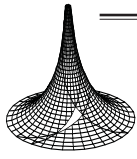

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tmcs@science.unideb.hu
http://tmcs.math.unideb.hu

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Integrating Didactic Games in Higher Education: Benefits and Challenges

Attila Körei, Szilvia Szilágyi and Zsuzsanna Török

Abstract. In our paper, we study the reasons for the introduction of didactic games and the way of their application in higher education, especially in teaching mathematics. After describing the main characteristics and needs of Generation Z students, we outline the advantages and drawbacks of gamification and game-based learning, followed by some new aspects to their classification. The idea of device-based grouping arose because the most commonly used methods require IC tools. Gen Zs naturally accept gamified learning materials available on digital and mobile platforms, but we must not forget about traditional games either. In higher education, especially in the case of small-group teaching there should also be room for traditional, specialized didactic games, of which we focus on the benefits of card games.

Key words and phrases: gamification, didactic game, game-based learning, teaching methodology, card games.

MSC Subject Classification: 97C70, 97D20, 97D40, 97U70.

Introduction

Most of the students in higher education nowadays are part of Generation Z. By now, teachers at all levels of education realized that they require a different way of communication and also different teaching methods. *"Old models, methods and approaches lost their edge. Student evaluation based on these, lead to incorrect assumptions"*(Besenyei, 2016, p.376).

Gen Zs are often labelled as digital natives, while their teachers are digital immigrants. Bridging the gap is difficult, but not impossible. Contrary to the

popular belief, Gen Zs like to engage themselves in all kinds of activities, and they carry out their tasks with passion. Compared to millennials, they are true initiators (Mohr & Mohr, 2017). Their tolerance for monotony is low, therefore frontal education and traditional methods shall be banished from the classrooms and small-group learning together with student-centered methods shall be applied. Auditory learning, such as lectures and discussions, is very strongly disliked by this group, whereas interactive games, collaborative projects, advance organizers, and challenges are appreciated (Rothman, 2014). Recent studies show that Gen Z students decide within 8 seconds if a subject worth their attention or not. This 8-seconds-filter help them to distinguish between interesting and boring content and allows them to concentrate on subjects of their interests (Brown, 2014). They need independence in their work, and they want rewards and positive reinforcement (Schäffer, 2015). Since Generation Z grew up playing computer games, one possible solution to the problems experienced in class is to base learning processes on the structure of such games (Besenyei, 2016).

Generation Zs "live and breathe" technology. In the higher educational setting these students rely on recordings rather than taking notes, are more eager to raise their questions online and demand instant information and communication. Some research actually illustrated that the brains of Generation Z are structurally different compared to those of earlier generations. "*The brains of Generation Zs have become wired to sophisticated, complex visual imagery. As a result, the part of the brain responsible for visual ability is far more developed, making visual forms of learning more effective*" (Rothman, 2014, p.2). Their world cannot be imagined without Internet connectivity and they feel lost without their smartphones. They are used to receiving instant information. Generation Zs are quick to find content of their interest. They are familiar with using different gadgets and functions, as a result of which multitasking is usually not a problem for them. IT has shaped their thinking, communication and learning methods. Consequently, the procession of ICT-based curriculum is easy for most of them, they eagerly participate in testing digital learning modules, and pilot projects, especially if we provide them with a gamified version.

In games, players utilize their creativity and find new approaches to problems. The devoted believers of gamification build their argument on this underlying potential of games. The difference between games in the traditional sense, gaming, game-based learning and gamification lies is in their goals (McGonigal, 2011). Games are for fun. They have been with us for thousands of years and served recreational purposes in an organized, competitive, rule-based manner. It is also

evident that most of our games are not only games, but they are also models of various cultural activities. Games in today's technology-driven societies are the same: they offer entertainment, sharpen our wits, and teach us about certain aspects of life. Gaming refers to playing with games, video games on PCs and game consoles. They usually provide an immerse experience for the players. Game-based learning (GBL) integrates games into the learning process. Games in this approach are actually design elements, similar to a video, graphic or table. Gamification is a complete pedagogical system. The entire curriculum is built around the concept of playing a game. It integrates game mechanics to the learning process to achieve learning outcomes. In 2007 Kapp pointed out that the diverse applicability of gamification as methodological tool is suitable to bridge the generational gap between teachers and students (Kapp, 2007). Therefore, the integration of games into all levels of the education, higher education included, should be considered and a new educational strategy including gamification and game-based learning shall be formed.

Our long-term goal is to implement GBL in the mathematics courses of the BSc programs at the University of Miskolc. The article presents the preparatory phase of this work. After a short summary of the literature focusing on the needs of students and the effectiveness of certain tools we provide a possible grouping of didactic games used in education and some essential rules for their application. Our article summarizes the reasons and possibilities for the introduction of GBL in higher education, with particular reference to the teaching of mathematics and present some of our initial results.

Games and Gamification in Education

The Merriam-Webster dictionary defines gamification as "*the process of adding games or game like elements to something (such as a task) so as to encourage participation (verb form: to gamify).*" ("Merriam-Webster definition for Gamification.", n.d.). The term "gamification" was initially coined by Nick Pelling in 2002 as a tool to improve user interface (with game elements) to make electronic transactions more enjoyable. Later it was adopted in a wide range of areas (Pelling, 2011). The notion appeared in the methodology of teaching in 2008 (Marczewski, 2013). In 2011 Detering at al. proposed the following definition of gamification: "*the use of game design elements in non-game contexts*" (Deterding et al., 2011). The general aim of gamification is to make a task more productive, exciting and entertaining. In education, enhancement of

motivation and engagement in learning tasks are the main drivers for gamification. It makes learning more captivating and attractive, resulting in more active and motivated students. Gamifying teaching and learning mean that teachers draw upon the operational mechanisms of games and incorporate those in their teaching methods, or use games as educational tools to cover certain topics of the curriculum. "*Compared to traditional systems of learning, game-based educational methods support learner-based education and motivate students to learn more, even at times of failure*" (Gábris, 2019).

According to Rigóczki, games and gamification share some distinctive characteristics. Voluntary participation, motivation and their end in themselves nature connect building, puzzle-solving, board, and PC games, sports and other game-like activities (Rigóczki, 2016). Aczél goes even further and name playfulness as one of the key competencies of today. He takes a look at the gaming experience, achievements, topic and idea of games and tries to find the common and necessary characteristics of games. *"Games do not want to create value that are useful outside the realm of the game. It is not the aim of games, even though, sometimes games give birth to such values. [...] Games have their own inner meanings, and games are games only if this meaning is not subordinate to anything outside the game. [...] The unique, symbolic goal of a game is strongly connected to the idea of the game and the process leading toward the end offers an immerse experience by allowing the player to relive this connection between symbolic goal and idea. [...] Without this immerse experience it is not a game, but the delivery of information, a repetitive practice, a method of education or training"*(Aczél, 2015).

Kapp, Blair and Mesch (2014) argue that there are two types of gamification in education: structural and content gamification (Kapp, Blair, & Mesch, 2014). Structural gamification is when we apply game-elements to take the students through the content of the curriculum without altering the content itself. The content itself is not game-like, only the structure is changed in order to motivate the students engage them in the process of learning. The most common form of achieving this goal is offering rewards for completing assignments, or doing coursework. The points, badges, levels serve as rewards and trackers of the learning process. Although gamification does not necessarily involve digital technologies, structural gamification is easy to carry out in virtual classrooms. Several Hungarian and international case studies have been published on examples of structural gamification (Kapp et al., 2014; Akpolat & Slany, 2014; Csikósné Maczó, 2019). Content gamification offers a different perspective, i.e.

it uses game mechanics such as storytelling, or challenges to grab the attention of the students and to immerse them in the learning process. Rewards are built around the content. Content gamification makes the curriculum more playful, more colorful, without making the content a game (Gábris, 2019). The boundary between game-based learning (GBL) and content gamification is blurry. If we occasionally integrate a digital or traditional game into the education process, then it qualifies as GBL, while the continuous usage of games or the application of game thinking into the entire curriculum is gamification.

According to Csapó (1999), learning has two basic types. The first sees learning as a passive, reproductive process. It identifies learning with gaining more and more knowledge, emphasizes memorization and application, involves the repetitive use of skills and knowledge gained. The second type of learning is active. It creates knowledge, transforms and constructs information. The emphasis is on understanding the content and applying it to reality. The learning process in this case encourages creativity and fosters the application of the curriculum in everyday practices (Csapó, 1999). Gen Zers do not tolerate passive learning well, active learning is the key to success. GBL and gamification both strengthen active learning approaches. Compared to preceding generations, Gen Zers like to be in touch with their friends when playing and also when learning. Working in small groups helps students to develop and enhance their reflexive and self-regulating learning skills, gives them an opportunity to articulate their ideas and understandings, it uncovers assumptions and possible misconceptions and help them create something unique based on consensus. Group learning has two basic forms: collaborative and cooperative learning. Collaborative learning emphasizes the contribution of each individual group members, while cooperative learning is more of a joint effort at every phase of the learning process. Motivation plays an important role in both, since their efficiency depends on the extent the students are willing to actively participate in the work of the group and in joining the learning process. Game-based learning and gamification also support differentiation. We can provide alternative ways of procession for our students. This is very important when teaching Generation Zers, since they all have their individual pace and way of reaching the same goal. GBL and gamification creates an opportunity for everyone to start at their own level and level up in accordance with their individual skills and knowledge.

Besides the countless positive effects of GBL and gamification we must call attention to some of their drawbacks as well. The competitive nature of games may cause unnecessary stress, anxiety, and performance pressure.

Competitiveness could lead to less cooperation and the digital environment may heighten online dependency. Researchers argue that GBL and gamification raise the need for constant rewards. If student are rewarded continuously they may loose their motivation toward spontaneous learning and could end up requiring more and more rewards (Hyrynsalmi et al., 2017). By setting up optimal targets and choosing the tools carefully, we can easily eliminate these threats.

Classification of Didactic Games

In recent years, the number of products related to game-based learning and gamification increased. The so-called didactic games, i.e. educational tools fulfilling certain didactic goals, differ from spontaneous games in being mandatory and serving well-defined educational goals. Kruszewski argues that didactic games are problem-based teaching methods that have a significant role in establishing creative thinking. They allow the re-learning of old knowledge and help forming new patterns (Kruszewski, 2005). Didactic games can be categorized along different lines. Kárová, Krejcová and Volfová classifies them as follows (Kárová, 1998; Krejcová & Volfová, 2001):

- based on the target of the game:
  - cognitive games - their main target is to help students gain new knowledge and acquire new skills,
  - diagnostic games - games that help teachers monitor the level of understanding lectures.
- based on the number of players:
  - individual games - for one student,
  - pair games - for two students,
  - collective games - for classes or large learning groups,
  - group games - for small learning groups.
- based on reactions:
  - action type games (or games requiring physical activities) - student are physically engaged,
  - calm, "silent" games - students in general are physically passive.
- based on the type of use:

  - universal games - they cover a larger body of knowledge with different learning and evaluation objectives (delivering knowledge, building skills, evaluating performance),
  - specific games - they are related to a specific subject, topic.

We would like to complement the list with the followings:

- based on device requirements:
  - games requiring specialized education tools - the games cannot be played without special teaching tools. We can further distinguish them by:
    * games requiring ICT devices,
    * games requiring traditional objects (e.g. board-, and card games, LEGO),
  - games that do not require specialized teaching tools - they can be played anytime and anywhere, no devices, tools or objects are necessary (e.g. algorithmic puzzles).

Playing didactic games requires coordination, control, and evaluation. They are used in organized didactic situations in which the players can achieve the set didactic and education-related goals. They have strict, explicit set of rules and require the activity and interaction of students. When working with didactic games we must remember the followings:

- they require careful planning - before applying them, we shall run a test-phase and adjust the games accordingly;
- their usage cannot precede learning - we have to deliver the knowledge first;
- we cannot alternate between game and learning - i.e. in a well-defined educational module we cannot alternate between game and learning;
- experience and diversity are the key factors - even the most exciting game can be boring if played constantly, it is necessary to offer a variety of games, tools and techniques;
- feedbacks are important - we have to allow students to give feedbacks;
- regularity - the positive effect of didactic games comes with regular playing.

The results of Kapp's and Sheldon's study support the assumption that, by the increased involvement of students, games offer an opportunity for teachers to improve the effectiveness of teaching. Compared to traditional educational methods, GBL and gamification proved to be more successful (Kapp, 2012; Sheldon & Shüler, 2011). The literature on gamification and education is rich (Faiella & Ricciardi, 2015; Damsa & Fromann, 2016). Teachers can choose

from already existing games or game templates, and - given that they have the necessary programming or creative skills - can develop new games fitting to a certain course or curricula.

When talking about learning process we are planning the learning experience of students. We usually focus on two aspects of it: in class and at home experiences. In the case of games requiring specialized educational tools, it is preferred to make the tools available for students at home and in the small study groups they work with. In line with the structure of the higher education, didactic games can be used in practical courses and consultations, following lectures at which the theoretical background is established. Learning in small groups is flexible, interactive, reflexive and engaging. Small group teaching opens up pedagogic spaces that are protean, dynamic and responsive. Working in small groups allows the repeated iteration of ideas and responses. Students get immediate and detailed formative feedbacks, both from their peers and their instructor. Small group teaching also cultivates creativity, passion and enthusiasm. Gen Zs are natural team players, they adapt to small group learning quite easily: they break down the task to smaller ones, optimize their resources. The subtasks are carried out by students who are willing to work on that particular task, and the success of the group is secured. Generation Zers are not afraid to express their opinions and views, they are eager to enter academic arguments. Consequently, the results of the group presented for evaluation has already been analyzed, argued and tested within the group. Due to the free flow of information among group members, the result of their work is coherent. In group work, groups revolve around centers. These centers can be lecturers, but also digital devices (tablets, smartphones, etc.) or traditional equipment, depending on the target set. When choosing didactic games as centers of the group work, we have to take the followings into account:

- *motivation*: it shall be engaging for the students, they should use it eagerly;
- *ease of usage*: the set of rules and instructions should be easy to follow;
- *evaluation, monitoring*: the tools should encourage and support self-evaluation processes;
- *practice*: the tools shall encourage repetition;
- *expansion*: advancement and expansion shall be key characteristics, so the tool can be used during different stages of the teaching-learning process and offer an opportunity to differentiate;

- *assessment*: while using the tool the lecturer shall gain information on the individual skill sets of the students in terms of the task, the working methods and the pace.

It is hard to meet all these criterion, therefore we should always start with a test-phase working with small groups to uncover the problems and fine-tune the games. From the lecturers' point of view the goal is to create methods that have well-defined frameworks but also leave space for changes and developments. Didactic tools meeting the above-mentioned requirements have a good chance to be used effectively in the teaching-learning process.

Mathematical Card Games in Higher Education

Recognizing the benefits of gamification and GBL, these tools are used more and more widely in higher education around the world. Good practices can also be found in Hungary, like a gamified marketing course based on a brand simulation software at the University of Miskolc (Nagy & Molnárné, 2019) or using wargames at the University of Public Service (Harangi-Tóth, 2020). However, using games in teaching advanced mathematics is not a common concept. This shortage motivated us to introduce playful elements into our math courses.

When talking about GBL, we usually think of digital technologies and only a smaller number of practitioners pay attention to traditional didactic games. The infrastructural inadequacies of the Hungarian educational institutions and the aversion of teachers towards IT mean that digital GBL is not widely used in schools. Therefore, we should take a look at well-known board and card games that can be transformed into useful teaching tools, with our didactic goals in mind. Realizing its positive effects on educational success, a simplified version of the complex Contract Bridge, called minibridge has already been incorporated in the curriculum of many European countries as a pilot project. It improves learning and problem-solving skills, has a positive effect on memory, logical thinking, decision-making and communication. Bridge teaches patience and the importance of teamwork.

Another example of card games in education is SET, a real-time card game developed in 1974. SET incorporates complex mathematical structures like the combinatory of finite affine and projective geometry or the error-correcting algebraic coding theory. SET can be played alone, but it has a great advantage: up to 20 people can play with one deck of cards. It also has an online version

in which players are given new challenges every day. Solutions are delivered the next day, including detailed explanations. The website also publishes the results of mathematical research related to the game.

Game-based learning can be achieved by commercially accessible card games, but also with card decks designed with specific learning targets and curriculum in mind. With the free app CardGameToolkit.com we can create our own deck in five simple steps. The final product is downloadable and printable. The main problem with this general purpose application is that it is not suitable for handling mathematical formulas. With some programming skills however it is easy to create apps that can generate special mathematical card decks. For example,

Figure 1. Editing cards in *Gemhunters* software

the article (Dudás et al., 2019) describes a custom-developed, Java environment software called *Gemhunters*, in which we can create a 112 cards deck for a mathematical skill-development treasure hunter game. The game itself is based

on Frederic Moyersoen's very popular card game, Saboteur. The Trigonometric deck used as an example in the article is a didactic game that helps in the game-based learning of trigonometric identities, the most important trigonometric functions, check the knowledge of value of important angles in trigonometry and, fill in the gaps in knowledge. The greatest advantage of the application is that mathematical formulas can be displayed in the cards using LaTeX commands. Fig. 1 shows the process of creating cards for the Trigonometric deck with the application *Gemhunters*. As a LaTeX editor is integrated into the software, one can easily make a full deck related to any mathematical field. Source (Körei et al., 2019) introduces a card game *Functions in the Box*, similar to the well-know Brainbox series. A card of the game is presented in Fig. 2. The game improves

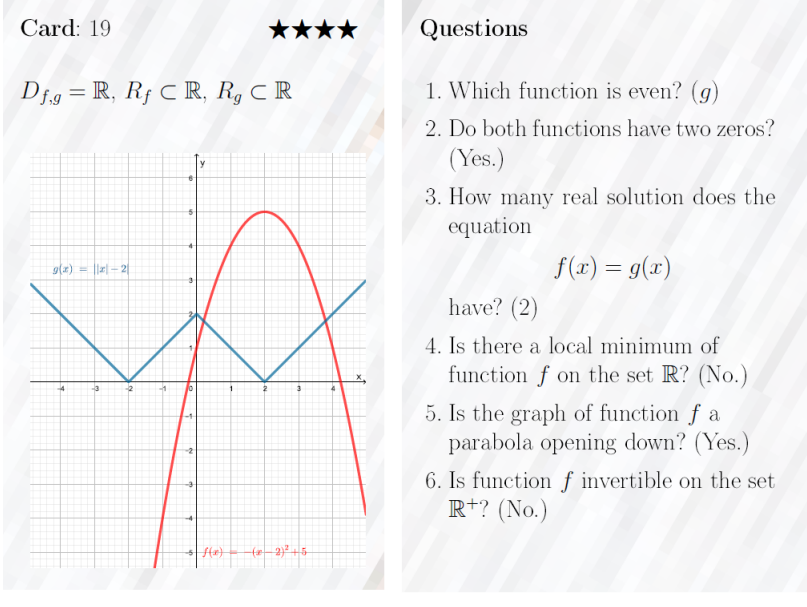

Figure 2. Front and back of a card in *Functions in the Box* game

observational skills and helps to learn the characteristics of the most important types of functions. It also illustrates how performing transformations on functions changes the domain and/or range. This game, similarly to the app *Gemhunters* was developed in the Institute of Mathematics at University of Miskolc in the last two years.

The article (Kordaki & Gousiou, 2017) offers a systematic review of digital card games (DCG) used in education between 2003 and 2013. The results show

that these games created good learning environments at all levels of education, regardless of the subject taught. DCGs are flexible digital games with a special framework - decks and rules - that can be adapted to the learning content. DCGs are inspired by the logic of well-known card games, by the modern, constructivist view of education, by the results of earlier educational research, and by modern, digital technologies.

Card games helping the teaching-learning process should be developed in accordance with the learning targets. The main goal is to make abstract, complex notions intuitive and more easily digested for students. By presenting the educational content in numbers, texts, images and a set of rules, we create simulations that allow the students to practice almost unnoticed. It is worth to create games in which the players shall describe the card in words as well, so they can also practice the use of terminology. Card games help in decreasing fear and anxiety at every levels of the education. While playing, even wrong answers or decisions could encourage the building of better strategies and motivate students to learn more. Playing cards is not limited to the classrooms. Decks can be created at a low cost, so the students can take them home and play with their siblings, friends, or parents. Compared to games on digital platforms, cards are real, solid things that require personal and not virtual interactions between players. If pairs or groups play against each other the partners form strategies together, which helps them to learn the basic rules of cooperation and collaboration.

Summary

Working with Generation Z students mean that we have to help them develop their individual skills, and frontal teaching should be replaced by or combined with small group learning. Small group learning is not necessarily centered around the lecturer, a well-chosen supporting tool can also be used. The different elements of the teaching-learning process can be easily linked together by using a game developed specifically for the given educational content. Such didactic tool can be used at all phases of the process: in gaining knowledge, practicing, monitoring and evaluation. Quick, easy to learn digital or traditional games with basic rules, like card games, teach and entertain at the same time.

Although the expectations regarding education are similar in all subjects, we shall note that different approaches, and methods may be the keys to success in teaching different subject. In parallel with finding the good practices in general, lecturers and teachers also have to find the subject-specific methods

and didactic tools that can optimize the teaching-learning process for Generation Z students. As the key of success in teaching Generation Zers is motivation, didactic games, game-based learning and gamification should have a role in their education. Game-based learning and gamification have a lot of possibilities that hold new challenges and rewards in store, for students and teachers as well.

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ATTILA KÖREI
UNIVERSITY OF MISKOLC, INSTITUTE OF MATHEMATICS, DEPARTMENT OF ANALYSIS
3515 MISKOLC, MISKOLC-EGYETEMVÁROS

E-mail: matka@uni-miskolc.hu

SZILVIA SZILÁGYI
UNIVERSITY OF MISKOLC, INSTITUTE OF MATHEMATICS, DEPARTMENT OF ANALYSIS
3515 MISKOLC, MISKOLC-EGYETEMVÁROS

E-mail: matszisz@uni-miskolc.hu

ZSUZSANNA TÖRÖK
UNIVERSITY OF MISKOLC, FACULTY OF SCIENCE
INSTITUTE OF ANTHROPOLOGICAL AND PHILOSOPHICAL STUDIES, DEPARTMENT OF CULTURAL AND VISUAL ANTHROPOLOGY
3515 MISKOLC, MISKOLC-EGYETEMVÁROS

E-mail: boltorok@uni-miskolc.hu

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