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# Digital games as creativity enablers for children

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This article deals with the issue of creativity and the way this can be supported within technology-enhanced learning experiments. Drawing on a long-term research project in the field of games-based learning, the article describes the methodology adopted during the in-field experiments carried out with the aim of developing young children's creativity. The results of the study, which are presented and discussed, confirm the hypothesis that digital tools can contribute to fostering creativity. As a matter of fact, the analysis of the available data showed that during the 3-year study, students' creative skills and attitudes appreciably increased, in particular those related to figuring out and enacting original solution strategies for the digital games at hand.

**Keywords:** creativity; games-based learning; digital mind games; creativity indicators; technology-enhanced learning; children

## 1. Introduction

Creativity has long since been recognised as one of the 'core values' of modern society (Faure 1972), and it is also considered by policy makers as a key factor to contribute to the development of the knowledge society (Markkula 2006, EC 2008a).

Creative thinking is considered a key competence for the twenty-first century (Beghetto 2007), and 'educating to creativity' is felt as a priority. Starting from 1972 when Edgar Faure put forward the idea that 'education has the dual power to cultivate and stifle creativity', the relationships between creativity and learning have been explored and, over the years, evidence has been provided by which there are techniques useful to trigger and enhance creativity (Csikszentmihalyi 1997, Nickerson 1999, Treffinger *et al*. 2002, Hewett 2005).

Coherently, creativity is currently regarded as an essential skill to be developed in the context of lifelong learning (EC 2008b), and in the New Taxonomy of Educational Objectives proposed by Anderson and Krathwohl (2001), it is considered the top educational objective to be met.

But what are the most suitable means to foster creativity? Nowadays it is broadly recognised that computer-based tools (henceforth, information and communication technology (ICT) tools) have a high potential to this end (Lubart 2005, Johnson and Carruthers 2006). This is true in the field of education for visual arts and music, as well as in other educational domains (Thomas *et al*. 2002, Edmonds *et al*. 2005); indeed, as argued by Craft (2005), creativity should not be considered the 'preserve of the arts alone'.

Looking more in detail at the actual employment of ICT tools to support creativity development, we see that, at present, considerable research efforts are directed towards designing and producing new tools expressly devoted to this end (Tzanavari *et al*. 2008, Sielis *et al*. 2009). For instance, new made-to-measure software tools have been produced, whose aim is to support creativity by relying on adaptive and context awareness learning techniques (Economides 2009).

This article, instead, concerns mainstream ICT tools (in particular digital games), which can be employed in a non-standard way, by 're-thinking' them as a means to support creative skills and attitudes.

In this article, a real long-term educational experiment carried out in the field of games-based learning (Bottino *et al*. 2007) is described. The main results of this experiment are presented, which actually confirm the idea that creativity can be, to some extent, fostered and enhanced by means of ICT tools.

The experiment was organised as follows:

- a number of 'creativity indicators' were defined by the authors of this article (Ott and Pozzi 2010)
- an educational context was chosen, where – thanks to an ongoing project – a number of classes of

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young children were engaged in learning activities based on the use of digital games
- a specific methodology (encompassing cognitive, meta-cognitive and affective aspects) was set to support and enhance students' creativity while using digital games
- a specific methodology was adopted to monitor children at play, which entailed selected 'observers' to assess students' performances and attitudes ('direct observation' method)
- data were collected and then analysed.

In the following sections, we describe how the idea of conducting the study emerged; then the experimental context is outlined; the research methods are presented and, finally, the results are discussed.

## 2. Background and general context of the study

Before starting the study reported in this article, the research team had conducted a number of research projects in the field of game-based learning. The main aim of these projects was that of helping primary school students develop strategic and reasoning abilities through the use of digital mind games, namely of those games that are strongly based on thinking skills (Bottino and Ott 2006, Bottino *et al*. 2007, 2009).

These games, which are generally based on a question-answer-feedback approach, are rarely regarded as 'creative tools'. The direct observation of children at work showed, instead, that a number of these digital mind games require a good level of individual originality in finding, imagining and figuring out solution strategies. As a matter of fact, during previous experiences, only some children had shown a peculiar and praiseworthy attitude to exploring and enacting original solution strategies, while others were absolutely unable to personally figure out different ways of solving the game.

Following the above-mentioned direct observations, it was decided that one of these contexts (which was, as mentioned above, primarily aimed at supporting children's reasoning skills) could be used to carry out a more specific investigation into the possibility of fostering those skills and attitudes, which were considered as a potential catalyst of creativity.

To this extent, since creativity is hardly a directly observable ability (de Klerk 2008) and is sometimes regarded as a 'complex issue, and difficult to describe' in terms of the specific underpinning constructs (Ferrari *et al*. 2009), a set of qualitative 'indicators of creativity' have been defined, which will be extensively detailed in the following paragraphs. As will be illustrated in the following, the proposed indicators were used by the 'observers' (researchers and teachers in charge of monitoring children at work) at a double level: to provide children, when needed, with ad hoc tutoring and support, oriented to helping them to figure out how to choose and adopt solution strategies for the games at hand and to monitor and assess their performance and attitudes.

### 2.1. *Participants and project lifespan*

The study was carried out in a primary school and involved two classes (selected by the school teachers on the basis of purely logistical criteria) for the duration of 3 years from third grade to fifth grade. The group of students involved in the study was, thus, made up of 40 children ranging from 8 to 10 years; they remained the same throughout the period, 26 were girls and the others were boys. Actually, one child dropped out, because he changed school, and three students were admitted in the subsequent years. Data concerning these four subjects were excluded from the analysis.

The research project was conducted by a research team comprising educational technologists, psychologists from the local health authority and primary school teachers from the school; the research team remained the same throughout the experiment.

### 2.2. *Tools*

In the framework of this educational experiment, 45 mainstream mind games were used by the students; by the term 'mind games' we refer to those games (such as Master Mind, Minefield, Battleship, Domino, Labyrinths, etc.), which require the user to exercise reasoning skills and strategies in order to solve specific problems (Muller and Perlmutter 1985). The adopted games, which are also called brainteasers or puzzles, can all be ascribed to the category that Prensky (2005) calls 'mini-games', that is 'games that take less than an hour to complete (often far less)' in order to fit with the time span of a typical single-class unit (Becker 2007). Their suitability to students of the target age had been tested in advance in a variety of school contexts.

### 2.3. *Experimental setting*

The children were divided into groups of five or six; each group took it in turns to attend a computer session of approximately 1 hour per week (over the 6 months of each of the 3 school years of the experiment). Each student played individually and, as a general rule, each game was used by the same student for two working sessions: the students were, then, engaged in repetitive play over time, thus tackling each game according to a multi-trial and multi-level approach (Garris *et al*. 2002).

## 3. Methodology

As the authors report elsewhere (Ott and Tavella 2010), the analysis of the results of the whole long-term project were mainly based on qualitative research methods (Holliday 2007).

In particular, the 'direct observation' research method was adopted (Herbert 1970), and, during the gaming sessions, each student was followed individually by a member of the research team (henceforth called 'observer').

The observers were in charge of monitoring student activities with the aim of both taking actions to support their creative skills and attitudes and assessing their performance and attitudes.

### *3.1. Methods adopted to assess students' creative skills and attitudes*

As already mentioned, observers were in charge of recording data related to students' actual performance (level of attainment of the educational objectives) and behaviour (a number of different behavioural aspects, including creative skills and attitudes).

The recording of data (related to both the students' performance and behaviour) was done by means of a specific 'monitoring sheet' (one for each working session) where the observers were required to score observable data, and to express personal opinions/ feelings, in the form of free notes.

Conveniently, the 'monitoring sheet' was divided into two parts: the former was devoted to containing data related to performance (scoring, difficulty level reached and level of attainment of the goals to be pursued) and the second dedicated to the recording of behavioural data (working approach adopted, enacted solution strategies, attention, motivation, etc.).

Data related to performance (first part of the sheet) were analysed by applying basic methods and tools for standard statistic analysis (Bottino and Ott 2006). The analysis of the 'free notes', in accordance with the 'grounded theory approach' (Glaser and Strauss 1967) began together with data collection and was done by means of the open coding framework offered by the Atlas.ti software (Muhr 2004).

With respect to the observation of students' behaviour (second part of the 'monitoring sheet'), first of all, the observers were asked to judge the actual ability of each student to imagine and enact original solution strategies. In particular, they were required to note down whether each student was:

- personally able (and willing) to figure out suitable solution strategies
- able to enact solution strategies, when suggested by the observers
- unable to personally find and even to enact those solution strategies that had been suggested by the observers.

In addition, the observers were also required to decide on the presence/absence of relevant creativity 'indicators'. Since creativity, as said above, is hardly a directly observable construct, a set of indicators had been defined by the research team (Ott and Pozzi 2010), based on the main literature in this sector concerning consolidated approaches already adopted in the educational area (Cave *et al.* 1995, Bainbridge Frymier and Houser 1999, Hui and Ngai Chun 2008).

As a matter of fact, it is widely acknowledged that creativity has to do not only with cognitive skills, but also with affective attitudes, as well as meta-cognitive abilities (Torrance 1974, Nickerson 1999, Treffinger *et al.* 2002); in this direction, the adopted indicators accounted for the three above-mentioned aspects: cognitive, meta cognitive and affective.

As to the *cognitive* aspects, three fundamental indicators were defined by referring to the New Taxonomy of Educational Objectives proposed by Anderson and Krathwohl (2001), where creativity is considered the top educational objective to be met:

- *Generating* (instantiated by actions such as: combine, estimate, compare, state, etc.)
- *Planning* (instantiated by actions such as: predict, infer, hypothesise, design, define, etc.)
- *Producing* (instantiated by actions such as: build, enact, apply, test, verify, etc.)

As to the *affective* aspects, two main indicators were considered among those mentioned by Rovai *et al.* (2009) in their review, namely those assessing the students' lively attitudes towards:

- *Receiving* (instantiated by behaviours, such as: be curious, be motivated, be frightened, etc.)
- *Responding* (instantiated by behaviours, such as: express joy, express disappointment, express fear, etc.)

As to the *metacognitive* aspects, following the recent works of Kim *et al.* (2009) and of Murphy (2008), three main indicators were considered, namely those related to the students' capacity of:

- *Monitoring* (instantiated by the attitude towards being aware of the global process enacted and of each single step made)

- *Regulating* (instantiated by the attitude towards controlling/adjusting the solution process)
- *Evaluating* (instantiated by the attitude towards: judge/appraise the outcomes)

A global number of eight indicators were thus established, which were included in the 'monitoring sheet'. For each student and for each gaming session, the observers were required to highlight the presence/absence of each indicator.

In order to facilitate the observers' role and task, they were provided with specific indications on the key points and the key features of each game where the ability underpinning each indicator could emerge and could, therefore, be more easily detected.

### 3.2. Methods adopted to support students' creative skills and attitudes

During the gaming sessions, as said above, observers were also in charge of taking appropriate actions to support the development of students' creative skills and attitudes, if needed and when needed. This creativity-oriented tutoring process was thus conceived to support students from three points of view: the cognitive, meta-cognitive and affective viewpoints. This is because the three aspects should be regarded as independent but synergic 'control levers', possibly leading to some kind of creative expression.

In this perspective, the observers were required to enact supporting actions in the three directions, and this was done by sharing a common methodology, which is briefly synthesised in the following.

As to the affective aspects, the psychologists of the research team were in charge of monitoring students actions and reactions (in particular reactions to failures) during the gaming session and to intervene when necessary with psychological help and incitement; in addition, once a month, they also had a personal interview with each student aimed at identifying preferences and general problems (if any) and at detecting the levels of self-esteem, satisfaction, tiredness or eagerness to continue with the experiment.

As to the task of supporting cognitive activities, observers were required to try, first of all, to help students develop solution strategies autonomously, subsequently to give them meaningful hints, orienting their thoughts and reasoning, then to suggest possible solutions strategies and, ultimately, to exemplify and ask students to reproduce what they had done.

Despite the type/level of cognitive help given, observers also sustained students from the meta-cognitive point of view. In this direction, the observers' role was mainly that of directing and supporting the students' reflections on the work done/to be done; moreover, they also supported the students' understanding of the concept itself of 'solution strategy' and of the differences between different possible solution strategies. The ability to personally judge the level of attainment of the objectives was also reinforced, and particular attention was devoted to fostering the identification and the comprehension of the role of specific interface elements.

## 4. Results

### 4.1. Ability to imagine and enact solution strategies

As to the part of the 'monitoring sheet' where observers were requested to evaluate the ability of each student to envisage original solution strategies for the game at hand, namely to distinguish whether students were: (A) personally able and motivated to imagine suitable solution strategies, (B) able to enact solution strategies suggested by the observer or (C) unable to enact suggested solution strategies; each student was classified in one of the above-mentioned categories by taking into account the proportion 'attempts made'/'successful attempts' at each of the five games (in the time allowed for each game). This information was then matched with the actual type of hint/help the observers had provided (codified in the observation sheet) in the two sessions in which each game was tackled. Each student was then finally ranked 'A', 'B' or 'C' according to the mean ranking he/she had obtained in the five games. As it will be explained in the following paragraphs, a significant consistency (stability) was noted throughout the gaming sessions for each child and for each game.

Figure 1 shows the main results coming from a total number of 3600 sheets compiled by the observers over the 3 years (40 students $\times$ 45 games – 15 $\times$ each year – each game used twice). While during the first year only 10 students (among the 40) resulted able to figure out a solution strategy[1] autonomously, the number increased to 17 in the third year of the experiment.

While the number of children who could not even apply suggested solution strategies remained almost the same through the 3 years, a considerable increment of children who became autonomous in personally finding a solution strategy was found, to the detriment of the group that was initially only able to apply suggested solution strategies.

The performances of each single student (ranked as 'A', 'B' or 'C', following the previously mentioned criteria) were tabulated and studied: they appeared to be basically self-consistent, which means that data collected for each student during the 3 years of the project were substantially coherent.

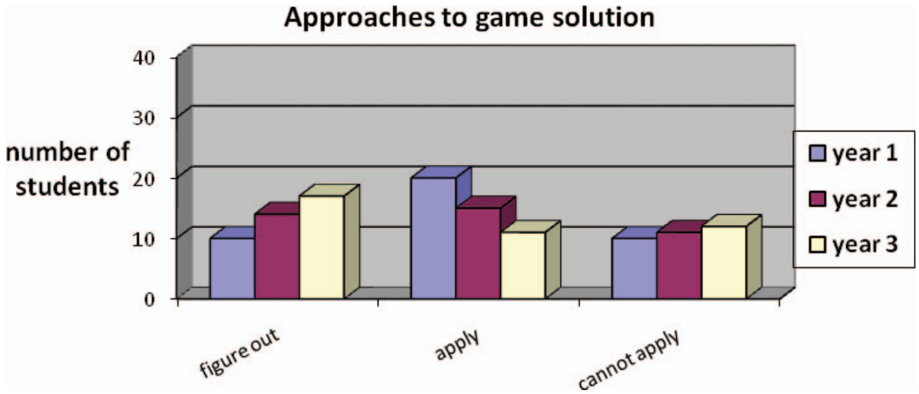


Figure 1. Number of students able to figure out/apply solution strategies.

To give an example of such coherence of data, in the following, we illustrate the results obtained by three students. In Table 1, the performances of Student 1 (S1), Student 2 (S2) and Student 3 (S3) are shown. Subject S1 in the first year of the experiment was ranked as A in 38% of the available sheets, ranked as B in 62% of the sheets and never as C; equally in the second and third year, he/she was never classified as C, and the A performance increased over the years with respect to B performances. Subject S2 in the first year of the experiment showed 51% of performances ranked as B and 49% ranked as C; even in the second year (s)he never performed at the highest level (A) but the number of B performances increased (72%) and C performances consequentially decreased; finally, during the third year, in 11% of the sheets (s)he also reached the A level, and (s)he also presented a significant number of B performances (69%), while C performances decreased to 20%. Subject 3, over the 3 years, was never ranked as A: as a matter of fact (s)he was ranked as B (respectively 16, 17 and 21% in the 3 years) and, mostly as C (respectively 84, 83 and 79% in the 3 years).

Subjects S1, S2 and S3 represent three different categories of students with different abilities as to figuring out creative solution strategies: in particular, S1 was always ranked as A and B over the 3 years, and S3 is the exact contrary: (s)he, indeed, over the 3 years, was predominantly ranked C, while S2 performances tended to increase, following the experimental actions.

The category of students exemplified by S2, namely those who, starting from being only able to apply suggested solution strategies, over the years, became able to figure out original solution strategies, was predominant.

However, reasonably enough, students' performances and their improvements should be looked at not only in the light of the use of digital games and of the received support, but also in the light of the fact that during the long-term experiment, they grew up, and they certainly had other significant experiences (both at school and outside), and this may also have had an influence on the increase in their creative attitudes.

Table 1. Percentage of performances of three sample subjects in the three ranks.

| | 1st year | | | 2nd year | | | 3rd year | | |
|---|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **A** | **B** | **C** | **A** | **B** | **C** |
| **S1** | 38% | 62% | | 45% | 55% | | 61% | 39% | |
| **S2** | | 51% | 49% | | 72% | 28% | 11% | 69% | 20% |
| **S2** | | 16% | 84% | | 17% | 83% | | 21% | 79% |

### *4.2. Creativity indicators*

Observers, as explained above, were also in charge of monitoring students' activities from the viewpoint of the eight creativity indicators.

As mentioned above, in order to guarantee homogeneity, the observers were provided with a detailed definition of each indicator, with examples and with specific indications showing where (and/or how) in each game the ability underpinning each indicator could better emerge.

Figure 2 illustrates the global percentage of the sheets that were considered 'positive' for each indicator (e.g. the indicator 'generating' was present in 26% of the sheets); it shows that indicators related to the cognitive aspects are represented the least; the affective sphere, instead, appears far more present, probably depending, to some extent, on the motivation/engagement shown by the children, despite their actual ability to perform the task at hand in a personal/original and effective way. Lastly, meta-cognitive indicators are in between the other two classes of indicators.

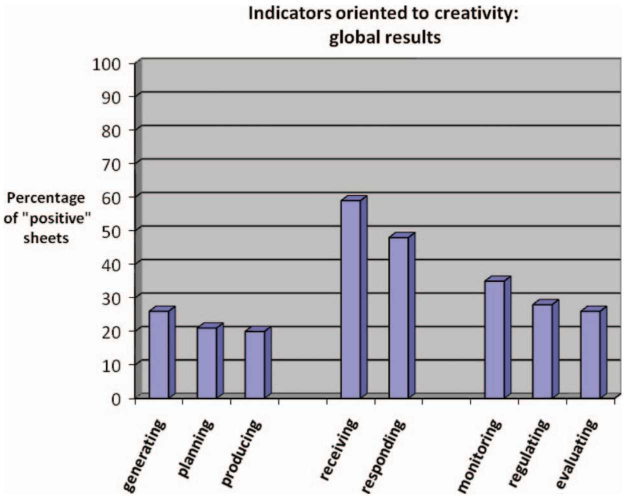


Figure 2. Percentage of positive indicators in the sheets.

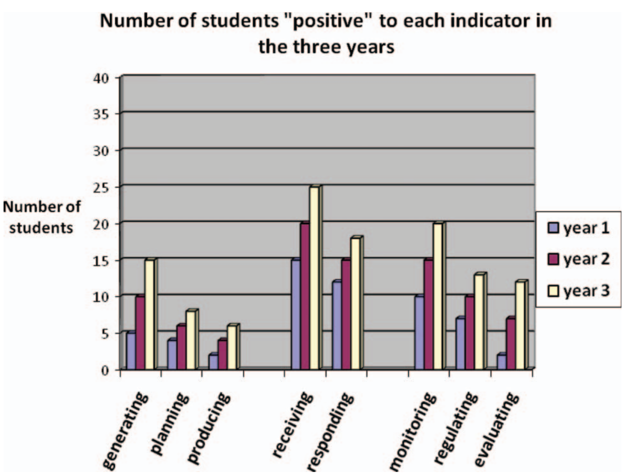


Figure 3. Indicators/students/year of the experiment.

Figure 3 reports on how many students (among the 40) were considered 'positive' for each indicator,[2] in each of the 3 years of the experiment. Such results, besides confirming previous findings, also show that the values related to the eight indicators increased year after year, namely that student performance improved, although moderately, in the subsequent years of the experiment.

Figure 4, instead, looks at the available data from the viewpoint of the games used; for each indicator, it shows the number of games that resulted 'positive' to each indicator in at least 50% of the sheets. Also, by assuming this perspective, a higher positivity to affective indicators (34% and 29%) with respect to the other two categories of indicators emerges.

A more in-depth analysis shows a fair consistency among games as to the observed positivity to indicators in that:

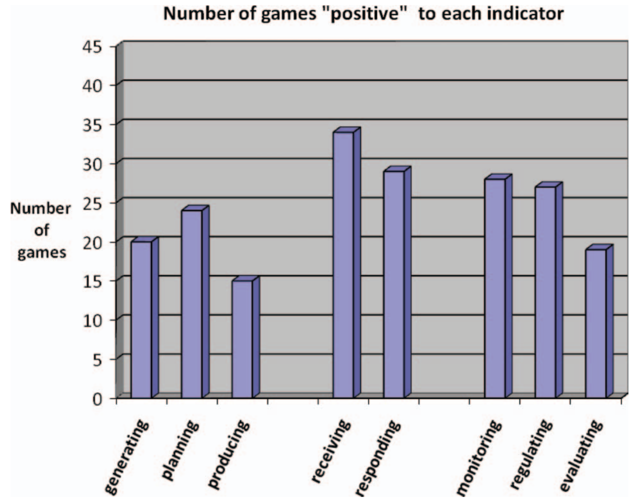


Figure 4. Number of games 'positive' to each creativity indicator.

- 22 games out of the 45 appeared to be positive to all the indicators in more than 70% of the sheets
- 15 games out of the 45 resulted positive to all the indicators in between 30% and 70% of the sheets
- 8 games out of the 45 were found positive to all the indicators in less than 30% of the sheets.

In addition to the data reported above, the free notes of the observers in the monitoring sheets confirmed that some of the actual features of the digital game at hand play a major role on this ground; in particular, it was noted that, while for some digital games only one effective solution strategy is available, for other games there are plenty of gaming strategies that can lead to achieving the solution more or less effectively. Direct observations and related comments revealed that such a difference highly affected the children's attitude towards looking for (and finding) a solution strategy.

According to these findings, the type of game at hand may influence the ability to evidence, trigger and foster the students' creative skills and attitudes.

## 5. Discussion and conclusions

This study has tackled the issue of 'children and creativity' in an educational perspective. It has investigated the actual possession of creative attitudes by primary school children (third to fifth grade, age 8–10), and it has also tackled the issue of whether digital mind games can be used to foster children's creative skills and attitudes.

As to the former point, namely whether children of the target age had shown creative skills and attitudes while facing simple problems like those entailed by mind games, the study has highlighted that:

- Creativity is a quality/ability/attitude which, at least at the age of the target population, is possessed by a minority of children. Data reported in Figure 1 show that only one-quarter out of the 40 students involved in the study, in the first year of the experiment, spontaneously showed a 'creative' attitude towards imagining, finding and ultimately enacting original solution strategies and, even in the following years, this attitude/ability was found in less than half of the target students.
- Children's personal attitudes and abilities seem to play a major role in respect to creativity development. Data presented in Table 1 indicate, for instance, that a significant number of low achievers did not show, over the years, considerable variations as to their creative attitudes.
- Nonetheless, overall creativity can be stimulated, and the endeavour of fostering creativity in learning contexts requires assuming a process-oriented approach (Naeve *et al.* 2008). In the 3 years of the experiment, an overall tendency towards increasing creative attitudes is shown by the whole group of students (Figures 1, 2 and 3); this datum, although a number of other variables (growth, additional educational/personal experiences, etc.) should be considered, suggests looking at creativity development as a process that can be supported, enhanced and fostered by means of suitable and well-focused educational actions.

As to the latter point, namely as to the issue of whether digital mind games can be regarded as educational means able to foster children's creativity, the study is a former effort in this direction, but further in-depth investigations and additional well-focused in-field experiments are necessary. As a matter of fact, the study suffers from a number of limitations, among which the most relevant one appears to be the lack of a control group. This is due to the fact that, as said above, the experiment on creativity was launched and carried out *in itinere* in the framework of a more general and wider experience focused on the educational use of digital mind games; at that moment, the control group adopted for the wider study (Bottino *et al.* 2007) had been already set up and was unfortunately unsuitable for the purpose of investigating creativity issues.

Despite this limitation, the findings of the study seem to advocate as a reasonable working hypothesis the fact that digital mind games can be considered powerful educational tools potentially able to foster creative thinking and, in particular, cognitive processes underpinning problem solution strategies and strategic decision making, at least for children of the target age. The study has also highlighted that, to pursue the aim, it is necessary for teachers/educators to enact appropriate educational actions (e.g. those illustrated in Section 3.1) and to choose appropriate digital games: as shown in Figure 4, in fact, the type of educational digital tool adopted cannot be considered as neutral as to the ability of supporting creativity development and a number of specific design and interface features are to be considered key to this end.

Overall, we claim that an alternative viewpoint can be taken to look at the educational potential of digital mind games. As a matter of fact, to date, these games have been merely regarded as 'brain training games' (Howard-Jones 2009), that is games able to improve cognitive functions by exercising the brain in a very mechanical way and by engaging the users in a sort of 'brain gym' to help the brain to better deal with specific cognitive tasks, mainly those largely grounded on working memory. Data and findings of this study indicate, instead, that further well-focused research efforts are needed to establish whether using digital games and supporting young children in finding original solutions to the games may also contribute to developing their creative skills and attitudes.

Lastly, the reported experience, which was conducted exclusively in the field of digital games, highlights the necessity to look also at other mainstream/standard educational digital tools, and to further investigate the possibility to use them as potential creativity enablers.

## Notes

1. Children were considered able to imagine and enact a solution strategy if they were ranked A in over 60% of the monitoring sheets compiled.
2. This means that they were considered as 'positive' in at least 80% of the sheets compiled for their performance after all the game sessions.

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