A Design Framework for Adaptive Gamification Applications

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Abstract

The application of gamification does not always achieve the expected results due to the shortcomings of the quite common "one size fits all" approach of standard gamification concepts. We therefore propose a design framework that can inform systematic development of adaptive gamification applications. The developed framework draws on the current body of gamification literature, focusing on the emerging research stream of adaptive gamification. It provides design paths and design principles that translate the individual elements into concrete guidelines to assist the design practice. The framework has been successfully applied to the design and implementation of a prototype application using gamification to incentivize knowledge exchange on an existing online platform for physicians in practical medical training. The evaluation in a case study indicated positive user acceptance and increased system usage after the introduction of the developed adaptive gamification solution.

1. Introduction

The concept of gamification as the use of game design elements in non-game contexts [6] has received great attention from researchers and is being increasingly applied to and studied in many domains [29], such as education [36, 13, 9], health [27] and crowdsourcing [24]. Well-known real-world examples include Khan Academy, a platform for online learning courses, Duo Lingo, a mobile application for learning languages or MySugr, a health application to support people with diabetes. However, research has shown that the application of gamification does not always achieve the expected results [20, 16]: the effectiveness is often mixed with

varying degree of success [29] and is highly dependent on the context in which the gamification concept is being implemented [29]. Such findings are commonly related to the shortcomings of the "one size fits all" approach of standard gamification concepts, such as the missing level of personality, the lacking consideration of specific user needs, goals and values as well as the diversity of users driven by different motivations [7, 14, 4]. This suggests that more user-centered gamification designs are needed that consider the support for different types of users.

At the same time current developments refer to the emerging and fast-growing research stream of adaptive gamification [2], which addresses personalized incentive mechanisms tailored to particular characteristics of different users and contexts in order to optimize gamification effects ([2, 5, 14, 21]). The importance of this is further stressed by recent work, showing that there is still a lack of understanding of how to properly design gamification solutions [23]. What is currently missing is a framework, which addresses design considerations and principles of such adaptive gamification solutions. Such a framework should help to explain the purpose of adaptive gamification elements, inform about potential challenges and serve as a structure for future studies to support the creation of adaptive gamification design patterns. Therefore the objective of this paper is to answer the following research question:

What are the main elements and challenges that need to be addressed for the design of adaptive gamification applications?

The design framework for adaptive gamification applications proposed in this paper is not a specific method for designing gamification solutions, but is rather a template for systematic design considerations for system designers. This is a major difference to approaches such as Morschheuser et al. [23] who

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considered best practices related to the gamification design process. Referring to the MDA – framework (Mechanics, Dynamics, Aesthetics) proposed by [12], our approach is to inform about possible criteria to adjust gamification mechanics and dynamics in order to design suitable gamification interventions, based on findings from the existing literature on adaptive gamification. Consequently, this would also lead to ideal aesthetics on the player side to keep lagging users interested for a longer period of time [12].

Accordingly, we introduce the design framework as a synthesis of the existing knowledge base from literature [2], demonstrate its application to a specific domain through a real-world prototype and discuss the results of its first validation in a case study. In doing so, we follow the design science research (DSR) approach by [11] which also embodies our theoretical and practical contribution in the IS field.

2. Theoretical background and related work on gamification frameworks

As already mentioned in the introduction, gamification is being used to motivate users to perform different types of tasks (e.g. health exercise, knowledge sharing, learning) and to increase the overall engagement in usage of a system. This chapter outlines the theoretical foundations and theories used in frameworks which support a more meaningful integration of gamification strategies. Considering the motivation, intrinsic and extrinsic types of motivation are often used as the main theoretical construct in gamification frameworks as grounded in self-determination theory (SDT) [29]. The latter has been successfully applied in several studies e.g. [33, 32, 37] to design motivational gamification strategies towards an adaptive gamification approach [2].

Furthermore, relevant research for the design of adaptive gamification approaches is introduced by [25, 3]. The user-centered theoretical framework for meaningful gamification in [25] focuses on intrinsic rather than extrinsic motivation. This framework reveals that effective gamification needs to properly connect the game-like experiences to the non-game setting by considering the given needs and goals of the end-users [25], which is an important aspect in the adaptive gamification research stream. Moreover the adaptive gamification framework proposed in [3] suggests the use of gamification analytics to monitor the perceived playfulness and engagement for different personalities in certain contexts, in order to define usage patterns and alter system rules.

Nicholson highlights several theories that support the idea of adaptive gamification concepts that aim at stimulating intrinsic motivation by supporting meaningful engagement [29]. First, the organismic integration theory (OIT) explores determinants and consequences of external motivations and suggests that meaningful gamification design motivates end-users intrinsically regardless of external rewards [29]. Second, the theory of situated motivational affordance outlines the importance of a fit between the background of the user and the gamification design to foster motivation and engagement [25]. However, none of these define a structured way or main types of elements informing the design of adaptive gamification.

3. Research Design

Design science research is portrayed as a problem-solving paradigm, which seeks to create new and innovative artifacts to address important unsolved real-world problems. The aim of our research is to define a design framework that can systematically inform the development of adaptive gamification applications. Hence we follow the design science methodology and process model, consisting of six phases, proposed by Peffers et al. [26].

In the first step, which covers (1) the *Problem Identification and Motivation*, we undertook a structured literature review (SLR)[2] where we identified main challenges and suggested a research agenda for scholars and practitioners who want to investigate and apply adaptive gamification strategies in non-game contexts. In the first stage of the SLR [2] we conducted an initial explorative search to conceptually define the term adaptive gamification by several keywords and applied the following search query to scientific databases (e.g. Scopus, ScienceDirect etc.): *gamif* AND adapt* OR personal* OR contextual* OR user-cent* OR analytics* [2]. The query describes the topic comprehensively and identifies research regarding different approaches to adaptivity and personalization in gamification applications, including gamification analytics and user-centered design informed by the research from [7]. The analysis corpus consisted of 43 identified studies and included contributions from related research areas [2].

As a second step (2) *Objectives of a Solution* have been defined based on the main challenges and insights (e.g. what is possible and feasible) of the identified studies. In the third sub-process (3) *Design and Development* we transferred the objective centered solution into a novel artifact by representing

a design framework with design principles to inform the development of adaptive gamification solutions[1]. In the following step *(4) (Demonstration)* we applied the design framework to a specific domain by using it to inform the design and implementation of a real-world adaptive gamification application prototype. The developed solution extends an existing online platform for knowledge exchange between medical doctors in postgraduate practical training (the KOLEGEA project) with adaptive gamification elements, aimed at incentivizing and increasing user activity and usage of the platform. The study also included an (5) *Evaluation* of the prototype as a first validation of the developed design framework. The first iteration cycle concluded with *Communication* (6) for the study participants.

4. Design Framework for Adaptive Gamification

Insights obtained from the literature analysis have been used to define the main elements and sub-elements of a conceptual matrix for analysing adaptive gamification introduced in [2]. The developed categorization ("Purpose of Adaptivity", "Adaptivity Criteria", "Adaptive Interventions", "Adaptive Game Mechanics and Dynamics") is based on an iterative analysis of the literature search process and has been inspired by the classification scheme for adaptive methods in hypermedia ("What is adapted?", "To which feature?", "Why", "How?") introduced in [34]. Accordingly, we adopted these conceptual elements as core elements of the proposed design framework and included their sub-elements to represent possible specific design considerations for system designers (Figure 2). Moreover, the research challenges and directions identified in the SLR have been included in the design framework to inform about possible barriers to be overcome (Table 1).

Table 1. Challenges identified in the SLR [2]

C1	To find the right balance in the design of adaptive gamification environments (e.g. micro level – support individual user vs. macro level – engaging users to commit to a common goal)
C2	Examine and understand the difficulties of the development and application of types of users (e.g. user types, player types) inside gamified environments
C3	Understanding the relationship between the mechanics and their effects on different individuals to react accordingly

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[1] The design framework was first developed based on a literature survey at the beginning of 2016. The survey was updated with newer publications in October 2016 for the published version of the SLR [2].

C4	(a) Design according to the underlying motivational theory (e.g. SDT) - (b) Balance the degree of adaptivity in the adaptive gamification approach
C5	Design a meaningful adaptive gamified reinforcement strategy to sustain the long-term engagement

In the next sections we introduce the proposed framework by providing an overview of its main elements and showing how they follow exemplary contributions from the literature. This includes putting the individual elements in relation to each other and highlighting the main challenges that need to be addressed. We also show how the main elements and sub-elements can actually be considered and applied as design elements by referring to theoretical and practical application examples in the literature. We then formulate design principles that translate the associated sub-elements of the framework into concrete guidelines that can support the design practice. Furthermore, we show how specific design paths, which can guide the design process, emerge from the framework structure and its relations. In this way we also exemplify our theoretical and practical contributions, that include both informing further research and supporting the design of adaptive gamification solutions in practice.

4.1. Structure and Elements

The first element of the framework is the *Purpose of Adaptivity (1)* (Figure 1, top left) that includes several sub-elements reflecting different types of purposes, identified in existing literature. *Change the state of the user* refers to altering the end-user attitude towards their goals, motivation and beliefs and aligning them with the benefits of using the system [32, 38]. *Support of Learning* refers to adaptive solutions supporting the end-users in their learning process [36]. This aspect has been shown in various forms, such as through the design of a dynamic score calculation in a web-based educational system [8], or by using learning analytics in combination with formative feedback inside a primary school level application [13]. Similarly, the aim of *Supporting the Participation* focuses on increasing user participation in information systems, for example by increasing the knowledge base through incentivizing contributions to certain topics or activating passive users to become more active. The last sub-element, *Create a Meaning between the End-User and the Activity,* refers to the user-centered theoretical framework proposed in [25], which focuses on creating a meaningful connection between the non-game context and the goals of the end-users.
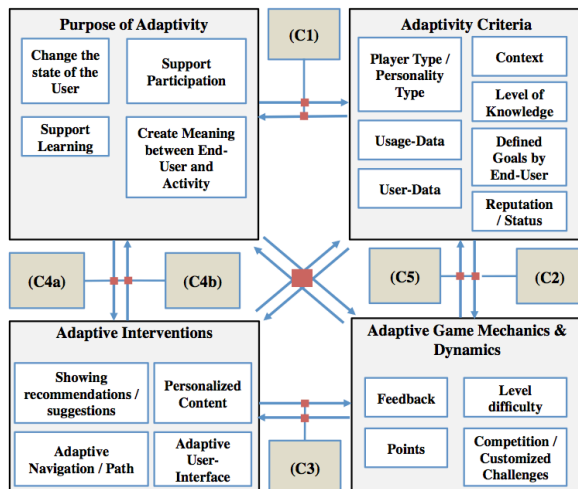
The second element *Adaptivity Criteria (2)* (Figure 1, top right) represents the criteria that form

the basis of existing adaptive gamification approaches. *Player Types and Personality Types* can serve as important input for adaptive gamification design, since every personality or user type exhibits different preferences and motivations to certain gamification elements [35, 9, 7, 30]. Increasing research has been investigating player typologies [10, 15, 1] and the associated gamification elements [7, 9]. This includes a recent development of the gamification user types framework Hexad ("*Disruptor, Free Spirit, Achiever, Player, Socializer, Philanthropist*") [19], which has a strong focus on gameful design. The framework also includes a survey to measure preferences towards different gamification elements [35], enabling adaptive design.

The sub-elements *User Data* and *Usage Data* consider information about the end-user (e.g. professional experience, position, gender etc.) and the system usage (e.g. active vs. passive usage) as design criteria for adaptive gamification approaches. Furthermore, in online environments activities and tasks are often connected to a certain *Status or Reputation* (e.g. Stackoverflow Q&A). These can be used to unlock different features, to motivate users to become more active or to increase the quality of community contributions [5]. The *Level of Knowledge* and *Defined Goals by the End-User* are important factors for adaptive functionalities as reflected in a growing number of applications that allow users to set their own goals (e.g. in health related contexts, [21]) or to adapt features to the level of their current knowledge level (e.g. knowledge space theory; [13]). The *Context* can also be used as a basis for the degree of adaptivity (e.g. course level) and can include factors such as the location or type of the end-user device (e.g. in mobile applications).

The third element, The *Adaptive Game Mechanics & Dynamics (3)* (Figure 1, bottom right) lists the actual adaptive gamification elements, discovered in the present body of the gamification literature. The common *feedback* mechanism has been used e.g. for adaptive warning messages if end-users do not follow the preconfigured set of eco-driving rules, based on a relative score of each user [18]. In [8], the authors reveal how to design the *Points* mechanic dynamically, dependent on particular activities completed by the end users. There, the *Points* mechanic is used as a basis for dynamically creating a suitable degree of *Level Difficulty* when end-users want to proceed to the next level. Finally, the usage of *Customized Challenges* has been an effective element in health-related contexts (e.g. [21]). This includes the *Competition* element, although mixed findings on the effects of different *Competitive* structures in the gamification design exist [28].

The final element, *Adaptive Interventions (4)* (Figure 1, bottom left) refers to gamification elements that show the results of the adaptation process as an intervention in the front-end layer. The most used intervention is the application of *suggestions and recommendations* to inform end-users about their personal learning progress (e.g. reminder on upcoming deadlines, personal feedback) [18, 36, 33]. Similarly, *Personalized Content* has been used for individualized progress feedback [36]. The sub-element *Adaptive Navigation / Path* provides a tailored learning experience by adapting the learning path to user's current skills or achievements or by providing multiple paths to the same goal ([32, 38]). The *Adaptivity of the User-Interface* has so far been mainly part of theoretical contributions such as [22], where gamification elements are dynamically adapted based on an analysis of user interactions.

4.2. Design Principles

The four main elements of the design framework serve as the basis for defining the meta-requirements [17] and design principles derived from literature (Table 2) that serve as high-level guidelines for addressing those requirements. They show how scientific findings can be related to the design practice and play a crucial role in design science research [17]. For example, in addressing MR1 (*Consider the Purpose of Adaptivity)*, DP1 was identified by looking at [36, 8] where the *Support of Learning* inside a gamified environment is investigated. Similarly, DP5 (include user information) points to possible approaches in choosing the *Adaptivity Criteria* (MR2) and has been informed by the framework from [3]. DP11 was informed by [21] showing how the design of

Figure 1. Design framework

Meaningful Adaptive Interventions (MR4) can be approached through self-selected difficulty levels and skill goal setting.

Table 2. Meta requirements (MR) and design principles (DP)

MR1: Consider the Purpose of Adaptivity (1)
DP1: Ensure to support learning and provide a gamified personal learning experience
DP2: Ensure to create a meaning between the end-user and the activity to support long-term engagement
DP3: Ensure to efficiently support participation to increase the quality and quantity of end-user contributions
DP4: Overcome the "one size *doesn't* fit all" problem with adaptive incentives for individual users/user types
MR2: Define the Adaptivity Criteria (2)
DP5: Include user information (e.g. gender, usage data, personality, user type, preferences for certain gamification elements etc.) as criteria for adaptive gamification design
DP6: Consider the context (e.g. levels, reputation, user goals, self-assessment, domain specific values etc.) as criteria for adaptive gamification design
MR3: Design the Adaptive Gamification Mechanics & Dynamics (3)
DP7: Add adaptivity to standard gamification mechanics in a meaningful way (e.g. adaptive levels, customized challenges, personalized feedback etc.)
DP8: Consider persuasive reinforcement strategies to sustain long-term engagement
DP9: Design adaptive gamification mechanics and dynamics which are seamlessly connected to adaptive criteria and follow the defined purpose of adaptivity
MR4: Design Meaningful Adaptive Interventions (4)
DP10: Design clear, personal adaptive interventions which inform the end-users about their current behavior or status and behavior improvements
DP11: Design multiple paths (choices) to achieve end-user goals and support their believes and motivation
DP12: Ensure to define time and location of the intervention and connect it to the gamification layer
DP13: Visualize end-user contributions and show possible next steps to achieve personal goals (e.g. skills, status etc.)

4.3. Design Paths

To further exemplify how the proposed design framework (Figure 1) can be applied to inform the design practice, we considered the logical connections between its main elements by identifying exemplary design paths (Table 3) with individual starting points, which present a series of steps that can guide the process of designing an adaptive gamification application. The five challenges have also been included as possible research and design barriers that need to be overcome [2] (Table 1).

The first design path (P1) in Table 3 represents the standard procedure, starting from the *Purpose of Adaptivity* and moving clockwise towards *Adaptive*

Interventions. At the beginning of the design process system designers should reflect possibilities and define objectives by asking: "What do we want to achieve or support with the adaptivity?" (e.g. increase the participation or support the learning process etc.). The possible *Adaptivity Criteria* should then be identified, e.g. based on the availability of user data or usage data (e.g. goals, skill level), and the most suitable for the given context selected. The next step in this path is the definition of the *Adaptive Game Mechanics & Dynamics* (e.g. points, level difficulty) and where the corresponding elements of the design framework inform about the specific design opportunities. In the final step the *Adaptive Interventions* are considered, which also include design considerations for usability (e.g. time and location of the intervention).

Table 3. Design path examples

P1	Purpose of Adaptivity ➔ (C1) ➔ Adaptivity Criteria ➔ (C2-C5) ➔ Adaptive Game Mechanics & Dynamics ➔ (C3) ➔ Adaptive Interventions
P2	Adaptive Game Mechanics & Dynamics ➔ (C3) ➔ Adaptive Interventions ➔ (C4a-C4b) ➔ Adaptivity Criteria ➔ Purpose of Adaptivity
P3	Adaptive Interventions ➔ (C4-C5) ➔ Purpose of Adaptivity ➔ (C1) ➔ Adaptivity Criteria ➔ (C2-C5) ➔ Adaptive Game Mechanics & Dynamics
P4	Adaptivity Criteria ➔ (C1) ➔ Purpose of Adaptivity ➔ Adaptive Game Mechanics & Dynamics ➔ (C3) ➔ Adaptive Interventions

The starting point of the next three paths deviates from this ideal procedure due to the consideration of real-world constraints. In practice, the opportunities are often restricted, especially in the design of gamification approaches for already existing information systems. If, for example, the system designers want to add adaptive functionalities to an existing gamified environment, they would probably set their starting point at the *Adaptive Gamification Mechanics & Dynamics* and investigate how to successfully design meaningful *Adaptive Interventions* (P2). Another example path (P3) shows the case of system designers having the possibility to integrate only one or two specific *Adaptive Interventions*. They probably start with them first and continue with analyzing which *Purpose of Adaptivity* can be achieved with the selected interventions and what *Adaptive Criteria* can be taken as the basis.

The design path P4 considers existing usage data (e.g. click events, logs etc.) as a basis for the adaptive gamification design. This pre-condition invites to start at *Adaptivity Criteria* to investigate "What is possible with the present data?". In the next step the

designers continue with asking "What purpose(s) of adaptivity can be achieved? After that the path continues as in P1. Additionally, the identified challenges should be taken into consideration, for example in the step of choosing *Adaptive Game Mechanics and Dynamics* and defining the *Adaptive Interventions*, the third challenge (C3) suggests to consider current research on the relationship between the mechanics and their effects on individuals (e.g. [7]).

5. Case study: Gamifying knowledge exchange in medical training
5.1. Application domain and goals

The developed design framework has been applied to the gamification of an online platform for knowledge exchange in post-graduate medical training (platform KOLEGEA). The post-graduate education of physicians is characterized by practical medical training through independent work practice at different medical institutions, which makes peer-based knowledge exchange difficult (unstable peer network). The KOLEGEA platform aims to support physicians in such settings through online sharing of medical patient cases (anonymized) from their work practice. Additionally, the platform offers to join learning groups, add articles and comments to the KOLEGEA forum as well as explorative search-queries through a knowledge browser [40], [31].

The requirement analysis and evaluation of the platform revealed a very heterogeneous user group with different aims and motivations of using it. As a result, after the rollout campaign and supporting interventions for the introduction of the platform in the target group had finished, the platform exhibited a relatively low level of subsequent usage. This was reflected in a low intensity of both active forms of use (e.g. creating comments, creating cases) and "passive" usage (e.g. viewing medical cases), beyond a few lead users. In order to incentivize more frequent usage and more intensive activity in such cases, we applied the proposed design framework to this case study including a subset of the derived design principles (Table 2). Acknowledging the heterogeneous target group and varying participation on the platform the goal was to develop an adaptive gamification application for incentivizing more active usage of the KOLEGEA platform.

5.2. Adaptive gamification model design
The developed adaptive gamification model depicted in Figure 2 shows the selected sub-elements of the design framework that have been applied in this case study. The design decisions have been informed by the corresponding design principles (Table 2) in the individual design phases. In doing so we followed the previously introduced design path P1 (Table 3). Therefore, we started with the *Purpose of Adaptivity*, which was to incentivize more active usage of the KOLEGEA platform (in both active and passive forms of use) (DP3), which should in turn support learning (DP1). Additionally we applied a lightweight adaptive gamification approach through adaptive incentives (suggestions in the activity monitor) to overcome the "one size fits all approach" (DP4) which should provide a meaningful connection between the gamified activities and the real-world context of users medical training and practice (DP2).

Next, we analyzed the most suitable and possible *Adaptivity Criteria,* based on the available data on user characteristics and the usage of the platform. In accordance with DP5 and DP6 we selected the design framework sub-elements *Context* and *Different Types of Users* (Figure 2). The *Context* has been modeled with several elements that include: i) the CanMEDS competence framework, ii) competence levels, iii) personal learning goals and iv) self–assessment. The CanMEDS framework describes the competences that the physicians need to acquire in order to meet the healthcare objectives. It consists of medical expertise and six additional competence areas: (1) Learning and Teaching (2) Communication (3) Management (4) Cooperation (5) Representation of the Patient and (6) Professionalism. The defined competences have been taken as the basis to which the gamified online activities are to be connected, in order to provide a meaningful link to the real-world goals of physicians in their practical training. Personal learning goals of CanMEDS competences and self-assessment have also been considered as adaptivity criteria, since based on those individualized incentives could be provided.
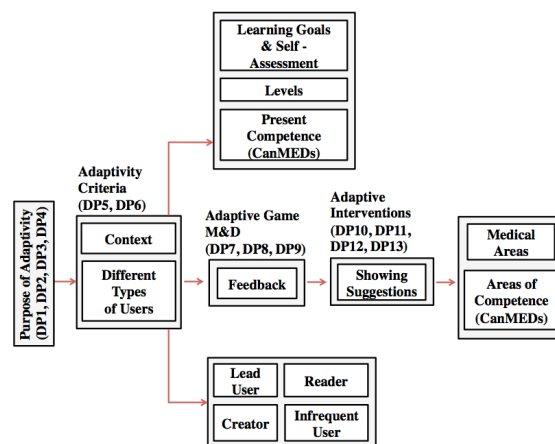

Figure 2. Adaptive gamification model

For each area three *Competence Levels* have been defined (low, medium and high competence) and in order to determine their thresholds, a cluster analysis of user activities (over the last three years) has been conducted. The results have been used to identify certain *Types of Users* (e.g. lead user, infrequent user) (DP5) and to understand the dynamics of their past usage behavior for a user-centered design of the level mechanic.

In the next phase, we analyzed the *Adaptive Gamification Mechanics and Dynamics.* We concluded that the classical *Feedback Mechanic* is the most suitable adaptive gamification element for the defined *Adaptivity Criteria* and can seamlessly be connected to the chosen adaptivity criteria (DP9), matching our requirements, in line with DP7. We also decided to consider reinforcement strategies (DP8) in form of a weekly email newsletter informing the participants about their achieved level of CanMED-related competences and expertise on the KOLEGEA platform. The weekly newsletter also includes activity suggestions for reaching the next level, with the aim to motivate active users to contribute more to reach their goals, and to reactivate infrequent users to become more active.

Subsequently, the *Adaptive Interventions* were defined in form of individualized activity *Suggestions* (e.g. "Share a medical case with the KOLEGEA Community to collect 70 points" or "Create one case regarding chronical disease" to receive the golden badge in this medical area"). These suggestions, informed by DP10 (design clear, personal adaptive interventions) and DP13 (visualize end-user contributions and show possible next steps) are based on calculations of missing points towards the next competence level (and medical expertise) or towards the user's personal goals

The model also offers multiple choices to achieve end-user goals by performing one of the twenty-one predefined activities on the platform, thus adhering to DP11 (design multiple paths to achieve ender-user goals). It foresees visualizing the user's current contributions and expertise (DP13) and the location, as well as the time of the adaptive interventions (DP12) is well defined.

5.3. Prototype Implementation

The described model has been implemented in the KOLEGEA platform in the following way. An activity monitor visualizes user activities in relation to CanMEDS competences, interpreted as achievements related to usage and interactions. It is the main element of the gamification model and offers three levels of competences (low, medium, high), which are visualized by the inner circles of the

competence radar (Figure 3). Users can set their own learning goals (solid line) or self-assess their CanMEDS competence (dashed line), on one of the three predefined levels (Figure 3). In addition, the dotted area, e.g. in *Learning & Teaching* competence*, shows the gap between the current and next level of competence (medium). On click, a pop-up window shows the missing points to the next level and activity suggestions. This visually provides information about missing points towards the next competence level (score gap) and includes adaptive suggestions about possible activities to reach the own learning goals (or the next competence level if no goals are defined).
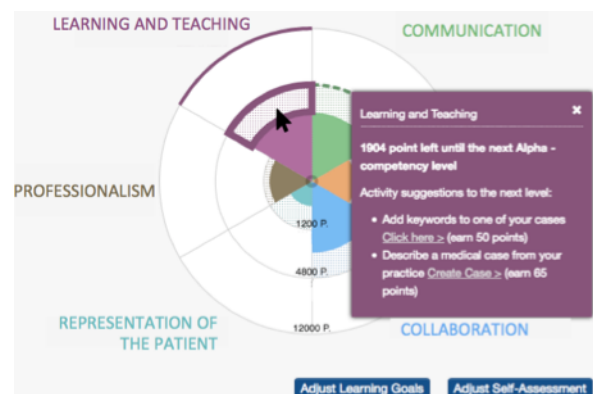

Figure 3. CanMEDS activity monitor

In this way, a form of adaptive incentives is realized, as the user is pointed to the next most feasible action based on the smallest point gap to the next achievement. The implementation of this approach for the medical expertise is similarly designed. It consists of twelve areas of expertise, each represented by a medical badge. After contributing to a medical area (e.g. creating a case or a comment on a case) the level of expertise gained on the KOLEGEA platform (low, medium, high) is calculated and represented by the color (gold, silver, bronze) inside its badge. A mouse-over function shows the current expertise and the value of the self-assessment in this area (Figure 3). This allows users to identify topics to which they have paid little or no attention.

6. Evaluation

The described prototype was rolled-out into everyday use of the KOLEGEA platform and evaluated in a field trial over the period of 6 months (Apr. 2016 – Sept. 2016). We followed a mixed method approach by performing a quantitative analysis of usage data and assessing user acceptance

through an UTAUT questionnaire [39]. The questionnaire invitation was sent to the 340 registered users on the KOLEGEA platform. In total we received 20 responses: 15 from the online respondents (4,4% response rate), and a further 5 from participants who participated in a user workshop and group discussion. Demographic data reveal that the majority of the respondents were female (75%), while the age group varied with a majority between 31- 40 years of age (54%), followed by 36% between 41- 50 years and 10% above 50 years of age. This dominance of female participants is representative of the overall user population and this target group (physicians in general medicine). The majority saw themselves as either experienced or professional computer users (63% and 15%, respectively), while 22% declared themselves as occasional users.

The overall usability and usefulness of the activity monitor was positively rated. The majority of the respondents stated that the gamified activity monitor is easy to use (68%), that the interaction is simple and clear (79%) and that it is easy to learn using it (74%). While 63% agreed that the activity monitor increases the usefulness of the platform for their practical training, 76% responded that it enables them to perform the tasks for their training more quickly. This is a bit in contrast with "only" 63% respondents seeing the activity monitor as helpful for their practical training, while 79% saw it as helpful for preparing their final specialization exam.

Furthermore, 85% of the respondents answered that the activities on the KOLEGEA platform contribute to their own expertise, which suggests a meaningful connection between the gamified online activities and their real-world practice. Half of the participants also acknowledged that both the prospect to achieve medical expertise badges for KOLEGEA activities, as well as the clear mapping of their KOLEGEA activities to the CanMEDS competences motivate them to use the platform. For half of the participants the prototype thus managed to create a meaningful connection between the gamified activity and the non-game context (DP2). This is promising, although a high portion of undecided users (35%) suggests this doesn't necessarily work for all types of users.

Feedback on the adaptive incentives i.e. activity suggestions (Figure 4) reveals that roughly half of the users perceived them as helpful for using the platform more efficiently (CanMEDs competences 50%, medical expertise 45%). More users agreed that they are helpful for reaching the next possible badge (70%) or level of competence (65%). This highlights the potential of adaptive gamification elements in this specific context, although the heterogeneity of user types is reflected by the differences in answers to specific purposes and goals of usage: 45% of respondents perceived the adaptive incentives as helpful for deepening their medical expertise, 65% for deepening their CanMEDS competences and 65% for reaching own learning goals.

The usage analysis (system logging) has compared user activity in the period of 6 months directly after introduction of the adaptive gamification prototype to user activity in the project period preceding it (where no interventions were performed to stimulate usage of the KOLEGEA system). As can be seen in Figure 5, overall system activity (number of active users per
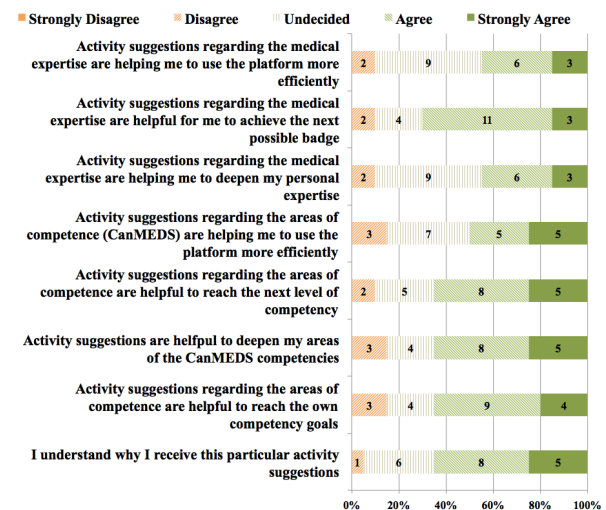

Figure 4. User acceptance results

month) increased after the introduction of the adaptive gamification prototype, except for a dip during the summer break. This suggests one of the effects of introducing the adaptive gamification prototype.
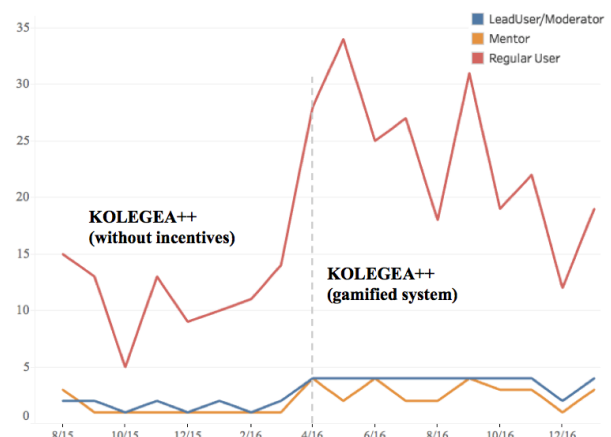

Figure 5. Number of active users per month

The analysis also revealed various effects on "active" forms of use (e.g. creating a patient case, comment etc.) and "passive" usage (searching and retrieving information). For regular system users (excluding mentors and moderators driven by different motivations), only minor effects have been observed on active use, such as creating comments on patient cases (Figure 6). No increase in the number of created patient cases or forum articles was observed. Clearer effects have been observed for "passive" system usage (e.g. opening a patient case), where a multiple increase in activity has been found (Figure 7). Hence, the implemented gamification model seems more suitable to support low effort activities, rather than high effort tasks. For more time consuming tasks (e.g. creating a medical case), with larger barriers to be overcome, more specific behavior profiling and adaptive interventions seem to be needed (e.g. to support different motivations in different contexts).
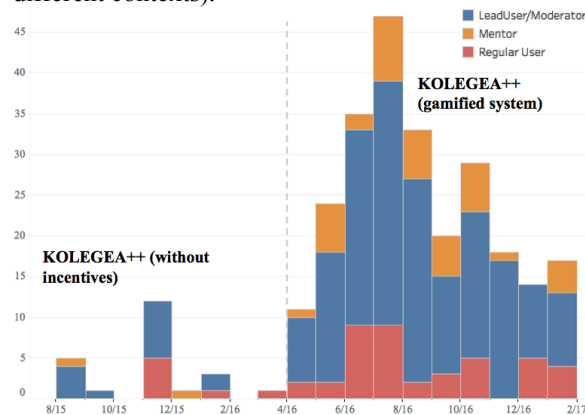
Figure 6. Number of comments on cases
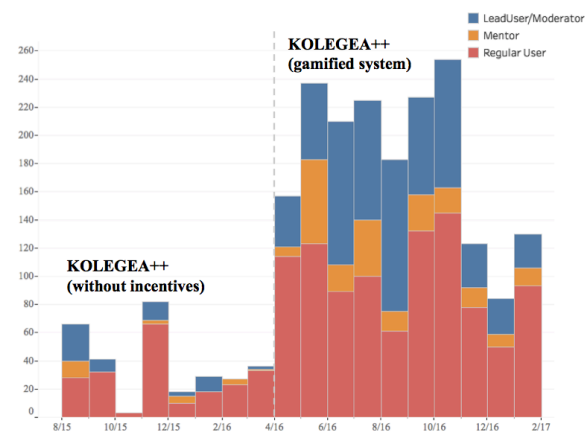
Figure 7. Number of views on medical cases

The results also reflect the characteristics of the target group and general online community dynamics, where typically only a small group actively contributes new content. This is even more

critical here, since doctors in postgraduate training have to shuffle many different activities competing for their time. Moreover, they do not readily share information online due to concerns over confidentiality of patient data (even if anonymized). Overall, the observed increase in (passive) system usage and the user feedback confirm the suitability of the implemented prototype for this domain. This suggests that the proposed design framework can inform the design of adaptive gamification systems.

7. Conclusions

We have applied the design science research approach (DSR) to develop our design framework for adaptive gamification applications. The proposed framework has been derived from literature and validated by applying it to the design of a concrete real-world application, which has been prototypically implemented and evaluated in a case study.

The results of the evaluation in a real-world trial include positive user acceptance and feedback, and increased system usage after the introduction of the developed solution. This suggests that the proposed design framework could be successfully applied to guide the design of an effective adaptive gamification solution. This supports the internal validity of the framework, though these results need to be taken with care. There are two main limitations of the presented results. First, the evaluation context of incentivizing knowledge exchange to support doctors in postgraduate medical training is rather specific and therefore limits the relevance of the results in terms of a more general validity of the proposed design framework. The second constraint is the small sample of the respondents and possible rebound effects due to the limited trial length (6 months). Overcoming these limitations requires longitudinal studies, while demonstrating a more general validity calls for framework application and evaluation in additional domains. This is planned in further studies.

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