Gamification Designs in Wearable Enhanced Learning for Healthy Ageing

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***Abstract*—Supporting healthy ageing through sustained physical fitness requires interventions that promote healthy levels of physical activity as part of daily life. Wearable devices, such as activity trackers are body-worn and may be seamlessly integrated into daily activities to promote fitness. Although wearables have been used by younger adopters to optimise physical fitness, little is known so far how these emerging technologies may be leveraged to enhance learning and improve well-being and fitness of seniors. In this paper we present a novel approach to designing Wearable Enhanced Learning (WELL) for healthy ageing as part of the R&D project "Fitness MOOC - interaction of seniors with wearable fitness trackers in the MOOC (fMOOC)". The fMOOC project is a cooperation between Beuth University of Applied Sciences and the Geriatrics Research Group at Charité Berlin and aims at enhancing healthy ageing through an embodied learning experience in a Massive Open Online Course (MOOC) with support of wearable activity trackers. This paper focuses on gamification designs in wearable enhanced learning for senior users and addresses the issue of user engagement.**

Keywords — gamification; wearables; wearable enhanced learning; healthy ageing; user engagement; instructional design

I. INTRODUCTION

Wearable Enhanced Learning (WELL) is beginning to emerge as one of the earmarks of the transition from the desktop age through the mobile age to the age of wearable, ubiquitous computing. While mobile devices are carried to a location and used in a state of temporal stationarity (e.g. standing), wearable, body-worn devices are used when the user is moving or engaging in other tasks (e.g. running) [2]. Wearables are a convergence of four major trends - mobile, internet of things, augmented reality and big data [14]. The primary purpose of wearables is to provide immediate, directly relevant, contextual information at the point of experience [14]. Recent studies have shown that the percentage of persons tracking fitness data through a smartphone has grown rapidly during the last two years with wearable devices and services enhancing the current trends towards mHealth and Quantified-Self [10], [11], [16], [17], [19]. However, as studies point out, currently available fitness trackers have not been able yet to drive long-term, sustained engagement for a majority of users independent of age [10]. Some of the key barriers to user engagement and impact on health include (a) limited functionalities (e.g. providing only basic health metrics such as steps taken and calories burnt), (b) missing activity triggers (e.g. activity trackers capture data but do not inspire action), and (c) missing mechanisms for sustained motivation to keep fit [10]. One of the key research questions is then how wearable fitness technologies may contribute to habit formation, goal reinforcement and sustainable impact on health and well-being [2].

II. USER ENGAGEMENT DESIGN

Physical activity is considered as one of the key factors of ageing healthy and at the same time one of the key motivational challenges for the elderly. Research shows that even 30 minutes of daily moderate-intensity physical activity may significantly reduce the risk of chronic diseases [12]. The fMOOC project founded by the German Federal Ministry of Education and Research (BMBF) has developed a wearable-enhanced fitness Massive Open Online Course as a novel approach to promoting healthy ageing. This approach focuses on enhancing user engagement on five levels of design (conceptual, requirements, instructional, architecture and interface design) with the aim of enhancing the daily fitness of senior users. User engagement (UE) may be defined as the quality of the user experience (UX) emphasising positive aspects, such as being captivated and motivated to use technologies [7]. The design of user engagement includes the gamification component as a method of persuasive design [2].

The conceptual design of fMOOC builds on extended Personal Learning Environments (eX-PLE) in sense of permeable physical and virtual spaces, which are constructed dynamically through the practice of "mobility" across spaces, contexts, concepts and time [2]. The instructional design of fMOOC combines the elements of a Massive Online Learning Course (MOOC) with elements of gamification and principles of seamless learning to create an engaging flow of learning experiences across contexts (online, offline), blending learning with everyday life. The fMOOC architecture combines wearable, mobile and learning technologies to capture and share fitness data and content such as training plans and exercise videos within the community of senior learners. Senior learners access fMOOC via the "fMOOC mobile App" using a laptop, a tablet or a mobile phone. The content service connects to the Learning Management System (LMS) Moodle where the content, such as training plans and exercise videos, is stored. The communication service uses the facilities of LMS Moodle. The tracking service connects with the fitness tracking data service of the wearable devices to retrieve appropriate data such as the number of steps as measured by an activity tracker. The learning analytics module displays an overview of their fitness data to learners including the exercises of the training plans they have completed. This module makes use of the interactions data stored by Moodle

and by the wearable devices. The fMOOC software includes a gamification service to incorporate rewards and playful elements in the course, including badges and battles. A more detailed description of the fMOOC multi-layer design can be found in Buchem et al. [2]. The next sections of this paper focus on gamification as one of the key elements of the overall fMOOC wearable enhanced learning design.

III. GAMIFICATION DESIGN

A. Applications and definitions of gamification

The concept of gamification stems from the field of game design and has entered the area of interaction and learning design only recently. Gamification has been applied in organisational management, marketing, health and education as an approach to enhancing user engagement through gameful experiences, e.g. increasing user activity, social interaction and quality of user actions [5], [6], [8], [12], [18]. A literature review of empirical studies on the effects of gamification revealed that most widely applied and examined elements of gamification design described in the literature have included points, leaderboards, achievements, rewards, badges, levels, stories, goals, feedback, progress and challenges [6]. Most studies on gamification have reported on on a number of positive effects and benefits of gamification, including motivation, engagement and enjoyment [6]. However, it has been reported that these and related outcomes may be short-term and caused due to a novelty effect [6].

Gamification as a concept has been framed in different ways. A widely recognised approach by Deterring et al. defines gamification as the use of game design elements in non-game contexts [4]. Gamified applications as opposed to fully fledged games use only certain elements of games which include both technical as well as social gaming elements [4]. Another definition has been proposed by Huotari and Hamari [8], differentiates between the systemic level (e.g. points, badges) and the experiential level (e.g. gamefulness, pleasure, involvement) of gamification. The experiential level of gamification results from a voluntary participation of an individual user and is determined by the user's individual perception [8]. Therefore the same gamification design may be experienced as enjoyable or motivating by one user and at the same time as annoying or indifferent by another user. Possible differences in outcomes may be caused by individual preferences, goals or skills [20]. From this perspective gamification can be defined as a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation [8]. The definition by Huotari and Hamari combines the design of "game-like mechanics" with the design of "gameful experiences" [8].

B. Gamification design and research questions

The gamification design implemented in the fMOOC project includes both *game elements* in sense of "game-like mechanics" (i.e. badges and battles embedded in the fMOOC system design) and *experiential elements* (e.g. interface and learning design), both aiming at promoting user engagement in view of healthy ageing [2]. Following the definitions of health by WHO [21] and by Bircher [1], the fMOOC design is based on the concept of healthy ageing as a dynamic state of physical, mental and social well-being, characterised by a physical and mental potential for active participation in society and enjoyment of good quality of life [3]. Since the approach to healthy ageing applied to fMOOC design views health as a set of learnable capabilities [8], the gamification design is closely connected to the learning/instructional design and other design layers including architecture and interface design. An overview of the different layers of the fMOOC design is provided by Buchem et al. [2].

The fMOOC gamification design attempts to support users in (a) retaining or improving their daily physical activity, and (b) enjoying the experience of the fMOOC in sense of user engagement. As we are not aware of any project so far implementing gamification designs in a wearable enhanced learning settings based on instructional principles of Massive Open Online Courses (MOOC), the high-level research question in the fMOOC project is about how to enhance user engagement by means of gamification. The key questions are:

- How can gamification enhance a sense of *orientation*, such as related to the way of improving own fitness?
- How can gamification enhance *motivation*, such as related to retaining physical activity as part of daily life?
- How can gamification enhance a sense of *enjoyment*, such as positive feelings related to achievement?

This paper explores the systemic level of gamification design of the fMOOC and focuses on two gamification design elements - badges and battles - and the effects these elements may have on user engagement. Badges and battles cannot be however considered in isolation from other design elements of the fMOOC, including learning design and the integration of wearable fitness trackers in the MOOC design. These different design layers are considered in further sections of this paper.

C. Gamification design elements

Gamification design of the fMOOC has been based on the theoretical and empirical analysis of the requirements of senior users. The theoretical analysis was based on the examination of gerontological literature especially in the field of learning and human computer interaction (HCI). The empirical analysis included incremental elicitation by means of semi-structured interviews and surveys both with end users and representatives of relevant stakeholders groups (who are members of the advisory board in the fMOOC project) as part of the agile development process. The requirements engineering process included elicitation, specification and design phases. Elicited user requirements were specified in form of user stories in the product backlog following the SCRUM methodology. Requirements related to the gamification design were iteratively tested with senior learners using different methods such as interviews and A/B testing. Based on this comprehensive requirements analysis, the key systemic gamification elements identified as appropriate means of enhancing user engagement included badges (digital achievements) and battles (digital competitions).

Badges as digital achievements have been applied in fMOOC both as triggers and awards [2]. As triggers, badges have been used to set goals and call users to action. As awards, badges have been used to mark progress and recognise achievements. Both as triggers and awards, badges have been applied to provide orientation and to enhance motivation before and during training. The fMOOC gamification design implements badges to enhance user activity in three key areas:

- Working out according to an individual *training plan* based on a previously measured fitness level (level 1, 2, 3) using validated fitness measurement instruments for senior persons. Training plans combined two types of exercises, i.e. endurance and strength training exercises, combined with recovery times;
- Progressing on a *number of steps made* daily. The number of steps was measured using fitness trackers both during working out according to the training plan and during daily activities like walking. A balanced range of steps was recommended per day with upper limits according to the individual fitness level;
- Engaging in *social interactions* with other senior users such as writing own posts (e.g. about the how successful the learner was on a given day, what difficulties he/she experienced), and rating posts written by others (i.e. how helpful posts of other users were for own learning).

These three activity areas have been considered crucial for promoting healthy ageing through (a) training and learning how to improve own fitness (training plans), (b) daily movement (walking, running, training), and (c) social interaction in the fMOOC (commenting, rating).

Based on the three activity areas described above, four categories of *badges* have been implemented to enhance fMOOC activities in view of healthy ageing, i.e. (1) training badges, (2) steps badges, (3) posts badges and (4) likes badges (cf. Table 1). Badges are issued automatically via the fMOOC system based on defined user activities. The fMOOC app visualises badges which can be obtained by using *progress bars* and *colour-coding* techniques as UI design elements.

Table 1: Summary of fMOOC badge categories and parameters

Mechanics	**Badge categories**			
	Training badges	***Steps badges***	***Posts badges***	***Likes badges***
Levels	silver gold	bronze silver gold	2 posts 4 posts 6 posts 8 posts	3 likes 6 likes 9 likes 12 likes
Increments	weekly	weekly	threashold	threashold

Training-badges are awarded for the "perfect training", i.e. for completing the training plan according to instructions, such as carrying out daily exercises, being mindful about certain movements (e.g. spine-friendly bowing) and keeping certain recovery times per week. Training badges are issued based on the completion of a to-do list integrated into the fMOOC app. Each participant can earn one badge per week by completing the to-do list. The silver badge is awarded to the participants who complete the training plan but do not keep recovery times. The golden badge is issued for completing the training plan and keeping recovery times. The fMOOC system records recommended recovery periods per participant.

Step-badges are awarded for progressing on a number of steps made per week without exceeding the recommended maximum number of steps. The aim of the fMOOC is to promote healthy ageing. Therefore the maximum number of steps is applied as an average value promoting balanced dose of daily movement. The aim is to avoid overexercising, which may have detrimental effects on health, especially for seniors. Step-badges can be issued on three levels - bronze, silver and gold. Step badges are awarded weekly, after the user has reached a defined step goal after 5 days (bronze), after 6 days (silver) and after 7 days (gold). The badge of a higher level resets the badge of a lower level as soon as the step goal has been reached.

Posts and likes badges have been implemented to enhance social interaction in the fMOOC. Post and like badges are issued based on the number of posts a user composes (2, 4, 6, 8 posts) and the number of likes (like button) made to express a user likes, enjoys or supports certain user generated content (3, 6, 9, 12 likes).

Battles as elements of gamification design have been implemented as competitive elements with the aim of enhancing motivation to improve physical fitness. Battles have been designed as a group competition between the female and male users. Group competition vs. individual competition between users, has been implemented in order to reduce the risk of negative emotions which may emerge when losing the battle on an individual level. For this reason, the group battle is designed for fun and focuses on positive representations of physical activity data within the group. Groups can compare progress based on the number of steps made in total in each gender group. To enhance motivation, individual user progress in battles is visible to the in-group but not to the out-group.

IV. User Study and Methods

The functional prototype of the fMOOC was tested in two consecutive studies in summer 2015 with two cohorts of 10 senior users (altogether 20 participants, with 5 male and 5 female participants in each cohort). All study participants first took part in an introductory workshop to the fMOOC. The workshop included the demonstration of the fMOOC app and the wearable activity tracker, followed by a medical consultation with a baseline testing of the overall physical fitness. Based on the results of the initial medical test, a personalised training plan with a combination of strength and endurance training exercises and integrated rest periods was composed for each individual learner depending on the measured fitness level (levels 1, 2, 3). One cycle of the fMOOC lasted for 4 weeks and was repeated for another cohort of senior learners. Learners learned and interacted online and at the same time performed physical exercises such as strength training, walking and jogging in physical settings.

Different types of data have been collected during both user studies using a variety of instruments, i.e. (a) activity tracking data (e.g. changes in the number of steps made), (b) learning analytics data (e.g. use and engagement with training materials), and (c) social interaction data (e.g. commenting, rating). Psychological and learning effects focusing on (i) orientation and motivation, (ii) embodied learning experience, and (iii) social engagement and enjoyment, as well as usability aspects have been investigated by means of surveys and validated psychometric measurements (e.g. the R11 resilience

scale). Data related to changes in health and physical fitness was obtained using specialised medical tests.

Results presented in this paper focus on the analysis of data related to badges and battles as elements of gamification design. This analysis is based on both data-driven methods (e.g. analysis of the log data) and psychological measurements (e.g. orientation, motivation, enjoyment). Results presented in this paper are preliminary in nature given a short time-span between the end of the first user study and the submission of this paper. Further research steps will focus on exploring multidimensional relationships between the different design elements and the observable effects related to psychological and physical outcomes. Future analysis will include exploration of relationships between gamification data (e.g. type and number of issued badges), fitness data (e.g. number of steps) and psychological data (e.g. motivational aspects). In view of exploring the relationships between the different variables in more detail, the results presented in this paper serve as a basis for formulating hypothesis and testing models.

V. RESULTS

Based on the results of the empirical study, this paper addresses the key high-level research question: To what extend gamification designs may enhance user engagement in view of healthy ageing? To answer this question three types of data related to gamification, i.e.: (A) log data obtained from digital log data, (B) survey data obtained from user surveys, and (C) narrative data obtained from user comments and interviews, have been analysed to arrive at first observations and conclusions. The results from the first user study (4 weeks) are presented in the sections below.

A. Analysis of log data

The systemic gamification design (game-like mechanics) has been implemented through two main elements badges and battles. In this section we present the data analysis conducted to explore if and how these gamification elements have been used in the fMOOC. The use of the different buttons in the fMOOC app has been analysed using the Piwik software [8].

Table 2 gives an overview of the use of the fMOOC app and of its gamification elements week by week. The first column “visit” gives an overview of how many times participants have logged into the app giving the maximum, minimum, average and standard deviation. The results show that the app has been used slightly more during the first week. This may be due to the fact that users had to be become familiar with the app at the beginning. Users logged more than 8 times on average each week, what is more than once a day if done regularly. The minimum value of 0 in week 3 and week 4 indicates that two users abandoned the app after week 2.

A prerequisite for the steps badges and the battles was measuring steps by synchronising the wearable tracker. The second column “sync” of Table 2 shows how many users have pressed the button “synchronise your steps”. Comparing the number of this column with the number of the “visit” column shows that most users synchronised several times when they were logged in. The data also shows that users synchronised less as the training progressed through the weeks.

Table 2: The use of the fMOOC app and its gamification elements. Number of participants n=10 senior users, 5 female, 5 male. Study duration - 4 weeks.

		Week 1	Week 2	Week 3	Week 4
visit	max.	24	21	17	20
	min.	12	9	0	0
	aver.	18.1	15	8.8	10.6
	std.	4.77	3.53	6.21	6.4
sync	max.	95	85	136	62
	min.	23	7	0	0
	aver.	45.5	30	36	21
	std.	25.12	23.48	42.96	19.9
battle	max.	52	73	54	48
	min.	5	7	0	0
	aver.	24	23	14	16
	std.	15.78	18.52	16.42	15.03
training	max.	14	31	29	23
	min.	0	0	2	0
	aver.	5.2	7.1	5.4	6.2
	std.	3.97	9.13	9	7.9
steps	max.	19	18	16	20
	min.	0	0	0	0
	aver.	4.3	4.7	3.3	4.3
	std.	5.25	5.12	5.3	6.3
posts	max.	7	19	15	14
	min.	0	0	0	0
	aver.	2.9	6.5	4.1	4.6
	std.	2.51	5.42	5.59	5.34
likes	max.	5	10	16	14
	min.	0	0	0	0
	aver.	2.3	3.5	4	4.2
	std.	1.77	2.95	5.87	5.51

To answer the question whether learners were interested in the battle, the data related to touching the button “show battle results” was analysed. The column “battle” of Table 1 shows how often learners viewed the results of the battle. User behaviours differ most for this gaming element as values (max.. min., std.) show. Although the interest in the battle decreases after week 2, comparing with the badges it remains the gaming element that participants viewed most. These high figures are confirmed when analysing the pages accessed from the app homepage: the page “battle” has the highest proportion of moves, followed by the pages “training” (start of training) and the “achievements” (display of earned badges). As this pattern stays stable four weeks, it can be assumed that the battle was the most popular gamification element within this cohort. It should be noted that battles are also the gamification element which is least constrained: as soon as a user walks more, these steps contributes to the group success.

To understand whether learners appreciated badges as gamification elements, the number of views in the app and the number of earned badges was investigated. Columns “training”, “steps”, “posts” and “likes” of Table 1 show how often user touched respective the buttons. Interestingly, except for steps badges, users seem to gain interest over time in badges as they access these elements week by week. The training badge is the most viewed, though it remains much less viewed than battles. The fMOOC *badges* can be divided into two categories: (a) badges that can be earned once a week only, and (b) badges that can be earned as soon as a threshold of activity is attained. Training badges and step badges can be

earned once a week only. Post and like badges can be earned as soon as the threshold is attained. Table 3 shows the number of badges earned per category in total, by female and male users. The results show that learners earned the majority of available training and steps badges. With the total of 40 training and steps badges each per cohort of 10 participants, users earned 70% of all available badges in these two categories. This indicates an overall good user engagement in the fMOOC regarding the components "training" and "steps". The results also show that male users earned more badges in all four categories. As male users earned the maximum number of steps badges, that seems to be the most engaging aspect of the fMOOC for this user group. Male users also slightly exceed female users on posts and likes badges. Interestingly, posts badges were much more popular than like badges indicating a preferred social interaction pattern in this cohort: Writing own posts is more engaging than liking posts written by others. These results are interesting as the user requirements analysis clearly indicated a lack of interest in social interaction features on part of senior users. Nevertheless, social interaction features have been considered important by the project team and member s of the advisory group and implemented in the fMOOC to test their actual use. The results indicate the value of social interaction.

Table 3: Number of badges earned per category. Number of participants n=10 senior users, 5 female, 5 male. Study duration - 4 weeks.

Badge category	**Badges earned per category**		
	Total	***Female***	***Male***
Training badges	28 (70%)	13 (65%)	15 (75%)
Steps badges	28 (70%)	12 (60%)	20 (100%)
Posts badges	34	16	18
Likes badges	10	3	7

Posts and likes badges can be earned as soon as a user has posted a defined number comments or likes to the comment of other users. Table 4 shows how many learners obtained posts and likes badges each week. During the first week only a fews users engage in social interaction by posting or liking, a use pattern that has been observed in other online courses [8]. However, at the end of week 2 every user wrote at least 2 posts. Similar to other online courses [8], some users engage more than others: two users wrote at least 8 posts by the end of week 2, while only 5 users won the badge "8 posts". This user engagement pattern may be also related to the topics of posts. Therefore next analysis will include content analysis of posts to gain a better insight of social interaction.

The fMOOC gamification element *battle* compares the number of steps achieved by the group of female users with the number of steps achieved by the group of male users. An indicator of user engagement in the battle is a number of times users viewed battle results (cf. Table 2). Table 5 gives an overview of the results of the battle per week. The results show that the group of male users beat the group of female users each week. This may indicate that individual male users were motivated by comparing the battle to reach an indicated number of steps. These presumptions will be tested further.

Table 4: Number of social interaction badges earned in the fMOOC. Number of participants n=10 senior users, 5 female, 5 male. Study duration - 4 weeks.

	Week 1	***Week 2***	***Week 3***	***Week 4***
2 posts	4	6	0	0
4 posts	0	6	0	0
6 posts	0	3	3	0
8 posts	0	2	1	4
3 likes	1	2	2	0
6 likes	0	1	1	0
9 likes	0	0	0	0
12 likes	0	0	0	0

Table 5: Number of badges earned per category. Number of participants n=10 senior users, 5 female, 5 male. Study duration - 4 weeks.

Gender	**Battles (number of steps per week per gender group)**			
	Week 1	***Week 2***	***Week 3***	***Week 4***
Female users	256.454	227.161	126.501	156.709
Male users	360.414	413.851	416.280	373.800

In summary, the analysis of the log data reveals that the element "battle" was the most engaging gamification element. The data also shows that users took their training seriously: most learners earned a training badge each week, and viewed this badge category more than other badge categories. Although other badge categories seem to be less engaging, they have been increasingly used with time which points to the importance of social interaction for user engagement. Steps badges seem not to be as engaging as training, maybe because the design has not been tailored to suits learner needs. Next studies could explore for example, if steps badges are more engaging when each user may set their own goal for the number of steps to reach in a week. These and related issues have been looked into by means of user surveys.

B. Analysis of survey data

Beside the analysis of the log data, survey data was used to get more insight into the effects of gamification design on user engagement. Learners participated in a number of paper and pencil surveys during the second workshop at the end of the fMOOC. Here we present the results of the survey related to badges, which encompassed 10 items related to three key elements of user experience with badges, i.e. orientation, motivation and enjoyment. In general, participants rated the orientation and enjoyment component higher than the motivation component. 50% of participants expressed a higher understanding of an effective training due to badges and stated that badges helped them to get a better overview of their training progress. The survey also results show that 50% of participants felt motivated by badges during the study period but only 20% felt motivated to move more on a daily basis due to badges. This indicates that badges as systemic elements of gamification design may have a motivating effect within the

system of the fMOOC user experience but not necessarily impact daily fitness outside the fMOOC. Most participants - 80% - reported, that they did not want to share their badges with other participants or show their achievements to others. This also indicates a specific pattern of user engagement in this cohort, which may be characteristic for this age group.

Further survey results show that the fMOOC scored high on usability and acceptance ratings. Specific features of the fMOOC were evaluated differently. For example, the acceptance of badges was rated positively by about 60% of participants. Overall, 80% of participants stated that they had a lot of fun when training and engaging with the fMOOC. Especially the training instructions and the wearable tracker were seen as important factors for motivation. Almost all, 90% of participants, expressed the desire to continue using fMOOC. These results indicate that the overall user engagement was high in this group, but further analysis are necessary to explore the effects of single design elements and the relationships between them.

C. *Analysis of narrative data*

The analysis of narrative data has been based on data obtained from user comments in form of posts in the fMOOC app. There were altogether 12 different training/learning units within the 4 weeks of the study. Each of the 12 units could be separately commented on. Table 6 summarises positive and negative aspects related to user experience mentioned in the comments organised by four content areas: training, outdoor, social and technology.

Table 6: Positive and negative aspects of user experience (user comments). Number of participants n=10 senior users. Study duration - 4 weeks

	Positive	***Negative***
Training	Boosting circulation, well-being, challenging	Some exercises too easy Some exercises too fast
Outdoor	Enjoy outdoor movement, e.g. garden, lake, forest	Preference for indoor training high temperatures in summer
Social	Spouse participation Sharing the feeling of motivation and well-being	-
Technology	Works well	Synchronising the tracker and touchscreen/finger interaction

In summary, the results of the narrative data analysis indicate that most users enjoyed both training exercises and the experience of outdoor training enhanced by wearable fitness trackers. The positive aspects mentioned by users related to feeling well due to exercises and outdoor training, effects of training on boosting circulation and the feeling of being positively challenged by the exercises and the fMOOC goals. Only one participant preferred indoor training in general. A number of participants complained about high temperatures in summer in view of outdoor training. Some participants found ways to keep up with the training despite the heat, e.g. found shadow places in the park or forest. Most participants enjoyed sharing the feeling of motivation and well-being with others. The social interaction in the group was open and cordial. Participants also reported a positive experience when a spouse participated in their daily training.

VI. DISCUSSION

In this paper, the potential impact of gamification design on user engagement has been explored in context of wearable enhanced learning for healthy ageing. Gamification has played an important role in driving user engagement in a number of technology-enhanced contexts including health and education. The fMOOC project developed a wearable enhanced learning solution to promote healthy ageing through a participation in a fitness-oriented massive online learning course with integrated fitness trackers. In this context, gamification has proved to be an important element of the overall user engagement design. The gamification design applied in the fMOOC has combined a variety of design elements both on the systemic and experiential level. This paper has focused on the systemic elements of gamification design, exploring how badges and battles enhanced user engagement in the fMOOC.

The empirical results from the first user study of 4 weeks in summer 2015 presented in this paper indicate that indeed gamification enhanced user engagement in a number of ways. The positive effects included a better orientation in the training program, increased motivation and an overall enjoyable experience. However, the results presented here cannot be generalised due to a number of limitations including the small sample size. Next analysis will compare two cohorts of senior learners as the second fMOOC user study is under way. Future studies with larger samples, especially in view of the scalability of the fMOOC design, will be necessary to obtain more reliable results. Also, the analysis of data presented in this paper focused only on the systemic elements of gamification design, which are just a part of a complex, multi-layer design of the fMOOC. In oder to measure the effects of different design elements, further analysis will be conducted after the second user study is completed. In addition, the different effects of gamification elements may be further explored in relation to user qualities such as player types, based on to the hypothesis that different player types experience the same affordances differently [6]. Furthermore, the lack of the control group in the fMOOC study should be also taken into consideration when interpreting the results presented in this paper. Future study designs should include larger samples and control groups, possibly implementing a longitudinal approach which could allow to measure long-term changes in health habits of senior learners. Despite these limitations, the current study has provided interesting insights into effects of gamification elements - badges and battles - on senior user engagement in wearable enhanced learning.

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