is refreshed. The purpose of a

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function is to get the array of JSON objects as a parameter and send this array of JSON objects as a JSON file using Ajax techniques. Ajax-Request takes this file as input data and uses the *POST* method to transfer data between a client and the server⁷.

After the Ajax *POST* method has sent an array of the JSON object, the server side is responsible for classifying received data to the corresponding user and storing its video activities in the JSON file. The JSON file holds all of a user's activities. The structure naming of the JSON file depends on the user's ID determined by Moodle libraries. If the JSON file already exists for the current user, the php functions provide an efficient way to merge currently collected activities with previously saved user activities. Afterwards, the created JSON file is saved in the *moodldata* directory.

4.2 Visualizations

The problem that arises is how to extract useful information from the large amount of data collected by the online learning platform (Huang et al., 2017). The dashboard is one of the possible solutions that displays various data on a single screen. The dashboard can be used to identify the user's behaviour, which can be used to improve or modify further learning processes (Podgorelec and Kuhar, 2011).

As part of this thesis, the existing Dashboard LA Cockpit for the iMooX platform will be extended by additional visualizations to represent video behaviours of users. The concept on which the LA Cockpit was implemented as Learning Analytic tool that should contain some parameters such as that the users could see their learning process (Maier, Leitner, and Ebner, 2019), the personal data are safe from unauthorized access, learning status and process should be provided

⁷https://www.w3schools.com/jquery/jquery_ajax_get_post.asp, 2019.

in short time and not after a certain time, the information is effective and easy to interpret from the dashboard, educators know how to use the information from dashboards to improve the quality of learning, all data should be available in one place and valuable information obtained through visualizations should also be used to make the tool better (Ebner et al., 2015).

The main part used to easily deliver and visualize data on the dashboard are metrics. Metrics are generated by analysing data captured by users' activities in MOOCs. This collected data is usually stored by the LMS system in its own LRS. In the past, simple visualizations were provided during the development of this tool to show the frequency of quiz usage, forums or site visits. The visualizations developed in this thesis are intended to illustrate users' video activities. Because the iMooX platform has not yet been able to capture video activity data, xAPI has been developed, as explained in the previous section. Gathering data which are collected by xAPI is explained in the following sections and how it builds on the current LA Cockpit and what metrics are used to visualize it.

4.2.1 Design

During the design of the dashboard, care was taken to enhance the understanding of user engagement on the platform and to provide some valuable guidance to further enhance the quality of learning on the platform. At the beginning of the prototype development phase of dashboard, during the testing phase, only the administrators of the platform had access to the tool. Later, in order to achieve the defined objective in the design, for instance to explore user behaviours or offer Learning Analytics tool for courses on the platform, course teachers are granted access to the dashboard.

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The visualization pipeline⁸ shown in Figure 4.4 represents the basic data transformation process of LA Cockpit. This data transformation process is visibly segmented into several components from the data creation to the data analysis and visualization.

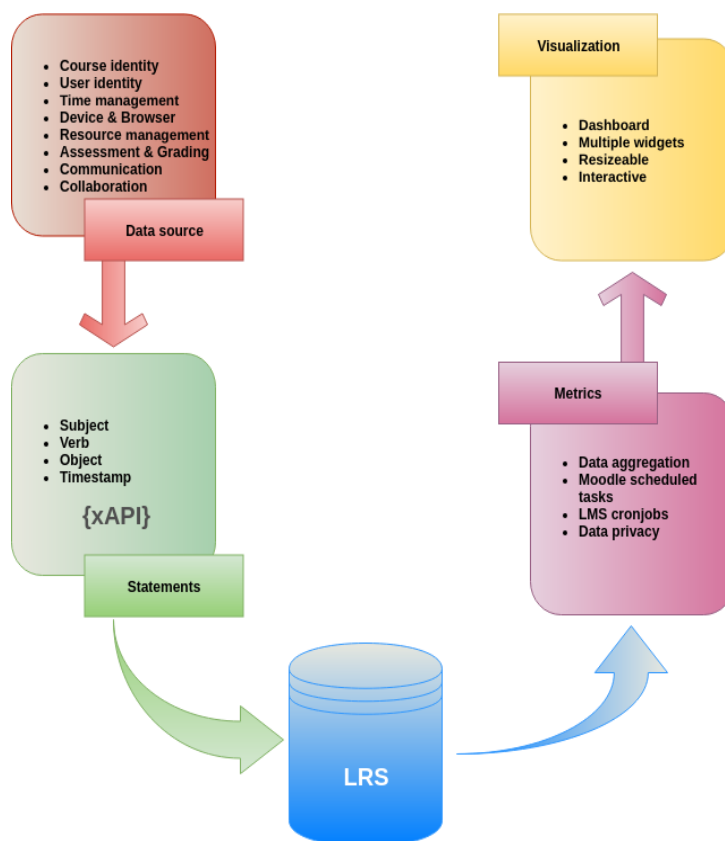


Figure 4.4: LA Cockpit visualization pipe

⁸https://infovis-wiki.net/wiki/Visualization_Pipeline, 2019.

The LA Cockpit visualization pipeline can be distinguished into five different processes:

- Data creation
- Data collection
- Data storage
- Data aggregation
- Data visualization

The LA Cockpit is designed as part of the Moodle LMS, and considering this the LMS tracks user performed actions on the system and stores as log files. For instance, Moodle tracks user login session, time of login, users' path as they are opening different courses, quiz activities and many other activities. These log files are stored in log tables, which are placed in Moodle LRS, which means that the first three processes in LA Cockpit visualization pipe are performed by the Moodle environment. In this thesis, data creation, collection and storage were performed with the H5P video tracker, which tracks the students' H5P video activities by collecting data in the form of statements and stores as JSON file in temporary data storage. The H5P video tracker is presented in the section 4.1.

The data stored in the LRS has no structure and is therefore not understandable for further evaluation. The visualization of this data, which is the goal of this section, also requires the aggregation of this data. How important it is to structure data to be understood and to be conceived is mentioned in section 2.2. Therefore, the data aggregation is a further process, which serves to receive a meaning, which is acceptable for the visualization.

Since LA Cockpit was implemented as a local plugin in the Moodle, data aggregation was performed as a Moodle task. The local plugin is mostly applied in cases where it should have a designated function that does not fit as standard plugin, and provides developers with freedom in terms of design, structure, and functionality. As mentioned above,

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the first three processes are executed by Moodle, which means that the data aggregation is built on these processes and can be seen as a starting point for the implementation of the LA Cockpit plugin. To make data stored in the LRS meaningful, the data aggregation process is used to get insight into the learning process and model the collected data into *metrics* (Maier, Leitner, and Ebner, 2019).

The term metric in the LA Cockpit is used to identify the learning process and provide clarity and simplicity of data presentation. The key metric characteristic consists of transforming the data which describes the learner's behaviour. The characteristics of the metrics in the prototype were to represent data at the global abstraction level within the LMS, and three basic metrics were designed:

- Login activities metric
- Quiz activities metric
- Forum post activities metric

The shared characteristics that were common to all three metrics were that data aggregation occurred daily, user-relevant data was not stored in table only aggregated numbers and all log files were deleted within a specified time period to comply with users' privacy policies. The metrics are stored in separated table in Moodle LRS.

Once data aggregation process is completed and as output metrics are stored in separate tables in Moodle LRS, these datasets can be displayed on the dashboard. While the metrics table provides a basic overview of its meaning and purpose of aggregated data, the dashboard allows the user to explore and analyse learning processes using provided metrics. The LA Cockpit dashboard is composed of two parts:

- **Dashboard menu** is located at the top of the cockpit and attention is focused on not occupying much space so that the information can be displayed at a glance (Few, 2006).

4.2 Visualizations

- **Widgets area** were all widgets added by the user are displayed. Each visualization is represented by a single widget. In this area, the user can freely place the widget at the desired location. It is also possible to resize or remove the widget. If multiple widget are added to the dashboard, they could not overlap each other. It also prevents adding visualizations of the same type to achieve display of different metrics on the dashboard.

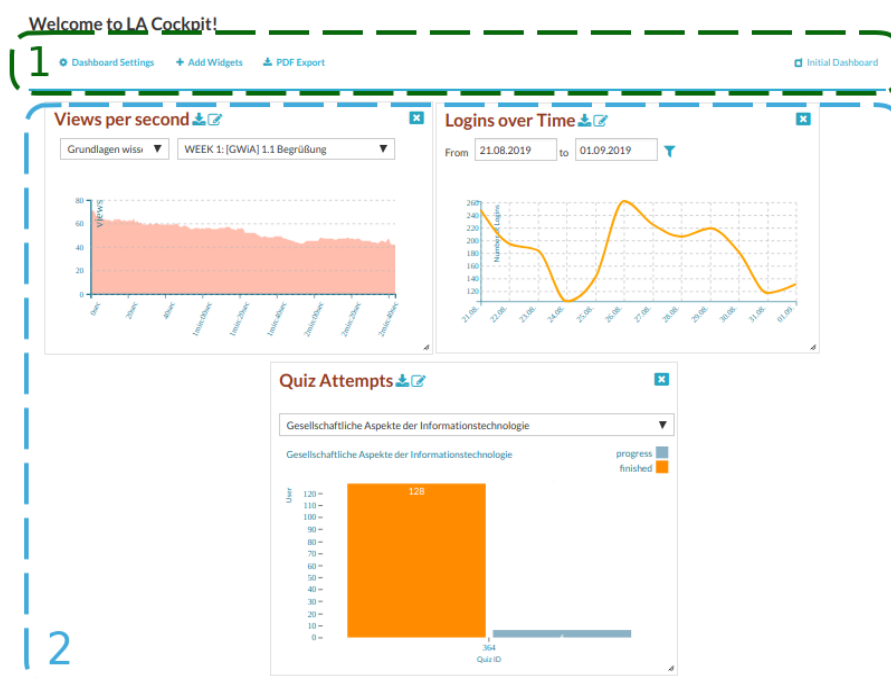


Figure 4.5: LA Cockpit dashboard and its elements: [1] Dashboard menu, [2] Widgets area

The design of a dashboard is structured in such a way that each user has own customized dashboard and it is possible to create multiple dashboards with different widgets. Advantage of this concept is that a user can create multiple dashboards for different courses and have a efficient representation of learning processes in different courses. Each

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dashboard can be given the desired name so that the user can later easily find the created dashboard.

The widget is an essential component in the LA Cockpit for displaying data. Data visualizations are presented in image or graphic form. The way the data is displayed and adjusted by the user in widget is stored in Moodle LRS. When the dashboard is recalled, the data in widget is restored to the state it was previously displayed. Each widget is specified by the following parts:

- Title area that contains the widget names, a button to export the content as a picture, and an option to add additional user-defined text which describes the displayed widget.
- Filter panel provides predefined options for dynamic interaction with the widget
- The Visualization area displays the metric of the selected widget and is represented through the SVG object. Using a parameter filter, it is feasible to display the metric in a different form, but metric properties does not change.

The same approach was followed while designing a new video metrics. First, metrics that describe the aggregate video activities are defined. Data generated by the H5P video tracker in Moodle LRS was applied to create new metrics. Like previous metrics, data aggregation is accomplished as a Moodle task. These tasks were defined in the local plugin folder of LA Cockpit.

The new metrics structures is defined first, which is then represented by new visualizations in the cockpit dashboard. Two metrics described the individual video activities that were performed on the video, and the other metric described the overall video activities in a course and its sections. With the new metrics, it is possible to determine which part of the video was most viewed by enrolled users in the course, whether the video was viewed in a consistent way throughout its timeline, which

video in course was viewed the most, and other interesting findings. The structure of three metrics is explained as follows:

- **M1 view_per_second** stores activities from videos that were viewed, paused, and finished. Video activity is stored by the H5P tracker, and data from the temporary LRS stored as JSON files is aggregated daily. The visualization of aggregated data is described in the next section. As this metric is displayed, it is important to note that the metric is designed to make the filtering options easier to perform in widget. The filter for this metric is that each video can display the total number of views per second and that the main attributes that characterize a video for easy visualization are the Course ID, Section ID, and Video Title. In addition, the user information is not present in this metric, so privacy is assured.
- **M2 view_rewind_forward** is similar to the first metric, where a metric has a comparative role. Here, the activities collected by the H5P Tracker are collected in addition to the watched, closed, and finished activities, as well as other activation types, such as playforwardseeking, pauseforwardseeking, playbackseeking, pausebackseeking. All types of collected activities are divided into three categories by type:
 - view: all the video activities that have been watched, closed and finished are retained here.
 - rewind: captures all video activities that have type of playbackseeking and pausebackseeking
 - forward: stores all video activities containing playforwardseeking and pauseforwardseeking types.

The visualization of these types is explained in the next section and how the comparisons between these types is represented. Similar to the first metric, the structure of metric is adapted to the filter option, and the basic elements that define a metric in addition to the types that are course id, section id, and video title.

- **M3 video_activities** as last metric covered in this thesis aims to

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display multiple videos in a single visualization and dynamically display the main properties of this group of objects to the user. The object defined in this metric is represented as a course, section in courses, or a video itself. All video activity types captured by the H5P tracker are collected and organized into three categories as previous described metrics. However, when these categories are displayed, the types of grouped items are also summarized here. Implementing this metric, introduced in the next section, makes it clearer how the activities in these three categories are summarized. The filter metric is based on a time frame so that the time in which video activities are visualized can be limited and interesting findings presented. Findings of this metric can be used to compare courses, course sections or videos in a section, and it is also possible to make comparisons between videos from diverse sections through widget interaction.

The video metric visualization was designed as part of the LA Cockpit dashboard. The new visualizations of video activities followed same approach by designing as prototype metrics mentioned above which are the login, quiz and forum posts metric. Each visualization is produced by a widget. The main components of the widget remained identical as in the previously developed widget in LA Cockpit and includes widget title area, the filter area and visualization as SVG object. Some new methods for interacting with the widget have been added to the visualization area which are provided by using the d3 dynamic library and jQuery techniques.

The following section provides implementation details. Visualizations of video metrics are presented, the methods that are used to provide visualization, techniques that enables interaction with the widget and ways to filter data.

4.2.2 Implementation and Visualization process

The LA Cockpit implementation consists of five processes that are represented by the visualization pipeline shown in the previous chapter, see Figure 4.4. The first three pipeline processes in this thesis were implemented using the H5P video tracker, in contrast to standard LA Cockpit metrics, where these processes are realized through Moodle technologies and its log tables. The H5P video tracker collects video activities and models these activities. As a result, JSON files are created in the temporary storage of the LRS and stored in the *moodledata* folder. The implementation of these processes is already discussed in the section 4.1. Data aggregation as the fourth process was implemented following the previous data transformation in LA Cockpit and provided output as a metric. The last process in this pipeline is the representation of metrics via widgets, the LA Cockpit widget implementation is reused and adapted to the video metrics.

The data aggregation was implemented using a Moodle technique known as Cron-Job. Moodle offers an automatic task capture processes that is controlled by a Cron-Job. The server starts a process or script at specific times during a Cron-Job schedules tasks to be executed⁹. In this case, the data is aggregated and stored as a metric. The metric are stored in table in Moodle LRS. The table was defined and created by using the Moodle XMLDB database library. XMLDB is a Moodle technique that enables database interaction and access¹⁰. In this case, it is called Moodle LRS. The table *lacockpit_videoacts* is created in Moodle LRS. Data aggregation is set to be executed.

In the *lacockpit_videoacts* table, the generated video metrics are stored, which serves later for visualization. The Cron-Job specifies the daily aggregation of data. The data is converted from a temporary storage created with the H5P tracker to a Moodle LRS. Each JSON user file

⁹<https://docs.moodle.org/37/de/Cron-Job>, 2019.

¹⁰https://docs.moodle.org/dev/XMLDB_Documentation, 2019.

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is analysed and transformed by a task started with a Cron-Job. The JSON structure has already been described in the previous section 4.1.1. Each element within the object is checked by Cron-Job task for a valid value, it verifies that the H5P tracker has correctly passed each value according to a predefined JSON structure. If an element has an empty or invalid data type value, this object is saved in the error folder as a JSON file. The *errors* directory is located in the *moodldata* folder and is intended to present an unexpected case to platform programmers where some video activity is not correctly captured by the H5P tracker or the values are not correctly written into the JSON file using Ajax technologies. When all JSON files are scanned and the data aggregation of each file in the *lacockpit_videoacts* table is recorded, the Cron-Job task deletes each file in temporary storage as a final step.

After saving the metrics in Moodle LRS, the LA Cockpit dashboard implementation process is next step to visualize metrics. The data visualization process is provided by the dashboard. As mentioned in the design section, the main visualization part of the dashboard consists of widgets. The task of each widget is to visualize the aggregated metrics. To retrieve metrics from the Moodle LRS, the widget uses external Moodle service technologies. For each widget a external function declaration and its description is stored in the file *db\services.php*. The implementation of the external service function is located in the file *externallib.php* in the plugin directory. The return values of the external function are usually passed to the client as JSON or array format. In this case, the return values are retrieved after the user's interaction with filter panel in the widget.

The implementation of the widget class structure is shown in Figure 4.6. All widgets have the same structure as defined in the abstract class *chart.php*. The following basic parameters define a widget: widget id in LRS, key (describe key), *svg_id* in dashboard, x- and y-position in dashboard, height and width of widget and annotations to the visualizations. In addition, the widget consists of functions that add HTML

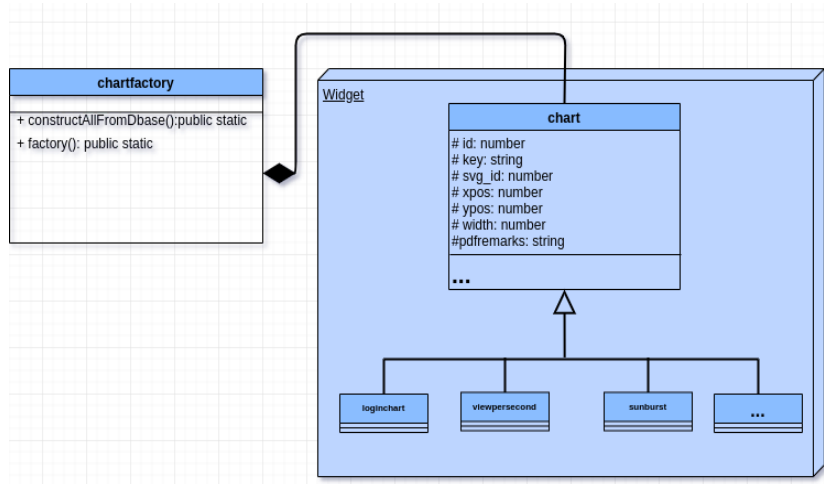


Figure 4.6: Widget class structure

elements to the widget space, and the output renderer class in the Moodle environment manages the rendering of the widget's visualization¹¹. The *chartfactory* class plays a key role in the creation of widgets on the dashboard. The file *index.php* in the plugin directory serves as a starting point for the implementation of the local plugin. In *index.php*, a public function called *constructAllfromDbase()* from *textitchartfactory* class is called, in which the dashboard *id* is checked and whether the dashboard has already been created on the platform. If the LRS dashboard table determines that the dashboard was already installed and widgets were installed, these widgets are displayed in the dashboard by calling the *factory()* function and retrieving the parameters of these widgets from the LRS widget table. When the function call is completed, the dashboard with the previously described menu and its elements is displayed to the user.

The following sections cover the video metric visualizations and their diagrams, filtering options, and interactions capabilities.

¹¹https://docs.moodle.org/dev/Output_renderers, 2019.

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4.2.3 V1 views per second

For the first video activity widget, the metric *view_per_second* was used to count previews per second of video. A d3 library was used to display the defined metric in the SVG object. This diagram shows total view activities per second of all users for selected video, where the x axis shows times in seconds and the y axis performed sum of activities on the second. To calculate the preview per second, the start and end times of each activity were given in the metric of this visualization. Since only a single video is selected via the filter panel, the video length is automatically determined via the metric. The preview value per second was calculated using the start and end times to define time period. Each second in the video is then increased by one if it is between the specified time period. The graphic is visualized as SVG object, *mousemove* and *zoom* event are provided by D3 Library.

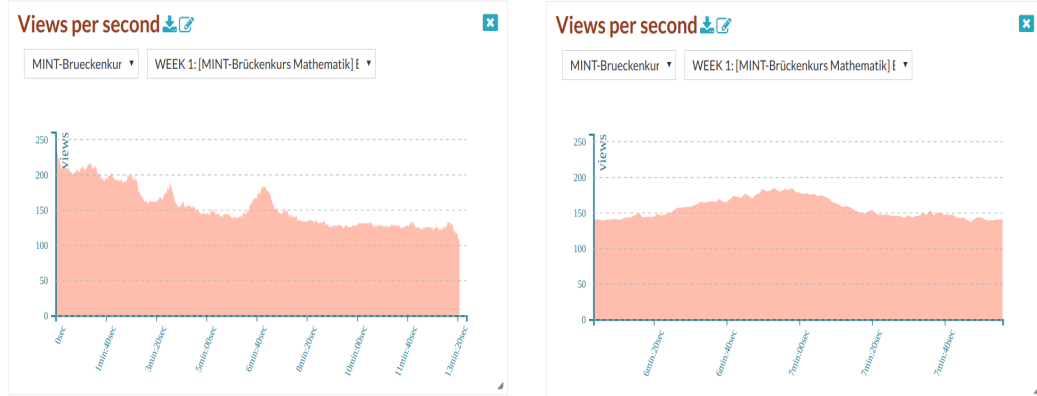
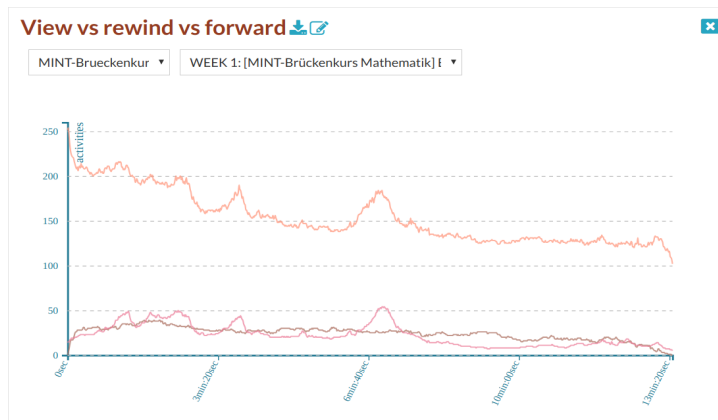
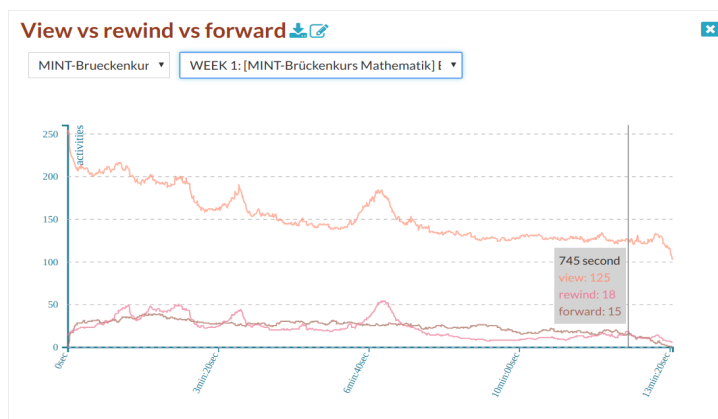


Figure 4.7: The widget views per second

4.2.4 V2 view vs rewind vs forward



(a) Standard widget visualization



(b) Mouseover interaction performed, toolbox is displayed next to a mouse pointer

Figure 4.8: The widget view vs rewind vs forward

This widget shows which states the users have executed during the video process. The comparison between the three states is illustrated in the chart as play, seek backward and seek forward. The orange line

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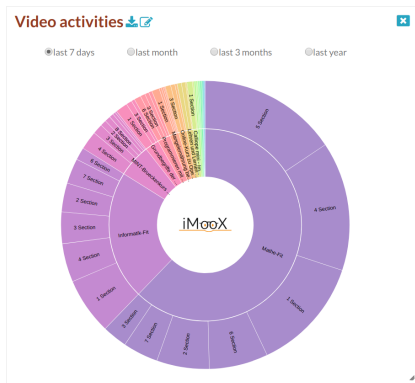
shows the sum of play activities per second, the pink line the total of seek backward actions per second and the brown line the total of seek forward calls per second. In the filter menu, the video is selectable by course name and in the section in which the video is placed. The video is tagged with its name. Using the jQuery techniques and external Moodle service, the filter panel was implemented and provided as a drop-down menu. On the x-axis using d3 method *ticks*, steps between seconds have been generated. These steps are performed on a *mouseover* event and the distance between the two steps is set to 5 seconds. Each *mouseover* call shows a toolbox next to a mouse pointer from which it can be read which seconds are chosen and how many play, seek backward and forward activities have been performed in total. This interaction process is shown in figure 4.8(b).

4.2.5 V3 video activities

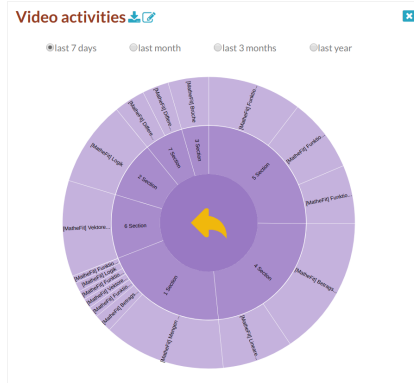
The Zoomable Sunburst Diagram¹² was used to sort the video by sections and courses to which they belong. The d3 library was used, as in previous visualizations, to implement this diagram. Two hierarchy levels are displayed at a time, and it is possible that the input data has more than two layers. Our metric for this widget consists of three layers. Two interactive options are available to the user: click and mouseover. When you click on an element in the graph, it zoomed into that element and its subelements. In this case, it is a course level. Clicking on the back icon reduces zoom out to the previous level. The mouseover event in the widget contains a tooltip where the user can see various video activities performed for that item. Features that enhance this widget: it is easy to get an overview of the number of courses, how many videos are offered in a section of the selected course, and it is even possible as a Learning Analytics tool to compare video activities between the elements, whether these are courses, sections or videos.

¹²<https://observablehq.com/@d3/zoomable-sunburst>, 2019.

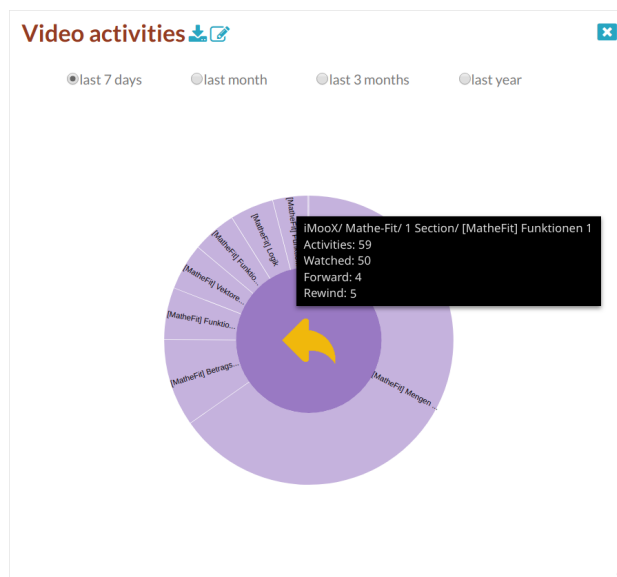
4.2 Visualizations



(a) Standard widget visualization



(b) First level of visualization



(c) Second level of visualization

Figure 4.9: The interactive video activities sunburst widget

5 GamifyBat

The focus of this chapter is on the development of the motivational tool for engaging students in online learning environment. In the previous chapter 2 it was discussed that almost all online platforms face a high rate of drop-outs of learners and how the learners motivation in online learning can contribute to decreasing drop-out rates. In order to keep the participants active and motivated in the course and ultimately to prevent them from dropping out of the course, a lot of researchers are developing a various strategies. What all of these studies have in common is that they investigate the behaviour of the participants through activities on the platform such as login activities, movement tracking, quiz attempts, discussion in the forum and many other activities. All these user activities are usually stored in the background by the platform tracking tool, but Learning Analytics field is still a young field of research and there is still plenty space for improvement in the future on how the collected data can make online learning more popular and effective among learners. A practical goal of this chapter is to contribute to the attractiveness of online learning using collected data among learners and provide tool for this purpose.

The following sections give a concrete overview of the tool, its design and purpose, the used technologies for deployment, and how it was implemented on the iMooX platform.

5.1 Overview

The motivation tool utilizes the game features to increase learners' engagements in the online learning environment. Since the previous version of iMooX already used the gamification element as features mentioned in the section 2.4 and the evolution results showed positive influence on the learner's behaviour in the course (Khalil, 2018). There was a need for stakeholders to implement an identical element in current iMooX version. The same concept is used to design and develop the gamification element on the current platform, with some improvements proposed based on the evolution of the previous elements.

The previous gamification element was based on the concept of using the Learning Analytics techniques to impact a learner's motivation based on their previous behaviours in the course. Using Learning Analytics, we can observe student behaviour by examining the completion or non completion of tasks and trying to represent these tasks through a gamification element. The aim was to track an unfulfilled task and visualize it to the students through a gamification element to motivate them, and try to change behaviour based on this visualization. For example, how many times students logged in last week to watch the video, completed a weekly quiz successfully, and interacted in a forum where students can write or read topics. For instance, how often students logged in last week, did they watch the video in previous week, successfully complete a weekly quiz, and participate in a forum where students can write or read posts.

The design and structure of the previous gamification element, as well as the improvements and redesign are presented in the next section.

5.2 Design

The gamification element of the previous iMooX version was presented in the form of a battery icon. The appearance of the battery icon was influenced by student behaviours of previous week:

- Login activity
- Forum activity
- Video activity
- Quiz activity

The battery had five different states, which could be displayed depending on the behaviours of the previous week. The design of the previous battery is shown in Figure 5.1. The idea is to construct a battery that

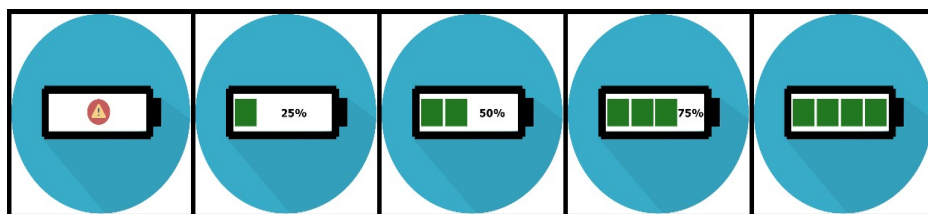


Figure 5.1: Five potential battery icons displayed as gamification element, from Khalil, 2018

indicates the level of participation in the course. The battery consists of four main parts. When you complete a task by task, the battery is charged. For example, when a student logs in to courses, the battery is easily charged. If the student interacts with video material from the course, the battery will receive an extra cell, if the student is doing a weekly quiz, the battery will be charged with another extra cell, and at the end the battery will be fully charged when the student participates in forum. The idea of using a gaming tool as a motivator gives participants an overview of their activities and informs them via the gaming element, in our case battery, how many tasks they completed last week.

5 GamifyBat

The battery symbol appeared inside the course page. This means that enrolled user could see his activities only if entered the course page. By designing the battery icon in the current version of iMooX, a future request by stakeholders was that the battery should be visible before the student visits the course page. As a result, if a student is not motivated to attend the course page, the battery will not have the desired motivational factor. If it is displayed outside the course page, the battery will be displayed before the user visits the course page, which could be an additional motivational factor. Following this request, there were two ways to place the battery icon, namely the overview page of all courses and my courses page where all enrolled courses of the user are listed.

The new design of battery was implemented by five different colours presented in Figure 5.2. The idea of using different colours was to send the student a signal in the form of traffic light colours (E. Arnold and Pistilli, 2012). Green is the highest level when a student is engaged well, yellow and orange are satisfactory, and a red or empty battery, which the student indicates is most likely to fail.

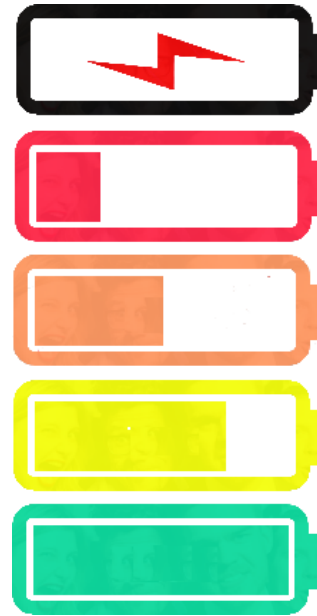


Figure 5.2: The new design of battery icons

5.3 Implementation

The gamification element was implemented as part of LMS Moodle, it is developed as a local plugin which provides developers with freedom in terms of design, structure, and functionality. The battery icon was created using JavaScript and jQuery techniques, in contrast to the previous version of the battery where the icon was rendered to the user in image format. Other techniques that are used to implement the plugin are CSS for the symbol styling, PHP for integrating the plugin into LMS Moodle, and Ajax for calling an external service to gather user activities and provide them to the plugin.

The battery icon is integrated as part of the Moodle iMooX theme into the `coursebox_content` function. A DOM element is added for each active course in which the student is enrolled and for which the first week has already passed. All DOM elements are placed as objects in HTML document that can be dynamically called, modified, added and deleted by using JavaScript techniques¹. Each added DOM battery element is defined by its `courseid`. The next step is the initializing step where the `init` function is called in the battery plugin directory. Then the `init` function creates a battery icon depending on user activities. User activities are retrieved through an

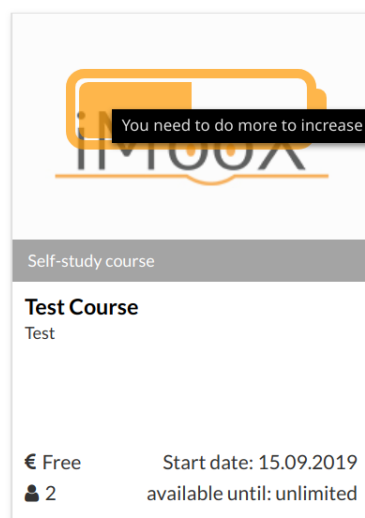


Figure 5.3: Displayed battery in course box

¹https://developer.mozilla.org/en-US/docs/Web/API/Document_Object_Model/Introduction, 2019.

5 GamifyBat

Moodle external service using log_tables that hold all user previous week activities that define the shape of the battery. After the battery icon has been defined and created, it is added as an object to the DOM element previously generated in the course page overview in the iMooX theme.

The Figure 5.4 represents flowchart of battery icon, which provides the sequence of operations to create and add icon to the course preview box.

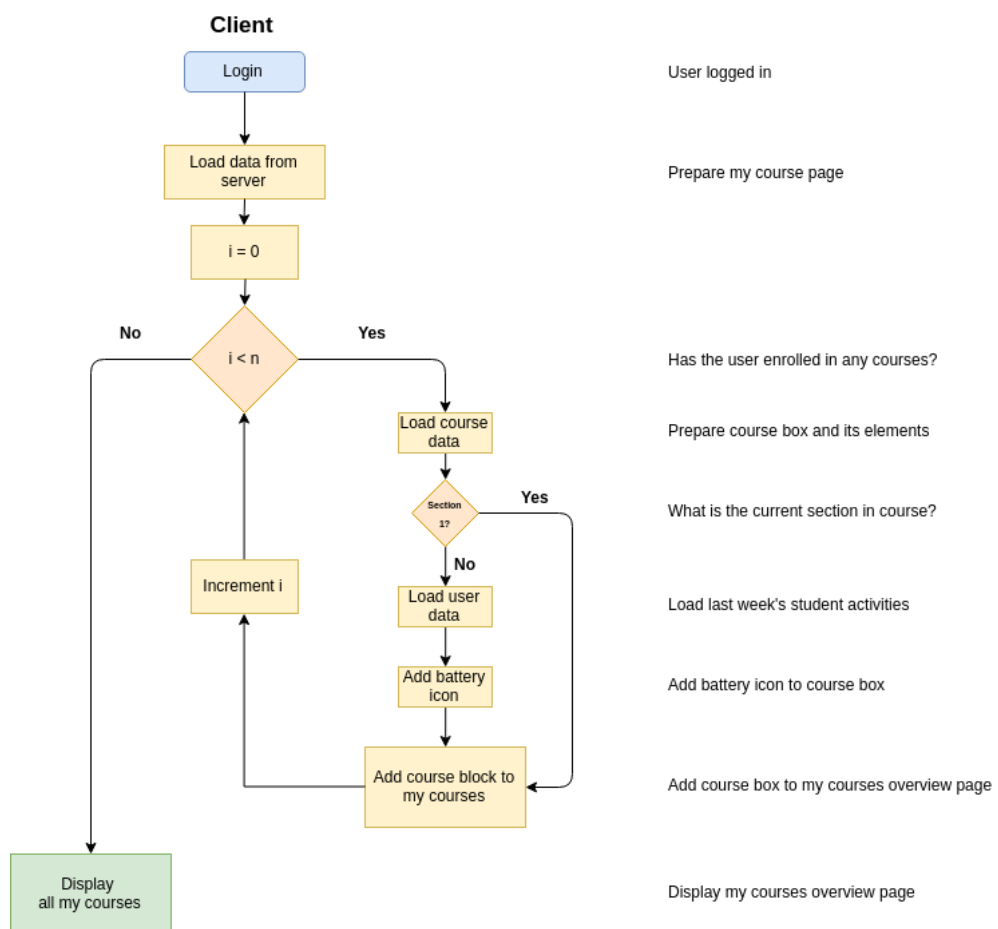


Figure 5.4: Gamification flowchart in mycourses overview page

In the last step to constructing a gamification element for a enrolled course, it is necessary to add a mouseover JavaScript event. In research study Khalil, 2018 the authors applied *mouseover* event on battery icon, which presents one of the following messages to the participants:

- No activity last week – we are looking forward to seeing you again this week!
- Your activity last week is 50%. Good! Increase your activities to score better!
- Your activity last week is 75%. Great! Keep it up!
- Your activity in the previous week is 100%. Congratulations. Your commitment is excellent. Keep it up!

The displayed message indicates accomplished activities of participant in the last week. This event was developed using the HTML attribute *titel*², which displays a tooltip to the element when the mouse is over it. In the Figure 5.3, a battery icon with an executed *mouseover* event is presented.

²https://developer.mozilla.org/en-US/docs/Web/HTML/Global_attributes/title, 2019.

6 Conclusion

Most people have limited amount of time nowadays and lack enough time to learn. In the lecture hall, the course session for student is too short to express their opinions, or they are afraid to ask or answer the questions. At the same time, teachers do not have enough time to teach students, analyse provided content and teaching methods and face other challenges that arise in traditional learning. The new technological possibilities empowers changes in the traditional forms of teaching in which the teacher gives a lecture and the student listens and writes as a passive participant.

There is a growing awareness of the new educational approach, in which pupils are involved to the maximum in the teaching process, content is critically reflected and their opinions respected, teaching is individualized. They have a sense of motivation, self-confidence and respect. All these characteristics can be obtained in a new form of learning called e-learning. Participants choose the time and place of learning, determine the pace of learning, and have full access to teaching content. This form of learning is time-saving and aimed at those who are looking for further education. This is also enabled for those who are under pressure due to everyday duties, regardless of whether they are working or have family. In this way, however, the student has a great responsibility because they engage in the process individually and determine when and what to do. Due to the daily responsibilities and the lack of physical contact with other learners, there may be a sense of isolation and a phase of abandonment of

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this type of learning. At this moment, a high level of motivation and self-discipline is extremely important.

One focus of this thesis is the use of Learning Analytics methods to identify student video behaviours in an online learning environment. The use of technology in the educational process is one of the main features which characterize e-learning. The iMooX, the Austrian MOOC platform was used for collecting video behaviours and for saving these data in its learning record store. The LMS Moodle is used in iMooX to provide e-learning content. The video is one of the main methods for delivering user content via MOOCs and the need to gain insight into the use of video among users for improving e-learning processes. With a developed plugin in this thesis called H5P video tracker, it is possible to track user behaviour on video content and save them in a simple and predefined way. After saving the data, a Learning Analytics tool developed in iMooX, LA Cockpit, can be used to visualize and find some interesting findings of video content. The data were visualized using the widget. Three new visualizations have been implemented, representing some interesting video characteristics, such as the most frequently used video, the comparison of videos from the same or different courses, which part of the video is popular, and others.

The second aim of this thesis is to provide a useful tool that is capable of positively influencing two characteristics of self-discipline and motivation aforementioned. Using Learning analytics, it is possible to determine when participants become less motivated and decrease their activities in MOOCs. The including of game elements is one of the methods of online learning that can have positive impact on learning outcome. In this thesis, a gamification element in the shape of the battery is implemented. The battery is based on a simple principle and can be used either as a self-discipline tool or as a motivation tool. It informs the participant of the level of effort performed in MOOC during the last week. The idea was to increase curiosity, reduce drop-out rates, motivate students and keep the course interesting by using game

elements in such a non-gaming environment.

The development of these two plugins shows how Learning Analytics can be applied in e-learning environments for data analysis, data visualization, presenting multiple visualizations, interaction with collected data, and to have a positive impact on student motivation.

6.1 Future Work

The developed dashboard, which presents data in a simpler way for the end-user through several visualizations, allows the addition of some additional functions through its simple structure. Future notable functions that can improve the dashboard as a Learning Analytics tool are the following:

- **Student as target group:** The Dashboard in its earlier development is accessible only to administrators and teachers. Making dashboard accessible for target group students would support their learning process in e-learning environment as numerous research papers show. Personalized dashboards to assist them in learning and on the iMooX platform would help increase the use of the LA Cockpit. To enable LA Cockpit accessible for the students, some additional attributes in the widgets can be defined in the current dashboard structure. Each predefined widget and each future widget should be defined by its targeted group. It would not be necessary to implement a new student dashboard, and each target group would have different widgets that can be added to the dashboard.
- **LA Cockpit usage:** Various evaluations are possible by defining new metrics and visualizing them in the LA Cockpit. In the current development, however, it is not possible to evaluate the use of the LA Cockpit. For example, different groups could deduce how

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valuable a LA Cockpit is, whether there are defects, and eliminate all defects that would be revealed by the La Cockpit metrics. In other words, there would be a double Learning Analytics process, that is, Learning Analytics on the LA Cockpit.

- **Visualize multiple metrics:** All metrics implemented and visualized in the dashboard cover a simple data aggregation that focuses on one dataset such as login, forum, video and more. Future metrics should combine several of these types and visualize them in a single widget, since D3.js provides many visualization techniques and dynamic options for the user to explore data and find interesting results.
- **Provide survey:** In order to determine the benefits of LA Cockpit for different target groups, especially for teachers of courses on the iMooX platform, a survey should be sent so that they can express their opinion about which course data they find interesting and which they can easily read from visualizations, finally define new metrics and provide them with the various visualizations.
- **LA Cockpit as warning system:** Develop a visualization by combining different metrics that represent students who do not perform well and who are at risk of dropping out. This visualization behaves like a warning tool to identify at risk students. On the basis of these visualization, warning messages tool may be developed that allows the teachers to make contact with the students and inform them that his contribution to the course is below the satisfactory level in comparison with other participants.

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