Comunicar, n. 58, v. XXVII, 2019 | Media Education Research Journal | ISSN: 1134-3478; e-ISSN: 1988-3293
www.comunicarjournal.com

Multiple intelligences and video games: Assessment and intervention with TOI software

Inteligencias múltiples y videojuegos: Evaluación e intervención con software TOI

Pablo Garmen is Predoctoral Researcher in the Department of Psychology at the University of Oviedo (Spain) (pablo@cuicuistudios.com) (http://orcid.org/0000-0001-7013-6518)
Dr. Celestino Rodríguez is Associate Professor in the Department of Psychology at the University of Oviedo (Spain) (rodriguezcelestino@uniovi.es) (http://orcid.org/0000-0003-4137-4503)
Patricia García-Redondo is FPU Predoctoral Researcher in the Department of Psychology at the University of Oviedo (Spain) (garciapatricia@uniovi.es) (http://orcid.org/0000-0003-2319-4541)
Dr. Juan-Carlos San-Pedro-Veledo is Professor of Teacher Training and Education Faculty at the University of Oviedo (Spain) (juancar@uniovi.es) (http://orcid.org/0000-0003-4686-5918)

ABSTRACT
Howard Gardner revolutionized the concept of intelligence with his Multiple Intelligences Theory. His vision was widely supported by the educational community, which considers different forms of learning and accessing knowledge. Despite its impact, there is still a lack of development of tools that can easily, practically and reliably evaluate multiple intelligences. This work describes the design, development, and piloting of TOI (Tree of Intelligences) software, a digital tool to evaluate multiple intelligences and perform interventions through video games. The aim of the study is to present the design of the TOI software and test its operation, analysing the distribution of the results game by game and checking whether there are differences according to gender or school year. A total of 372 primary school students participated, aged 5 to 9 years old (M=7.04, SD=.871), from three schools in Asturias and Madrid. The results show that 9 out of 10 games had a normal distribution and that there were no gender differences in most games, but there were differences in relation to the school year. We concluded that due to its operation and design TOI software has the potential be a suitable instrument for the evaluation and intervention of multiple intelligences.

RESUMEN
Howard Gardner revolucionó el concepto de inteligencia con su Teoría de las Inteligencias Múltiples. Su visión fue acogida por la comunidad educativa como la oportunidad para una educación más personalizada y que atienda las diferentes formas de aprender y acceder al conocimiento. A pesar de su impacto, todavía hoy hay una carencia en cuanto al desarrollo de herramientas capaces de evaluar de forma sencilla, práctica y fiable las inteligencias múltiples. Por ello, este trabajo plantea el diseño, desarrollo y pilotaje del software TOI, del inglés 'Tree of Intelligences', una herramienta digital para evaluar e intervenir las inteligencias múltiples a través de los videojuegos. El objetivo del estudio es presentar el diseño de TOI y testar su funcionamiento, analizando la distribución de los resultados juego a juego y comprobando si existen diferencias en función del género y el curso. Participaron un total de 372 estudiantes de primero a tercer curso de educación primaria de tres centros de Asturias y Madrid, con edades comprendidas entre 5 y 9 años (M=7.04, DT=.871). Los resultados muestran que 9 de 10 juegos presentan una distribución normal y que no existen diferencias en función del género en la mayoría de los juegos, pero sí en relación al curso. Se concluye que por su funcionamiento y diseño el software TOI puede ser un adecuado instrumento de evaluación e intervención de las inteligencias múltiples.

KEYWORDS | PALABRAS CLAVE
Multiple Intelligences, videogames, gamification, assesment, intervention, digital tools, education.
Inteligencias múltiples, videojuegos, gamificación, evaluación, intervención, herramientas digitales, educación.

Received: 2018-05-29 | Reviewed: 2018-07-15 | Accepted: 2018-08-01 | Preprint: 2018-11-15 | Published: 2019-01-01
DOI https://doi.org/10.3916/C58-2019-09 | Pages: 95-104

Comunicar, 58, XXVII, 2019

1. Introduction

In the eighties, Howard Gardner revolutionized the world of psychology and education with his Theory of Multiple Intelligences (MI). His vision of intelligence, not as something unique but rather a set of skills, talents and abilities, called intelligences, which are independent from each other and potentially present in all people (Gardner, 2013), breaks with the traditional conception of human intellect and opens up a world of possibilities for education professionals, who see the opportunity for more personalized education that respects the many differences between students and their different ways of learning and accessing knowledge. It is becoming more and more common to find schools including aspects related to the development of multiple intelligences in their curriculum planning. There are some successful cases which are well known in the educational community, such as the Montserrat School in Barcelona, which implements a methodology based on multiple intelligences that respect emotional aspects and turns students into protagonists of their own learning (Del-Pozo, 2005).

Despite the impact of this theory on the world of education, thirty years later there is still no mechanism to evaluate multiple intelligences in a simple, practical and reliable way. The most significant experience is Project Spectrum (Gardner, Feldman, & Krechevsky, 2008), developed with the objective of evaluating the intelligence profile and working style of children, observing their behavior when solving problems related to each of the eight intelligences. The activities used in the project have proven to be valid and reliable for evaluating multiple intelligences (Ballester, 2001; Ferrándiz, Prieto, Ballester, & Bermejo, 2004), but despite Gardner suggesting that the model was ideal, it is a very laborious and slow process, which means that it is not widely used in schools or research on MI (Gardner, 2013). The most commonly used assessment practice for the classroom is the assessment scales for parents, teachers, and students that Thomas Armstrong compiled in his book "Multiple Intelligences in the Classroom" (Armstrong, 2006). These lists make it possible to organize faculty observations of a student's multiple intelligences, but according to Armstrong himself (2006), the lists cannot be considered a standardized test since they have not been subjected to the necessary protocols to determine their reliability and validity, and should therefore only be used informally.

Designing an instrument that teachers can use to easily, validly and reliably assess different intelligences would have significant educational implications. It would encourage a concept of education that is far removed from the traditional school, and it would allow for more individual-centred teaching, taking into account that everyone is different in the degree to which they possess different intelligences and different combinations of intelligences.

For this reason, in this study, we look at the design, development, and testing of software to evaluate MI and perform interventions. The software is attractive and motivating for both students and families (Gardner, 2012), and complies with the evaluation characteristics proposed by the Theory of MI: continuous, systematic, varied, dynamic, contextualized, meaningful, motivating, etc. (Ballester, 2001; Ferrándiz, 2000; Gardner, Feldman, & Krechevsky, 2008; Gomis, 2007). At the same time, it is practical for use in both schools and research. Our aim is to produce an instrument "that in addition to evaluating constitutes a learning experience" (Gardner, 2013: 237).

Video games may constitute an appropriate evaluation procedure. They allow for the introduction of evaluation and educational objectives without sacrificing entertainment (Starks, 2014) and they can provide a dynamic MI evaluation process if activities are designed that work on basic skills defining each learning area and if these activities are planned within a meaningful and motivating learning context (Escamilla, 2014; Marin & García, 2005).

In addition, the dynamic and playful nature of video-games makes them motivating and influential at a cultural and social level, taking up a large part of children's, young people's and adults' leisure time (Dorado & Gewerzc, 2017; Sedeño, 2010; Spanish Association of Video Games, 2015). Due to their potential, it is increasingly common to find video-games in the classroom, with specific methodologies that allow them to be incorporated into the educational process, such as gamification (applying the principles of the game to a different context than that of the game, for example, a classroom) or game-based learning which is based on in introducing video-games into the learning process in order to improve it (Díaz & Troyano, 2013; Zichermann & Cunningham, 2011).

The literature on the use of video games as a training and cognitive assessment tool is growing (Buckley & Doyle, 2017). In recent years, studies have emerged that analyse the measurement of intelligence through video games (Quiroga, Román, De-La-Fuente, Privado, & Colom, 2016), prove their effectiveness as a tool for the prevention of cognitive diseases such as Alzheimer's (Hsu & Marshall, 2017) and evaluate the effectiveness of cognitive training in aspects such as work memory and attention (Ballesteros & al., 2017; Oh, Seo, Lee, Song, & Shin, 2017).

In the area of MI and video games, the studies by Del-Moral, Fernández & Guzmán (2015: 244) are prominent. They state that "the introduction of appropriate educational video games in the classroom and their systematic

© ISSN: 1134-3478 • e-ISSN: 1988-3293 • Pages 95-104

exploitation promote the development of MI". The same authors point out that so-called "serious games" can stimulate the development of MI since they have multisensory components that provide learning contexts that are capable of holding the player's attention and involving them in the game.

In this work, we describe the design, development, and testing of TOI software, which is an instrument composed of a variety of pedagogically designed video games. According to the ideals of MI assessment (Armstrong, 2006; Gardner, 2012; 2013; Gardner, Feldman, & Krechevsky, 2008), it should be able to assess multiple intelligences and be used in interventions in an attractive and motivating way. Plus, it should not only provide useful information about individuals' abilities and potential, but it should also be capable of doing so in real time, facilitating its application in both school and research environments. We begin with a description of the software (Tree of Intelligences) in order to then examine more deeply its use in teaching and its application in intervention and evaluation. The aim of the study is to describe the educational design of the TOI software and to analyse its operation. That analysis will be done by analysing the distribution of the sample, any differences in terms of gender and any differences in terms of a school year. These aspects will allow us to check whether the difficulty of the games is sufficient to deal with the whole sample, whether it is valid for use in both boys and girls and whether the difficulty and content are suitable for the target age range.

> Tool such as TOI, which allows teachers to discover students' intelligence profiles or strong and weak areas, opens up the possibility of knowing which learning style best suits students' profiles or discoveries which activities they feel most comfortable with in order to work towards more personalised, inclusive education, taking into account the fact that everyone is different and therefore should not learn in the same way.

1.1. Description of the TOI software

TOI, Tree of Intelligences, is software designed and developed to evaluate multiple intelligences and assist in interventions in a playful and interactive way. It began with the objective of providing information about people's abilities and potentials, offering a useful response that helps reinforce strong areas and/or develop and compensate for weak areas. It uses video games as an instrument and is built on two fundamental pillars: instructional design understood as the planning and design of educational materials, and the understanding of intelligence as the ability to solve problems or create valuable products (Gardner, 2013).

TOI was developed following an innovative and detailed process of the same name, the TOI Method (Figure 1). Our starting point was Gardner's conception of human intellect (2013), bearing in mind that intelligences always work in concert (Armstrong, 2006; Gardner, 2013), that they are triggered by information presented internally or externally (Gardner, 2013) and that there are different ways of being intelligent within the same intelligence (Armstrong, 2006). Game mechanics were designed to that they pose logical, visual, naturalistic, linguistic, bodily, emotional and musical challenges. People's performance in solving different challenges determines their intelligence profile.

TOI is currently made up of ten tests in a video game format. The instructional design means that the tests cover all eight intelligences proposed by Gardner (2012), as shown in Table 1. TOI is a mobile touchscreen application compatible with both iOS and Android operating systems. It is also optimized for use on computers with Windows 10 operating systems with the classroom in mind.

1.1.1. From instructional design to intelligence assessment

Unlike the vast majority of video games on the market, the TOI software is based on an instructional design that defines game mechanics, content, game-playing and evaluation criteria. Each game is designed to challenge the

Comunicar, 58, XXVII, 2019

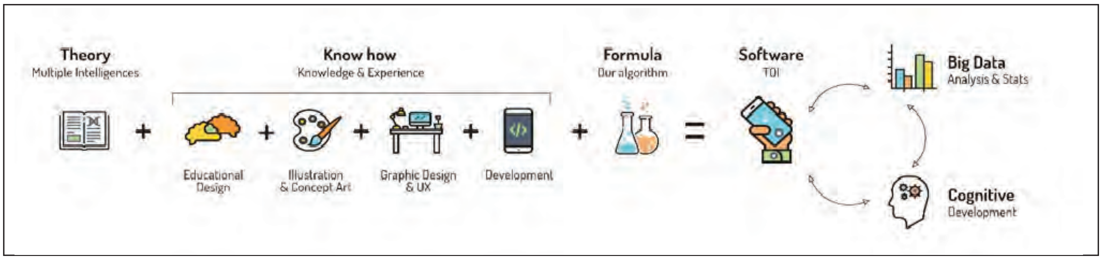

Figure 1. Graphic description of the TOI Method.

player. Depending on the skills or abilities required to solve the challenge, one intelligence will primarily be activated, and one or more will be activated in a secondary manner. One challenge may require the speed of reaction activating the visual and motor intelligences, while another may require knowledge about the different species in the animal world, activating naturalistic intelligence. We used three criteria for judging whether a game triggers an intelligence: the mechanics, or gameplay, and the content. The mechanics of the game demands skills or abilities to solve the problem, while the content requires more knowledge that may be related to intelligence. For example, a game that poses the challenge of classifying tools according to their geometric shape will work by content on logical and visual intelligences, and by mechanics on visual and bodily intelligences. In this case, we established that due to its weight in solving the challenge, the principal intelligence worked on is logical-mathematical intelligence and the visual and body-kinesthetic intelligences are triggered in a secondary way.

Once we had defined the mechanics and content of the game, the evaluation criteria were established defining the dependent variables: successes (hits, or correct responses), errors, level of difficulty, time and score. In this process, elements and interactions were also taken into account, determining both the speed at which objects exist and the possible number of interactions needed to change the difficulty level.

Following the instructional design phase, the pedagogical design was placed in the hands of creatives and programmers, who gave the games and software the aesthetic and technical resources that encourage engagement and guarantee playability. These aspects, along with emotional design, play a key role in introducing assessment objectives without sacrificing entertainment.

1.1.2. The games, the TOI software engine

All games are designed to work primarily on one intelligence, and one or more on a secondary basis, taking into account the key competencies and skills associated with each intelligence, as indicated in Table 1. The eight intelligences defined by Gardner are not all represented to the same extent in the games. Visual-Spatial intelligence is covered in many of the games, while interpersonal and intrapersonal intelligences are only addressed in one game. It is worth mentioning that this social intelligence (inter- and intra-personal) is one of the most difficult to evaluate in this software.

The initial duration of each game is 60 seconds, but the time increases with correct answers and decreases with wrong answers; so the player's performance determines how long the game lasts. It ends when the timer reaches zero, at which point the TOI algorithm analyses the number of successes and errors, the total playing time, the player's accuracy and the gamma elements.

Most of the data is collected internally, but in order to enhance the gamification, users are shown the total number of hits, the accuracy of their responses and the number of trophies and virtual coins they managed to collect. The latter allows for a gamma tool design.

1.1.3. Profile of Intelligences

The main mission of the TOI software is to provide users with information about their intelligence profile, showing a graph of their more and less developed intelligences (Figure 2), which allows them to discover their potential and to be able to take action depending on the results to enhance or improve their intelligences. To this end, the ability and performance of the player is analyzed in each of the pedagogically designed games, establishing a weighted score based on whether the game works an intelligence in a primary or secondary manner.

The score obtained is compared in real time with the recorded performance of other users in each of the games, showing the percentile for each intelligence and a bar graph that allows users to see at a glance their most and least developed intelligences.

© ISSN: 1134-3478 • e-ISSN: 1988-3293 • Pages 95-104

Table 1. Game description			
Game	**Description**	**Intelligences**	**Key skills**
Blu's garage	Sort the tools according to their geometric shape.	Logical-mathematical (Main) Visual-spatial and bodily-kinesthetic (Secondary)	Visual perception Vision-motor coordination Categorization
Mathlon	Solve mathematical problems and win stamina to run for longer	Logical-mathematical (Main) Visual-spatial (Secondary)	Numerical reasoning Processing speed Mental arithmetic
Electric colours	Connect the cables according to their colour and simple mixing.	Visual-spatial (Main) Logical-mathematical (Secundary)	Logical reasoning Discrimination Visual perception
Mecaboom	Type the letters that appear on the toxic barrels to prevent them from reaching the river and polluting it.	Verbal-linguistic (main) Visual-spatial and bodily-kinesthetic (Secondary)	Lexical route Selective attention Decision making
Letter soup	Find the hidden words in the soup before it gets cold.	Verbal-linguistic (main) Visual-spatial (Secondary)	Lexical route Visual tracking Flat figure
Lunch time	Quickly collect and serve the dishes, demonstrating reaction speed.	Bodily-kinesthetic (Main) Visual-spatial (Secondary)	Vision-motor coordination Visual tracking Reaction speed
Yog's Band	Identify the instruments and repeat the sound sequence.	Musical (Main) Logical-mathematical (Secundary)	Auditory memory Auditory perception Logical reasoning
Musical drops	Identify the tone and rhythmic pattern that the drop makes when it falls.	Musical (Main) Verbal-linguistic (Secundary)	Sensitive memory Sensitivity to rhythm Auditory discrimination
Say cheese	Identify the emotions and moods of the characters.	Interpersonal (Main) Intrapersonal, visual-spatial and verbal-linguistic (Secondary)	Access to lexicon Recognition Empathy
Cleaning robots	Sort and recycle river waste according to the material it is made of.	Naturalistic (Main) Visual-spatial and bodily-kinesthetic (Secondary)	Visual perception Vision-motor coordination Categorization

The TOI software also offers feedback on the intelligence profile, providing relevant information on what the percentage in each intelligence means. This analysis allows us to offer advice and make recommendations to enhance or develop intelligence through complementary analog and digital activities.

2. Method

2.1. Participants

A total of 372 students participated in the study. They were aged between 5 and 9 years old (M=7.04, SD=.871), in the first three years of primary education, and from three private Spanish schools in Asturias and Madrid. The group consisted of 199 boys (53.5%), with an average age of 7.07 (SD=.91) and 173 girls (46.5%), with an average age of 7.01 (SD=.82), with no significant differences between the age groups (p=.511). There were also no differences in the gender distribution in the sample [$\chi^2(1)=1,817$, p=.178].

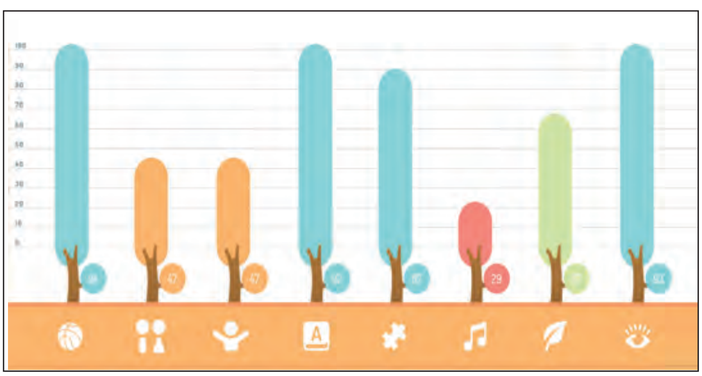

Figure 2. Profile of Intelligences.

2.2. Procedure

The schools were selected according to accessibility criteria. Once the consent of the families had been obtained, the participants carried out the test by playing all the video games in the

TOI software individually, during teaching hours and in periods of 90 minutes. Each of the tests was supervised and guided by a specialist from the research group.

3. Analysis and results

3.1. Distribution of the sample

We performed a game by game analysis to check the distribution of the sample in the variables successes, total time and accuracy. The game variables are normally distributed according to the criteria laid down by Finney and Di-Stefano (2006), in which asymmetry scores between 2 and –2 and kurtosis scores between 7 and –7 of kurtosis mean sufficiently normal distributions. The exception is the game "Electric colours", which works with visual-spatial and logical-mathematical intelligence. The distribution in this game is asymmetrically negative in the successes variables (asymmetry=2.21) and time (2.64). For the analysis of results, non-parametric tests were used, as the distribution of the sample did not meet the parameters of normality in all the games. Thus, the Mann-Whitney U was applied for the analysis of gender differences, and the Kruskal Wallis tests for the analysis of differences according to the school year.

3.2. Gender differences

In order to find out whether there were significant differences according to gender, we performed a comparative analysis of the matching game on the means and standard deviations of the variables successes, time of play and accuracy index.

In the results, there were significant differences (p=.000) in the successes variable in the mathematical-logical intelligence game "Mathlon" (U de Mann-Whitney=11132,00; (p=.000) between boys (M=40.92, SD=18.51) and girls (M=32.95, SD=15.10). Significant differences were also found in the successes variable of the body and visual intelligence game "Lunch Time" (U de Mann-Whitney=7,233.00; p=.033) in boys (M=39.72, SD=13.39) compared to girls (M=42.95, SD=13.87). We also found significant differences in the accuracy variable of the emotional game "Say Cheese" (U de Mann-Whitney=11,611.00; p=.039) between boys (M=72.12, SD=15.50) and girls (M=75.58, SD=14.08). No significant gender differences were found for the remaining variables and games.

3.3. Differences by school year

We looked at the variables successes, time and accuracy for each game in terms of the children's school year (Table 2). We found significant differences in all the games analysed. Both the mean and the standard deviation of all three variables were higher in the second year when compared to the first year, and they were higher in the third year than in the second year.

4. Discussion and conclusions

In addition to the description of the TOI educational software, the other aim of our study was to test its operation through a game-by-game analysis of the distribution of the sample, differences by gender and the differences by school year in the variables successes, time and accuracy. The results show that the variables in all games, with the exception of "Electric colours", were normally distributed; therefore, their design in terms of difficulty is appropriate. In the case of "Electric colours", which was designed to work on and analyse visual-spatial and logical-mathematical intelligence, it will be necessary to make a design adjustment for the successes and game time.

The results also indicate that there were no significant gender differences in most of the variables. The exceptions were the successes variable in the "Mathlon" game for logical-mathematical intelligence, successes in the body and visual intelligence game "Lunch Time", and the accuracy variable in the emotional game "Say cheese", which will all need some revision in design. It is important not to have gender differences to ensure that neither evaluations nor interventions are affected by gender issues and that the tool is applicable to both boys and girls. Our results differ from those in the study by Del-Moral, Guzmán, and Fernández (2018), who observed gender differences in all intelligences.

The results show that there were significant differences in terms of the school year, and therefore age, in the variables successes, time and accuracy in each game. This is a positive finding as it shows that the content is appropriate for the age group that was analysed (5-9 years), adjusting the results to each educational stage.

Table 2. Comparison of successes. time. and accuracy for each game by school year								
	First Year		Second Year		Third Year		Chi-Squared	Sig.
	Mean	SD	Mean	SD	Mean	SD		
Blu's garage - N=365 – First Year=102 / Second Year=142 / Third Year=121								
Successes	30.14	15.22	40.60	17.40	56.58	20.99	90.29	.000
Time	88.87	27.76	106.56	26.08	128.40	28.45	86.79	.000
Accuracy	49.59%	16.18	57.83%	11.56	64.49%	8.81	64.64	.000
Mathlon - N=346 – First Year=100 / Second Year=127 / Third Year=119								
Successes	25.04	11.58	33.39	13.02	51.46	15.79	139.03	.000
Time	110.57	42.33	141.56	36.08	169.60	31.52	110.59	.000
Accuracy	54.56%	25.66	72.34%	14.87	81.93%	14.87	65.29	.000
Electric colours - N=357 – First Year=97 / Second Year=142 / Third Year=118								
Successes	6.89	2.05	8.93	3.55	11.94	5.33	83.26	.000
Time	78.10	12.51	87.75	17.83	102.12	26.84	65.81	.000
Accuracy	67.01%	11.15	75.41%	13.45	82.54%	11.70	66.86	.000
Mecaboom - N=290 – First Year=61 / Second Year=121 / Third Year=108								
Successes	18.00	12.81	29.52	13.33	43.84	12.02	114.26	.000
Time	54.86	45.48	95.12	43.76	139.92	36.46	114.89	.000
Accuracy	24.67%	16.15	38.41%	12.79	47.79%	7.86	97.62	.000
Letter soup - N=359 – First Year=98 / Second Year=142 / Third Year=119								
Successes	11.98	5.04	15.87	5.72	23.79	9.61	124.96	.000
Time	214.85	47.38	245.93	44.18	302.03	62.98	123.18	.000
Lunch time - N=262 – First Year=43 / Second Year=99 / Third Year=120								
Successes	31.60	11.07	36.43	13.08	48.63	10.89	69.36	.000
Time	93.84	27.32	103.44	30.74	128.72	19.78	65.11	.000
Accuracy	51.36%	9.52	53.63%	10.54	61.61%	5.43	61.73	.000
Yog's Band - N=76 – First Year=14 / Second Year=19 / Third Year=43								
Successes	4.14	1.70	7.68	0.94	7.62	1.19	27.80	.000
Time	145.76	17.06	178.50	10.08	178.03	13.77	24.31	.000
Accuracy	33.14%	22.76	49.47%	11.57	49.16%	12.61	8.39	.015
Musical drops - N=64 – First Year=0 / Second Year=38 / Third Year=26								
Successes	-	-	9.23	4.41	11.96	4.12	6.15	.013
Time	-	-	129.54	20.74	141.69	22.09	5.02	.025
Accuracy	-	-	45.53%	22.62	56.26%	19.36	4.96	.026
Say cheese - N=328 – First Year=82 / Second Year=125 / Third Year=121								
Successes	10.74	4.41	14.24	6.15	18.34	5.73	76.81	.000
Time	100.04	21.71	113.46	26.36	127.29	21.27	58.29	.000
Accuracy	70.29%	16.91	73.79%	16.79	75.98%	10.52	4.16	.125
Cleaning robots - N=338 – First Year=81 / Second Year=138 / Third Year=119								
Successes	39.58	19.64	47.80	20.64	65.12	20.77	71.03	.000
Time	121.12	36.75	135.43	34.77	159.94	30.15	70.99	.000
Accuracy	64.86%	14.93	69.94%	12.42	78.00%	9.53	72.67	.000

When analysing the intelligence profile, it should be noted that the results show the profiles compared to each students' peer group. Differences between school years are only analysed to determine the suitability of the content and the difficulty.

TOI is an appropriate tool for assessing MI because its design and development encompass features of the ideas proposed by Gardner and his collaborators for assessing multiple intelligences (Armstrong, 2006; Gardner, 2012; 2013; Gardner, Feldman, & Krechevsky, 2008): intrinsically interesting and motivating materials due to the use of gamification and new technologies, neutrality, a natural learning environment and feedback (Buckley & Doyle, 2017).

Marín, López and Maldonado (2015) highlight video games as a positive resource for learning, stating that young people consider them attractive, and Del-Moral and al. (2018) point out that in addition to improving skills and abilities, video games are a powerful strategy facilitating learning. The fact that it is the children themselves who discover knowledge through cognitive efforts and in turn relate that knowledge to things they already know and are familiar with makes video games especially interesting (Gramigna & González-Faraco, 2009). As for neutrality, both in the test instructions and in test development, we tried to avoid the influence of verbal and logical intelligences, instead directly analyzing the intelligence that is operating in response to the challenge posed.

Comunicar, 58, XXVII, 2019

Using video games as an instrument makes it more likely for the evaluation to be "part of the natural interest of the individual in a learning situation" (Gardner, 2013: 233), because children perceive it as a game due to its potential to motivate and its attractiveness, and they are not aware of being evaluated, engaging in the activity because they want to. This motivating factor of video games is one of the aspects which has been most widely analysed by the educational community and can be found in both recent (Ferrer, 2018; Prena & Sherry, 2018) and past studies (Alfageme & Sánchez, 2002).

The software also offers feedback with analysis and advice to help interventions in the intelligence profile. For Gardner (2013), it is very important that the evaluation is helpful because psychologists often spend too much time classifying people and too little time helping them (Escamilla, 2014).

In conclusion, due to its design and performance results, TOI has the potential to be a suitable instrument for assessing MI and associated interventions; and its inclusion in the classroom could have significant educational implications and provide value to the educational community as long as it is treated carefully to avoid stigma or classification of students. While many teachers accept individual differences, few address them or attempt to improve children's intelligences (Bartolomé-Pina, 2017). This is why a tool such as TOI, which allows teachers to discover students' intelligence profiles or strong and weak areas, opens up the possibility of knowing which learning style best suits students' profiles or discoveries which activities they feel most comfortable with in order to work towards more personalised, inclusive education, taking into account the fact that everyone is different and therefore should not learn in the same way.

> Gardner's theory of Multiple Intelligences currently presents an opportunity to develop students' different educational skills and potentials. Gamification and new technologies can contribute to increased opportunities for evaluation and intervention based on this theory.

It is necessary to point out some limitations to be addressed in future work. First, a psychometric analysis is needed to determine whether the TOI software is valid as a measurement tool. In this regard, and bearing in mind that for an assessment to be legitimate, it must cover a wide range of measuring instruments and methods (Armstrong, 2006). It would be useful to compare and contrast the profile results obtained by this method with those of other MI assessment instruments such as the MI self-perception scales aimed at families and teachers (Prieto & Ballester, 2003; Prieto & Ferrándiz, 2001). In addition, a test-retest assessment would allow us to analyze other important aspects such as the learning or training effect. It would also be interesting to gather feedback from teachers and the educational community on the use of TOI software in the classroom.

Secondly, it is worth noting possible sample bias as the tests were only carried out on students in private schools. Tests should also be carried out in public schools so that the results can be generalized to the rest of the population.

In addition, in order to avoid the use of video games as part of the model and thus provide greater reliability, we are planning the development of an educational program of multiple intelligences to accompany the use of the tool in a more analog sense, with activities that complement the development of skills in real contexts, inside and outside the classroom. Furthermore, due to the difficulty in evaluating inter- and intrapersonal intelligence, any evaluation of this type will need further development in order for it to be represented appropriately.

As for the design of the tool, in addition to the previously mentioned adjustment of the "Electric Colours" set due to its negative asymmetry, it would also be useful to make an adjustment to the "Letter Soup" set. Although the sample is distributed within the normal range, the current version does not take into account the error variable, and this means less difficulty, with most of the subjects scoring values above the average.

With a view to future lines of work, we hope to apply the methodology for the design of games to cover different age groups, as well as to verify the validity and reliability of TOI for intervention with groups with specific educational needs, such as high capacity or ADHD.

© ISSN: 1134-3478 • e-ISSN: 1988-3293 • Pages 95-104

References

Alfageme, B., & Sánchez, P. (2002). Learning skills with videogames. [Aprendiendo habilidades con videojuegos]. *Comunicar, 19*, 114-119. https://bit.ly/2P27D77

Armstrong, T. (2006). *Inteligencias múltiples en el aula*. Barcelona: Paidós.

Asociación Española de Videojuegos (Ed.) (2015). *Anuario de la industria del videojuego*. https://bit.ly/2bRFQq9

Ballester, P. (2001). *Las inteligencias múltiples: Un nuevo enfoque para evaluar y favorecer el desarrollo cognitivo (Tesis de Licenciatura). Murcia: Universidad de Murcia*.

Ballesteros, S., Mayas, J., Ruiz-Marquez, E., Prieto, A., Toril, P., De-Leon, L.P., & Avilés, J.M.R. (2017). Effects of video game training on behavioral and electrophysiological measures of attention and memory: Protocol for a randomized controlled trial. *JMIR Research Protocols*, *6*(1). https://doi.org/10.2196/resprot.6570

Bartolomé-Pina, M. (2017). Diversidad educativa. ¿Un potencial desconocido? *Revista de Investigación Educativa*, *35*(1), 15-33. https://doi.org/10.6018/rie.35.1.275031

Buckley, P., & Doyle, E. (2017). Individualising gamification: An investigation of the impact of learning styles and personality traits on the efficacy of gamification using a prediction market. *Computers and Education*, *106*, 43-55. https://doi.org/10.1016/j.compedu.2016.11.009

Del-Moral Pérez, M.E., Fernández-García, L.C., & Guzmán-Duque, A.P. (2015). Videojuegos: Incentivos multisensoriales potenciadores de las inteligencias múltiples en Educación Primaria. *Electronic Journal of Research in Educational Psychology*, *13*(2), 243-270. https://doi.org/10.14204/ejrep.36.14091

Del-Moral-Pérez, M., Guzmán-Duque, A., & Fernández-García, L. (2018). Game-based learning: Increasing the logical-mathematical, naturalistic, and linguistic learning levels of primary school students. *Journal of New Approaches in Educational Research*, *7*(1), 31-39. https://doi.org/10.7821/naer.2018.1.248

Del-Pozo, M. (2005). *Una experiencia a compartir: las inteligencias múltiples en el Colegio Montserrat*. Barcelona: Fundación M. Pilar Mas. https://bit.ly/2LoEMrc

Díaz, J., & Troyano, Y. (2013). El potencial de la gamificación aplicado al ámbito educativo. *III Jornadas de Innovación Docente. Innovación Educativa: respuesta en tiempos de incertidumbre*. https://bit.ly/2Pvzpdb

Dorado, S., & Gewerc, A. (2017). El profesorado español en la creación de materiales didácticos: Los videojuegos educativos. *Digital Education Review*, *31*, 176-195. https://bit.ly/2BF9soC

Escamilla, A., (2014). *Inteligencias múltiples. Claves y propuestas para su desarrollo*. Barcelona: Graó. https://bit.ly/2LlZ8RQ

Ferrándiz, C. (2000). *Inteligencias múltiples y currículum escolar (Tesis de Licenciatura)*. Murcia: Universidad de Murcia.

Ferrándiz, C., Prieto, M.D., Ballester, P., & Bermejo, M.R. (2004). Validez y fiabilidad de los instrumentos de evaluación de las Inteligencias Múltiples en los primeros niveles instruccionales. *Psicothema*, *16*(1), 7-13. https://bit.ly/2whZio7

Ferrer, J.R. (2018). Juegos, videojuegos y juegos serios: Análisis de los factores que favorecen la diversión del jugador. *Miguel Hernández Communication Journal*, *9*, 191-226. https://doi.org/10.21134/mhcj.v0i9.232

Finney, S.J., & DiStefano, C. (2006). Non-normal and categorical data in structural equation modeling. In G.R. Hancock, & R.O. Muller (Eds.), *Structural equation modeling: A second course* (pp. 269-314). Greenwich, CT: Information Age.

Gardner, H. (2013). *Inteligencias múltiples. La teoría en la práctica*. Barcelona: Paidós. https://bit.ly/2o4edi0

Gardner, H. (2012). *La inteligencia reformulada. Las inteligencias múltiples en el siglo XXI*. Barcelona: Paidós. https://bit.ly/2OWZf8Y

Gardner, H., Feldman, D., & Krechevsky, M. (Comps.) (2008). *El proyecto Spectrum: Manual de evaluación para la educación infantil (Tomo III)*. Madrid: Morata. https://bit.ly/2MqXbsW

Gomis, N. (2007). *Evaluación de las inteligencias múltiples en el contexto educativo a través de expertos, maestros y padres (Tesis doctoral)*. Alicante; Universidad de Alicante.

Gramigna, A., & González-Faraco, J.C. (2009). Learning with videogames: Ideas for a renewal of the theory of knowledge and education. [Videojugando se aprende: renovar la teoría del conocimiento y la educación]. *Comunicar, 33*(17), 157-164. https://doi.org/10.3916/c33-2009-03-007

Hsu, D., & Marshall, G.A. (2017). Primary and secondary prevention trials in Alzheimer disease: looking back, moving forward. *Current Alzheimer Research*, *14*(4), 426-440. https://doi.org/10.2174/1567205013666160930112125

Marín-Díaz, V., & García-Fernández, M.A. (2005). Los videojuegos y su capacidad didáctico-formativa. *Pixel-Bit*, *26*, 113-119. https://bit.ly/2P27D77

Marín-Díaz, V., López, M., & Maldonado, G.A. (2015). Can gamification be introduced within primary classes? *Digital Education Review*, *27*, 55-68. https://bit.ly/2xLZcqq

Oh, S.J., Seo, S., Lee, J.H., Song, M.J., & Shin, M.S. (2018). Effects of smartphone-based memory training for older adults with subjective memory complaints: a randomized controlled trial. *Aging & Mental Health*, *22*, 4, 526-534. https://doi.org/10.1080/13607863.2016.1274373

Prena, K., & Sherry, J.L. (2018). Parental perspectives on video game genre preferences and motivations of children with Down syndrome. *Journal of Enabling Technologies*, *12*(1), 1-9. https://doi.org/10.1108/JET-08-2017-0034

Prieto, M.D., & Ferrándiz, C. (2001). *Inteligencias múltiples y currículum escolar*. Málaga: Aljibe. https://bit.ly/2woWupk

Prieto, M.D. & Ballester, P. (2003). *Las inteligencias múltiples. Diferentes formas de enseñar y aprender.* Madrid: Pirámide. https://bit.ly/2NbyLQx

Quiroga, M.A., Román, F.J., De-La-Fuente, J., Privado, J., & Colom, R. (2016). The measurement of intelligence in the XXI Century using video games. *The Spanish Journal of Psychology*, *19*(89), 1-13. https://doi.org/10.1017/sjp.2016.84.

Sedeño, A. (2010). Videogames as cultural devices: Development of spatial skills and application in learning [Videojuegos como dispositivos culturales: las competencias espaciales en educación]. *Comunicar*, *17*(34), 183-189. https://doi.org/10.3916/C34-2010-03-018

Starks, K. (2014). Cognitive behavioral game design: A unified model for designing serious games. *Frontiers in Psychology, 5*(28). https://doi.org/10.3389/fpsyg.2014.00028

Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps.* O'Reilly Media, Inc. https://bit.ly/2w6oEWF