REDESIGNING LEMA: A WEB BASED CLASSROOM APPLICATION TO PROMOTE MATHEMATICAL REASONING IN AUTISTIC CHILDREN

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Abstract

The purpose of this work focused in some design characteristics of Learning Environment on Mathematics for Autistic Children (LEMA), a digital mathematical learning environment with modalities of dynamic adaptations of the proposed activities having in consideration the user's profile. The activities designed to enable adaptation were also conceived to promote the development of mathematical reasoning in children with Autism Spectrum Disorders, (ASD) aged between 6 and 12, fostering access and equity in the teaching and learning of mathematics. In this paper, the readjustments on LEMA's interface are presented, namely considering the new dimension of gamification integrating game-design elements and game principles in non-game contexts, as a form of enhancing the user' motivation.

Keywords: Autism Spectrum Disorders, Mathematical Reasoning, Inclusion; Universal Participation, Gamification.

1 INTRODUCTION

Autism Spectrum Disorders (ASD) are considered as one of the disorders that cause greater challenge to both educational and health professionals, given their repercussions in social interaction and communication and their repetitive patterns of behaviour, interests or activities, characteristics that can compromise their personal and social autonomy in various contexts [1].

The use of Digital Technologies can be an effective way to create innovative learning opportunities to these children and to develop creative, personalized and constructive environments, where they can develop differentiated skills [2]. These children often respond well to learning activities involving information presented visually. Digital environments present opportunities for dynamic customizable visual displays, which can be used to individualize instruction by selecting appropriate difficulty levels according to a particular student's ability level [3], [4].

Some individuals with ASD have above average mathematical skills, and are even considered mathematically gifted [5]–[7]. On the other hand, beyond such rare cases, researchers on mathematics abilities of individuals with ASD have identified that individuals with ASD have difficulty with mathematics, especially in problem solving tasks, recognizing that mathematics has been pointed as an area of relatively spared or even enhanced performance in a large proportion of individuals with ASD [5], [8]–[10].

Despite the cognitive deficits that these students may have, it has been noted that the altered developmental trajectory that defines ASD (e.g., slowing, plateauing, and skill loss) can also lead to remarkable cognitive strengths and that children with ASD might present "islets of ability" in various domains; one such domain is mathematics [11]. Mathematicians score higher on tests of autistic traits and have higher rates of diagnosed autism, compared with people in the general population [12].

The development of mathematical reasoning in students with ASD is of major significance, as these skills play a fundamental role in their social inclusion, intellectual development and autonomous living [13]. In this context, the research project we are developing aims to prototype a digital environment Learning Environment on Mathematics for Autistic Children (LEMA), with modalities of dynamic adaptation of the proposed activities, able to promote knowledge and skills in mathematics in children, aged between 6 and 12 years, diagnosed with ASD. Here, we present the readjustments on LEMA's interface based on the primary evaluation results considering the dimensions: "interaction", "execution of the activities" and "motivation".

1.1 State of the art

1.1.1 User interface design recommendations for children with ASD

Given the heterogeneity of children with ASD, adaptivity is a key element of a successful user experience for these children, as ASD encompasses a spectrum of symptoms that vary in severity among individuals with very different personal preferences and needs [14]. According to Pavlov [14] there are specific requirements that must be considered in order to improve the accessibility of interfaces presented to users with ASD. This author provides an overview of methodologies oriented to increase the accessibility of applications for this target population. Personalization is a key component, since users with ASD have different preferences and needs. Among other recommendations, Pavlov [14] suggests the following requirements to be taken into account in the conceptualization of an application accessible to users with ASD: contrast between font and background; simplicity, with few items on the screen; clear interface with soft colours, without distracters or background images; and use of buttons and icons. Also Mintz [15], Putnam and Chong [16], Greis and Raposo [17] and Ramdoss et al. [4] suggest that clear instructions and orientation about tasks should be provided to ease user understanding of the content and content language, in order to stimulate, motivate and engage the user.

Children with ASD have generally strong visual processing skills and a preference for multimedia formats. Multimedia components such as video, animations, and images have been identified by different studies as effective tools for gaining the attention of children with learning disabilities, especially children with autism [18]. It is therefore likely that the intervention through digital means is particularly appropriate and motivating for these individuals [19]. In this context, it is important to develop effective teaching methods through digital technology for children with ASD.

1.1.2 Teaching mathematics to autistic children

Teaching Mathematics to children with ASD with some creative thought and an emphasis on visual aids and personal interests can be very challenging but it can be very successful [20]. Mathematical difficulties for children with ASD focus in the "language of math" (words describing mathematical concepts), word problems (problems where the significant background information is presented as text rather than in mathematical notation), estimation, and prediction. This happens because many children with ASD have language weakness, which may lead to the fact that they will mostly have below average in math word problem solving.

The executive functioning (EF) deficits associated with ASD compromise the development of higher level thinking, reasoning, and problem-solving skills. EF deficits include poor organizational skills, attention difficulties, motivational issues, work completion problems and difficulties with abstract concepts, inferences, and applied problems [21], [22]. In this sense, the complexity underlying mathematical activities can be problematic for children with ASD.

Some authors, namely Su [23], mentioned that, in mathematics instruction, students with ASD benefit from interventions that use frequent feedback, explicit instruction and practice. According to the study of Su, Lai and Rivera [24] students with high-functioning autism were able to increase their knowledge of mathematical concepts when exposed to systematic instruction in math.

For students with ASD the interventions or strategies should be selected considering student's age, instruction needs, motivation of each student and the need to use direct instruction. One of the strategies that has been used in math instruction for students with ASD is self-regulation because it involves students completing checklists as they perform calculations, with reminders for each step; another strategy is verbal feedback that will strengthen the concepts, helps create structure, and ensures that the student understands each step [25].

Bae et al [26] propose that instruction should integrate students' everyday life experiences into problem solving processes to help them understand the meanings of word-based questions, since the ultimate goal of mathematics instruction for these students is the learning of basic and functional skills to solve their real-life problems.

2 METHODOLOGY

The methodological options of this proposal are framed by prototyping and development techniques. This methodological framework combined with the analysis of a set of case studies of ASD children using the digital environment under development, embraces a multidisciplinary approach. Given its exploratory nature, this research follows a process of successive refinements and prototype developments, starting from a theoretical base enriched by a qualitative analysis of requirements resultant of the prototype exploration sessions that have been occurring over time, as proposed by Richey and Klein [27].

This approach requires that end users and other stakeholders are involved in all stages of the development process, providing their insights about the required features of the product and testing different design solutions. This is a delicate aspect of this project, as the target users are children with special needs. Hence, we took special care with regard to the ethical aspects of this work. All children with ASD who participated in the development process of LEMA were authorized by their parents or tutors, as well as by the different educational and care professionals involved. The identity and integrity of all participants were preserved.

3 EMPIRICAL WORK

LEMA integrates modalities of dynamic adaptation of the activities to be proposed to the user. These activities were designed to promote the development of mathematical reasoning, having in account a preliminary study carried out with children aged between 6 and 12 years diagnosed with ASD [28]. The functional profiles of the selected students for this study have played, as naturally expected, a fundamental role in the design of these activities

LEMA is being designed and developed based on the requirements and recommendations brought up from the literature review and based on the principles of universal design for learning (UDL). UDL has its roots in the architectural principles of universal design, which states that design of products, environments, programs and services should be usable by all people to the greatest extent possible, without the need for adaptation or specialized design. UDL is an approach to address the diversity of learner needs by suggesting flexible goals, methods, materials, and assessment processes that enable educators to meet varied needs. It is an approach whose aim is that all students have equal opportunities to learn [29].

The technical implementation of LEMA was assured by a multidisciplinary team (mathematicians, educators, developers and designers) which are currently affiliated to the Thematic Line Geometrix (http:// geometrix.web.ua.pt) of the Centre for Research and Development in Mathematics and Applications (CIDMA), located in the Department of Mathematics at the University of Aveiro (Portugal).

In order to make the environment accessible via multiple platforms, LEMA is being developed as a web-based application according to HTML5 recent standards.

LEMA is based on a set of functions allowing direct manipulation of visual items, such as: selection of items, data entry (number or text to justify the answer), link items, drag items, click on items and watch animations. Beyond the simple and careful design of the layouts for each activity, we also incorporated feedback in order to allow reinforcement with visual and sound animations; some activities include feedback tutorials with animations the resolution of an example problem (see Fig. 1).

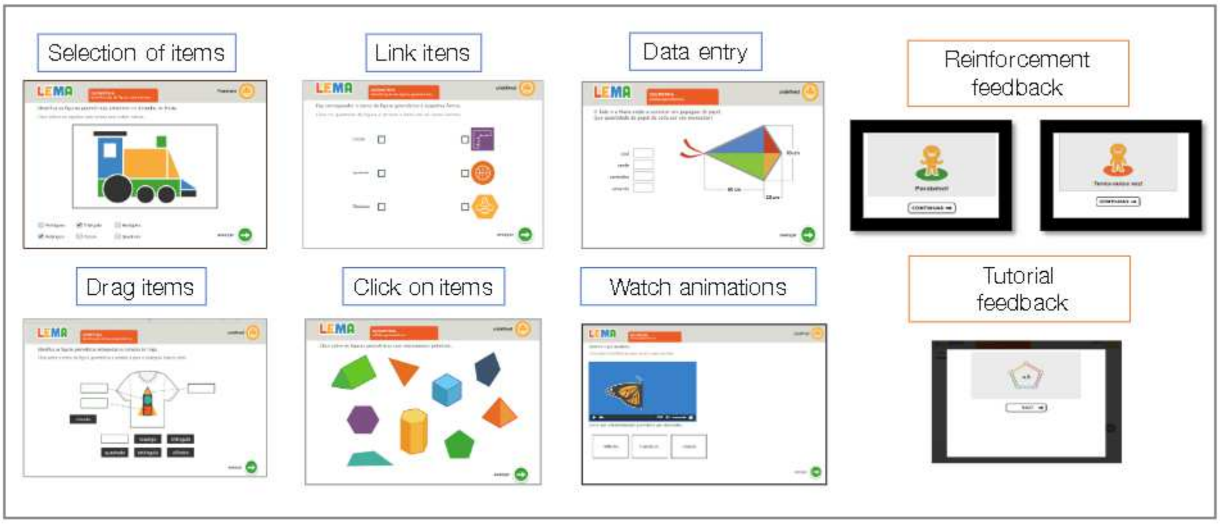

Figure 1: LEMA's interface design previous

3.1 Design approach of learning activities

As already mentioned, LEMA's math learning activities were designed according to the literature review and a preliminary study carried out with students diagnosed with ASD, aged between 6 and 12, [28]. We also took in consideration the Mathematics and Curricular Goals for Portuguese Basic Education[1].

Our proposal to design LEMA activities focused on the following geometric topics: bi-dimensional geometric shapes, perimeters and areas of planar figures and planar isometries. In these activities, the skills to be worked on are: mathematical communication, mathematization, and different types of geometric figures, representation, mathematical reasoning involving geometric and visual thinking. elaboration of strategies for problem solving, use of language and symbolic operations and use of mathematical tools.

A primary evaluation with end-users was already conducted focusing on "interaction", "execution of the activities" and "motivation". This primary evaluation was made through direct observations of different sessions with 4 students with ASD and enabled that collection of important data that pinpointed the need to made some changes in the environment: (1) redesign the interface and the activities in order to better motivate the users; (2) partition complex mathematical problems into simple tasks; (3) incorporate feedback tutorials with step-by-step clues; (4) incorporate reinforcement feedbacks; (5) incorporate audio instructions; and (6) restructure the instructions to support the human-computer-interaction [30].

3.2 Redesign LEMA's interface and learning activities

The readjustments on LEMA's interface (conducted in the context of the above mentioned primary evaluation results) are presented, namely considering the new dimension of gamification and the application of game-design elements and game principles in non-game contexts, as a form of enhancing the user' motivation. Yu-kai Chou [31] defines gamification as "the craft of deriving all the fun and addicting elements found in games and applying them to real-world or productive activities" Pp. 3.

More specifically, gamification is an application of game-thinking and game mechanics to engage users and solve problems. This strategy is both powerful and flexible, it can readily be applied to any

[1] Basic education is compulsory and free and lasts for 9 years, covering children and young people between six and 15 years of age. It comprises three consecutive cycles: the 1st cycle (4 years) provides a general education, with a single teacher (sometimes supported in specialized areas); the 2nd cycle (2 years) and the 3rd cycle (3 years) are taught by a single teacher per subject or multidisciplinary educational field. The Portuguese Educational System is organized in different levels of education, training and learning: pre-school education, basic education, secondary education, post-secondary education not higher, education and training of young people and adults, and higher education.

problem that can be solved through influencing human motivation and behaviour in different interactions contexts, like in learning platforms [32].

The adoption of gamification is justified since, in real life, people do not feel that they are as good in some task performance as they are in games. When confronted with obstacles, people may feel depressed, unsafe or frustrated: feelings that are not present in the gaming contexts. Indeed, play can change behaviour for the better, with greater user engagement [31], [32].

Besides, children with ASD often respond with good results in learning activities involving information presented visually [33]. In order to pass efficiently, the learning messages between LEMA and the children a set of design characteristics was taken into account.

The LEMA interface provides a good contrast between font and background. For example, in the identification of activities, the title has a small white contort, to fit in different colour backgrounds (see Fig. 2).

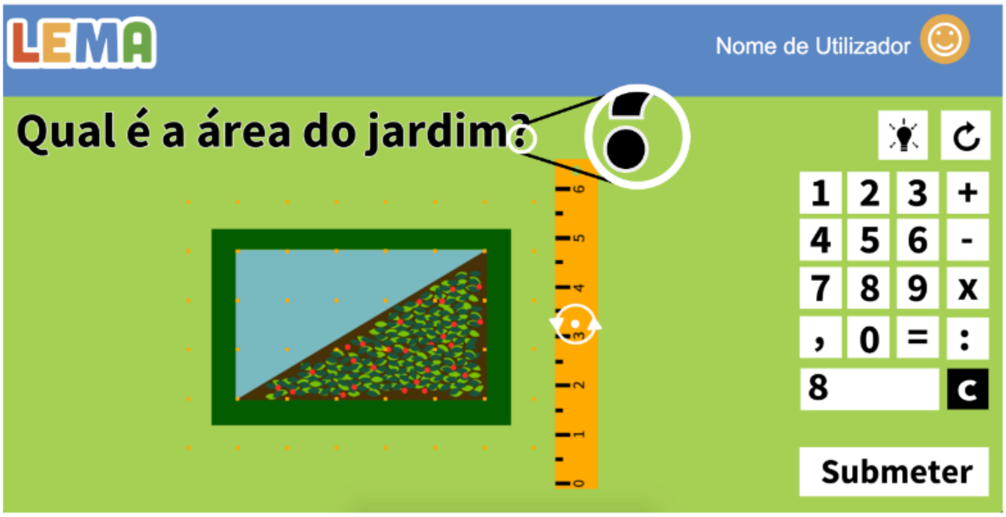

Figure 2: LEMA's activity designation font contrast

As children with ASD may face barriers in understanding information and decoding language, the recommended ways to design the interface are: the use of simple, visual and textual language; to avoid jargon, spelling errors, metaphors and acronyms; the use of terms, expressions, names and symbols familiar to the users' context [34]; to be succinct, avoid writing long paragraphs and use mark-ups that facilitate the reading flow such as lists and heading titles and icons; and use images and menu labels and actions should be compatible to the real world, representing concrete actions and everyday life activities in order to be easily recognized [35], [36]. All activities were designed within a thought minimalism, with few items on the screen, clear interface with soft colours, without distracters or background images and use of buttons and icons.

Several authors also underline the importance of feedback for children with ASD to guide them to perform tasks [17], [36], [37]. In accordance, LEMA provides clear instructions and orientation about tasks to ease the user understanding of the content and content language, in order to stimulate, motivate and engage its users. So for this reason, and aiming to promote an efficient communication between the system and the user, LEMA provides five kind of feedback:

- Visual: every key object of a level, such as, the object that player select in the activity environment, appears with an extra contour to provide visibility [31].
- Sound: there is an audible feedback when the user makes an action and for every activity is presented its correct answer performed by voice-over.
- Reaction feedback: the user controls the activity objects in real time according to his movement.
- Informative feedback: in the end of each activity the user is informed if the activity is correct or not (see Fig. 3).

LEMA also provides learning content feedback, in two different ways, as described bellow.

- General Instructional goals: in an activity context, and after 10 seconds, if the user doesn't perform any task, in the top of the screen appears a "hint" button, with helpful instructions including concept definitions.
- Specific Learning Goals: in the end of every activity, if the user misses the correct answer more than 2 times, LEMA forces the user to solve the problem step by step, i.e. LEMA will divide the prosed problem into simpler tasks, providing clues through an interactive video to help to solve it. And if the user misses the correct answer more than 3 times, LEMA shows an interactive video that shows a solution of the proposed activity.

Figure 3: End of an activity - correct answer (left) at the top "Congratulations!" and at the bottom a "next" button to go to the following activity; wrong answer (right) at the top "Incorrect" then a clue to solve the activity "The garden area is half of the lake area" and in the bottom a "try again" button.

4 CONCLUSION AND FUTURE WORK

The functional design [38] of the prototype fulfils the aforementioned requirements in order to meet the needs of users with ASD: simple interfaces, with few elements, presenting only the features and content needed for the current task to be performed by the user [34], [36]; avoid of elements that distract or interfere with focus and attention [14]; provide clear instructions and orientation about tasks to ease the user understanding of the content and the content language, in order to stimulate, motivate and engage the user; use buttons, icons and contrast between font and background [4]; use a simple visual and textual language [34]; provide options to customize information visualization with images, sound and text according to individual user's preferences [16]; provide information in multiple representation, such as text, video, audio and image for better content and vocabulary understanding, also helping users to focus on content [34]; and provide feedback to confirm the correct action [39], [40].

The next step in this research project will be the validation LEMA's interface. This validation will have a longitudinal time frame to ensure consistent data collection and analysis of results providing clues about the actual impact of the use of the prototype on the learning consolidation of children with ASD.

We hope that the digital environment that is being developed may prove to be a learning tool able to offer learning activities dynamically adapted to the individual needs of students with autism, thus ensuring access and equity to the process of teaching and learning, and to provide a powerful tool to support teachers and educators. It is also expected to foster new opportunities and educational strategies and improve math skills in students with ASD, thus preparing their transition to a more active, autonomous and inclusive life.

ACKNOWLEDGEMENTS

This work was supported in part by Portuguese funds through the CIDMA – Center for Research and Development in Mathematics and Applications, and the Portuguese Foundation for Science and Technology ("FCT – Fundação para a Ciência e a Tecnologia"), within project UID/MAT/04106/2013. M. I. Santos also acknowledges the support of FCT through the Research Grant SFRH/BD/108154/2015

REFERENCES

[1] American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders*. American Psychiatric Association, 2013.

[2] C. Burton, D. Anderson, M. Prater, and T. Dyches, “Video Self-Modeling on an iPad to Teach Functional Math Skills to Adolescents With Autism and Intellectual Disability,” *Focus Autism Other Dev. Disabl.*, 2013.

[3] V. Knight, B. R. McKissick, and A. Saunders, “A review of technology-based interventions to teach academic skills to students with autism spectrum disorder,” *J. Autism Dev. Disord.*, vol. 43, no. 11, pp. 2628–48, Nov. 2013.

[4] S. Ramdoss, A. Mulloy, R. Lang, M. O’Reilly, J. Sigafoos, G. Lancioni, R. Didden, and F. El Zein, “Use of computer-based interventions to improve literacy skills in students with autism spectrum disorders: A systematic review,” *Res. Autism Spectr. Disord.*, vol. 5, no. 4, pp. 1306–1318, Oct. 2011.

[5] H. Chiang and Y. Lin, “Mathematical ability of students with Asperger syndrome and high-functioning autism A review of literature,” *Autism*, vol. 11, no. 6, pp. 547–56, Nov. 2007.

[6] P. Howlin, S. Goode, J. Hutton, and M. Rutter, “Savant skills in autism: psychometric approaches and parental reports,” *Philos. Trans. R. Soc. London Ser. B, Biol. Sci.*, vol. 364, no. 1522, pp. 1359–1367, 2009.

[7] T. Iuculano, M. Rosenberg-Lee, K. Supekar, C. J. Lynch, A. Khouzam, J. Phillips, L. Q. Uddin, and V. Menon, “Brain organization underlying superior mathematical abilities in children with autism.,” *Biol. Psychiatry*, vol. 75, no. 3, pp. 223–30, Feb. 2014.

[8] C. R. G. Jones, F. Happé, H. Golden, A. J. S. Marsden, J. Tregay, E. Simonoff, A. Pickles, G. Baird, and T. Charman, “Reading and arithmetic in adolescents with autism spectrum disorders: Peaks and dips in attainment.,” *Neuropsychology*, vol. 23, no. 6, pp. 718–728, 2009.

[9] B. S. Myles, G. P. Barnhill, T. Hagiwara, D. E. Griswold, and R. L. Simpson, “A Synthesis of Studies on the Intellectual , Academic , Social / Emotional and Sensory Characteristics of Children and Youth with Asperger Syndrome,” *Educ. Train. Ment. Retard. Develojnnental Disabil.*, vol. 36, no. September, pp. 304–311, 2001.

[10] X. Wei, E. R. Christiano, J. W. Yu, M. Wagner, and D. Spiker, “Reading and math achievement profiles and longitudinal growth trajectories of children with an autism spectrum disorder,” *Autism*, vol. 19, no. 2, pp. 200–210, Feb. 2015.

[11] S. Baron-Cohen and M. K. Belmonte, “AUTISM: A Window Onto the Development of the Social and the Analytic Brain,” *Annu. Rev. Neurosci.*, vol. 28, no. 1, pp. 109–126, Jul. 2005.

[12] S. Baron-Cohen, “Autism, maths, and sex: the special triangle,” *The Lancet Psychiatry*, vol. 2, no. 9, pp. 790–791, 2015.

[13] P. O. Malley, D. Ph, S. Jenkins, M. Ed, B. Wesley, C. Donehower, M. S. Ed, D. Rabuck, M. E. B. Lewis, D. Ed, and P. O. Malley, “Effectiveness of Using iPads to Build Math Fluency Effectiveness of Using iPads to Build Math Fluency,” no. April, 2013.

[14] N. Pavlov, “User Interface for People with Autism Spectrum Disorders.,” *J. Softw. Eng. Appl.*, vol. 2014, no. February, pp. 128–134, 2014.

[15] J. Mintz, “Additional key factors mediating the use of a mobile technology tool designed to develop social and life skills in children with Autism Spectrum Disorders: Evaluation of the 2nd HANDS prototype,” *Comput. Educ.*, vol. 63, pp. 17–27, Apr. 2013.

[16] C. Putnam and L. Chong, “Software and technologies designed for people with autism: what do users want?,” *Proc. 10th Int. ACM …*, 2008.

[17] L. C. S. Greis and A. B. Raposo, “Metáforas de Perspectivas Culturais na (re) definição de padrões de colaboração de um jogo de multi-toque para usuários com autismo,” vol. 5138, pp. 112–121, 2013.

[18] B. Banire, N. Jomhari, and R. Ahmad, “Visual Hybrid Development Learning System (VHDLS) Framework for Children with Autism,” *J. Autism Dev. Disord.*, vol. 45, no. 10, pp. 3069–3084, 2015.

[19] A. L. Wainer and B. R. Ingersoll, “The use of innovative computer technology for teaching social communication to individuals with autism spectrum disorders,” *Res. Autism Spectr. Disord.*, vol. 5, no. 1, pp. 96–107, 2011.

[20] A. Sula, E. Spaho, K. Matsuo, L. Barolli, R. Miho, and F. Xhafa, “A Smart Environment and Heuristic Diagnostic Teaching Principle-Based System for Supporting Children with Autism during Learning,” in *2014 28th International Conference on Advanced Information Networking and Applications Workshops*, 2014, pp. 31–36.

[21] F. Happé, R. Booth, R. Charlton, and C. Hughes, “Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: Examining profiles across domains and ages,” *Brain Cogn.*, vol. 61, no. 1, pp. 25–39, 2006.

[22] P. J. Whitby, “The Effects of Solve It! on the Mathematical Word Problem Solving Ability of Adolescents With Autism Spectrum Disorders,” *Focus Autism Other Dev. Disabl.*, vol. 28, no. 2, pp. 78–88, 2012.

[23] H. F. H. “Angie” Su, “Using an exploratory approach to help children with autism learn mathematics,” *Creat. Educ.*, vol. 1, no. 3, pp. 149–153, 2010.

[24] H. Su, L. Lai, and H. Rivera, “Effective Mathematics Strategies for Pre-School Children with Autism,” *Aust. Prim. Math. Classr.*, vol. 17, no. 2, pp. 25–30, 2012.

[25] J. Donaldson and M. Koffler, “Mathematics Interventions for Students With High Functioning Autism/Asperger’s Syndrome,” *Teach. Except. Child.*, 2010.

[26] Y. S. Bae, H.-M. Chiang, and L. Hickson, “Mathematical Word Problem Solving Ability of Children with Autism Spectrum Disorder and their Typically Developing Peers,” *J. Autism Dev. Disord.*, vol. 45, no. 7, pp. 2200–2208, Jul. 2015.

[27] R. C. Richey and J. D. Klein, “Developmental research methods: Creating knowledge from instructional design and development practice,” *J. Comput. High. Educ.*, vol. 16, no. 2, pp. 23–38, Mar. 2005.

[28] M. I. Santos, A. Breda, and A. M. Almeida, “Brief Report: Preliminary Proposal of a Conceptual Model of a Digital Environment for Developing Mathematical Reasoning in Students with Autism Spectrum Disorders,” *J. Autism Dev. Disord.*, vol. 45, no. 8, pp. 2633–2640, Aug. 2015.

[29] D. Rose, A. Meyer, N. Strangman, and G. Rappolt, *Teaching Every Student in the Digital Age: Universal Design for Learning*. Association for Supervision and Curriculum Development, Alexandria, VA., 2002.

[30] M. I. Santos, A. M. D. A. Breda, and A. M. Almeida, “Learning Environment for Autism Spectrum Disorders: a universal approach to the promotion of mathematical reasoning,” in *DSAI 2016, 7th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion*, *In press,* 2017.

[31] C. Yu-Kai, *Actionable Gamification: Beyond Points, Badges, and Leaderboards*, 2nd editio. Fremont: Octalysis Media, 2015.

[32] G. Zichermann and C. Cunningham, *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*, 1st editio. O’Reilly Media, Inc.

[33] K. Oxland, *Gameplay and Design*. Pearson Addison Wesley, 2004.

[34] A. Darejeh and D. Singh, “A review on user interface design principles to increase software usability for users with less computer literacy,” *J. Comput. Sci.*, vol. 9, no. 11, pp. 1443–1450, 2013.

[35] F.-K. Lau, A. H. K. Yuen, and J. M.-G. Lian, “Adapted design of multimedia-facilitated language learning program for children with autism,” *Psicol. Esc. e Educ.*, vol. 11, no. spe, pp. 13–26, 2007.

[36] R. Muñoz, T. Barcelos, Noe, R. L, and S. Kreisel, “Development of software that supports the improvement of the empathy in children with autism spectrum disorder,” *Proc. - Int. Conf. Chil. Comput. Sci. Soc. SCCC*, pp. 223–228, 2013.

[37] K. Sitdhisanguan, N. Chotikakamthorn, A. Dechaboon, and P. Out, “Using tangible user interfaces in computer-based training systems for low-functioning autistic children,” *Pers.*

Ubiquitous Comput., vol. 16, no. 2, pp. 143–155, May 2011.

[38] R. Strauss, *Managing Multimedia Projects.* Focal Press, 1997.

[39] L. Delmolino, A. P. Hansford, M. J. Bamond, K. E. Fiske, and R. H. LaRue, “The use of instructive feedback for teaching language skills to children with autism,” *Res. Autism Spectr. Disord.*, vol. 7, no. 6, pp. 648–661, Jun. 2013.

[40] S. Narciss, “Designing and evaluating tutoring feedback strategies for digital learning environments on the basis of the interactive tutoring feedback model,” *Digital Education Review*, vol. 23, no. 1. pp. 7–26, 2013.