Adding Narrative to Gamification and Educational Games With Generic Templates

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Abstract: Adding narrative, that is, a story, to gamification and educational games can boost students' motivation and engagement. This requires a narrative fitting the course in which it will be deployed to and a gameplay to which the narrative fits without seeming to be tacked on. In this article, a gamification template called Reification and an education game template called Synapses are introduced both aiming at relieving educators from having to find an appropriate game or gamification leaving them only the task of finding a fitting narrative. Reification is making something abstract concrete with the intention of making the represented concept more tangible. In case of the gamification mechanism Reification, a learner's progress in a course is made concrete through visualization: A student's progress is visualized as a landscape in which each object, such as a tree, makes concrete one of the student's accomplishments, such as a solved exercise. Reification aims to provide students with a tangible overview of their learning progress and allows them to compare their landscape to their peers'. Reification is illustrated in the article with a course on Egyptology. Synapses is a game which supports students in overcoming and preventing the development of misconceptions, which are commonly held incorrect beliefs by students about courses' contents. After each lecture, students are tasked to organize parts of the lecture's content in a concept map, or to revise their concept maps in reaction to mistakes made in exercises. The game's narrative takes different turns depending on the percentage of students having a correct concept map. Synapses is illustrated in the article with a course on Logic. This article represents a work-in-progress: The concepts are grounded in theory with evaluations of the introduced implementations planned for future work.

Keywords: gamification, game-based learning, gameful design, motivation, learner's misconceptions, concept maps

1. Introduction

Insufficient motivation by learners to engage with learning content or partake in learning is nowadays often addressed by adding gamification, in most cases in form of points, badges, and leaderboards (Nicholson, 2015) which have been shown to have a positive effect on students' motivation and learning (Hamari et al., 2014; Seaborn and Fels, 2015). Points, badges, and leaderboards reduce *games* to their most basic components and ignore other aspects of games, such as narrative and gameplay. Adding narrative to gamification and educational games has been shown to have positive effects on students' motivation and engagement (Wood and Reiners, 2015; Kapp, Blair and Mesch, 2013), but adding narrative to points, badges, and leaderboards is not an easy task, as those elements – even if found in real games – are not conceived to have an associated narrative. It is similar with educational games: Often a very generic narrative (e.g., a space race) is used with only the domain of the learning activities being changed. Nonetheless, there are educational games and gamification with a more sophisticated narrative dimension (O'Donovan et al., 2013; Villagrasa et al., 2014), but those are most often custom built which is time and cost intensive.

With the aim of freeing educators from having to have an idea for a game or gamification, this article introduces two templates: a gamification template called *Reification* and an educational game template called *Synapses* which are nearly as generic as points, badges, and leaderboards, but can easily be enriched with a narrative.

Reification makes students' learning progress tangible through visualization: A student's progress is visualized as a landscape in which each object, such as a tree, represents one of the student's learning achievements, such as a solved exercise. Depending on the student's progress in solving the exercise, the object can be shown in different states, such as a small tree for an unfinished submission to a big tree for a complete submission. Optionally, objects in the landscape can decay when students show insufficient activity in the course. Therefore, active students are presented with a lush landscape, while the landscape of passive students looks withered. *Reification* aims to provide students with an accessible overview of their learning progress and allows them to assess their learning progress by comparing their landscape to their peers'. Building their personal landscape and having to fear to lose their progress by inactivity uses similar mechanisms as social games, which have been suggested to be the reason why players keep on playing those games (Newheiser, 2009).

Synapses is a game which supports students in overcoming and preventing the development of misconceptions. After each lecture, each student is tasked to organize the lecture's contents in a concept map to be built with concepts and associations provided by lecturers. Correctly constructed concept maps contribute to a student's score. Concept maps are visualized in form of a network of synapses and are connected to exercises: A mistake in an exercise is seen as an error in the corresponding region of the concept map resulting in the student being tasked to rebuild that region of their concept map. The game's narrative takes different turns depending on students' performances; the best outcome only being achieved when the majority of students has a correct concept map.

The contributions of this article are twofold: First, the introduction of two novel generic templates for game-based learning which can easily be enriched with a narrative that fits the context they are deployed in and second, two planned exemplary implementations of the templates in course on Egyptology and Logic, respectively, to be evaluated in the future.

This article is structured as follows: Section 1 is this introduction. Section 2 introduces related work. In Section 3 both templates and their exemplary implementations are described. Section 4 concludes the article and gives perspectives for further research.

2. Related work

The approach discussed in this article is a contribution to gamification and educational games and is related to misconceptions and behavioural change.

2.1 Gamification

Deterding et al. (2011) define gamification as "the use of video game elements in non-gaming systems" (Deterding et al., 2011, p. 1) and cite Reeves and Read (2009) for examples of game elements who list among their ten ingredients of games "narrative context", "feedback", and "reputation, ranks and levels" (Reeves and Read, 2009, p. 80) as game elements. Even though there are more game elements besides "reputation, ranks and levels", most often gamification focusses on that element in form of points, badges, and leaderboards which nonetheless have shown to produce positive results in the majority of studies (Hamari, Koivisto and Sarsa, 2014; Seaborn and Fels, 2015; Nah et al., 2014).

Zichermann and Cunningham (2011) exclude narrative explicitly from their list of gamification elements, as gamification (according to them) is used to build "non-fiction experiences" (Zichermann and Cunningham, 2011, p. 35). While the majority of studies examined in a survey on gamification in education by Nah et al. (2014) only used points, badges, and leaderboards, three of them included some kind of narrative: O'Donovan, Gain and Marais (2013) gamified a course on computer games development with a storyline set in a steampunk world where students took on roles as members of a secret order who are tasked to retrieve a certain item which is achieved by solving learning tasks. Students reacted positively to the gamification and the course had higher attendance compared to other non-gamified courses, but students criticized that the storyline was not integrated throughout all the tasks of the course. Villagrasa, Fonseca and Durán (2014) gamified a course on 3D modelling where students took on the role of creating a pavilion for a fictional world expo on a parcel of a virtual island, which then could be visited by other students using a virtual reality headset. Students showed a positive attitude towards the gamification, but a negative attitude towards points and badges. In their book on implementing gamification in learning and instruction, Kapp, Blair and Mesch (2013) state that "storytelling is one of the most effective yet underused methods for enhancing adult learning" (Kapp, Blair and Mesch, 2013, p. 118). Nicholson (2015) coined the term "meaningful gamification" as a form of gamification that goes beyond reward-based gamification and introduces six areas in which the aforementioned "meaningful gamification" can take place, "exposition" being one of them. Exposition refers to the "process of presenting a narrative layer through game design elements" (Nicholson, 2015, p. 7). While McGonigal (2011) only sees "goals", "rules", "feedback system", and "voluntary participation" (McGonigal, 2011, p. 21) as the four defining traits of games, according to her "a compelling story can make a goal more enticing" (McGonigal, 2011, p. 21).

2.2 Educational games

Backlund and Hendrix (2013) define educational games as “serious games specifically used for education“ (Backlund und Hendrix, 2013, p. 1). In turn, they define serious games as “games (…) for purposes beyond pure entertainment” (Backlund und Hendrix, 2013, p. 1). Qin, Chui and Pang (2010) consider computer games as a spectrum which can be seen in Figure 1. The more left, the more learning and training takes the main focus; the more right, the more fun takes the main focus. Qin, Chui and Pang (2010) consider serious games and simulation games as a mixture of both; as games that make learning and training fun.

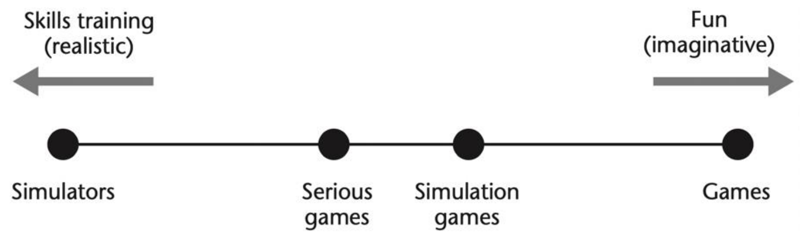

Figure 1: Computer game spectrum (taken from Qin, Chui and Pang (2010, p. 46))

Backlund and Hendrix (2013) examined in their study both games specifically built for learning as well as *real games* used in educational scenarios. In the majority of examined studies a positive effect of games on learning was shown, with the authors concluding that games can be “effective learning materials” (Backlund and Hendrix, 2013, p. 6). Vogel et al. (2006) conducted a meta-analysis which reports “higher cognitive gains and better attitude toward learning” (Vogel et al., 2006, p. 237) when comparing interactive simulations and games to traditional teaching methods.

When looking at a few of the examined studies from Backlund and Hendrix (2013) for higher education that used games specifically built for education, results are mixed: Ebner and Holzinger (2007) developed a game that supports students in learning internal forces in Mechanics. The game consists of multiple choice questions with time limit and a leaderboard. Their evaluation showed that students learn a similar amount from the game when compared to traditional methods and had fun while playing the game. Wangenheim, Thiry and Kochanski (2009) developed a game for learning software measuring which puts students in the role of a measurement analyst tasked to do software measurement in a realistic scenario. The authors could not find evidence of a learning effect in the group playing the game compared to a group not playing the game. Qin, Chui and Pang (2010) developed a game teaching medical students how to stop a patient’s bleeding during an operation. They developed two games unrelated to medicine but schooled the psychomotor skills required to stop bleeding and found that students who played those games beforehand consistently performed better than a group that was not schooled using said games, even after that group had repeatedly performed the same task.

2.3 Misconceptions and conceptual change

Student misconceptions (also referred to, among others, as preconcepts and naive concepts (Leonard, Kalinowski and Andrews, 2014)) have been subject of numerous scientific studies (Confrey, 1990). While the research on student misconceptions arose in the field of science education, where misconceptions are often rooted in concrete phenomena (such as photosynthesis (Fisher and Moody, 2002)) authors recently use the notion of *misconceptions* in computer science education (Qian and Lehman, 2017), where the term *systematic errors* was previously more commonly used (Confrey, 1990). Gurel, Eryılmaz and McDermott (2015) found that misconceptions are most commonly identified using open-ended questionnaires and interviews, which have to be evaluated by hand. An approach similar to identifying misconceptions by analysing concept maps was performed by Köse (2008), who analysed conceptual drawings of students (Köse, 2008).

The conceptual change model, first defined by Posner, Strike and Hewson (1982), describes the process of overcoming misconceptions: The model states that misconceptions are abandoned for better concepts if the previous concept is perceived as inadequate, while the new concept is perceived as intelligible, plausible, and fruitful. This model has found applications in face-to-face teaching strategies, which would typically consist of invoking a conflict between the misconceptions held within learners and concepts to be learned (e.g, by showing a concrete experiment contradicting a common misconception) (Scott, Asoko and Driver, 1992). Another, more scalable approach to invoking conceptual change is the use of *refutation texts* (Tippett, 2010), which provide an argumentation against common misconceptions.

Misconceptions are often developed while acquiring the knowledge (Confrey, 1990). To prevent their development while knowledge is acquired, concept maps can be beneficial. Reategui et al. (2018) propose to use concept maps for acquiring knowledge. Their results show that students organizing their knowledge using concept maps had higher learning gains compared to students using traditional teaching methods.

3. Generic gGames

This section introduces the gamification template *Reification* as well as the education game template *Synapses* and illustrates them by means of two exemplary implementations.

3.1 Reification

Reify, the process of reification, is defined as "to consider or represent (something abstract) as a material or concrete thing" (Merriam-Webster, 2019). An example for reification can be found in cars where growing plants on the dashboard reify eco-friendly driving style as in Ford's EcoGuide (see Inbar et al. (2011)).

The gamification mechanism *Reification* introduced in this section aims at making learners' progress tangible through visualization and at the same time motivating learners to maintain their activity. A similar approach is proposed in Raymer (2006) who envisioned a system in which learners are rewarded with items to show on a virtual character for completing learning tasks. Concepts discussed in this chapter were initially introduced in Hartmann (2018) as part of a master thesis supervised by the authors.

3.1.1 Concept

Reification visualizes each learner's progress in form of a landscape on which the student can freely place objects which are associated with learning tasks, e.g., doing an assigned reading, attending the lecture, or doing homework. There are two different types of tasks:

- An atomic task rewards a learner with an object as soon as the task's goal, e.g., visiting the weekly lecture, is accomplished.
- A progress tasks rewards the student with an object before any goal is reached whose state (and with it the visualization) changes when the learner reaches certain goals, e.g., for every submitted exercises on a homework consisting of multiple exercises.

Figure 2 illustrates *Reification*: The left side shows part of a learner's landscape with two objects, the right side shows three associated tasks. The first task is a progress task, where the tree is growing for each part of the homework the learner submits resulting in a tree carrying apples after all parts have been submitted. The second task is an atomic task which rewarded the learner with a flower to place in the landscape after they attended the lecture.

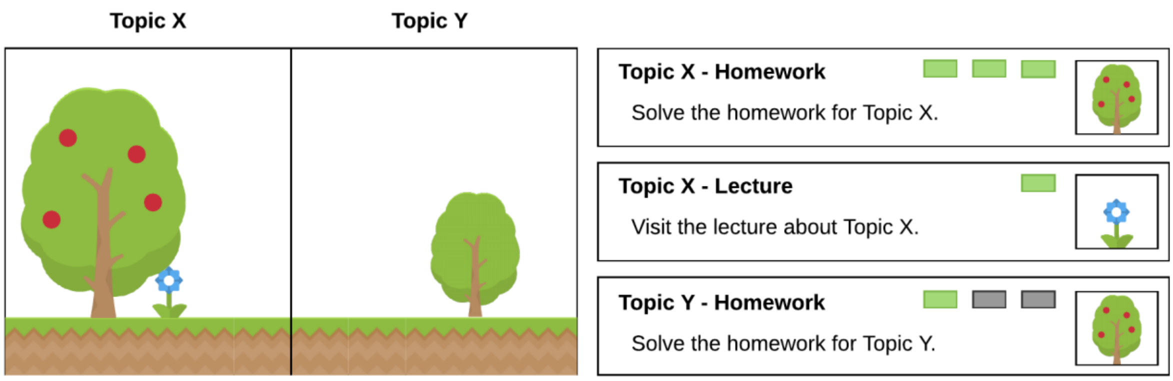

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Figure 2: Reification with two segments and one progress and one simple task referring to Topic A (adapted from Hartmann (2018); images taken from Kenney (https://www.kenney.nl))

Another key part of *Reification* can be seen in Figure 2 as well: The landscape can be divided into different segments, e.g., by topic or by week. A segmented landscape allows learners to easily identify areas they have taken sufficiently care of, and areas where more work is needed as well as assess their learning progress by comparing their landscape to their peer's landscapes. For example, the third task in Figure 2 refers to the homework about Topic Y and the associated tree signals – through its size – to the learner that there is work to do in regard to Topic Y. To motivate learners to work throughout a course's duration and not only shortly before the examination, *decay* can be used: If a student's activity is not above some threshold, their landscape begins to decay, e.g., by changing from a lush jungle to a dry desert, which should motivate students because of loss aversion (see Tversky and Kahneman, 1991).

Reification is grounded in social games, such as FarmVille, which motivate their players to keep on playing with similar mechanisms: Crops are given at the beginning (progress tasks), have to be tended to (doing the homework) in order for the player to be finally able to harvest them. If the player does not regularly tend to their crops, they wither (decay) and have to be disposed of. While FarmVille is criticized for its addictive nature in combination with the ability to spend real money in the game (Newheiser, 2009; Griffiths, 2010), it has been suggested that exactly that core gameplay loop is what keeps players playing the game (Newheiser, 2009). Even ten years later, FarmVille is still successful (with around $11 million being spent by players in the first quarter of 2019 (Wilson, 2019)) which points at the core gameplay loop of planting, tending to, and harvesting crops is still able to motivate players in 2019**.** Utilizing similar mechanisms for *Reification* can be seen as less critical, as the number of exercises is limited and doing more than the assigned exercises has no positive effects on a student's landscape.

Reification can be applied in most contexts where points, badges, and leaderboards can be applied as well and should turn out to be more motivating for students because of its narrative. When teaching Art History, students could be given an art gallery instead of a landscape with tasks rewarding them artworks. A course on Geography could reward students with a landmark of a country after learning about the country to be placed on a world map. The next section illustrates *Reification* by the means of a course on Egyptology where students incrementally build historical structures of Ancient Egypt by solving quizzes.

3.1.2 Application

At the authors' university, Egyptology major students are taught in the same courses as Egyptology minor students due to a low number of students which leads to an audience with heterogenous knowledge. Aiming at supporting students in catching up to their peers, an online course consisting of a large number of quizzes was created. *Reification* will be applied to motivate students to keep on working on their knowledge.

Ancient Egypt spans 5000 years during which structures in different building styles were built. Therefore, the different structures are suitable as rewards, as they allow an overview of which periods have been covered and which still have to be covered.

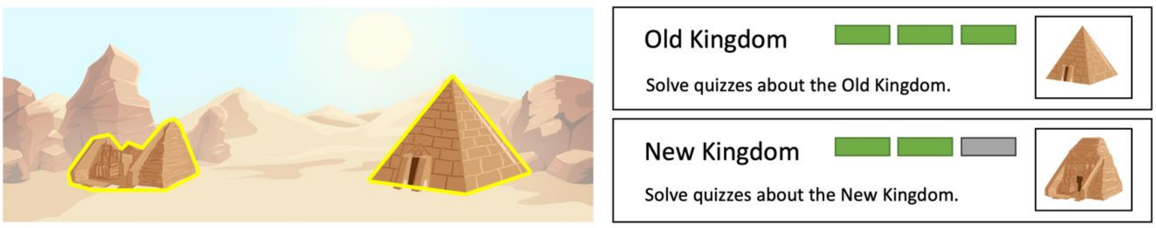

Figure 3: *Reification* for course on Egyptology showing one finished progress task and one progress task two-thirds finished

Figure 3 shows how *Reification* applied to that course will look like: For each period, a number of structures were drawn in three different stages of completion, from foundation only to half-done to finished. Each student can choose a period, place the foundation of one of the period's structures, and begin to complete the structure by correctly answering quizzes referring to that period. An example for the three states a structure runs through can be seen in Figure 4.

Figure 4: Example for the different states a temple goes through while a student is answering quizzes

Decay is not intended to be used in this implementation, as the goal is not getting students to do the quizzes regularly rather than motivating them to do them at all: The course allows students to catch up and motivates them throughout the process. After they acquired the knowledge required to follow the lecture, working on the quizzes is no longer important, as further learning is done through other learning activities.

3.2 Synapses

Synapses is a template for an educational game that aims to engage students with lecture's contents after a lecture by letting students elaborate on them in a playful way aiming to overcome and prevent the development of misconceptions.

3.2.1 Concept

Synapses represents the content of a course as a concept map with each lecture adding new concepts and associations available for use on the concept map. After each lecture, students are tasked to work newly acquired concepts using the new (and existing) associations into the concept map. By doing so, students are reflecting and elaborating on the lecture's contents, which, as shown in Section 2, can help overcome and prevent the development of misconceptions. Correctly constructed concept maps contribute to a student's score. The general narrative of the game is the organisation of the newly acquired knowledge in the student's brain. Therefore, the concepts and associations are visualized in form of (simplified) synapses, an example of which can be seen in Figure 5.

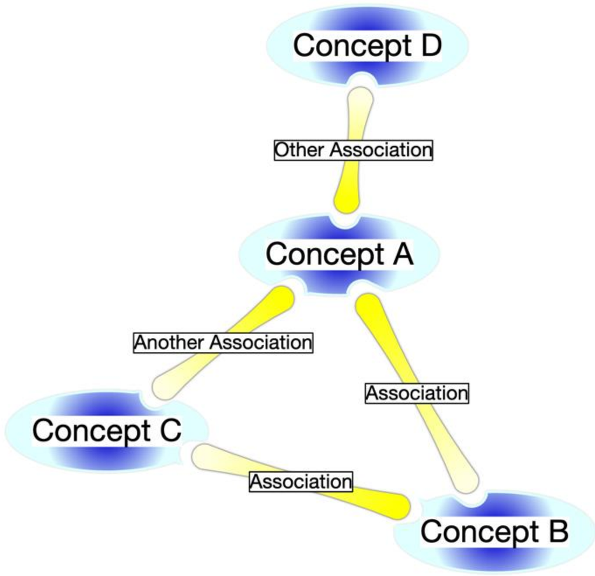

Figure 5: Visualization of a learner's concept map in form of (simplified) human brain

Students' misconceptions most often become apparent as mistakes done in exercises. The authors' found that the frequency of misconceptions follows a power law: Few misconceptions constitute the majority of all mistake occurrences (see Appendix). When misconceptions for a topic are known (e.g., by collecting them from a previous term's exercises), most of them can be mapped to regions of the concept map. If a student makes a mistake which teachers identify as a mistake stemming from a misconception, the system tasks the student to rearrange the associated region of the concept map.

An example for the mapping of a mistake resulting from a misconception to a region of the concept map can be seen in Figure 6. In the submission on the left side of Figure 6**,** the order of operations of multiplication and addition was violated leading to a wrong result. The right side of Figure 6 shows a part of the concept map where the region from which the misconception most likely stems from is highlighted, namely the binding power of operators. Letting the student who made that mistake elaborate on operators and their binding power should help them understand why their result is wrong and what is the correct result.

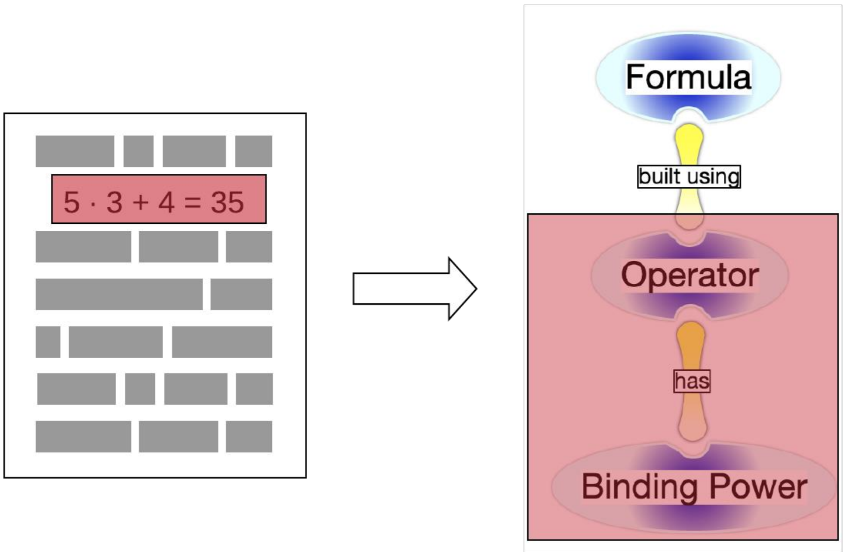

Figure 6: Exemplary mapping of a common misconception in arithmetic to a region in the concept map

The intention of this intervention is to prompt the student to reflect and elaborate on the concepts and associations and their connection to the mistake made. Therefore, the intervention moves away from feedback given as a monologue towards a dialogue with the system. As mentioned above, the majority of mistakes stem from a limited number of misconceptions, therefore preparing such interventions (i.e. associating misconceptions to regions of the concept map) should be feasible without too much extra work.

The game follows a social narrative with a story taking different turns depending on the percentage of students having a correct concept map, e.g., something positive happens if the majority is correct, nothing or something negative happens if the majority is incorrect; the best outcome only being achieved when the majority of students has a correct concept map.

Synapses has limitations in its genericity: Not every subject is suited to be represented in form of a concept map, not all misconceptions may follow the power law, and misconceptions may not always be able to be mapped onto regions of the concept map. Besides, the process of building the initial (correct) concept map used for scoring and the mapping of misconceptions to regions might be time-consuming, but can be reused each term a course is taught.

3.2.2 Application

An exemplary application of *Synapses* was conceived for a course on Logic where students are confronted with a large number of new concepts to be immediately applied in weekly homework exercises. As narrative, Paris and its Métro were set in a fictional world where the laws of nature are determined by the opinion of the majority of its inhabitants. For example, if the majority thinks that elephants can fly, elephants would fly in that world. The Paris Métro was chosen because it is an example for a system parts of which were validated for correctness using propositional logics. For the game, the audience is thought of as the entire population of the fictional world: If the majority of students have an incorrect concept map, that world's formal logic is broken and therefore the Paris Métro no longer works leading to delays. Throughout the term, the audience's accumulated delays lead to changes in the virtual world's Paris and different outcomes each week.

4. Conclusion and perspectives

This article introduced a template for a gamification mechanism and a template for an educational game with the aim of providing educators with templates which can be filled with a narrative that engages students more than gamification without narrative. *Reification* takes learning progress and makes it visible in form of a landscape in which each element can be placed by the learner and represents a learning task. *Synapses* aims at overcoming and preventing the development of misconceptions by tasking students to organize the concepts learnt in a lecture in a concept map. Both templates are generic which relieves educators of the task of developing a gamification or educational game and only leaves them the task of finding a fitting narrative and can be provided to educators that are unable to implement those by themselves to allow them to motivate their students with engaging storylines. For both templates, exemplary implementations were introduced, but no evaluations were done. While the concepts are grounded in theory and there is evidence that adding narrative can make gamification and game-based learning more engaging, empirical evaluations are required: Can *Reification* motivate learners to do the desired learning activities and can *Synapses* help overcome and prevent the development of misconceptions? Furthermore, narrative as engagement mechanism in educational games and gamification is underrepresented in research and should be examined in other contexts and for other concepts in the future as well.

Appendix 1

In a course on theoretical computer science the mistakes stemming most likely from misconceptions were compiled using 2 judges ($\kappa = 0.7$). Figure 7 shows the misconceptions and their occurrences exhibiting a power law. A more detailed look on the data can be found in Heller and Bry (2018).

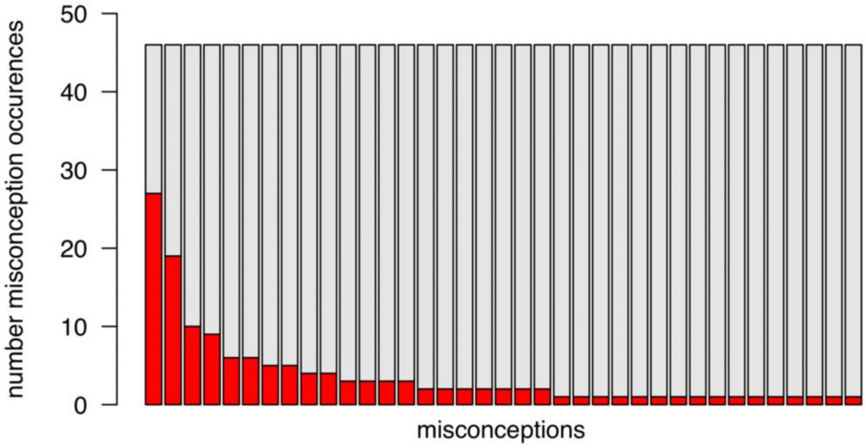

Figure 7: The number of students doing exhibiting a certain misconceptions

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