Digital video games in education system-A Systematic Review

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Abstract: Introduction: *The adult brain was once seen as a static organ but now it is clear that brain circuitry and organization is constantly changing with new experiences and learning. The past decade has seen a surge of interest in so-called 'brain training'. One creative and user interactive method of 'brain training' is "digital video games" also called "Serious games". Video games play a role in enhancing the learning as well as intelligence especially fluid intelligence in healthy individuals.*

Aims and objectives: *The paper overviews the educational relevance of video games on memory, cognitive and executive function which constitutes a person's fluid intelligence and reasoning ability.*

Methods: *The following databases were searched electronically: GOOGLE SCHOLAR, PUBMED, PEDRO, COCHRANE LIBRARY, MEDLINE, GAME STUDIES, PROQUEST and several others. The paper presents the most influential research on the subject based on an extensive search of the literature between years 2001 till 2013. Any articles other than English language were excluded.*

Result and discussion: *The articles were reviewed thoroughly. Certain studies showed a strong evidence towards improvement in learning, memory, attention, execution and fluid intelligence. Maximum articles showed improvement in learning (Mean=0.8, N=20). However, on a negative perspective, video games also lead to aggression in behaviour in one of the studies.*

Conclusion: *The critical analysis was done and the articles were compared which led to the conclusion that using video games in education plays a major role in improving learning than the traditional learning system. The judicious use of video games should be incorporated in education system so as to avoid the negative effects such as aggression.*

Keywords: *fluid intelligence, attention, perception, cognition, execution and serious games.*

I. Background

Digital games are a growing part of our culture; the global market is worth billions of dollars, related activities range from published magazines to spontaneous internet communities, and the impact of games play on young people has attracted significant interest from the popular media. Exploring games and education is inherently controversial. Games can seem uneducational. But in this review, we tried to bring out a new perspective of video games i.e. digital game based learning. A **serious game** or **applied game** is a game designed for a primary purpose other than pure entertainment. The "serious" adjective is generally prepended to refer to products used by industries like defense, education, scientific exploration, health care, emergency management, city planning, engineering, religion, and politics . examples include Dimenxian Evolver, Geography explorer, NIU Torcs, River City, Supercharged, Virtual Cell etc. So far we all know that video games are used for entertainment purpose. These are considered as leisure time activities. But serious digital video games can increase our intelligence especially fluid intelligence. Fluid intelligence is the capacity to think logically and solve problems in novel situations, independent of acquired knowledge. It is responsible for strategic thinking, planning, executive function, perception and cognition.

II. Objectives

This review provides:
- To collect various researches and articles available for the use of digital games for educational purpose.
- To critically analyse the literature available suggesting the use of video games for educational purpose.
- To provide an overview of the main developments in research into gaming and the educational relevance of video games, and a summary of the literature resulting from this research.
- To propose a new way of learning and increasing intelligence in the education system.

This study provides an evidence for incorporating digital video games in the education system as these are useful for learning purpose in addition to traditional learning methods and also analyses the pros and cons of using digital video games in detail.

III. Methods

Criteria For Selection Of Studies:
* All articles other than English language were excluded.
* The articles published in databases like: GOOGLE SCHOLAR, PUBMED, PEDRO, COCHRANE LIBRARY, MEDLINE, GAME STUDIES, PROQUEST are only selected.
* The titles and abstracts of all reports were screened for the previously mentioned search criteria.
* All articles deemed 'relevant', 'dubious' or 'unknown' were examined in full text. If necessary, additional information was sought on the publisher's website or through correspondence with the authors.
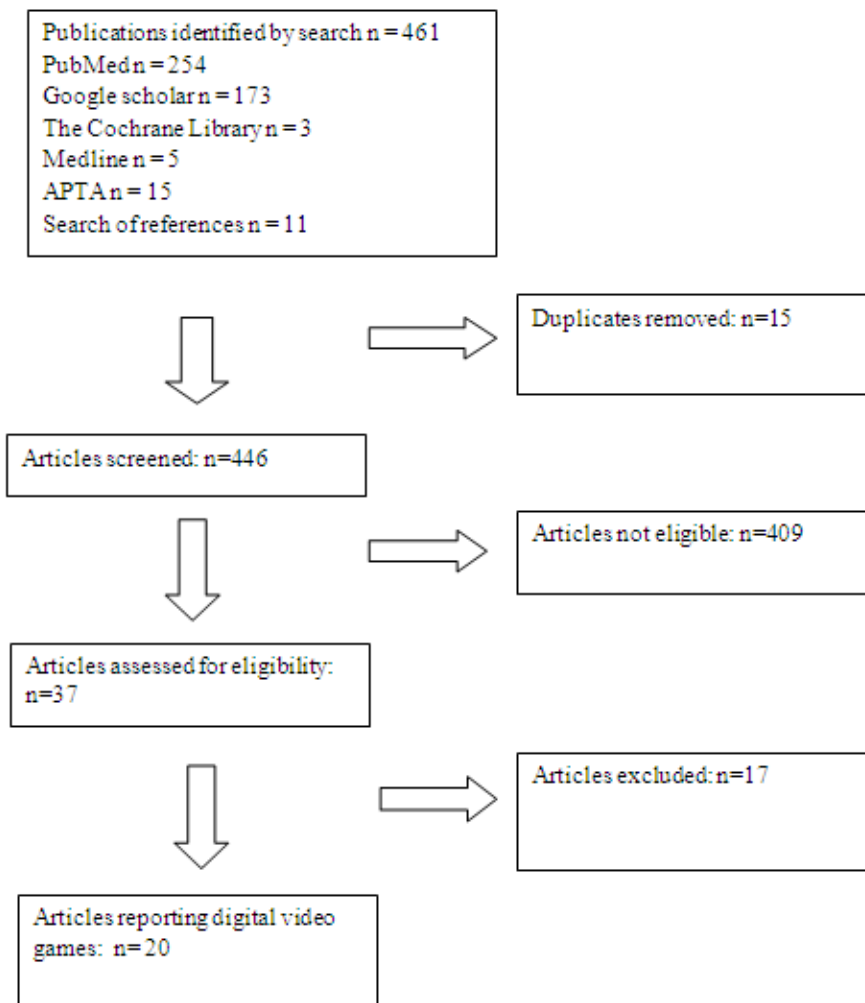* 20 articles were selected relevant to this review.

To further summarize our findings, we used the following levels of evidence (Sackett 2000; van Tulder 2003) - of benefit, of no benefit, or of reduced benefit relative to the comparison treatment:
* Strong evidence - denotes consistent findings in multiple high quality randomised controlled trials
* Moderate evidence - denotes findings in a single, high quality randomised controlled trial or consistent findings in multiple low quality trials.
* Limited evidence - indicates a single low quality randomised trial.
* Unclear evidence - denotes inconsistent or contradictory results in multiple randomised trials.
* No evidence - means no studies were identified.

Outcome Measures:
The primary outcome measures include: learning, short term memory, long term memory, attention, execution, fluid intelligence and aggression.

FLOWCHART SHOWING THE PROCEDURE OF SELECTION OF STUDIES

Publications identified by search n = 461
PubMed n = 254
Google scholar n = 173
The Cochrane Library n = 3
Medline n = 5
APTA n = 15
Search of references n = 11

Duplicates removed: n=15

Articles screened: n=446

Articles not eligible: n=409

Articles assessed for eligibility: n=37

Articles excluded: n=17

Articles reporting digital video games: n=20

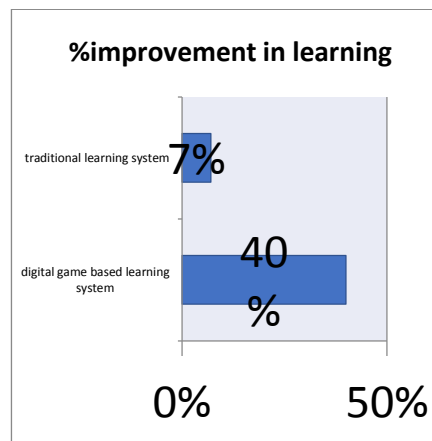## IV.   Effects Of Intervention

%improvement in learning

Figure 5.1

In a study by Gee et al, (figure 5.1) it was proved that there was 40 % improvement in learning by digital game based learning methods while with traditional learning methods it was only 7%.

%correct responses with trials

Figure 5.2

In a review by C.S Green et al, 2012, (figure 5.2) a series of different learning tasks were given to solve. Although experience with many tasks with the same underlying structure did not result in enhanced performance on trial number one, it did result in a substantial increase in the rate at which new tasks were learned.

In a study by Koepp et al in 1998, it was found that playing video games stimulates substantial dopamine release. As we know dopamine is a precursor to the memory storage event, playing video games can enhance memory.

In a study by McClean at al in 2001, digital game "Virtual Cell" on the topic of cell biology was being practiced by 238 college students. The learning outcome was inmproved by 40% over traditional lecture system. In one study by Squire et al in 2004, two groups each with 32 and 58 students respectively played an electrostatistics game called Supercharged. The control group improved their understanding by 15% while the gamers improved by 28%.
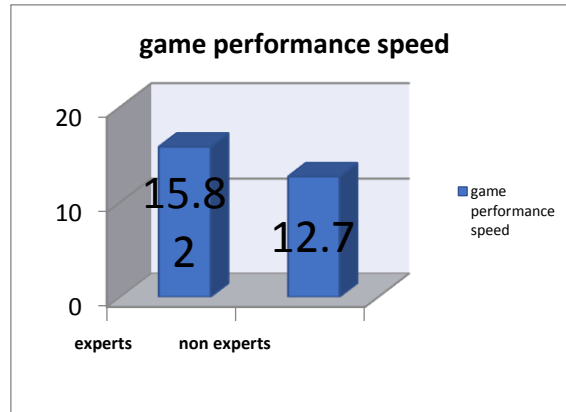
game performance speed

Figure 5.3

In a study by Boot et al in 2008, (figure 5.3) 82 participants were divided in three groups for digital video games. A no practice control group was also taken. The practice sessions of total 21.5 h were provided to the participants. The primary measure included the speed at which participants could track three items while maintaining near perfect accuracy. Experts far outperformed non-gamers in their ability to track at higher speeds.
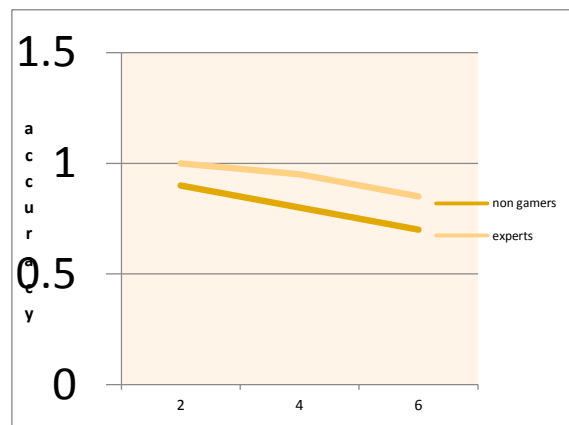
Figure 5.4

The accuracy was also measured in the study (figure 5.4) which suggested that there were increased accurate responses in experts than non-gamers.
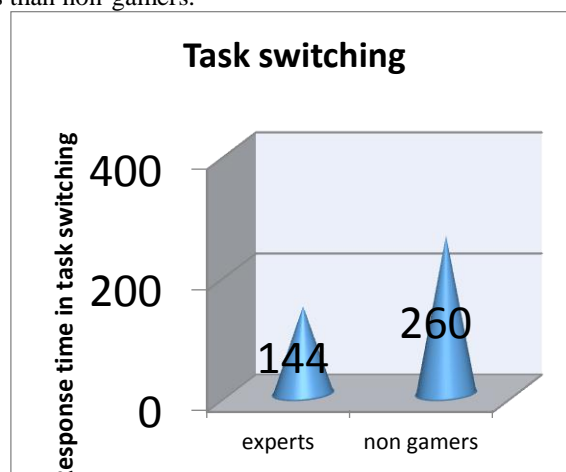
Task switching

Figure 5.5

The execution of tasks or response time in task switching was measured in the same study (figure 5.5). Experts showed a smaller switch cost compared to non-gamers.

In a study, of two groups, there was an improvement in understanding by 15% in control group (N=32) who learned via interactive lectures and teacher's demonstration while improvement was 28% in group (N=58) who learned via video game. (Mayo M, 2007).

V. Critical Analysis

Critical analysis was performed on the basis of strong evidence for the outcome measures and means were calculated for N=20.

	Improvement in learning	Improvement in attention	Improvement in memory	Improvement in execution	Increased aggression	Improvement in fluid intelligence
Mark Griffiths,2002	Strong evidence	×	×	×	×	×
Kirriemuir J. , 2002	×	Strong evidence	×	×	×	Strong evidence
BECTA survey	Strong evidence	×	×	×	×	Strong evidence
Miguel de Aguilera et al, 2003	Strong evidence	×	×	×	×	Strong evidence
Paul J. , 2003	Strong evidence	×	×	×	×	×
Paul J. Gee, 2004	Strong evidence	×	×	×	×	×
Buckley, K et al, 2006	Strong evidence		×	×	Strong evidence	×
Vogel et al, 2006	Strong evidence	×	×	×	×	×
Oblinger D, 2006	Strong evidence	Strong evidence	×	Strong evidence	×	Strong evidence
Weber et al, 2006	Strong evidence	×	×	×	Strong evidence	×
Merrilea J. , 2007	Strong evidence	×	×	×	×	×
Begona gros. , 2007	Strong evidence	Strong evidence	×	×	×	Strong evidence
Boot et al. , 2008	×	Strong evidence	Strong evidence	Strong evidence	×	×
Jaeggi et al, 2008	×	×	×	×	×	Strong evidence
Merrilea J. Mayo et al, 2009	Strong evidence	×	×	×	×	×
Perrig et al, 2009	×	×	×	×	×	Strong evidence
Boot et al. , 2011	Strong evidence	Strong evidence	×	×	×	Strong evidence
Green et al, 2012	Strong evidence	Strong evidence	×	×	×	×
Graafland M et al, 2012	Strong evidence	Strong evidence	×	×	×	×
Rondon et al, 2013	Strong evidence	×	×	×	×	×

- The means of the above articles improving the outcomes are shown as follows:

Outcome measures	Means of articles supporting the improvement (N=20)
Learning	0.8
Memory	0.05
Attention	0.4
Execution	0.1
Aggression	0.1
Fluid intelligence	0.4

- Thus, the results were in favour of digital game based learning especially cognitive learning> fluid intelligence > attention> execution> memory.
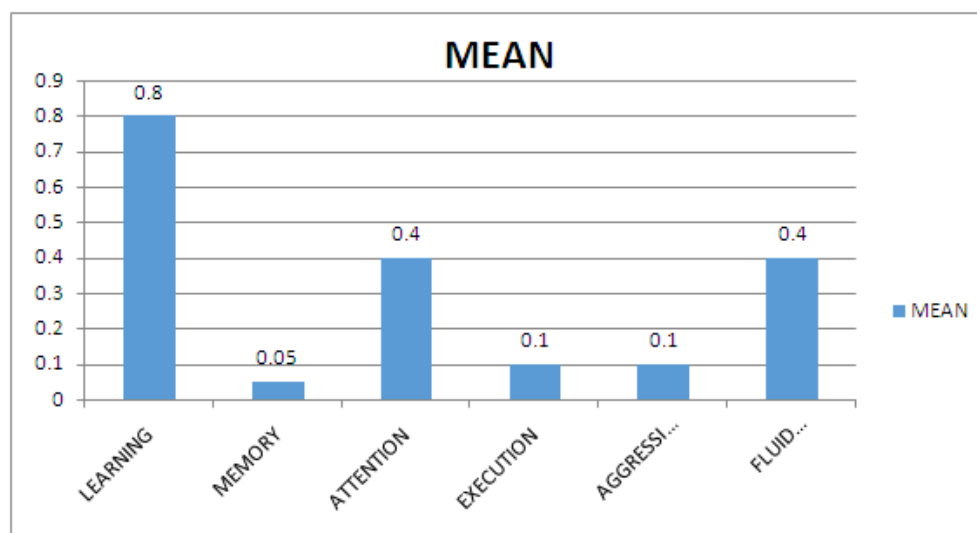
Graph to represent the means of articles supporting the improvement

VI.   Discussion

This review led to the results that video games can enhance learning and intelligence. The articles were reviewed thoroughly.

- Video games compared with traditional teaching methods are better for cognitive gains. (Vogel et al, 2006) (z=6.051, p<.0001(N=8549)).
- Edutainment is a new and imaginative method of learning. (Kirriemuir J).
- Video games cause activation of dorsal cognitive part (p<.027), rostral affective part (p<.003) and amygdala (p<.014) reflecting a long term learning impact through video games.(Weber et al, 2006).
- Video games have the potential to directly provide massive parallel education in science and engineering (Merrilea J, 2007).
- Video games have a positive effect on memory, attention and executive control.(Boot et al, 2008)
- Video games help in development of skills like language skills, basic reading, math skills, and social skills in autistic children. (Griffiths M, 2002).
- Video games can be instrumental in acquiring abilities and skills like:
  o Spatial perception and recognition.
  o Development of visual attention.
  o Development of inductive logic.
  o Cognitive development.
  o Development of complex skills.
  o Iconic code construction. (Aguilera, 2003).
- Role playing in a digital video game improves learning. (Paul J, 2003).
- The design of the video game should be such that it is easily adaptable to normal people. (Gee, 2004).
- Short- and long-term benefits of cognitive training revealed a significant improvement on the trained task in the experimental group; t (31) = 6.38; (p < 0.001). In contrast, there was no significant performance improvement in the active control group; t (29) <1. (Susanne M. Jaeggi, 2011).
- Video games can improve cognition and perception.(Boot et al, 2011)
- Video games can also improve task switching, multi-tasking, and visual short-term memory tasks. (Green et al, 2012).
- Computer games have been effectively used to teach algebra and geometry (Corbett et al, 2001), biology, golfing skills and computer programming.
- A recent metaanalysis of effectiveness of using educational software programs found positive effects on both early reading development (d=0.35; N=26) and math (d=0.45; N=13) (Murphy et al, 2002).
- Video games also increase perceptual skills. (Rosser et al, 2004).
- Research has yet to prove that video games are intellectually harmful but on the contrary many studies defend their great importance in development of intellectual abilities. (Aguilera, 2003).
- Video games can yield a 7 to 40% positive learning increase over a lecture program. (Mayo et al, 2009).
- Serious games can be used for medical education and surgical skills training (Graafland M et al, 2012).
- On the negative perspective, video games also lead to aggression in behaviour, obesity and other health related problems.

VII.   Conclusion

Long term effects of video games:

- Factual learning: Educational softwares focussed on practised routines to enhance the learning of specific concrete facts. This type of software can be incorporated in classrooms. Students will receive quick feedback about their performance and are able to repeat tasks until they are successful.
- Learning behaviours: Video games can also enhance learning of many types of complex behaviour by simulation and role playing.
- Changes in personality: As with the development of various well rehearsed knowledge structures, development of personality also occurs.

The implementation issues in the education system include:

- cost
- Are computer laboratories available?
- Is the right equipment available e.g.: joystick,
- Is technical support available for the games?
- Are there instructional designers available who can develop games?
- Is gaming integrated into the curriculum?

Following key points are noted:

1. Digital video games enhance intelligence, cognition, perception, attention to a great extent in comparison to the traditional teaching methods.
2. The role of teacher in structuring and framing the activity of the learner is crucial. Also, he requires some understanding of controls, menus and skills about the game.
3. Games have a significant advantage in developing motivation, skills and encourage collaboration.
4. Development of gaming softwares that incorporate the best features of educational and gaming techniques are required.
5. Development of game design, plot, character development, user interface design should be relevant to academic courses in education system (Kirriemuir, J, 2002).
6. Digital games can be used in various educational sectors: business, management, budgetary economics, accountancy, science and engineering. (Mayo M, 2007).

Hence we conclude that digital game based learning is a new era of education system. The game based learning should be incorporated in the education system according to relevant academic courses. The design and implementation should be as per the subjects offered. To avoid the negative impact of digital games on health, judicious use of games should be done.

Future scope of the study

- **Many research studies** can be done comparing the improvements in all the outcomes discussed in this review with traditional teaching methods vs game based digital learning.
- The game based learning can also be applied to patients with **intellectual disabilities** for their daily living.

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