# Can elementary school students really benefit from using video games at school?

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## ABSTRACT

*Can playing video games improve expected learning outcomes for elementary school students? To address this question, we examined relationships between the knowledge and competencies that students developed through video gaming and the common core of knowledge and skills covered in France's education competency framework. We used an experimental design to investigate elementary school students who played a serious video game. The results reveal associations between playing Food Force and the key competencies described in the competency framework, and more particularly, that this type of serious gaming can help students develop these key competencies.*

## KEYWORDS

*Serious game, learning, knowledge, skills, elementary school*

## RÉSUMÉ

*La pratique du jeu vidéo amène-t-elle à des apprentissages officiellement attendus à l'école primaire? Pour répondre à cette question, nous avons interrogé le lien entre les connaissances et les compétences développées par la pratique d'un jeu vidéo et celles officiellement attendues en contexte scolaire. Pour cela, une démarche expérimentale a été mise en place auprès d'élèves en école primaire que nous avons fait jouer à un jeu sérieux. Nos analyses confirment qu'un lien existe entre pratique du jeu sérieux et référentiel de compétences et surtout que cette pratique amène à des apprentissages officiellement attendus à l'école.*

## MOTS-CLÉS

*Jeux sérieux, apprentissages, connaissances, compétences, école primaire*


## Introduction

Can children really learn by playing? And can children play as they learn? These provocative questions have nagged at generations of researchers and agitated the thinking of countless writers, philosophers, educators, and other pundits. Some authors, such as the communication anthropologist Hall (1984), contend that "*play and learning are intimately intertwined*". This idea of the cultural significance of play recalls the proposition of Comenius, as cited in Wulf (1999), whereby play is a mimetic process that makes the world visible to children. Rousseau, cited in Duflo (1997), grants play a central place in child development, as does the psychoanalyst Winnicott (1975), who views play as a growth factor for children: the imaginary world of play allows the child to make the leap into the world of cultural experience. Playing also fosters social ties, integration into society, and communication with others.

Now, as digital technologies continue to spread throughout classrooms and transform learning spaces (Devauchelle, 2012), we must consider the real educational impacts. Will they have a positive influence on what we think of as traditional learning? And what happens when they are used for classroom teaching? Do students learn differently? On this topic, a number of studies have identified a variety of benefits for learning (Jones, 1998; Shaftel, Pass & Schnabel, 2005; Barmeyer & Franklin, 2016). With respect to video gaming, authors frequently invoke Csikszentmihalyi's (1990) flow theory. Flow, also called the zone, is the mental state of operation that occurs when a person is fully immersed in an enjoyable activity, and video gamers can experience this kind of energized focus. This flow state is remarkably conducive to learning because gamers concentrate intensely on the game and are consequently free of outside distractions.

In this article, we present the results of a study conducted in France. The aim was to examine potential associations between video gaming and the expected learning outcomes set forth in the competency framework (i.e., a set of key competencies) established by France's Ministry of Education (hereinafter, the Ministry, ministerial). The main objective was to determine the impact of video gaming on the expected learning outcomes, or the key competencies, in elementary school students. First, based on the anthropologist Hall's (1984) intercultural communication approach, we identified relationships between video gaming and the key competencies in the competency framework. To do so, we considered the video game as a cultural system, according to Hall's cultural language and communication symbol system. We then broke the video game down into elements, sets, and themes. This level of analysis allowed obtaining high granularity (i.e., personalization) with respect to the competencies that were mobilized during gaming, along with their relationship to the key competencies in the framework.

We then applied the analysis to the video game called Food Force (WFP, 2006), a serious, "humanitarian" game designed to raise children's awareness of the battle against global hunger. We found a number of correspondences between Food Force and the key competencies. Next, we related the key competencies to the competencies that are mobilized by playing Food Force. Table 1 below presents some examples.

**Table 1**

*Activity: "Acquire knowledge in diverse scientific disciplines and apply it to various scientific situations and current life settings" and the relationships with Food Force*

| KEY ELEMENTS OF MATHEMATICAL, SCIENTIFIC, AND TECHNOLOGICAL LITERACY | | | |
|---|---|---|---|
| **Key competency** | | | **Food Force** |
| **Activity** | **Area of application** | **Operational level** | **Relationship to the game** |
| Acquire knowledge in diverse scientific disciplines and apply it to various scientific situations and current life settings | Human biology (health, hygiene, nutrition) | Hygiene and health: the beneficial or harmful effects of our behaviors, particularly in terms of sports, nutrition, and sleep | All the missions in Food Force convey the message that drought has led to acute shortages of water, which are particularly destructive for people and livestock, leading to illness and death.<br>At the same time, when people lose their animals, they have no money to buy the food that is available for sale. Lack of food also leads to illness and death. The overall aim of Mission 2 is to "deliver food to the millions of hungry in the world!" Besides providing emergency food assistance to a hunger zone, it is important to understand what kind of food is required. "It's all about nutrition." Students learn about essential foods and then try to find the right combination of these foods so they can provide a nutritious and balanced diet to endangered populations, and at low cost. |

Based on our analysis of the relationships between the elements of Food Force and the key competencies, and following a number of trial games, we selected Food Force for our experimental study.

Second, we used an experimental approach to confirm these relationships in young video gamers. We describe the experimental part in detail below.

### *Research question*

Schools generally have, as their stated mission, to teach what is needed for the present and for the future (Wulf, 1999, p. 25). The formal education that schools provide is usually structured into levels, or grades, which students must pass in order to complete a particular education program. Being responsible for developing the common knowledge, schools therefore play a leading role in society (Jacobi, 2001, p. 169). Moreover, in order to compare and harmonize learning outcomes, principles and frameworks must be established (Rey, 1996, p. 29). This ensures that student learning outcomes are guided by a common vision, or a framework that is suitable for everyone, but into which each student must fit, at least until they have completed their compulsory schooling. The school is therefore responsible for the dissemination and acquisition of knowledge and competencies according to common definitions and standards (Schugurensky, 2007). In addition, in France and the majority of countries around the world, education systems are structured as levels through which students advance in a progressive and orderly manner (e.g., preparatory class, middle class, sixth grade).

Nevertheless, education is not the sole prerogative of schools. Learning also takes place outside the school, in the multitudinous aspects of daily life (Brougère, 2002, 2007, 2009a, 2009b; Brougère & Bézille, 2007). This kind of learning can occur while watching television (Pain, 1990), through family interactions (Reboul, 1989), when playing sports and games (Roucous, 2007), or when hanging out with friends (Delalande, 2009). This is known as informal learning. Among the many ways to acquire informal learning, educators frequently mention gaming. Gaming has been variously described as a voluntary, free, imaginary, uncertain, second degree, and rule-guided learning activity (Huizinga, 1951; Caillois, 1958).

Today, as information and communication technologies (ICT) become the "new normal" for teaching and learning practices (Ontario Public Service, 2016), we must think about what tools to use and which objectives they can help achieve. Among these new digital tools, there is one that particularly caught our attention, and what is more, it represents the largest cultural industry worldwide: the video game. It has been demonstrated that gaming contributes to improvements in several aptitudes, including sociability, cooperation (Nachez & Schmoll, 2003), and socialization (Greenfield, 1994), and that gaming can develop student motivation (Plass et al., 2013). Moreover, as Gee (2003) argues, video games can be highly beneficial because they are motivating, and unmotivated students do not learn much. According to Gee (2005), video games allow players to assume a virtual role. This way they can imagine situations, understand and make sense of things, and test the consequences before acting in the real world. Thus, if an appropriate video game is "embedded inside a well-organized curriculum" (Gee, 2005), it can foster "deep learning" that transfers to other knowledge areas.

Mitchell and Savill-Smith (2004) point to a "firmly entrenched" computer gaming culture in youth, and warn us that excessive use could have negative effects on social behavior. At the same time, they identified several benefits of gaming for learning:

among others, through their seductive appeal they engage students; they motivate via fun, challenge, and instant feedback; they provide an immersive experience; they sustain interest; and they can handle enormous amounts of updatable content.

Hochet (2011) found that video gaming helped students understand history and geography. He contends that gaming has strong teaching and learning potential because it allows diverse types of assessment. For example, students can visualize concepts in terms of architectural spaces that they build in real time (p. 107). Moreover, the rapid feedback loops enable students to "correct" themselves through trial and error (p. 108). Video games can therefore be a rich source of academic support (p. 107).

In addition, commercial games such as Minecraft and Assassin's Creed (Spring, 2015; Boutonnet, 2016) can be used to support certain academic competencies, and this has become increasingly common practice in schools.

Consequently, we decided to examine the use of video games, and more particularly the use of serious games, to assess the learning dimensions of gaming. As Michael and Chen (2005) remind us, "a serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment". For many years, video gaming was not a widespread practice at schools. However, a shift is underway. Recently, Minecraft and other popular games such as Civilization (Lee & Probert, 2010) and Assassin's Creed have entered the arena.

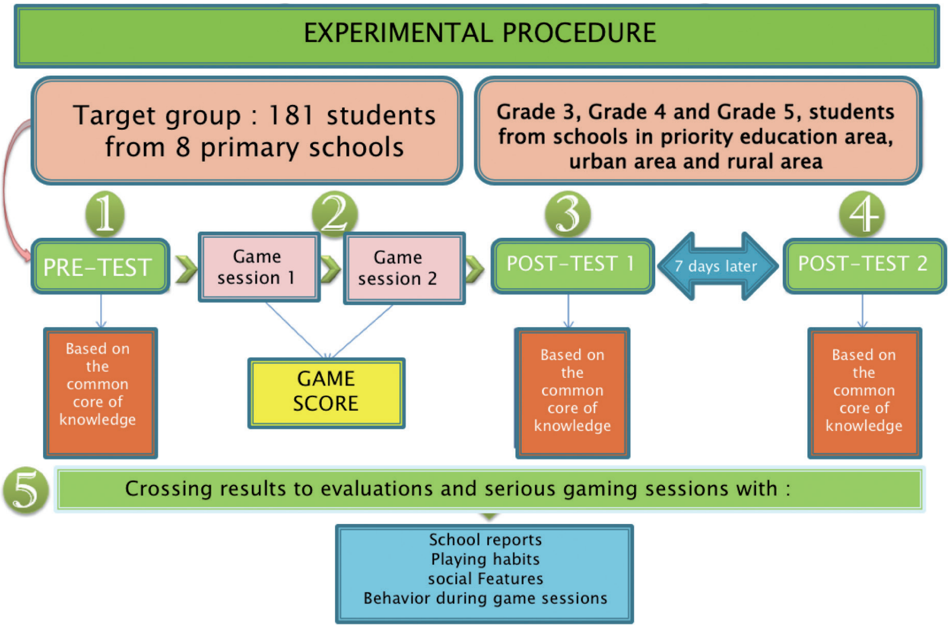
We therefore sought to determine the extent to which video gaming at school, and more particularly, playing a serious game, could generate or improve expected learning outcomes. To do so, we used an original research approach, which we describe below de part, as games are really still rarely used in school settings for educational purposes.

## Method

Once we had identified certain correspondences between video gaming and the key competencies in the competency framework, we developed and implemented an experimental procedure (illustrated in Figure 1) to determine whether video gaming can result in tangible learning outcomes for players.

We conducted a pre-assessment of the students' key competencies based on the ministerial framework. In France, in order to complete their compulsory schooling, students are expected to acquire a common core of knowledge and skills, or the set of key competencies that are defined in the national education competency framework. We therefore focused on these key competencies. The students then played two sessions of Food Force and were subsequently re-assessed. Seven days after the gaming sessions, we assessed the students once more to measure learning retention. The pre-assessment was meant to determine the students' learning status before gaming. Using a different set of assessment items, we then reassessed their learning status after the gaming sessions. The items in the second set were derived from those we identified in our game analysis based on Hall's (1984) approach. All the assessments were conducted with reference to official Ministry assessments, assessments in current elementary school manuals (for middle class level 2), and the schools' key competency assessment guides.

**FIGURE 1**




*Schematic representation of the experimental procedure*

We used paper and pencil assessments. Items were included to assess reading, writing, comprehension, calculation, spatial awareness, and geography. All items were based on correspondences we identified between the gaming elements and the key competencies, according to Hall's (1984) cultural coding system. The purpose was to relate the assessments to France's official framework of key competencies, as described in the school manuals and assessment guides. Table 2 presents the assessed items.

It is worth mentioning that the three assessment questionnaires were verified and validated by practicing teachers to ensure reliability. Prior to assessment, we administered a pencil-and-paper questionnaire to the students to gather information on individual characteristics (age, sex, school level, favorite subjects, favorite video games, weekly gaming frequency) so we could cross these data with the gaming and learning results.

**TABLE 2**

Assessed items

| |
|---|
| Item 1 – Reading comprehension |
| Item 2 – Text-response questions |
| Item 3 – Vocabulary |
| Item 4 – General knowledge |
| Item 5 – Understanding acronyms |
| Item 6 – Fill-in-the-gap texts |
| Item 7 – Writing |
| Item 8 – Hygiene and health |
| Item 9 – Scientific and technological culture: Issues of human activity |
| Item 10 – Problem solving |
| Item 11 – Mathematics |
| Item 12 – Geometry |
| Item 13 – Spatial awareness |
| Item 14 – Landscape analysis |
| Item 15 – Map reading |
| Item 16 – Graphs |
| Item 17 – Knowledge about the game |

### *Food Force: the Game*

Following the initial student assessment, the serious game Food Force was selected for its realistic scenarios and appealing gaming features, for the fact that the game was suitable for our research objective, and above all, for the strong educational potential of the narrative theme. This strategy video game was conceived jointly by the World Food Programme (WFP) and the United Nations. The first "humanitarian" game to be developed, it was intended to familiarize children aged 8 to 13 years with the battle against world hunger. The scenario is a fictional island called Sheylan located in the midst of the Indian Ocean. Players must carry out six missions in all. The overall objective is to provide food assistance to the inhabitants, who are suffering the damaging consequences of drought and civil conflict. The immediate goal is to put together the correct combination of food items and deliver them safely to the population. The long-term goal is to get the people back on their feet by supporting development projects so that they can feed themselves and maintain their health. The game was launched by the World Food Programme (WFP) in 2006 and produced by Ubisoft®. According to Neil Gallagher, WFP's Director of Communications, the game is meant to "generate kid's interest and understanding about hunger, which kills more people than AIDS, malaria and tuberculosis combined." It was designed to provide a "fun and action-packed alternative" to the gratuitously violent games that children are so frequently exposed to (World Food Programme, 2006).

### *Study participants*

We examined school children aged 8 to 13 years. We selected schools located in different environments: urban, rural, and priority education areas. The aim was to cover a wide range of students and to potentially observe different uses and learning outcomes across schools and socioeconomic settings. Our final sample comprised 11 classes containing 228 students, with 166 in middle class 2 (MC2), 51 in middle class 1 (MC1), and 11 in elementary school 2 (EC2).

### *Method and data collection instruments*

All the assessments were corrected and coded to obtain a score out of 100 points. The classroom gaming sessions by the experimental group were videotaped and sound-recorded for analysis of the students' statements and conversations. All recordings were analyzed using Actogram Kronos 2. Students' game scores were recorded for each session. We also analyzed the students' academic grades (1st, 2nd, and 3rd term of school year 2012–2013) to categorize their academic performance. Table 3 summarizes the data collection.

**TABLE 3**

*Summary of collected data*

| DATA SOURCE | COLLECTED DATA | DATA TYPE | DATA PROCESSING |
|---|---|---|---|
| Students' academic scores | 8 classrooms; 165 students | Paper and digital tests | Coding and categorization |
| Video Game performance – sessions 1 and 2 | 181 students | Scores | In database |
| Video recording - behavior | 63 videos (40 minutes to 1 hour) | Video | Actogram Kronos software |
| Video recording – game – players' actions | 130 videos (40 minutes to 1 hour) | Video | Actogram Kronos software |
| Pretest – Experimental Group | 181 tests | Paper tests: 16 items | Paper test design. Assessment guide design. Test correction |
| Post-test 1 – Experimental Group | 180 tests | Paper tests: 17 items | |
| Post-test 2 – Experimental Group | 160 tests | Paper tests: 17 items | |
| Post-test 1 – Control group | 53 tests | Paper tests: 17 items | School session design. Paper test design. Assessment guide design. Test correction. |

Once the students had undergone the preliminary assessment, they were invited to play two one-hour sessions of Food Force. All classes were divided into two parts to accommodate the size of the schools' computer rooms. In France, elementary schools rarely have more than 15 computers available at a time. One part of the class played the video game for the first hour, and the second part played for the second hour. We gave the same guidelines to all parts of all classes at all schools. In particular, we asked the students not to remove the educational videos between missions (i.e., they should not proceed to the next step).

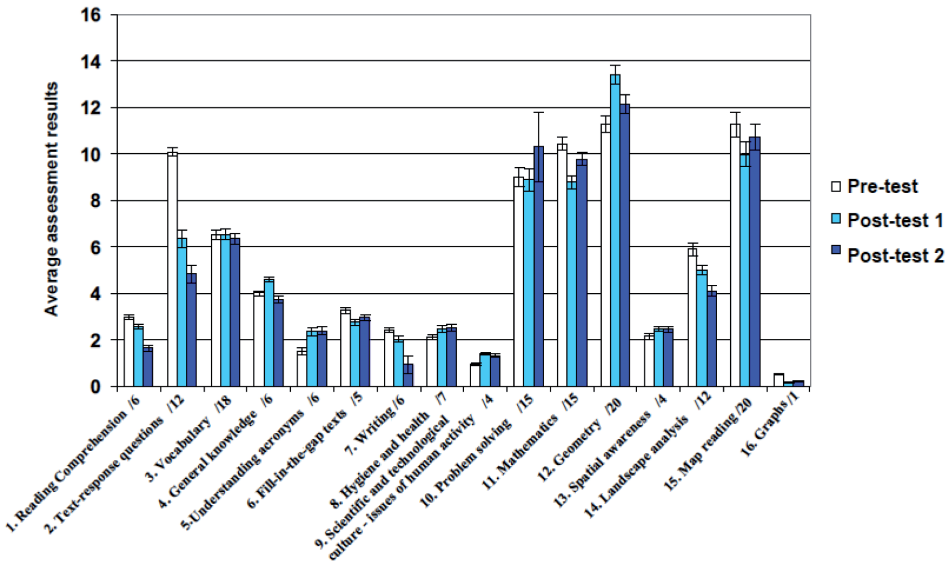
## Results

We present here the results and main conclusions.

### *Development in some learning areas*

Figure 2 presents the students' average scores for the three assessments.

**Figure 1**




*Average scores on each item for the pre-assessment, post-assessment 1, and post-assessment 2*

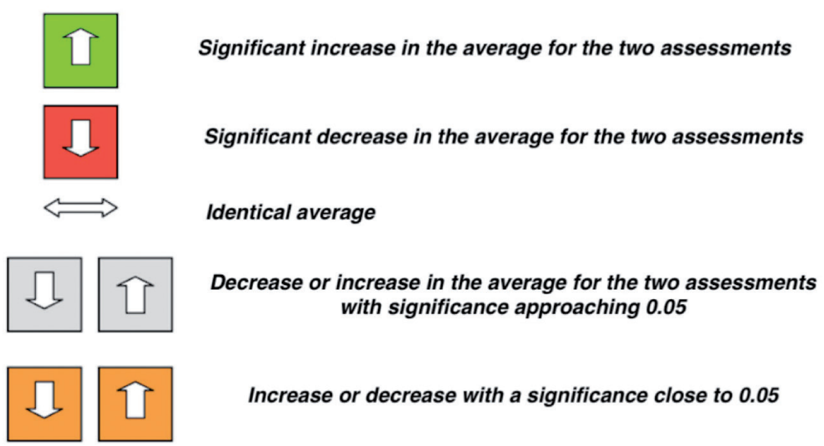
We note that after playing Food Force, the students made progress on some of the assessed items, with significant progress on items 4 (general knowledge), 5 (understanding acronyms), 8 (hygiene and health), 9 (scientific and technological culture – issues of human activity), 12 (geometry), and 13 (spatial awareness). Gaming therefore appears to have had a short-term effect on these items, indicating development in some areas of the key competencies.

The above-mentioned items are associated with key competencies 3 (the main elements of mathematics and scientific and technological culture), 4 (mastering common information and communication technologies), and 6 (social and civic skills) for level 2 of the competency framework. Because the items were measured on different scales, we mention the scale for each item. In effect, the items do not contain an equal number of questions, so in order not to have to transform the collected data, we decided to retain the original, unadjusted scales.

Due to the presence of several disparities, we used paired sample t-tests to compare item averages. This allowed us to compare two groups of measures for the same sample of students and at two assessment times.

We used SPSS for the analysis. Table 4 presents the variation between assessments for all items. For greater clarity, we used a color code (see Figure 3 below) to highlight significant and nonsignificant results. Next, we present the quantitative analysis results.

**Figure 3**




*Interpretation codes for Table 4*

We see that items 1 (reading comprehension), 2 (text-response questions), 6 (fill-in-the-gap texts), 7 (writing), 11 (mathematics), 14 (landscape analysis), 15 (map reading), and 16 (graphs) show significant decline. In contrast, items 4 (general knowledge), 5 (understanding acronyms), 8 (hygiene and health), 9 (scientific and technological culture – issues of human activity), 12 (geometry), and 12 (spatial awareness) show significant improvement between pre-assessment and post-assessment 1.

**Table 4**

*Increasing and decreasing trends for items between assessments. PRE–PA1: Pre-assessment compared to post-assessment 1; PRE–PA2: Pre-assessment compared to post-assessment 2; PA1–PA2: Post-assessment 1 compared to post-assessment 2*

| Assessed items | PRE – PE1 | PRE - PE2 | PE1 - PE2 |
|---|---|---|---|
| 1 – Reading Comprehension | ↓ | ↓ | ↓ |
| 2 - Text-response questions | ↓ | ↓ | ↑ |
| 3 - Vocabulary | ↔ | ↓ | ↓ |
| 4 – General knowledge | ↑ | ↓ | ↓ |
| 5 – Understanding acronyms | ↑ | ↑ | ↓ |
| 6 – Fill-in-the-gap texts | ↓ | ↓ | ↓ |
| 7 - Writing | ↓ | ↓ | ↓ |
| 8 – Hygiene and health | ↑ | ↑ | ↑ |
| 9 – Scientific and technological culture - issues of human activity | ↑ | ↑ | ↓ |
| 10 – Problem solving | ↓ | ↓ | ↑ |
| 11 - Mathematics | ↓ | ↓ | ↑ |
| 12 – Geometry | ↑ | ↓ | ↓ |
| 13 - Spatial awareness | ↑ | ↑ | ↓ |
| 14 – Landscape analysis | ↓ | ↓ | ↓ |
| 15 - Map reading | ↓ | ↓ | ↑ |
| 16 - Graphs | ↓ | ↓ | ↑ |
| 17 – Knowledge about the game | | | ↑ |

### *A potential explanation for the learning*

This serious, humanitarian game appears to have affected several areas of the key competencies. This suggests that the competencies acquired by playing Food Force were transferred to and reinvested in the students' academic competencies, as reflected in subsequent assessments. This concurs with Rey's (1996) concept of transversal skills, or cross-disciplinary competencies. We designed our experimental approach so that the students would have to resolve problems in the game that closely resembled problems that were presented in the assessments. This way, they could re-utilize their problem-solving skills in the post-assessment.

For example, for item 3 (spatial awareness), the students drew on the opportunities that Food Force provided to (virtually) experience travel and action and reinvest the knowledge in their written assessments.

Table 5 presents an example of the progress made by students in terms of competency 3: the main elements of mathematics and scientific and technological culture. Figure 4 presents an example of how this competency was assessed.

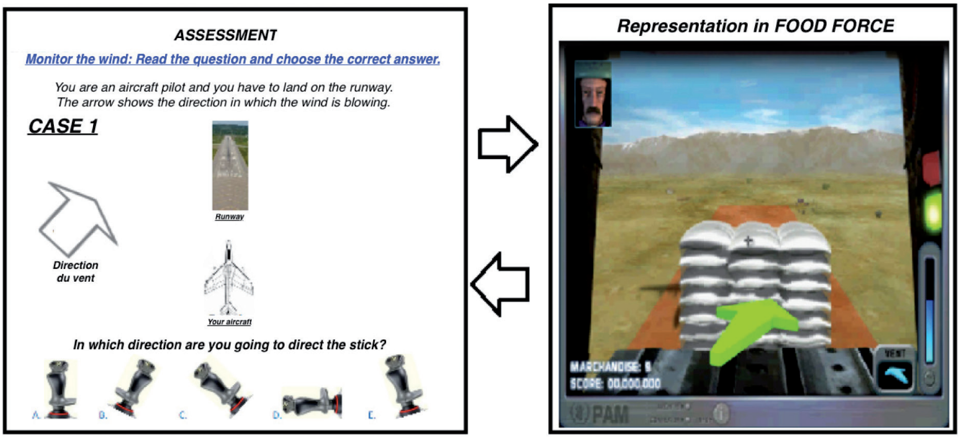
**TABLE 5**

*Progress made by students on key competency 3 after playing Food Force*

| Key competency | Target activity | Framework item | Item description | Official assessment indicator | Assessed item |
|---|---|---|---|---|---|
| Competency 3 – The main elements of mathematics and scientific and technological culture | Use knowledge in diverse scientific disciplines and apply it to various scientific situations and life settings | The human body: functioning and health | Hygiene and health: the beneficial or harmful effects of our behaviors, particularly in terms of sports, nutrition, and sleep | Students can make objective observations in order to characterize diverse types of behavior that are desirable or harmful for health and discuss the consequences | 8 – Hygiene and health |
| | | Use scientific knowledge to understand issues related to the environment and sustainable development, and take appropriate action | Use scientific knowledge to understand and take appropriate action on issues arising from human activity and the environmental consequences. | Students must apply their knowledge to various subject areas (notably, science, geography, and history) | 9 – Scientific and technological culture – Issues of human activity |
| | Geometry | Recognize, describe, and name common plane and solid shapes | Recognize, describe, and name common geometric shapes: square, rectangle rhombus (diamond), triangle (and the different types), parallelogram, circle | Recognize the axes of symmetry for a shape drawn on graph paper or blank paper. Describe shapes using the correct terms and the correct spelling (if written) | 12 – Geometry |
| | Geometry | Situate oneself in space | Use maps, plans, diagrams, and a system of coordinates | | 13 – Spatial awareness |

Figure 4 illustrates an example of an exercise used to measure spatial awareness in the paper assessment. This exercise is very similar to what the students were asked to do in one of the Food Force missions.

**FIGURE 4**




*Representation of item 13 in the assessment and in Food Force*

In addition, the game provided insights into real-life situations that enriched the students' semantic memory, enabling them to contextualize their knowledge and deepen their understanding (Lieury, 2010). This could explain why the students showed progress on certain items. Is it possible that the competencies that were represented in the game encouraged the development of certain learning areas?

To respond to this question, we re-examined all the items that showed progress and related them to the Food Force content. We wanted to explore how these particular items were represented in the game so as to understand the strong influence on learning outcomes. As Samuelle Ducrocq-Henry (2011) reminds us, the "contextual affordance" of an activity environment is one of the conditions that can foster new types of experience-based learning.

We note that all the items that showed improvement between pre and post-assessment are represented in Food Force in three different aspects: in the amusing animations, in the depictions of the missions, and in the players' manipulations. In fact, all the items are generated by the players' actions, and not just by the presented animations. Here, we should make an important distinction between playing a video game and passive viewing of images: we must underscore the fact that the combination of these three aspects of the video game substantially enhances the player's learning experience. Thus, it appears that for a video game to make a real contribution to learning, all its aspects should be planned with the learning objectives in mind.

These would include the characters, features, backgrounds, situations, and gaming moves, among others.

Indeed, only item 5 (understanding acronyms) shows no association with player manipulation. Nevertheless, this is the only item that results from repeated sounds and visuals throughout the game. For example, Table 6 presents the relationships between the improvements on items 9, 12, and 13 and their treatment in the game. Note that the items that showed no improvement did not receive the same treatment in the video game.

**TABLE 6**

*Treatment of items that showed improvement*

| **Items that showed improvement** | Treatment of items ***in Food Force*** |
|---|---|
| **9. Scientific and technological culture – issues of human activity** | Explicitly treated in the game: through the form (visual + audio), the background (purpose of the missions), and the player's manipulations (to achieve the missions). |
| **12. Geometry** | Explicitly treated in the game: through the form (visual + audio), the background (purpose of the missions). and the player's manipulations (to achieve the missions) |
| **13. Spatial awareness** | Explicitly treated in the game: through the form (visual + audio), the background (purpose of the missions), and the players' manipulations (to achieve the missions). See Figure 4, which illustrates this triple relationship to the game. |

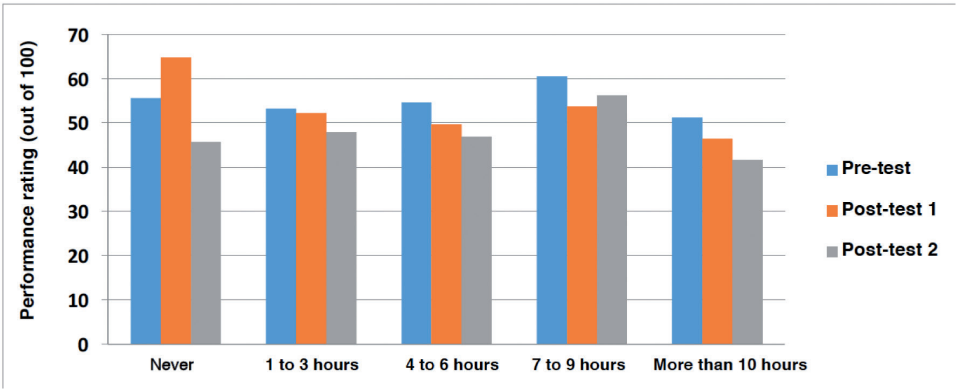
The other items were not directly treated in the game. In other words, the game does not include any learning or memorization in relation to those items, and the associated key competencies are not represented in the game's graphics or backgrounds or by the player's moves. These competencies were not addressed in multiple ways in Food Force, and therefore were not considered as direct learning objectives in this study. These results confirm our hypothesis that representations of the key competencies in a video game can foster learning in these particular areas. Thus, gaming appears to have a strong influence on knowledge transfer in gamers.

However, do players' characteristics (gaming skills or socioeconomic status) also influence their learning?

We saw that playing a serious, humanitarian game improved student learning in schools in priority education areas and urban areas between pre- and post-assessment 1. At the priority education schools, the pre-assessment results were lower, but playing Food Force enabled the students to make greater improvements in their academic performance. The fact of attending a priority education school supports this finding: the students in priority education generally scored lower on pre-assessment. At the same time, the students in priority education showed the greatest progress between the two assessments (+4/100 points), whereas the students in the two other areas (urban and rural) showed declining performance (-2.4/100 and -8/100 points, respectively). It appears that the educational content of Food Force has a stronger impact on students in certain areas, in this case, priority education areas.

Moreover, students who habitually played only serious games (like Food Force) showed the greatest progress (p=0.043). Students who had never played video games improved from pre- to post-assessment 1 by 9.12 out of 100 points, whereas students who played video games from 1 to 3 hours per week showed declines of 1.03/100 points, and those who played more than 10 hours per week declined by 478/100 points. This suggests that gaming habits are an influential condition for the effects of Food Force on learning (See Figure 5). This could be explained by the fact that, due their mastery of the video game, which would have improved their ability to operate within a digital space, these students were able to concentrate better on the game content, which would have fostered learning in turn.

**FIGURE 5**




*Weekly gaming habits of students in relation to learning assessments*

In conclusion, our results show that students who get good grades are generally good in all situations, including video gaming. We found that these students scored the highest in the two gaming sessions, and they also showed the best performance on the assessments (pre-assessment, post-assessment 1, and post-assessment 2). These high-performing students belonged to the category that scored an average of 57.18 out of 100 in the pre-assessment, which is 9 points above the average and weak categories (48.38/100 and 48.81/100, respectively). At the first post-assessment, the students with good academic grades scored an average of 54.60/100, compared to average students with 47/100 and weaker students with 41.37/100. At the second post-assessment, the high-performing students scored an average of 49.58/100, compared to 40.72/100 and 38.65/100 for the average and weaker groups, respectively. These results indicate that the students who got good marks at school were better at playing the serious video game, and for both sessions.

## Conclusion

Our results show, first of all, that students improved significantly on certain learning dimensions after playing the serious, humanitarian game Food Force. They showed significant progress in several respects, including general knowledge, understanding acronyms, hygiene and health, scientific and technological culture, geometry, and spatial awareness.

Playing Food Force appears to have positive effects on certain dimensions of three key competencies in the competency framework:

- The main elements of mathematics and scientific and technological culture
- Social and civic skills
- Autonomy and initiative.

Supervised video gaming in class therefore appears to have a positive effect on student learning.

Also, in our complementary analysis, we uncovered some particularly encouraging results. Among others, we found that for some students who are considered disadvantaged, serious gaming had stronger effects on learning. Thus, students from schools in priority education areas showed greater progress on their assessments after playing Food Force. This suggests that these students, whom schools find difficult to handle and educate, could in fact be capable of learning, and have the potential to do well at school. In light of our results, similar approaches could be expected to have a positive influence on their progress.

Furthermore, we demonstrated that playing Food Force has a particularly strong effect on the learning progress of students who never or seldom played video games compared to regular gamers, and the priority education students were among the moderate players.

To conclude, we would like to underscore the educational potential of gaming at school. We should keep in mind that video gaming is a steadily growing pastime that has gained widespread acceptance, thanks mainly to advances in digital technology. By integrating play, and more precisely video gaming, schools can take a giant step forward to enable students to immerse themselves in a universal culture. Nevertheless, in order to confirm our findings, this experiment needs to be relativized through comparison with a control group.

Serious gaming would boost students' motivation and help them make connections between classwork and the outside world. Herein lie the benefits of play for education, in the truest sense. In the end, and according to Comenius, school and play may be considered synonymous, in that they share the same goal: to emancipate the student. However, in order to integrate serious video games and other educational games into school lessons and reap the full learning potential, it is important to provide a dedicated gaming space. This means a space where children can play comfortably, free of consequences, and enjoyably. The challenge is to relate the aspects of the game that can foster informal learning to the required components of standard learning assessments.

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