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# Learning Analytics Supported Gamification: The Case Study of AR4STEAM for Class Application

Ala Alsaleh, Jan Schneider, Dana Kube

DIPF | Leibniz Institute for Research and Information in Education, 60323 Frankfurt am Main, Rostocker Straße 6, Germany, Jan.Schneider@dipf.de, Kube@dipf.de

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## Introduction

21st Century day to day life is immersed with all sorts of technological means and educational sectors are no exception. However, technological integration in certain sectors, such as...e-commerce, banking or the ICT-shaping silicon valley area companies, are many steps ahead in tapping into the innovative potentials and limits of technology. Comparably, educational systems tend to be behind in adapting to such a world.

Using digital facilitation to make learning more attractive and engaging for students, however, can be established. The young generation is more than ever exposed to technological media that compete for their attention. Many times these media distract from productive tasks like learning. Therefore, tackling these issues in education with methods of the same level of digital immersion can potentially engage young students and encourage them to pursue promising careers in science, technology, engineering, art, and mathematics (STEAM). Here, it is the role of projects like AR4STEAM supported by the European Commission to raise awareness of the importance of choosing STE(A)M studies to pursue successful careers.

AR4STEAM's main goal is to enhance current teaching methodologies and make learning more engaging and enjoyable with the help of augmented reality (AR). It also provides school teachers and educational institutions with the tools and learning analytics supported gamification strategies for effective integration of AR in today's classroom, while also providing feedback mechanisms for teaching support.

To establish an efficient, effective, and enjoyable learning experience, Learning Design (LD) is crucial. Learning design shifts the focus from traditional 'Instruction' to 'Learning' as a key goal for any educational attempt [1]. LD is, therefore, an advocate of approaching the learning experience as a whole, where learning environments, complex learning, and access to student data are of special importance [1]. Learning Analytics (LA) has a promising potential in utilising these learning aspects as a reflective practice for optimal LD [1]. LA are also capable of increasing the robustness and reliability of LD [1]. Furthermore, integrating game elements like digital badges and dashboards that reflect the learning performance of students (a.k.a. gamification) is shown to positively impact learning motivation, knowledge status within a particular learning environment, and transparently display achievement level [2]. Generating digital badges and dashboards initially require LA as an engine for collecting meaningful data on student learning processes [3].

## What is LA?

Learning Analytics (LA) is the measurement, collection, analysis, and reporting of data about learners and their contexts for purposes of understanding and optimizing learning and the environments in which it occurs [3]. For example, LA can be used to make timely predictions about learning outcomes, and based on the analysis provide feedback and recommendation to learners, teachers and institutions [3].

## Gamification Strategies: LA Substrates for Motivation

Using game elements in educational contexts has been proven to compensate for shortcomings of traditional educational approaches, ensure better learning, and prompt changes in behaviour [4]. Game elements like badges, dashboards, and avatars provide feedback both for the learner as well as for the teacher, which eventually promotes self-improvement and personalized teacher orientation respectively, all in the pursuit of a specific learning goal.

Digital badges and badging systems have gained special traction in education as online learning environments have grown [4]. To begin with, badges in an educational frame have been used as a reward and a source of extrinsic motivation for learners [4]. However, as the utilization of badging systems grew, sustained research has found that not only do badges have the extrinsic motivator property but they also developed into direct indicators of the level of knowledge, learning progress, and engagement a learner projects [4]. They also became a source for a feedback loop that gradually shifts intrinsic motivation towards certain future learning objectives [4].

Moreover, LA can quite generously serve digital badges by creating valid and easily accessible visual information about a student’s accomplishments, interests, level of knowledge, and engagement [4]. These pieces of information are valuable, in essence, because they allow timely predictions about the learning success and eventually leave room for teachers to decide which sorts of interventions they could implement to help a student get back on track with their learning progress and stay focused on it. Therefore, this case study is trying to document and explore how to integrate badging systems in learning environments that employ AR.

## Again, what was AR?

AR simply overlays the real world with virtual content to create an immersive platform that places the learner in a real-world context, engaging all his/her senses having the potential to facilitate complex learning. The AR-applications that are going to be exemplified here are going to utilize badging systems as well as dashboards and point systems which provide useful visual representations of LA, to further engage and increase students' motivation while on a learning task.

## AR-Apps and Gamification Strategies

All 6 European partners (from Belgium, Cyprus, Germany, Italy, Netherlands, & Turkey) working on AR4STEAM will be utilizing AR-Apps as a part of the implementation stage (AR4STEAM innovative laboratories, IO3) of the project with school students and teachers in the corresponding countries. To further illustrate how a badging system in the context of AR and education could look like, 3 examples of the AR-apps used in the innovative AR4STEAM laboratories will be presented. For brevity purposes, 1 app is going to be most extensively elaborated on.

### AR-Mindpalace (StudyCore, Germany)

AR-Mindpalace is an application that imposes AR-cues and questions on a real-world predefined environment (see figure 1). The purpose of the App is to strengthen memorising techniques of students using a psychologically viable methodology known as the method of "loci" (Latin for places) [5]. The method of loci is a memory-supporting technique that makes use of familiar environments and visually associates them with target information that is to be memorized. And because memory enhancement techniques are useful for almost any STEAM subject, the app is very much tailorable across all subjects (e.g., economics, math, chemistry etc.). Indeed a learner approaches the target familiar place (such as the schoolyard) with a camera (of a cell phone or tablet), and reality is instantly enhanced with sets of strategically placed questions on the particular place (such as a bench in the yard) viewed through the app (see figure 1). By answering the question that pops up in a particular marker in the real environment, a mental coupling between the correct answer and the real-world familiar place is established, especially after repetitive exposure to this immersing learning experience. The quiz questions are coloured with gamification approaches like continuously updating badging systems, short sound feedback for correct and wrong answers activated based on answer confirmation click, and a scoring system for each completed chapter. The badging system reflects achievement difficulty and can be decomposed into 3 types: a bronze shield for low difficulty, a silver shield for average difficulty, a platinum shield for high difficulty, and an achievement status marker for a perfect round in the weekly challenges. After answering questions from each chapter a diagram pops up to show the difference in performance throughout the last 3 sessions as a feedback mechanism.


**Figure 1:** A familiar environment in Frankfurt, Germany (Bockenheimerwarte) for students to explore and find the question cues (The blue pop-up folder on the top left side of the figure) and answer them.

LA can be collected from 2 different interfaces: the student quiz interface and the teacher interface, both provided by StudyCore.
The student interface is where the digital badges are very much visible along with other progress and analytics markers of their performance (see figure 2). These further game elements are reflected in a visual bar of learning level progress and overall received credit points, a calendar symbol that tracks if students have answered at least 1 question in the last 3 days, and then there is the student's main dashboard that is split into 3 categories: the 'progress sector' where stats about the answered questions (over a course of 1 week) compared with the average of all other students are presented in illustrative diagrams, and similarly the latest activity of a student and progress per chapter are also provided.

The 'chapter sector' where access for all the different topic chapters is to be found and finally the 'weekly challenges sector' where data is provided about the latest challenges solved, and above all about the placement a student earns in relevance to their peers who also had already participated in the weekly challenges.

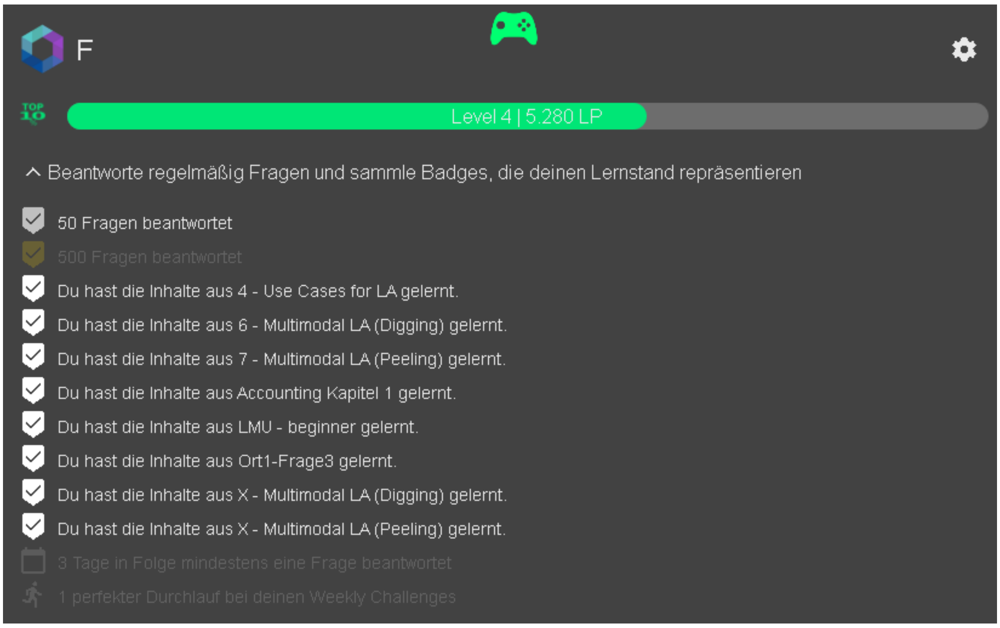


**Figure 2:** StudyCore student interface with learning level bar (in green), so far collected digital badges (the colour-coded shields), the tracking calendar marker, and the perfect-round (in the weekly challenges) earnable badge (the running man icon).

The teacher interface (also called lecturer cockpit) is on the other hand quite more elaborative and extensive in terms of the stats and LA sources that it displays. The main teacher dashboard is composed of 6 sectors: the 'quiz editor', the 'activity dashboard', the 'performance dashboard', the 'chapter details', the 'distribution dashboard', and the 'user dashboard'. The 'quiz editor' entails, as the name insinuates, editable questions and chapter sections. The 'activity dashboard' provides illustrated stats about average student success rates, time on app, and further stats of overall student activity (see figure 3).

However, the 'performance dashboard' provides information about which chapter is the chapter that students are most successful (unsuccessful) at. Additional detailed information is delivered in the 'chapter details' sector where the information specifically brings to light which questions per chapter were the most problematic and successful in terms of average student performance on them. This is illustrated in bubble charts that pop up the particular question when the cursor is placed on a particular

colour-coded question bubble (see figure 4). As for 'dashboard distributions' provides stats on e.g. distribution of students according to success rates per chapter, or according to success rate alongside other single question-based distributions. And finally the 'user dashboard' grants teachers exclusive information on the performance of each individual student within the app.
Finally, the badging system used in this app is created based on particular thresholding criteria (e.g., 50 questions are correctly answered), that, if surpassed or achieved, a corresponding type of badge is granted. Which conveniently represent summarized amounts of information that can reflect student learning progress and ignite motivation and a competitive spirit in the pursuit of optimal learning.

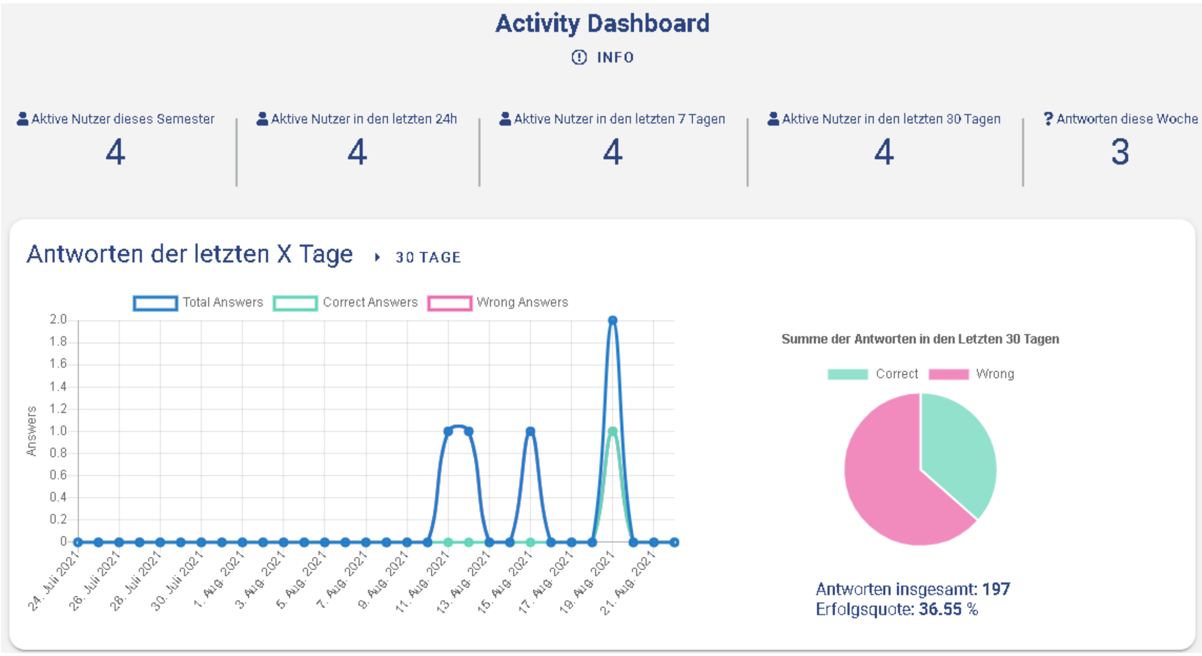


**Figure 3:** StudyCore activity dashboard in lecturer cockpit for average student activity in the app.

## Ars Chimica-S (Lucana Sistemi S.R.L., Italy) and Mirage Crystallography (Mirage – réalité augmentée et virtuelle pour l'enseignement, France)

Ars Chimica-S and Mirage Crystallography are 2 further apps that also integrate AR in the usage of game elements while learning on a particular subject, namely chemistry; and a combination of physics, chemistry and mathematics respectively. On the one hand, Mirage

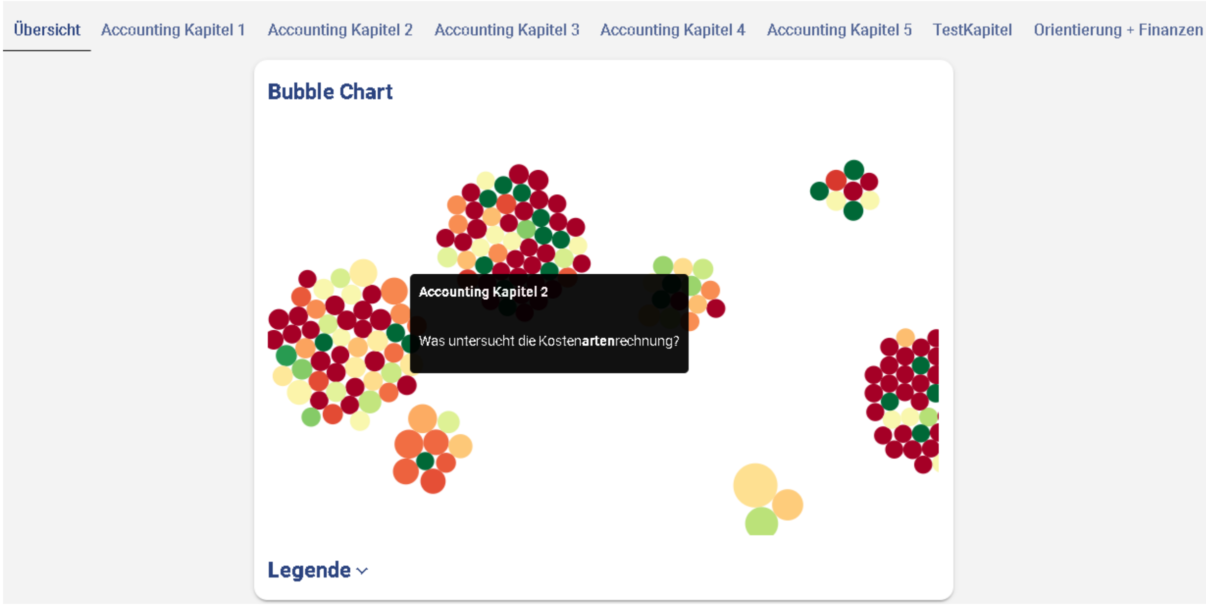


**Figure 4:** Bubble chart for question performance per chapter (a scale from red bubble: most students answered incorrectly, to green bubble: most students answered correctly)with a question popping out on cursor placement.

Crystallography app refers to the use of a computerized 3D representation of the crystal whose centred cubic structure is a structure adapted to metallic crystals, such as iron, copper, silver. It also offers 17 augmented reality clue cards: These cards provide visual clues to students to move forward in their process (see figure 6). From various LA indicators (mainly game elements like badges). On the other hand, Ars Chimica-S app is focussing on chemistry while also employing gaming cards. With some cards of assigned chemical elements, the students, divided into groups, will be able to calculate the difference in electronegativity between two elements and identify the type of bond that is formed, then figure out the compound that could be obtained among other tasks like identifying patterns and rules that make up then the periodic table of elements. And in a similar manner here, game elements are exploited as a useful extension of LA to predict and accommodate students' performance more conveniently than any time before.


**Figure 6:** A chemical structure pops up from a clue card of a crystal using Mirage Crystallography.

## Conclusions

21st-century technological advancements beg the attention of educational sectors to tag into digital enhancements for learning that could potentially compensate for shortcomings of traditional teaching approaches. Not only the latter, digital facilitation that makes learning more attractive and engaging for students can also be established by providing a viable, potentially more productive, competitor for the attention of young generations that are exposed to all sorts of digital distractors.

Projects like AR4STEAM aim to integrate AR in education with a key target to raise awareness of the importance of choosing STE(A)M studies to pursue successful careers and to eventually make learning more engaging and enjoyable. Moreover, optimization of learning design by shifting the focus from 'instruction' to 'learning' is important. Furthermore, relevant learning aspects can be addressed by utilizing LA, to eventually help provide an adaptive personalisable learning experience.

The simple usage of AR technologies in the form of apps that also makes use of game elements like badging systems, dashboards, and avatars is very accessible to almost all students through their smartphones or tablets. This is an aspect that substantially adds to a potential 'widespread' integration of such motivational and engaging approaches in educational sectors because they indeed require minimal pieces of equipment that are otherwise on the pricey side (e.g., virtual reality approaches). As extensively exemplified in this case study, apps like AR-Mindpalace combine psychological-pedagogical techniques like the method of loci for better efficient memorizing strategies with AR and gamification strategies like digital badges, dashboards and performance progress analytics for learners. Where all these individual aspects combined together promote an overall immersing learning experience. Furthermore, these same elements that motivate and engage could also be strategically recycled and used as tracking markers for student learning progress, learning pitfalls, and learning improvements which are, in other words, a viable asset of LA that provide fruitful feedback loops for students (self-evaluation) as well as for teachers (for potential personalized interventions). Having user-friendly interfaces for both students (to track their own activity) and teachers (even more extensively, to track student activity and to also edit the different learning material provided for students in the different AR-environments) makes such a learning environment easily achievable. Imposing AR in a real environment as well as using card cues can be the first step into tangible applications of AR in education with many engaging game elements that are economically affordable in contrast to other costly EdTech solutions. However, no matter how immersive game elements and AR could be, there is always the threatening fast growth rate of gaming industries and similar technological distractions that utilize cutting-edge engagers. Therefore, to compete with the emerging distracting technologies, the educational sector must continuously be up to date with the latest research and implementations of game elements that could help students stay engaged in learning. In conclusion, AR and gamification strategies framed with LA feedback loops can promisingly improve the learning experience making it learner-centred as well as enjoyable. And for these strategies to succeed in capturing and maintaining the learners' attention, hence, their cognitive resources, considerations of continuously updating them in a way that they reflect the high-tech, 21st-century media can be fundamental.

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