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DESIGN AND DEVELOPMENT OF A DIDACTICAL EDUGAME TO FOSTER SPATIAL THINKING

PROGETTAZIONE E SVILUPPO DI UN EDUGAME DIDATTICO PER PROMUOVERE LO SPATIAL THINKING

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Abstract

The paper presents the results of a research project, begun in 2014, aimed at creating a video game able to evaluating and fostering the development of spatial thinking, and more specifically, the ability of perceptual perspective taking (PT). The research, conducted by the University of Salerno in collaboration with the Collège de France, produced an educational video game, named "schoolcam", designed to assess and fostering the development of PT in students aged between 8 and 13 years. The results of the studies conducted (Di Tore et al, 2020) seem to support the validity of the game produced in evaluating the development of PT. The data collected in the experimentation phase led to a re-evaluation of the video game design, suggesting the need to implement new features, new forms of interaction and a new graphic style. This article will discuss the results of the experiments conducted and the changes to be made to the video game.

L'articolo presenta i risultati di un progetto di ricerca, iniziato nel 2014, volto alla realizzazione di un videogioco finalizzato a valutare e favorire lo sviluppo dello spatial thinkin, e più in particolare, della capacità di perceptual perspective taking (PT). La ricerca, condotta dall'Università degli Studi di Salerno in collaborazione con il Collège de France, ha prodotto un videogioco educativo, battezato "schoolcam", progettato per favorire lo sviluppo della PT in studenti di età compresa fra i 8 e i 13 anni. I risultati degli studi condotti (Di Tore et al, 2020) sembrano sostenere la validità del gioco prodotto nella valutazione dello sviluppo della PT. I dati raccolti nella fase di sperimentazione hanno inoltre portato ad una rivalutazione del design del videogioco, suggerendo la necessità di implementare nuove features, nuove forme di interazione e un nuovo stile grafico. Nel presente articolo saranno discussi i risultati delle sperimentazioni condotte e le modifiche che si intendono apportare al videogioco.

Keywords

Educational Technologies , edugames, spatial thinking, simplexity, inclusion

Tecnologie didattiche, edugame, spatial thinking, semplessità, inclusione

1 Stefano Di Tore: Author. Michele Domenico Todino oversaw the analysis of the literature relating to the frameworkon edugames. Lucia Campitiello oversaw the analysis of the literature relating to the framework

Introduction

The connection between space, cognition and learning is articulate, non-mechanical, in some areas still little investigated. The ability to have an overall vision of space (a coherent functional representation) is associated with the ability to consider the world in different ways, to change not only the point of view but also the interpretation of reality, the attribution of values, and to tolerate difference. The ability to change the point of view, socially or in terms of reality interpretation, seems linked to the ability of Visual Perspective Taking. Visual or Perceptual Perspective taking can be described as the ability to inhibit our self spatial point of view and adopt the point of view of another person (Di Tore, Aiello, Sibilio, Berthoz, 2020). This work is based on the acknowledgment that this ability is central in the teaching-learning process. Indeed, the scientific debate on the relationship between egocentric perception and spatial thinking has focused on two main factors. First of all, the age in which the individual, on average, abandons egocentric perception. The disagreement between the various positions is strong, and sometimes results in very distant conclusions (Piaget & Inhelder, 1948; Rochat, 1995). Moreover, the ability of perspective taking, when examined separately, does not seem to be sufficient to demonstrate one's capacity to have a coherent representation of space to the extent that points of view can be manipulated (Frith & De Vignemont, 2005). Latest research links overcoming egocentric perception with the capability of performing a mental rotation on oneself while maintaining an initial perspective of the environment (Berthoz, 2011). In line with the neuroscientific perspective of the perception-action process, which appears to be reversed with respect to the traditional paradigm, perception and action understood as a continuous process in which perception is a function of action, is structured for action, motivates and prepares it and not as distinct, sequential, discrete moments (Sibilio, 2012; Decety & Jackson, 2004; Decety & Lamm, 2006; Hommel et al, 2001). The generative core of this process is the body acting intentionally and purposefully. Scientific literature suggests that this ability is a milestone for the development of the individual's social skills (Piaget, 1972; Baron-Cohen, 2001; Sibilio, 2014), more specifically of empathy (Berthoz, 2011), and that its maturationhave a crucial role for the development of STEAM (Science, Technology, Engineering, Arts, and Mathematics) Competences. Piaget's studies had already shown how a correct development of the spatial perspective taking skill (PT) was a prerequisite for the acquisition of topological and Euclidean skills (Piaget, 1948), which are fundamental for a correct acquisition of the transversal school competencies of literacy and numeracy. Furthermore, according to various authors, the representation of space is a trans-nosographic trait, i.e. it seems to be a common factor to various pathologies and disorders not otherwise connected (Autism spectrum disorders, Learning disabilities, phobia, schizophrenia) and it represents one of the pillars of the "who-system", that is to say one of the first cognitive mechanisms of distinction between the self and the other, at the basis of the development of intersubjectivity. Even the internationals education systems seems to acknowledge that the development of this skill has a central role in training processes, as can be demonstrated by the numerous assessment tests, administered by INVALSI (in Italy) for primary and secondary school, which include specific tasks aimed at assessing the development of PT (Figure 1-2).

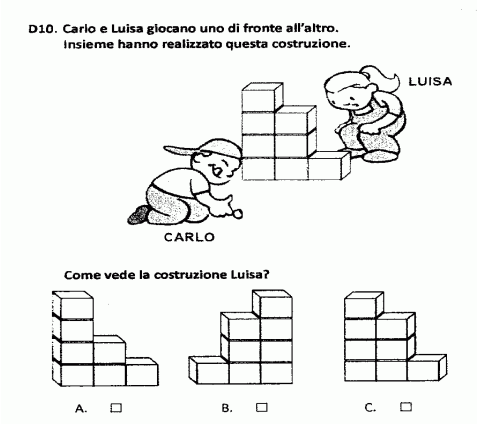


Figure 1: PT Task for primary school

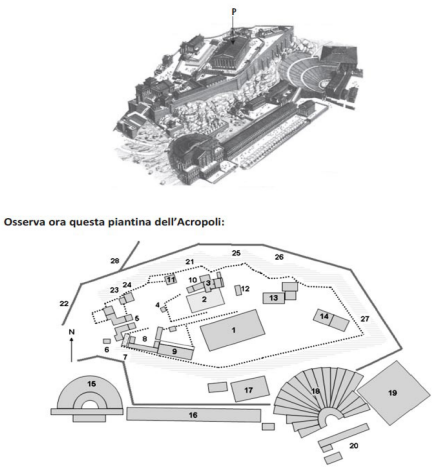


Figure 2 PT Task for secondary school

However, notwithstanding the fact that scientific literature acknowledges the significance of this topic for learning and personal development processes, and despite the fact that the Italian education system provides tasks aimed mainly at assessing the level of development of PT, studies and teaching methods specifically designed to promote an adequate acquisition of this skill are still scant. In this regard, it should be noted that, as stated in literature, there actually is the possibility to effectively train this skill (cox, 1977; Chase, 1983; Maguire, 2000, 2003; Dünser, 2006; Knoll, 2000; Rosen, 1974; Burns, 1979). In this perspective, the evolution of digital systems for the representation of space seems to offers valuable elements for the construction of inclusive educational tools aimed to fostering the development of Perspective Taking ability. Within this framework, the competences and the research strands already present in DISUFF with respect to edugame development and the studies on human-machine interaction, immediately suggested the use of digital technologies for gaming applied to the educational field (Unity 3d suite in particular) because they can create accurate, realistic, and interactive three-dimensional spatial reconstructions.

On the basis of these theoretical reflections, the first version of and edugame, named Schoolcam, was developed. Schoolcam is an edugame aimed at assessing the level of development of PT and mental rotation skills, as well as training visuospatial skills. The game was targeted for children from the age of eight to thirteen. It was developed in collaboration with the Laboratory of physiology of perception and action of the Collège de France and the faculty of psychology of the University of Neuchâtel (S. Di Tore, Aiello, Sibilio, & Berthoz, 2020), and it will be described below.

Schoolcam edugame

Schoolcam is an edugame aimed to asses and foster the development of Visual Perspective Taking in students aged between 8-13 years. It is developed in Unity 3d framework, it is a standalone microfost Winsows x64 software.

The game consists of three different tasks. The first measures the egocentric perspective taking ability, the second measure the allocentric perspective taking ability, the third measures Mental Rotation ability ,understood as an ability which is partially independent from PT (Hegarty, 2004; Kozhevnikov, 2001; Zacks, 2000, Wraga, 2000). The three tasks are described in further detail below:

- Task 1: In this activity the user is presented with a 3D classroom (figure 3). The screen

is divided into two frames. The frame above shows the 3D classroom through a semi-allocentric perspective (bird's eye view at an angle of 45°). The frame below shows the perspective of one of the students present in the frame above. The user is asked to identify to which student the view shown in the frame below belongs. Every time the user gives the correct answer, one point is awarded. No points are scored if the answer is wrong or no answer is submitted within 15 seconds.

Figure 3 : Schoolcam first task

- Task 2: In this activity a 3D classroom is presented (figure 4). The screen is divided into two frames. The frame on the left shows the 3D classroom through an allocentric perspective (bird's eye view at a 90° angle). The frame on the right shows the point of view of the student presented in the frame on the left. The user is asked to identify to which student the view shown in the frame on the right belongs. Every time the user gives the correct answer, one point is awarded. No points are scored if the answer is wrong or no answer is submitted within 15 seconds.
- Task 3: In this activity a compex 3D object is shown (figure 5). The screen is then divided into two frames. The frame above shows the 3D object from a specific perspective. Instead, in the frame below 4 objects are shown from different angles. Out of these 4, two show the same object shown in the frame above from a different perspective. The user must identify the two corresponding objects.

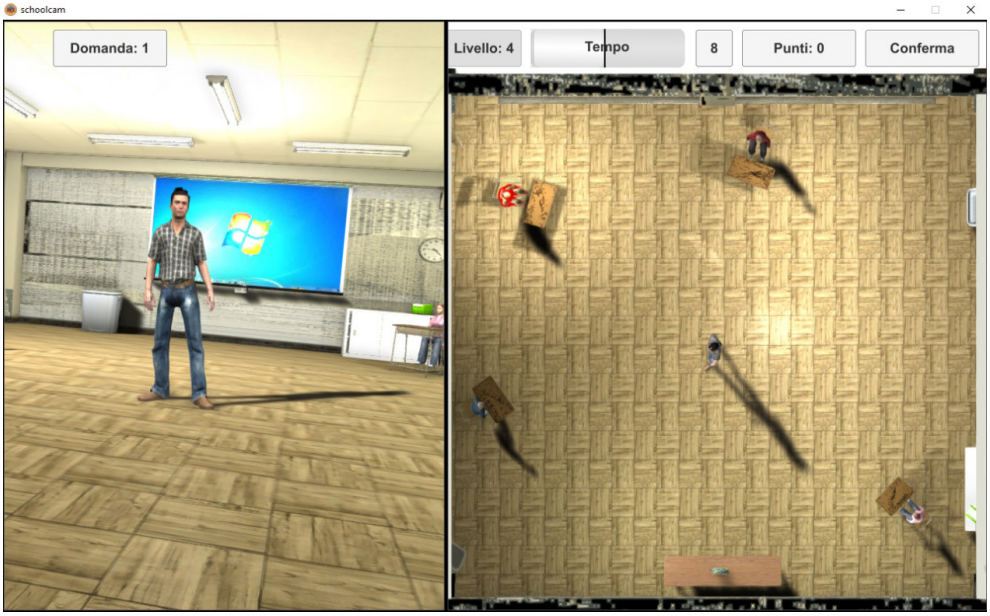


Figure 4: Schoolcam second task

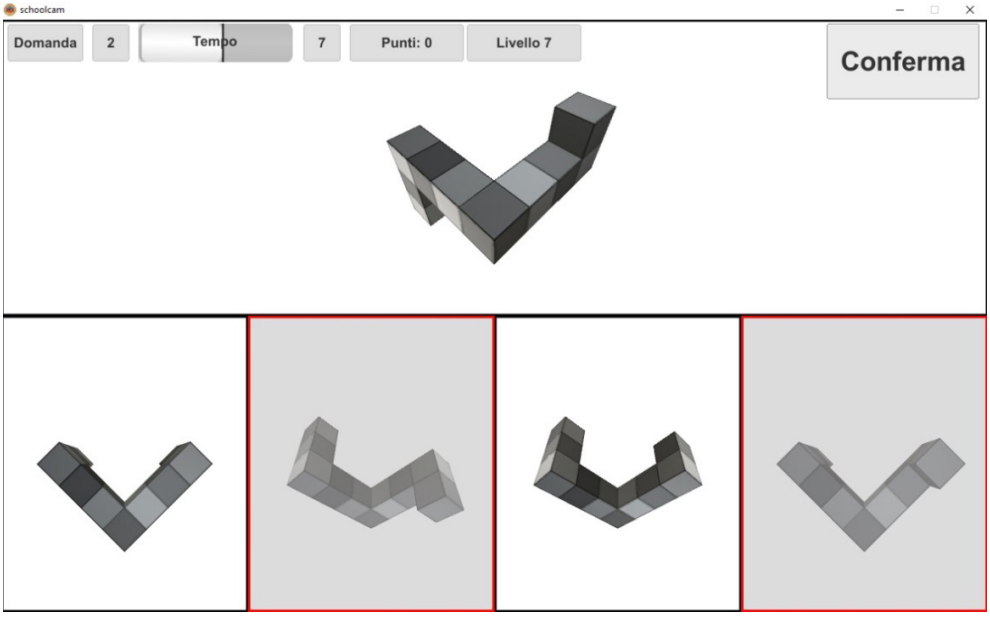


Figure 5: Schoolcam third task

Furthermore, the edugame proposes two gameplay modes. One is aimed at measuring the user's ability, while the second mode is used for training purposes. In the first mode, the sequence of the questions and the respective spatial configurations are always the same and includes 15 questions, whereas the training mode the spatial configuration and the students and objects' positions are changed randomly. In both cases, the difficulty level gradually increases.

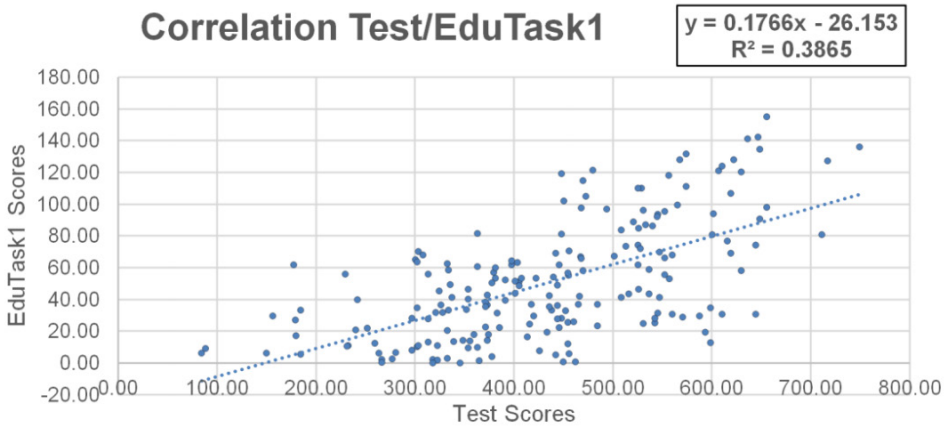
The number of students increases with every 3 correct answers given, reaching a maximum of 15 students. The time available to answer each single question is 15 seconds. The edugame also has an automised system for data collection. The following data is recorded and exported in XLS and CSV formats:

- the time taken to give each single answer;
- the score for each question;
- the sequence of answers given for each task;
- the total score;
- the total duration to complete each level.

A demo video of the tasks and some experimental sessions can be viewed at: https://www.youtube.com/watch?v=LJzO_u_8Ae8

Schoolcam v2.0

Schoolcam was administered to over 200 students aged between 7 and 13 years together with a set of paper and pencil test designed to evaluate the PT ability. The data analysis highlight that only the first task of the videogame presents a significant correlation with the results of the paper and pencil test as showed in Graph 1 and Table 1 (for more detail on tests, methodologies and statistical analysis used in the validation processes of the edugame, please see Di Tore et al, 2020).



Graph 1: Schoolcam /paper and pencil test score correlation

Regression Statistics		ANOVA					
R	0.62		*df*	*SS*	*MS*	*F*	*Significance F*
R squared	0.39	Regression	1	1228070.42	1228070.42	1.2E+02	5.0E-22
Adjusted R squared	0.38	Residual	191	1949675.04	10207.72		
Standard Error	101.03	Total	192	3177745.46			
Observations	193						

Table 1: Analysis of Variance.

Regarding the other two tasks of the edugame, the data seems to indicate that those are too hard for the selected user (Probably because of the age range of the selected user). Furthermore the scores obtained at the second & third task do not presents correlation with the paper and pencil tests scores. During the game was also collected suggestion of the user (students and teachers) regarding the design of the videogame and new features needed.

The most frequent suggestions are:

- Adapt the age of the virtual students avatar (16-18 years old) to the age of the users (7-13 years old)
- Insert also a female teacher
- Insert the same number of male and female virtual students avatar
- Reduce the number of the virtual students
- Change the graphical style of the edugame with a more cartoon style one
- Design the game to be used by a group and not by a single user
- Design the game to work with other Operative System
- Furthermore also other suggestions emerged from the direct observations of the operators that administered the game. Those are:
- Change the spatial assets of the game
- Insert Tutorials for teacher and expand the training sessions

The suggestion that emerge from data analysis is that the second and third task was unuseful regarding the aim of foster the development of PT in the age range selected. For this reason, the second and the third tasks will be discharged, and the game will focus on the first task that will be expanded.

Actually, is under development a second version of schoolcam that will include all this suggestions.

The new version of Schoolcam will be designd as a crossplatform game able to work directly online. A new graphical style is still in development (figure 6, figure 7).

Figure 6

Figure 7

When the new version will be fully developed, it will be tested administering Schoolcam V1 and this new version (Schoolcam v2) to check if a score correlation is presents. The aim of this phase will be to validate the V.2 of the videogame trought a comparison with the first, yet validate, version.

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