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Collaboration and co-location: making sense of digital design for early childhood games

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Abstract

The relationship between physical activity and educational and health outcomes is well known. As the significance of digital devices continues to increase, along with societal reliance on them, the provision of programs that draw technology and physical activity together is increasingly important. The recent Pokemon phenomenon is an example of a digitally-driven physical activity that appealed to both adults and children alike. This paper reports on the proof of concept phase of a development that brings to digital life a physical activity program designed specifically for preschoolers. The aim of the JumpStart project was to find a way to engage more parents with their children in physical activity. The brief from the customer was to ensure that the app was appealing to both parent and child with the view to creating a double motivation (push from the child and the parent). It was found through the design process that it was important for the application to appeal to both the child and their significant adult who would be an active participant in explaining and teaching the various skills. The proof of concept phase was introduced to a small group of child users. Informal feedback was collected to inform the completion of the proof of concept. Through the feedback, refinement of the design characteristics was uncovered which allowed a more comprehensive specification to be developed. Based on this proof of concept, the full application is now in development, continuing to explore the connection between co-location and collaboration in digital game design for preschoolers in a more comprehensive research study.

Keywords

co-location:, childhood, early, collaboration, design, making, digital, sense, games

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Abstract**—***The relationship between physical activity and educational and health outcomes is well known. As the significance of digital devices continues to increase, along with societal reliance on them, the provision of programs that draw technology and physical activity together is increasingly important. The recent Pokemon phenomenon is an example of a digitally-driven physical activity that appealed to both adults and children alike. This paper reports on the proof of concept phase of a development that brings to digital life a physical activity program designed specifically for preschoolers. The aim of the JumpStart project was to find a way to engage more parents with their children in physical activity. The brief from the customer was to ensure that the app was appealing to both parent and child with the view to creating a double motivation (push from the child and the parent). It was found through the design process that it was important for the application to appeal to both the child and their significant adult who would be an active participant in explaining and teaching the various skills. The proof of concept phase was introduced to a small group of child users. Informal feedback was collected to inform the completion of the proof of concept. Through the feedback, refinement of the design characteristics was uncovered which allowed a more comprehensive specification to be developed. Based on this proof of concept, the full application is now in development, continuing to explore the connection between co-location and collaboration in digital game design for preschoolers in a more comprehensive research study.*

Keywords; design, human-computer interaction, collaboration, co-location, early years education, preschool, physical education

I. INTRODUCTION

JumpStart is a project designed to improve preschooler levels of physical activity and motor skill development through positive parent/carer interaction in a shared experience. In this increasingly digital age, the JumpStart app was created to share experiences that link digital with real world experiences. This paper describes the process of a cross-disciplinary team involved in converting a paper-based physical education program for preschoolers, into an interactive, digital game. A multi-disciplinary design and development team was formed comprising researchers from graphic design, human-computer interaction, socio-technical systems and physical education. The outcomes of this paper are to present a greater understanding of how both collaboration and co-location have an impact on the digital design process.

A. JumpStart – A Background

JumpStart is a Physical Activity program designed for early childhood educators to help children develop competence in 13 gross motor skills through a series of fun and developmentally appropriate activities [1]. JumpStart has the potential to promote health by increasing the fundamental motor skill competence, and levels of physical activity among preschoolers, both of which have been shown to be sub-optimal and are linked with health and educational outcomes at this age [2 Zask, & Okely 2012]. The significance of developing this application for such a young audience is found in the recent evidence that shows that regular participation in physical activity contributes to better health and developmental outcomes in areas such as: behavioral self-regulation, executive function and motor skill competence, weight status and bone health [3-6]. These are each indicators that build a strong foundation for childhood education, health and development.

In its implementation, JumpStart includes a 20-minute structured session, reinforcement of the learning in this session through and unstructured play each day, music-based activities to break up prolonged sitting, and activities to connect gross motor development and physical activity with other learning areas. Each of these requires Early Years educators to be trained prior to implementation of the program. Although being successfully delivered in centres, there are limitations of this approach which include the availability being confined to trained early years educators to deliver the program, and getting traction in the home environment to continue the development of gross motor skills between the parent and child. Another limiting factor has been the paper-based system which restricts the accessibility and portability of the program in different environments. By developing a corresponding digital JumpStart experience that engages both the parent and child, the enhancement of the parent child relationships in the physical activity domain has potential to contribute to improved learning and health outcomes for these children.

II. Design Process

The establishment of the project team brought together a graphic design researcher with information systems, to service the project created by the physical education researcher. For the success of the project, it was important to have a common language and process to bring the diverse backgrounds together. The language of design is comprehensible and made sense between the members. At the simplest level, design can be considered as a process. Best [7] describes this as a "specific series of events, actions or methods by which a procedure or set of procedures are followed, in order to achieve an intended purpose, goal or outcome". Central to this is the activity of thought and planning that leads towards targeted outcomes [8, 9]. The process of design typically leads to the development of an artefact, in this instance, JumpStart. Throughout the design process, three factors were encountered by the team which were most aptly described by Dorst [10], "*determined factors* that include 'hard' unalterable needs, requirements and intentions; *under-determined factors* which include aspects that are only revealed during the design process; and *undetermined* factors which are those that afford the designer freedom to create solutions to their own taste, style, and abilities" [10, p. 3]. Design is also considered to be an exploratory process where uncertainty and incomplete information form a rough road map for further refinement and clarification [8, 11], which gave our research team the room required to make sense of our multi-perspective project. Our design process allowed analysis, synthesis, critical evaluation and problem solving to take place in an inquisitive manner [12, 13].

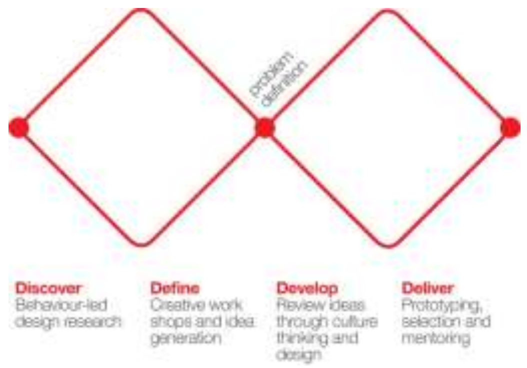

Fig. 1. Design Council (UK) Double Diamond model.

An accepted model to describe the design process was developed by the Design Council (UK) [14] in 2005. It is known as the Double Diamond model (Fig. 1.). The Design Council is recognized as a leading authority on the use of strategic design, covering multi-faceted approaches to design in: built environment, product, service, and user experience. This model describes a four-stage process: Discover, Define, Develop and Deliver. The discovery phase looks at the whole project to understand how expectations and project description fit together. The define phase is significant in making sense of, and prioritizing the issues identified in discovery. At the end of this stage the scope of the project should be clearly understood. The third phase, develop, is significant for the development through iterative prototyping, testing and refining. The final stage, delivery, signifies the end point of the process when it is finalized and delivered.

As a model to understand design, there are direct correlations with a software analysis and design process; Satzinger et al. [15] considers the process of iterative development to consist of the following six core processes that can be repeated over a number of iterations:

- Identify the problem and obtain approval
- Plan and monitor the project
- Discover and understand details
- Design system components
- Build, test, and integrate system components
- Complete system tests and deploy the solution

The purpose of using an iterative development process from a software development perspective is that the system can be created in an organic method as greater understanding of the problem and requirements emerges throughout each iteration; this supports the design process from Dorst's perspective [10]. Iterative development also allows for the use of a participatory design approach [16], this allows for the collective concerns of stakeholders involved in the development process to be aired and addressed. At the core of participatory design is the individuals affected by the system being recognized as having a legitimate reason to be involved in the design process (a stakeholder). Considering stakeholders during the design process is critical in identifying an appropriate user experience based on the problem definition.

III. User Experience and Co-Locative Design

Human-Computer Interaction (HCI) endeavors to understand and determine how users interact with systems in varied contexts of use. The purpose of understanding HCI is to identify the users of the system's usability needs and to improve the overall user experience. HCI can be explained as the study of human factors and system aspects in the interaction process. For a system to be effective it requires appropriate user experience based on the user's knowledge of the domain and tasks that are to be performed [17]. Factors that help determine the user experience are initiation, flexibility, option complexity and cognitive load. It is important to consider that interaction styles may differ according to individual users. The primary aim of research into HCI is to gain deeper insight into how systems can be made more intuitive and result in an improved user experience [18]. As

JumpStart is seeking to engage both parent and child users, there were particular opinions of interest to the development team about motivation, persuasion and collaboration to be explored from a HCI perspective.

Recently, research within the area of HCI has shifted focus towards "collaborations, connections, emotions and communication" [19]. These are all factors that need to be understood when developing systems for children for use in conjunction with adults, as they are central to the user experience. The user interface is best described as the part of the computer and its software that the user can "see, hear, touch, talk to, or otherwise understand or direct" [20]. The two primary components of the user interface are input and output: the former providing the means by which the user is able to communicate with the device; whereas the latter is the presentation of the results of the device's computations. Effective interface design seeks to provide a proper mix of input and output mechanisms to deliver a satisfactory user experience. For a system to be accepted and adopted by its users it needs to demonstrate its usefulness. One method to allow for systems to be designed considering the co-locative use is through the adoption of user-centered design, which is characterized by: active involvement of potential system users and a clear understanding of their task requirements; an appropriate understanding of the functions between users and technology; an iterative process in the development of the system design; and a multi-disciplinary design and development team.

The process of collective interaction is a daily occurrence, for example when individuals work together to achieve a common goal. Collective interaction can also occur when a parent or educator use expertise in helping a child to gain a new skill, which is precisely what JumpStart was designed to do. From a user experience perspective Battarbee and Koskinen [21] identified that neglecting the concept of a co-experience leads to a limited understanding of the overall user experience and concurrently a limited understanding of the potential design opportunities.

From a different perspective Krogh and Petersen [22] state that co-locative design has been researched for a number of years under the banner of Computer Supported Collaborative Work (CSCW) however what is important to note is that while there is the potential for co-located interaction, most systems are designed for individual use or those who are not co-located but are working collaboratively. Hindmarsh [23] considers this issue when discussing museums that systems are designed for a lone experience rather than with other visitors. HCI focusing on how children and parents (or educators) interact with systems is a relatively new area of research. Hoda et al. [24] argued that systems designed for the use of children are often strongly criticized for not aligning technological, pedagogical and psychological considerations. Their study identified that how users in co-located settings are positioned had an impact on their system use and experience; collaboration occurred when they were sitting next to each other and competition occurred when they were sitting opposite. Lauricella et al. [25] conducted a study into how a parent-child reading activity facilitated through the use of computers compared to traditionally reading a book. This study identified that the processes that parents used did not differ between traditional and computer based approaches, however parent engagement was higher using a computer based approach. Similar finding were reported by Aram and Bar-Am [26] in their study with mothers and teaching spelling to preschool children. The increased engagement of parent with child is a finding that we hope to replicate in the full development of the JumpStart app.

When new systems are being designed a key concept that needs to be considered from the initial idea is what kind of experience the user is meant to have whilst interacting with the system; from the perspective of Dorst [10] this would be considered to occur during the Discover and Define stages. Within the early years context system designers need to remember that children are not "miniature adults" [27] and need to design systems with this concept at the fore. For systems to be built primarily for young children, developers need to understand their needs and how they interact with the world. Marhan et al. [27] argues that it is critical for both "parents and teachers to support children in ways that are useful, effective, and meaningful for their needs" (p. 371). This User Experience also needs to be interwoven with a system that the parent or educator sees value in using to aid in the development of the child. A positive user experience will result in a pleasurable experience with a high level of satisfaction when using the system.

IV. Proof of Concept

A collaborative development team of four, comprising researchers from diverse backgrounds: graphic design, human-computer interaction, socio-technical systems and physical activity, was involved in the translation of the original paper-based JumpStart program to develop an iPad app as a Proof of Concept. The motivations for delivering the program in this format included increased accessibility for parent child engagement, flexibility for reaching more early years services and providing a gamified structure that appeals to both the child and adult engaged in the program. A driving influence of the development team was the desire to empower parents to bring about positive changes in their family environment though increased interaction with their children in activities that are designed to strengthen their social relations.

The design team believed that the use of digital delivery, in combination with a gamified approach (as a corollary physical activity) would enhance parental motivation to spend time with their child, participating in activities that will develop their child's fundamental motor skills. By delivering the program in a digital format, it allowed parents to access the activities from anywhere utilizing the inbuilt camera to capture progress and skill acquisition.

A. Discover

Initially, the project team sought to understand the significance and scope of the components that made up the JumpStart program. JumpStart was developed by physical education researchers to educate and improve motor skill and physical activity levels in preschool aged children. It became apparent in this process that there were significant determined factors, as defined by Dorst [10] that provided boundaries and specifications that had to be included. The example of this was the 13 physical skills being taught by JumpStart. Because the JumpStart program was already tested and deployed, this digital version needed to remain true to the developed program. The other team members, from design and IT backgrounds, were listeners at this stage of the process looking to understand where relevant breakdown of ideas would need to occur to further specify requirements of development.

The role of technical translator became essential to this initial requirement gathering, as discussions deepened, the need to understand the significance of various vocabularies and expectations increased.

B. Define

JumpStart had many under-determined factors which as Dorst [10] describes, are unearthed during the ongoing meetings where further details were teased out. Within each of the core skills being taught in JumpStart were a series of subskills. It was decided at this stage that "Kick" would be our test skill. In order to learn how to kick, the three required subskills were: Eyes on the ball, foot position and position of ball on the shoe. The significance of under-determined in this phase of design enabled the team to explore different ways in which these subskills could be communicated effectively to the audience.

A core step here was to use a systematic approach to identifying relevant body parts involved in developing the skill and then exploring ways to represent these actions in visual forms.

C. Develop

There were two phases of development. Firstly, graphic design students were engaged as part of their coursework to propose potential character sets for the application. The students employed the Double Diamond process model to structure their approach. Through the Discover stage the students identified the needs and conditions for the target user group, researched other applications and digital games targeted at the user age group, including identifying and analyzing other character sets. The students then analyzed and synthesized the material and observations identified during the Discover stage into a document that then guided the design activities in the third design process stage (Develop). Through this stage, three different design proposals for the character sets were created (see Figure 2) as were concepts for the overall structure of the game. This included the information architecture, a navigation system, and background environments. This design activity involved the process of ideation, and iteration of the ideas through the creation and testing of prototypes. Once the primary forms of the three-character sets and game the structure were established, the designers entered into the final Discover stage. This involved refinement and implementation of the ideas and proposals that emerged from the Develop stage.

Fig. 2. Three initial design styles presented to preschoolers.

The three-character sets shown in Figure 2 were presented to a room of preschoolers for informal feedback. Overwhelming support was shown for the second friendly, monster-like characters. The animals were not easily identified with and the last set of monster-aliens were too scary. The user testing, identified the monster set as friendly and funny. Design issues that were subsequently considered included how the characters would animate and represent the motions of the physical activities, for example kicking the ball. This stage also included collaboration with the code developers to fine tune and integrate the design outcomes within the coding structures. A design PhD student was employed to manage and facilitate this final stage, which included coordinating communications with the coding team.

An important element of the design approach throughout the 4-stage design process was the incorporation of a structured approach to reflection [28]. This guided the design students to think about their design process in ways that surfaced the thinking embedded in the activity of designing and in ways that informed further development of the designs and facilitated discussions amongst the design team and the researchers. This involved the design team engaging in a deliberate process of pausing to think back over the project by describing their process; exploring the understandings that they brought to the handling of the process by identifying critical situations and making value claims about the significance of the situation; and drawing generalized principles from the project by considering how they might now approach further development of their project. This has been described as fostering the conditions for transfer [28]. Throughout this process, opportunities for reflection came about as the monsters were animated. In this process, it became obvious that the designs needed clarification and modification to be able to undertake the necessary physical activities. Figure 3 is used to describe this.

Fig. 3. Sample feedback on physical characteristics.

The coding of the application was done by a research assistant employed by the project team. At each stage of development, the project team was updated to clarify, refine and then approve each section. In the first iteration, children were shown the app by their educator to ensure that the gestures and intention of each skill were clearly understood. This involved verbal feedback from 25 children. Issues that the project team needed to resolve included misrepresentation of physical movement by some of the chosen characters. This was easily resolved in some cases: for example, arms were made longer, monsters started wearing lace-up shoes (see Figure 4), or modifications to perspective were made to make the skill being taught more obvious.

Fig. 4. Character refinement: bigger eyes and feet, and shoes on feet for clarity when kicking.

D. Deliver

The JumpStart proof-of-concept was delivered in November 2016 and tested by a small group of preschoolers. It was met with enthusiastic response to the monster characters teaching them how to kick. The children were able to watch and respond to the characters and practice the skills. The character set was happily received. Read [29] argues that when using children in the evaluation process they do not unearth every design issue with the system, however they act in ways that are often unpredictable when using systems. Significant feedback on the child experience came through the voice of the parent. There were no verbal prompts, so although the child could watch and/or mimic the behavior, they were unable to read the instructions.

Fig. 5. Character in environment for "Eyes on the ball" game.

A small group of parents were invited to provide feedback on the app. From the six parents approached, feedback indicated satisfaction with the application. The combination of video and text instruction enabled parents to confidently engage with application and their child. Adult feedback focused on the design of the characters in terms of realism and trying to understand the physical accuracy of the monster characters in light of their body proportions. Figure 5 shows a screenshot of the final application, with the character in their environment, and the skill development identified. In this instance, although there were initial concerns about the monster having four feet, in this particular game, the skill being taught is based on eye movement. The red monster with one eye was able to demonstrate this skill in a very obvious way.

V. Conclusion

The JumpStart proof of concept provided a number of findings for the research team. Firstly, development on iPad had been instructed by the popular use of iPads in early years education settings, particularly through the partnership agreements with University of Wollongong Early Start Engagement centres, where testing would take place. Although satisfactory results were achieved, the future development is being done in a device non-specific way to allow both android and iPhone users to engage, which is more in line with the expected user community. Secondly, based on the outcomes of the exploratory work, further funding was secured through the

University of Wollongong Global Challenges program at the end of 2016 to complete the delivery of the application. Going forward, the framework developed in the Proof of Concept process is currently being applied to the remaining eleven skills. The feedback received from both children and parents about the characters has been addressed by the team through further character design and testing. By involving both adult and child users, the perspectives on design and implementation of gaming have been challenged. The significance of engagement and motivation was embedded through gamifying components of the skill development. In the context of this project, the practice of gamification is focused on making the learning of motor skills fun and engaging while ensuring the integrity of the learning experience [30].

The third finding is in relation to research in the design and HCI space as it pertains to children. The JumpStart research contributes to the work of Hoda et al. [24] by aligning technological, pedagogical and psychological considerations, often considered lacking in system design for children. It also extends the work of Lauricella et al. [25] and Aram and Bar-Am [26] by including the significance of the adult experience through the design that is targeted to children. The roll out of the full project is collecting comprehensive user experience information from children, children and their educators, children and their parents or carers and adult users. Particularly in the age group of three to five-year old's, there is very little primary data about design preference and user experience. It is a unique period of child development. Current literature in this field is small but often from ages six and older. This research provides a good opportunity to understand the younger perspective and its significance to the design process.

REFERENCES

[1] R. M. Stanley *et al.*, "Increasing physical activity among young children from disadvantaged communities: study protocol of a group randomised controlled effectiveness trial," *BMC Public Health*, Article vol. 16, no. 1, pp. 1-13, 2016.

[2] L. Hardy, T. Reinten-Reynolds, P. Espinel, A. Zask, and A. Okely, "Prevalence and Correlates of Low Fundamental Movement Skill Competency in Children.," *Pediatrics*, vol. 130, no. 2, pp. E390-E398, 2012.

[3] J. Best, "Effects of physical activity on Children's executive function: contributions of experimental research on aerobic exercise. ," *Development Review* vol. 30, no. 4, pp. 331-551 2010.

[4] W. Byun, M. Dowda, and R. Pate, "Correlates of objectively measured sedentary behavior in US preschool children. ," *Pediatrics*, vol. 28, no. 5, pp. 937-945, 2011.

[5] S. Carlson, "Developmentally sensitive measures of executive function in preschool children.," *Developmental Neuropsychology*, vol. 28, no. 2, pp. 595-616, 2005.

[6] D. Cliff, A. Okely, L. Smith, and K. McKeen, "Relationships between fundamental movement skills and objectively measured physical activity in preschool children. ," *Pediatric Exercise Science*, vol. 21, no. 4, pp. 436-449, 2009.

[7] K. Best, *Design Management: Managing Design Strategy, Process and Implementation*. Lausanne: AVA Publishing, 2006.

[8] K. Friedman, "Creating design knowledge : from research into practice," in *Design and technology educational research and development : The emerging international research agenda*, E. W. L. Norman and P. H. Roberts, Eds. Loughborough, UK: Loughborough University, 2001, pp. 31-69.

[9] B. Lawson, *How designers think: The design process demystified* 4th ed. Oxford, UK: Architectural Press, 2006.

[10] K. Dorst, "The Problem of Design Problems," in *Expertise in Design, Design Thinking Research Symposium 6*, University of Technology, Sydney, 2003.

[11] N. Cross, "Forty years of design research," *Design Studies*, vol. 28, no. 1, pp. 1-4, 2007.

[12] N. Cross, "The nature and nurture of design ability," *Design Studies*, vol. 11, no. 3, pp. 127-140, 1990.

[13] J. Moon, *A Handbook of Reflective and Experiential Learning: Theory and Practice*. London: Routledge Falmer, 2004.

[14] Design Council. (2005, 27/05/17). *The 'double diamond' design process model*. Available: http://www.designcouncil.org.uk/about-design/How-designers-work/The-design-process/

[15] J. Satzinger, R. Jackson, and S. Burd, *Systems Analysis and Design in a Changing World*, 7e ed. Boston: Cengage Learning, 2016.

[16] J.-S. Baek and K.-P. Lee, "A participatory design approach to information architecture design for children," *CoDesign*, vol. 4, no. 3, pp. 173-191, 2008.

[17] A. Smith, *Human-computer factors: a study of users and information systems*. London: McGraw-Hill Higher Education, 1997.

[18] A. Jaimes and N. Sebe, "Multimodal human–computer interaction: A survey," *Computer vision and image understanding*, vol. 108, no. 1, pp. 116-134, 2007.

[19] J. Lazar, J. H. Feng, and H. Hochheiser, *Research methods in human-computer interaction*. UK: John Wiley & Sons, 2010.

[20] W. O. Galitz, *The essential guide to user interface design: an introduction to GUI design principles and techniques*. USA: John Wiley & Sons, 2007.

[21] K. Battarbee and I. Koskinen, "Co-experience: user experience as interaction," *CoDesign*, vol. 1, no. 1, pp. 5-18, 2005.

[22] P. G. Krogh and M. G. Petersen, "Designing for collective interaction: Toward desirable spaces in homes and libraries," in *From CSCW to Web 2.0: European Developments in Collaborative Design*: Springer, 2010, pp. 97-113.

[23] J. Hindmarsh, C. Heath, D. Vom Lehn, and J. Cleverly, "Creating assemblies in public environments: Social interaction, interactive exhibits and CSCW," *Computer Supported Cooperative Work (CSCW)*, vol. 14, no. 1, pp. 1-41, 2005.

[24] R. Hoda, A. Henderson, S. Lee, B. Beh, and J. Greenwood, "Aligning technological and pedagogical considerations: Harnessing touch-technology to enhance opportunities for collaborative gameplay and reciprocal teaching in NZ early education," *International Journal of Child-Computer Interaction*, vol. 2, no. 1, pp. 48-59, 2014.

[25] A. R. Lauricella, R. Barr, and S. L. Calvert, "Parent–child interactions during traditional and computer storybook reading for children's comprehension: Implications for electronic storybook design," *International Journal of Child-Computer Interaction*, vol. 2, no. 1, pp. 17-25, 2014.

[26] D. Aram and O. C. Bar-Am, "Mothers helping their preschool children to spell words: A comparison between interactions using the computer vs. pencil and paper," *International Journal of Child-Computer Interaction*, vol. 7, pp. 15-21, 2016.

[27] A. M. Marhan, M. I. Micle, C. Popa, and G. Preda, "A review of mental models research in child-computer interaction," *Procedia-Social and Behavioral Sciences*, vol. 33, pp. 368-372, 2012.

[28] G. Ellmers, "The graphic design project: employing structured and critical reflection to guide student learning," *Communication Design: Interdisciplinary and Graphic Design Research*, vol. 3, no. 1, 2015.

[29] J. Read, "Children as participants in design and evaluation," *interactions*, vol. 22, no. 2, pp. 64-66, 2015.

[30] C. Muntean, "Raising engagement in e-learning through gamification," presented at the The 6th International Conference on Virtual Learning ICVL, Romania, 2011.