Chapter 5

Multiple Intelligences and Videogames: Intervention Proposal for Learning Disabilities

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Abstract

In recent years, there has been much research into the possibilities offered by digital tools for intervention in learning disabilities. The most recent studies have found that these tools can have positive effects on diverse aspects of learning, such as the acquisition of reading, writing, vocabulary and mathematics, as well as improvement of executive functioning and behavioural control skills. Despite the results showing the positive effects of using digital tools for students with learning disabilities, it remains necessary to widen their use in areas such as identification, assessment and intervention as early as possible. Within the current chapter, the application of the conceptual framework of multiple intelligences to the design of educational video games is proposed to facilitate diagnosis and improve intervention success in cases of learning disability. In this regard, a proposed novel tool is presented that may be used for the evaluation and intervention for students with learning disabilities.

Keywords: multiple intelligences, learning disabilities, evaluation, intervention, serious games, gamification, game-based learning

1. Introduction

Throughout history, our concept of intelligence has evolved from restrictive ideas positing a direct, unidirectional, static relationship between intelligence, learning ability and academic achievement, to current approaches characterising intelligence from a non-unitary perspective. These new approaches try to understand the relationships between intelligence, learning and academic achievement from a more complex, bi-directional and dynamic perspective.

This new perspective highlights the multiplicity of capabilities, structures and processes involved in intelligent behaviour, as well as the possible contributions teaching can make to the improvement and optimisation of intellectual skills and learning abilities [1–4]. Within these non-unitary theories, there is one which stands out: Howard Gardner's Theory of Multiple Intelligences. This theory postulates that intelligence is composed of a mixture of abilities, skills and capabilities called intelligences, which are independent of each other, and which may be found in everybody waiting to be developed [2]. These postulates can be considered in the development of serious games.

In recent years, there has been much research into the possibilities offered by digital tools for intervention in learning disabilities. The latest research has found that these tools can have positive effects on various aspects such as the acquisition of reading skills [5, 6]; the development of vocabulary, language and listening skills [7]; treatment of dysgraphia [8]; mathematics learning [9–11]; and improvement in executive functioning in students with attention deficit hyperactivity disorder (ADHD) [12–14].

Despite these studies showing the positive effects of digital tools, it is still necessary to look more closely at the usefulness of these tools in the identification, evaluation and earliest possible treatment of those students with learning disabilities.

What is proposed here is the fusion of two aspects—the postulates of the Theory of Multiple Intelligences and the use of digital tools—with the aim of designing and testing a tool that facilitates the diagnosis and treatment of students with learning disabilities.

The current state of the art on digital tools applied to learning difficulties identification and intervention is presented below. Multiple intelligences postulates are also described in relation to the new tool, Boogies Academy.

2. Learning disabilities and digital tools

The term 'learning disabilities' refers to a heterogeneous group of disorders which manifest as significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical skills [15]. The DSM-5 [16], the primary reference in professional and research practice in this field, includes difficulties in writing, reading and calculating, along with unspecified difficulties in a category called Specific Learning Disorders. These disorders are understood to be intrinsic to the individual, supposedly due to a dysfunction of the central nervous system, and may occur at any time throughout a person's life. Nonetheless, extrinsic circumstances arising from an individual's surrounding context, such as inappropriate teaching, or the presence of comorbid conditions such as ADHD, can have a strong influence on the diagnosis and progress of learning disabilities [17, 18].

Many studies emphasise the need for identification, evaluation and intervention as early as possible for students with learning disabilities. To expedite early diagnosis, newly developed, empirically substantiated and validated strategies can be implemented to complement the

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various mechanisms for identification, reinforcement and support already in use with students with learning disabilities.

These new techniques must also be consistent with new ways of student learning and the growing changes in society in which communication and information technologies play an increasing role. One example of this type of methodology is the use of digital tools developed through gamification in the form of educational video games or 'serious games' [19]. According to Sánchez-Peris [20], the use of these types of games is an excellent way to improve a player's concentration, effort and motivation, due to the recognition, success, competition, collaboration, self-expression and educational power inherent in such recreational activities. Recent studies [21] concluded that serious games could be stimuli which encourage the development of multiple intelligences, as they already have the multi-sensorial components which favour learning contexts capable of grabbing the player's attention and keeping them involved in the game.

Serious games share technology with video games, but, compared to video games, the aims and uses of serious games is outcome-driven and extremely varied [22]. For this reason, it is fundamentally necessary to define the objectives, content, skills and behaviours to develop, while not forgetting aesthetic, narrative and technical resources to encourage engagement and playability [21, 23, 24].

Thus, digital tools can bring together the necessary requirements to facilitate diagnosis and intervention in specific groups. It must be remembered that, as with all individuals, students with learning problems present unique characteristics, interests and needs when it comes to learning. The current paradigm advocates education that is centred on the person and considers individual differences. This approach makes it necessary to develop learning systems and contexts which are adapted, as far as possible, to each student's characteristics.

In terms of potential usefulness of serious games, it is important to note that, in comparison with traditional educational tools, digital systems have the advantage of presenting content in a variety of formats (written texts, images, animation, sound, etc.) [25]. A benefit of this is that the images, sounds, text and other methods of presentation are present at the same time, so simultaneous activation of both verbal/auditory and visual channels is possible. In addition, working in this kind of environment gives the learner better control over their learning processes by, for example, allowing them to choose a specific sequence.

Another characteristic of these systems is that information is organised in the same way that the human mind processes information—that is, in knowledge structures represented by interconnected networks of concepts. These structures are made up of nodes, with ordered relationships connecting them in such a way that distinct content that is related can be activated simultaneously and very rapidly [26]. Compared to traditional forms of organising information, such as the linear organisation used in textbooks, this type of organisation has been shown to have advantages as it encourages content acquisition and retention, and makes the learning process easier, which in turn has been shown to have its own impact on levels of student motivation [27, 28].

The benefits of using digital tools have been demonstrated in various studies of students with learning disabilities. The use of these systems has been shown to have positive effects on the acquisition of reading skills [5, 6]; acquisition of vocabulary, language and listening skills [7]; on the treatment of dysgraphia [8]; and on learning mathematics [9–11]. Its effects have also been studied in cases involving ADHD. Students with this developmental disorder face problems including abnormal executive functioning or the reduced capacity to control behaviour, and difficulties in regulating emotion, motivation and arousal or activation in general. These problems have been shown to be reduced by using digital tools [12–14]. In an earlier study [29], the use of this type of tool demonstrated a positive effect on academic achievement in a sample of students with ADHD, while more recent studies [30] found that students with ADHD exhibited increased levels of attention and better achievement in tasks when they were shown simultaneous videos, images and short narrations, whereas they demonstrated more difficulties when presented information in the form of linear texts. One of the explanations for these results is linked to the inherent properties of digital tools—that is, they make it easy to receive information through multiple channels. So, if one channel is being ignored, the information may be captured via another channel instead of being lost. Thus, presenting information through multiple channels increases the probability of relevant information being retained [28].

A very important aspect to consider is the level to which these new systems are adaptive [8]—that is, whether the functioning and difficulty levels adapt to variables of individual students, such as previous knowledge or pace of learning. While there is a lot of current research into the impact of digital tools on learning disabilities and ADHD, investigations into the adaptability of these tools when used in this population has so far been limited. Some exceptions include programs such as Number Race [31] for the treatment of dyscalculia and Agent-Dysl for dyslexia [32], both of which are aimed at treating students in primary education.

Number Race [31], primarily for children aged 4–8, is especially designed to address mathematical learning disabilities (dyscalculia) by strengthening the brain circuits for representing and manipulating numbers. Children who are making their first steps with numbers learn the basic concepts of number and arithmetic, while older children, who are already familiar with numbers, build their fluency in arithmetic and in mapping numbers to quantities (number sense).

The objective of Agent-Dysl [32] is to help narrow the gap between good and poor (due to dyslexia) readers in school-aged children. Agent-Dysl is an intelligent assistive reading system that gives personalised treatment, customising the presentation of the reading material (usually study material for a school lesson) to help each child improve their reading. The system builds and maintains individual profiles by observing each child reading the text on the system's viewing area and recognising the reading errors. The individual profiles are then used to customise text presentation for that individual so that each child's reading performance is improved. By employing image analysis techniques, the system can also assess the child's emotional and physical state and dynamically adapt the document presentation accordingly. Similar system adaptability should be considered and incorporated during the future development of tools designed for the contexts of learning disabilities and ADHD also.

The studies described above demonstrate how digital resources, utilised in the right way, can bring about improvements in students with learning disabilities. However, there have also

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been studies which demonstrate the potential that these types of systems have in evaluation and early diagnosis of these problems. Two completed studies [33] propose early evaluation systems for the identification of students in primary education at risk of presenting with learning disabilities, and which provide predictions of student learning based on a profile of performance in digital environments. Although the diagnostic efficacy of both systems is still being tested, positive data have already been acquired demonstrating the diagnostic efficacy of this type of instrument and indicating some of the required fundamental aspects for these systems: that they have a high level of automation and are accessible for use by teachers; that they offer relevant information on the student's effective learning and acquired skills; that the data provided is persistent over time; and that they have an accumulative character, allowing the student to be evaluated in different stages.

Despite the novelty of these systems in the context of intervention and evaluation in learning disabilities, something they suffer from in some cases is the presence of a stable theoretical reference framework. The current proposal is to begin with Gardner's paradigm of multiple intelligences, an aspect of which is that individuals possess different capabilities which can be gateways to facing their weaknesses. A new digital tool, called Boogies Academy, can hopefully utilise these individual capabilities in both the identification of and intervention in learning disabilities.

3. The Theory of Multiple Intelligences

The Theory of Multiple Intelligences is one of the most prevalent in the context of non-unitary theories of intelligence. This theory emphasises a combination of skills, abilities and capabilities that are independent of each other and are present in everyone, to a greater or lesser extent, waiting to be developed. Gardner called these abilities 'intelligences' and his theory considers each individual to exhibit a unique profile of intelligences. That is, although we are all born with these intelligences, there are no two people who have identical intelligences in the same combinations [34]. In accordance with these ideas, Gardner defined intelligence as a biophysical potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture [34]. He originally identified seven intelligences: musical, bodily kinaesthetic, logical-mathematical, linguistic, spatial, interpersonal and intrapersonal; he later added naturalistic intelligence to his theory [34]. Gardner did not only identify these types of intelligences. He also equated them with linguistic and mathematical intelligence as, at that time, these where considered key to determining an individual's intelligence and were the only intelligences used as references in traditional tests of capability [2, 3, 15–38].

This theory was the subject of great interest in the educational community and gave rise to a concept of education far removed from the uniform school model. It proposed individual-centred teaching that considered each student as distinct in terms of the level and combination of intelligences they possessed. Thus, it suggested that different students should not have the same content, methods or evaluations [2, 3, 35, 36, 38, 39].

The fundamental aspect of this approach is the need to discover the intellectual capabilities and outstanding aptitudes of each individual in order to develop them from the very earliest stages of education by designing learning tasks which foster development of the basic skills and abilities of each intelligence [2]. The theory focused not only on the need to evaluate the skills that stand out the most but also on seeking ways in which this information could be used to modify methodologies for individual needs and thus foster academic achievement and adaptation to school [2, 36, 38–40].

Once evaluation has identified stronger areas (areas in which a student exhibits better motivation and more confidence), it is necessary to move to the key step, which is intervention.

This intervention utilises the concept that these skills or strong points can be used to 'bridge the gap' in areas where the student has difficulties [2]. Thus, there are two necessary phases of a procedure incorporating this theory: it must begin with an evaluation of the individual's abilities and strong points, and then an intervention must be prepared which uses those strong points as a way to improve weak or problematic areas.

4. Evaluation of multiple intelligences

Evaluation means gathering information about the abilities and potential of the subjects that is useful both to the individual being evaluated and to the community around them [2]. Gardner [34] thought that finding reliable, valid measures of intelligence was of great interest to educationalists. However, his theory criticises the view that there is only a single intelligence that may be measured by the Intelligence Quotient and standardised tests [2]. Therefore, in this approach, it is suggested that we cannot continue measuring intelligence as we have up to now, and that it is necessary to develop a different, better way of thinking about human intellect [34], along with more appropriate ways of unbiasedly evaluating people with differing intellectual profiles [2, 3, 38, 41, 42].

It should be noted that it is essential to evaluate intelligences using methods which are neutral with respect to the intelligences, that is, using methods that directly examine the intelligences rather than through instruments which depend on linguistic or logical intelligence, such as traditional pen and paper instruments [34]. In this sense, evaluation instruments and materials that are usually applied cannot be considered neutral, and the use of materials that are familiar, motivating and relevant to the child's context will allow better evaluations of an individual's level of competence [36–38, 43]. This raises the need for an evaluation system that can unbiasedly detect students' capabilities, abilities and interests in order to provide educational experiences which encourage students to capitalise on strong areas, while addressing and aiming to improve detected weaknesses [36, 38, 39, 43].

The first and most significant experience of this kind of evaluation was 'Project Spectrum' [43–45]. The aim was to evaluate intelligences and encourage development of processes and skills implicit in them, as well as seek ways in which teachers could use this information to better adapt their methodologies to individual needs. The types of activities used in this

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project allowed for the evaluation of children while they were playing, rather than needing to use the written word. Therefore, the evaluation was of intelligence functioning in natural settings and in situations involving the resolution of everyday problems [36, 38, 39, 45]. These activities have been shown to be valid, reliable instruments for the evaluation of multiple intelligences [36, 37, 46].

Although this model of evaluation, a long way from traditional tests and pen and paper assessments, is the ideal proposed by Gardner for the very young, it has the disadvantage of being rather laborious to implement, so it is not used very widely in either the educational field or in research into multiple intelligences. One way to overcome this limitation may be to use interactive digital evaluation instruments that can be applied easily to evaluate all the intelligences described by Gardner. This requires the use of instruments that, in addition to being evaluation tools, are also learning experiences [2]; conform to the characteristics for evaluation proposed by Multiple Intelligences Theory (continuous, systematic, varied, dynamic, contextualised, meaningful and motivating) [36–38, 45]; and are sufficiently practical to be used in both education and research.

In this sense, digital tools offer numerous possibilities both in research and in intervention, using the Theory of Multiple Intelligences as a point of reference.

5. A digital tool based on multiple intelligences: Boogies Academy

Boogies Academy is a library of video games designed to evaluate and improve multiple intelligences in primary education. It was created with the aim of giving families and education professionals a tool which was both attractive and motivating for students and easy to use in both educational and research and evaluation settings.

The design and development was done using a proprietary methodology called the tree of intelligences (TOI) method. This methodology has, at its roots, the fundamental Theory of Multiple Intelligences from Gardner [2, 29, 47] added to the design of educational video games. The result is an algorithm which allows the real-time measurement of a player's achievement, providing information about their profile of intelligences, as well as advice for improving strong areas and compensating for weaker areas.

To make the information measurable, the Boogies Academy tool is constructed on two fundamental foundations: instructional design, that is, the planning, preparation and design of resources so that learning happens [48]; and the idea of intelligence as the ability needed to resolve problems or create products which are important in a specific cultural context or community [2].

The game mechanics, content and evaluation criteria were defined following instructional design, allowing data to be recovered and difficulty levels to be set. For video games to be catalysts capable of activating multiple intelligences, thought must be given to the content, skills and abilities they aim to develop, without forgetting the aesthetics, narratives and video game techniques which encourage engagement and guarantee playability [21–24]. To that

end, once the instructional design was done, the game was given shape by illustrators and graphic designers before programming was completed by the technical team.

It should be noted that the game mechanics were designed with regard to the concept of intelligence being the ability needed to resolve problems or create worthwhile products [2], while bearing in mind that intelligences always work synergistically [2, 49], and that there are different ways of being intelligent within a single intelligence [49].

Each game presents the gamer with a problem to solve. Depending on the skills or abilities the challenge requires, one principal intelligence and one or more secondary intelligences are activated. In this manner, one problem may require speed of reaction (activating visual-spatial and bodily kinaesthetic intelligences), whereas another may ask for knowledge of various animal species (activating naturalistic intelligence).

When creating the problems and defining the game mechanics, the designers considered the key abilities Gardner and his colleagues recognised in Project Spectrum [43–45], such as musical perception or sensitivity to rhythm in the case of musical intelligence.

To date, a total of 10 games have been designed and developed, covering at least one key ability [43–45] from each of the 8 intelligences recognised by the theory. The games are:

- Tool time: classification of objects according to similarity to geometric shapes (visual-spatial and logical-mathematical intelligence).
- Electric colours: perception and recognition of primary colours and simple mixtures of colour (visual-spatial and logical-mathematical intelligence).
- Marathon Boogie: performing mathematical operations to develop mental arithmetic skill (logical-mathematical intelligence).
- Rubbish rush: classification of rubbish according to material (naturalistic intelligence). The mechanics also need hand-eye coordination to classify the rubbish (visual-spatial and bodily kinaesthetic intelligences).
- Catch the cakes: reaction speed and hand-eye coordination (bodily kinaesthetic and visual-spatial intelligences).
- Photo booth Boogie: perception and identification of feelings from body, facial and gestural expressions (interpersonal and intrapersonal intelligences).
- Word-search: recognition of words and basic vocabulary management (linguistic and visual-spatial intelligences).
- Exploding keys: recognition of letters and writing training through widgets (linguistic, visual-spatial and bodily kinaesthetic intelligences).
- Musical Drops: listening, recognition, identification and discrimination of sounds and rhythmic patterns (musical and linguistic intelligences).
- Yog's band: recognition and identification of instruments and their sounds (musical intelligence).

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One of the strengths of the Boogies Academy tool is the real-time result readout. This means that the tool is not limited to classification as it can also provide feedback to help the player address their skills and abilities by, for example, offering a learning itinerary of suggested games that will use the player's stronger skills and abilities to work on their weaker points. According to Gardner [2], psychologists spend too much time classifying individuals and not enough time trying to help them. Hopefully, thanks to Boogies Academy, education professionals, as well as parents, will be able to identify a student's strong points in addition to the weaker areas in their capability profile, and use this information to, among other things, guide the search for educational experiences that best fit the student's profile and will bring about development and strengthening of their different intelligences and abilities, as well as guide their future study or work in subsequent stages of education [2, 49].

6. Conclusions and future perspectives

Digital tools may constitute an appropriate dynamic process for evaluating multiple intelligences as long as there are activities which work on the basic skills that define each learning area, and as long as these activities are planned within a meaningful and motivating learning context [23]. These types of tools also allow the introduction of evaluation and educational objectives without sacrificing entertainment and using a motivating and meaningful methodology [24]. Thanks to technological development, the current potential for digital tools is limitless. Based on these new methodologies, it is now possible to formulate an educational system capable of unbiasedly detecting students' skills, abilities and interests; the design of such a system must provide the opportunity to create intervention contexts which support and utilise student strengths while addressing and improving student weaknesses, especially in cases where there is a learning disability [36–38, 43].

Gardner's Theory of Multiple Intelligences has significant educational implications, in that identified skills and abilities speak to the student's learning preferences, methods and styles, as well as their strengths. This is a fundamental element of the current educational context, and, even more so, in the context of learning disabilities, it involves a radical change in perspective as models based on deficits are rejected in favour of a model based on abilities and strengths [50, 51]. Thus, as students have different learning capabilities and these are expressed in multiple facets, a deficit in one specific area may be compensated by strengths in others [52].

In addition, these intelligences are measurable and may be revealed in various contexts in day-to-day life, particularly in the classroom [53]. Increasingly, teachers are recognising that students learn and excel in a wide variety of ways, and if strengths in their intelligences can be identified, the processes of teaching-learning will be enhanced. A class which offers a variety of learning opportunities increases its students' chances of success [51, 54].

In terms of intervention, the study of multiple intelligences is currently a promising field of research. Many researchers are adopting this perspective as a way of including alternatives for improving the acquisition of language, reading and mathematics, as well as basic skills of

behaviour control and attentional processes, with positive results [50, 51, 55, 56]. They have also found positive effects on motivation, self-concept, self-efficacy and, in general, academic achievement in students of varying ages with and without learning disabilities. One study [57] analysed the effect of instruction based on multiple intelligences in a sample of fourth year students and found improvements in academic achievement and school self-concept.

Taken together, these studies provide empirical evidence supporting the use of a perspective based on multiple intelligences in evaluation of, and intervention in, learning disabilities, although they also indicate the need for additional research in this field. Accordingly, and aware of what new technologies and digital tools have been shown to offer to these processes, the principal use proposed here is to combine both perspectives (digital systems and multiple intelligences) in tools which allow identification and intervention in cases of learning disability. Therefore, by incorporating these perspectives with the results of previous research, we have developed a digital tool which combines a series of educational video games based on the postulates of the Theory of Multiple Intelligences: Boogies Academy.

Having developed the tool, our current objective is the analysis of its use as a complement in evaluation of and intervention in students with learning disabilities. More specifically, current research is aimed at two fundamental aspects: firstly, at the delimitation of students' profiles of intelligences, which will provide information on key points and highlight skill areas; and secondly, at the study of effects of the Boogies Academy software on levels of attention, motivation and anxiety in a sample of 80 students with learning disabilities aged 6–12. To do this, pre-test and post-test evaluations will be done, and a control group will receive intervention with the tool once the study is complete. The hope is that this intervention will produce positive results in the experimental group, specifically increased levels of attention, increased motivation to learn, and reduction of anxiety when compared to the control group.

Although Boogies Academy is a newly created tool, it is hoped future research will produce positive results regarding its use as a complementary method of evaluation and intervention in school-aged children. In terms of future perspectives, there is a plan to create a new tool for use by older children, and to use the current tool in other populations with different problems, such as ADHD. This research will allow us to have a more accurate understanding of the potential of these digital tools, based on multiple intelligences, in different age groups and populations.

Based on the studies that are being conducted using the new tool, it is expected that Boogies Academy will be a reliable and valid assessment measure of multiple intelligence components, whose factorial structure fits the multiple intelligences model previously described. This type of evaluation seeks to go beyond traditional intelligence tests, providing a more comprehensive view of an individual's intelligence, skills, strengths and weaknesses. We expect that the different tests that comprise the Boogies Academy tool will show good reliability and validity, as well as significant correlations with other standardised intelligence tests.

On the other hand, it is also expected that this new tool will have an important impact on current intervention practices, by giving some clues on how to design and implement intervention programmes adjusted to individuals' intelligence profiles. The main objective in this sense is to design a tool that offers a tailored training itinerary, based on the analysis of intelligence profiles. For this purpose, Boogies Academy is intended to take advantage of an

individual's strengths and use them as starting points to offset possible difficulties. It is also important to note the wide range of options that this new tool will offer to researchers, as it can provide real-time data. Given its characteristics, the designed tool should also be helpful when conducting research on multiple intelligences in individuals with learning disabilities and associated clinical conditions (e.g. attentional problems, low motivation or self-esteem).

Overall, it is expected that the current research on digital tools opens a new and promising path in the field of evaluation and interactive intervention in students with different learning difficulties.

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