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Comparing effects of brain training and role-playing games on problem-solving speed

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Abstract: Problem-solving skills are increasingly becoming a desired skill in the workplace today. Although formal education will be the best way to develop one's own problem-solving skills, the problems addressed are often clearly defined and structured. However, problems in the real world are often ill-structured and requires complex problem-solving. Many researches indicate that video games can be an alternative to developing problem-solving skills given that the problem and environment are ill-structured. Based on prior comparative findings on strategy-fast-paced video games and role-playing-brain training games, this study investigates whether participants will evidence greater learning gains in problem-solving speed within a sandwich Tower of Hanoi-a fast-paced-brain-training or a strategy role-playing video game-Tower of Hanoi methodology. There is closer similarity between the fast-paced video game to the Tower of Hanoi. Hence, we hypothesize that this closer similarity may result in improved problem-solving speed since the development of rules may be analogically similar. In our study, findings indicate that participants who play Idle Supermarket Tycoon (strategy role-playing video game) evidence more pre-post- test learning gains (problem-solving speed) compared to Mario Kart Tour (fast-paced-brain-training video game). This finding confirms prior research that strategy and role-playing video games are more effective than fast-paced and brain training games in developing problem-solving skills. It also hints that increased cognitive load due to multivariate complexity may be traded off by motivation to form or activate rules when the problem is personally relevant or simulates real-life challenges. However, there are several limitations to the experiment in terms of specificity due to the small sample size. This is due to the research being carried out during the country's COVID-19 movement control order/lockdown and the need for more data to be conclusive. Nevertheless, we hope it can serve as a catalyst for more research and studies in the field.

Keywords: Problem-solving, analogical transfer, fast-paced video game, strategy video game, role-playing video game, brain training video game, Tower of Hanoi

1. Introduction

Problem-solving has become essential to school, career, and life in general (Bransford & Stein, 1984; Jonassen, 1997). However, formal education will usually provide assessment situations which are often clearly-defined and structured while the problems found in the real world are often ill-structured and require complex problem-solving skills (Shute, Wang, Greiff, Zhao & Moore, 2016). Hence, informal education has great potential and have flourished in many countries.

One form of informal education is video games. Video games encourage strategy and goal development (Gee, 2005). With this in mind, video games can be seen as an alternative in developing problem-solving skills among people. Some studies, which aim to examine the link between video games and problem-solving skills development indicate the following:

a) sustained playing of strategy games improves the problem-solving skills of students which in turn increases their academic grades more than fast-paced games (Adachi & Willoughby, 2013).
b) participants who play *World of Warcraft,* a roleplaying video game, obtain better results for both the *Tower of Hanoi* and the PISA problem-solving post-tests compared to those who play *CogniFit*, a brain training video game (Emihovich, 2017).

These findings are interesting as they compare the efficacy of playing strategy vs. fast-paced video games, brain training vs. roleplaying video games and reveal that multivariate games which relate to

personal and/or real-life relevance evidence greater gains in learning than those which are more focused on speed or brain training (more details on these two studies are presented in the following related work section).

1.1. Objective

Analogical model-based transfers such as by Goel and Craw (2005) are fundamental to the Learning Sciences. Many studies have revealed positive effects towards problem-solving skills, arising from playing video games. Due to differences in culture (Canada, US and Malaysia), we aim to:

a) reconfirm Emihovich's (2017) findings;
b) investigate whether the closer similarity between the fast-paced video game *Mario Kart Tour* to the *Tower of Hanoi* would result in improved problem-solving speed since the development of rules may be analogically similar.

If the findings are positive, then strategy and role-playing video games should be given more attention interspersed with speed and brain training games in developing problem-solving skills. In the following section, we review related work.

2. Related work

4.1 Aggregated assessment of problem-solving skills

To assess problem-solving holistically, Shute, Wang, Greiff, Zhao and Moore (2016) ask participants to play a video game *Use Your Brainz* for three hours across three consecutive days. *Use Your Brainz* is a modified version of the video game *Plant vs. Zombies 2* created by *Popcap Games* and its publisher *Electronic Arts*. On the fourth day, two tests are carried out, i.e., *Raven's Progressive Matrices* (to measure reasoning and simple problem-solving skills) and *MicroDYN* (to measure complex problem-solving skills).

The participants in the study are 55 7th grade students at a middle school located in suburban Illinois. Data is collected using stealth assessment, similar to an audit trail. A competency model (Figure 1) divides problem-solving into four facets, i.e., "analyzing givens and constraints," "planning a solution pathway," "using tools and resources effectively and efficiently" and "monitoring and evaluating progress." Data such as "players plant iceberg lettuce within the range of a snapdragon attack is not ideal as planting both iceberg and snapdragon near each other will negate each other's effect" will be mapped to the four facets in the competency model. This in turn will contribute to the overall score.

Hence, the competency model not only provides a more well-defined assessment of problem-solving skills but also provides a means to focus on a player's stronger or weaker aspects.

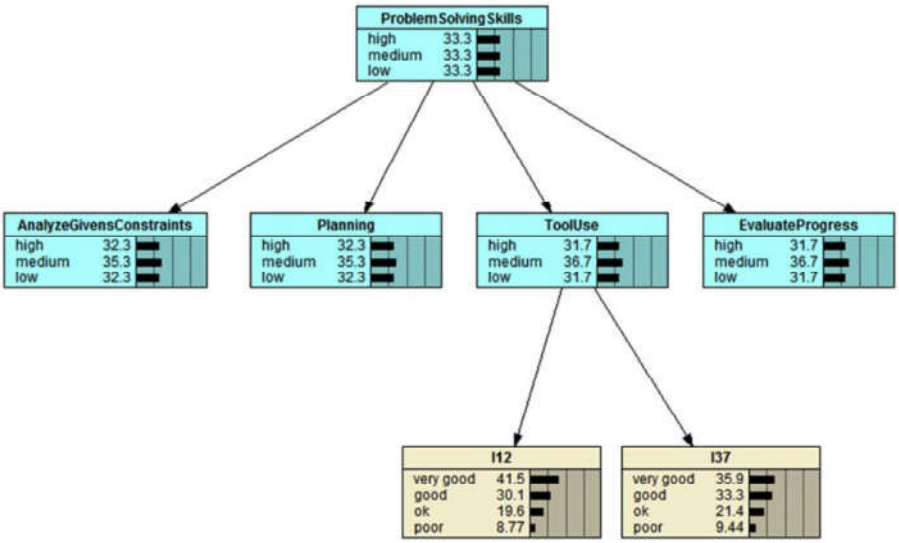


Figure 1. Shute, Wang, Greiff, Zhao and Moore's (2016) competency model

With these four facets of problem-solving skills in mind, we next look into another two comparative studies, i.e. the efficacy of strategy game vs. fast-paced game and the efficacy of brain-training video game vs. roleplaying video game.

2.1 Strategy game vs. fast-paced game

Adachi and Willoughby (2013) hypothesize that if video games can increase students' problem-solving skills, they can also positively improve students' academic grades. As such, they investigate the efficacy of strategy video games in contrast with fast-paced video games. With regards to strategy video games, Adachi and Willoughby hypothesize that sustained playing can improve problem-solving skills. This is because strategy games encourage players to gather and collect information first and then proceed to use that information to think of strategies to the problem.

For example, for the video game *Splinter Cell*, players take control of the role of a black-ops agent and must use stealth and remain undetected from the eyes of the enemies in the game. As such, players are encouraged to study the scene in the game, the behavior of the enemies and formulate a plan or strategy of attack. In contrast, fast-paced video games require players to take immediate action. This leaves very little time for players to gather information and formulate strategies in solving the problem. Hence, Adachi and Willoughby hypothesize that sustained playing of fast-paced video games will not be able to increase players' problem-solving skills.

They send out surveys to students from eight different high schools in an Ontario, Canada school district. Students in grades 9, 10, 11 and 12 are tracked as they progress through different grades. Questions include gender, the number of computers they have at their homes, parents' education level, whether students have had prior experience in playing strategic and fast-paced video games, the frequency of their playtime, how much they thought of strategies in the game and the academic grades they obtain through the years. Findings indicate that sustained playing of strategy games do increase the problem-solving skills of the students and academic grades. However, this does not apply to fast-paced games.

2.2 Brain-training video game vs. roleplaying video game

Emihovich's (2017) comparative study on the effects of brain training video game and roleplaying video game on problem-solving skills sheds more light on how we can develop problem-solving skills. He hypothesizes that brain training video games will be able to improve rule application in problem- solving better than a roleplaying video game. This is because brain-training video games enable players to

repeatedly apply explicit rules to solve problems. On the contrary, roleplaying video games will be able to promote the transfer of problem-solving skills better than brain-training video games because the former requires players to address authentic ill-structured problems in a richly detailed immersive environment.

Rule application requires the problem-solver to constantly reify the representation of the problem space. In the experiment, participants are tasked with two pre-tests at the beginning of the experiment. One of these is playing a game *Tower of Hanoi* for 20 minutes as well as taking the PISA problem-solving test. *Tower of Hanoi* is used to measure the rule application of the participants while the PISA problem-solving test is used to measure the transfer of problem-solving skills from video gameplay to novel scenarios. Subsequently, participants are randomly assigned to play one of the two video games in the experiment, i.e., a brain training video game *CogniFit* and a roleplaying video game *World of Warcraft*. This is followed by two post-tests, i.e., re-playing *Tower of Hanoi* for 20 minutes and another PISA problem-solving test.

Findings reveal that participants who play *World of Warcraft* are able to obtain better results for both the *Tower of Hanoi* and the PISA problem-solving post-tests after playing their assigned game for 20 hours compared to those who play *CogniFit*. This is interesting as it indicates that increased variation and complexity does not have necessarily reduce problem-solving performance. This study forms the key reference to our research.

3. Research design

3.1 Sample

A total of 15 students participate in the experiment. Most of the participants in this study are undergraduate students interested to develop their skills, knowledge and problem-solving skills. Three participants are omitted as they did not follow instructions correctly, attributing to incomplete data.

3.2 Methodology

The methodology for this study is similar to Emihovich's (2017), but carried out fully online due to COVID-19's movement control order. Emihovich's study is chosen as the key reference as its objectives are the most similar to our research objectives, i.e., to compare the effects of brain training video game and roleplaying video game on problem-solving skills.

There would be a pre-test where participants will be tasked to complete the game *Tower of Hanoi* within 20 minutes. In *Tower of Hanoi* (Figure 2), the goal of the game is to move all of the disks from the first stand to the third stand (the stand on the far right). However, the players can only move one disk at a time and the upper most disk must be moved first before the lower disks can be moved. Also, the bigger disks cannot be placed on top of the smaller disks. Participants are encouraged to attempt the game as many times as they would like within the 20 minutes mark. They are asked to record the number of moves to complete each attempt and submit them through a questionnaire.

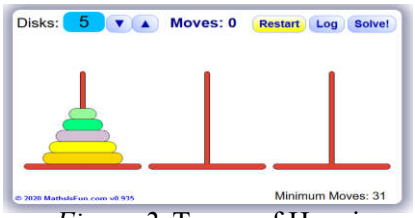


Figure 2. Tower of Hanoi

Once they have completed the pre-test, they would be randomly assigned to play one of two video games for an hour. The video games chosen for this study are *Idle Supermarket Tycoon* (Figure 3a) and *Mario Kart Tour* (Figure 3b). *Idle Supermarket Tycoon* is a video game that would encourage more thought

process from its players as they need to make decisions on the best way to invest their money to result in the best possible value gained. For *Idle Supermarket*, players are tasked with the management of a supermarket. They would need to buy and add new items for sale, and increase existing items for sale so that they would earn more profit or engage in other activities that would increase the revenue of the supermarket. *Mario Kart Tour* is a very fast-paced racing video game. For *Mario Kart Tour*, players would play as beloved characters from *Nintendo* franchises and race with them, players may also able to compete against their friends as well as other players that may be online.

Figure 3a. Screenshots of *Idle Supermarket Tycoon*

Figure 3b. Screenshots of *Mario Kart Tour*

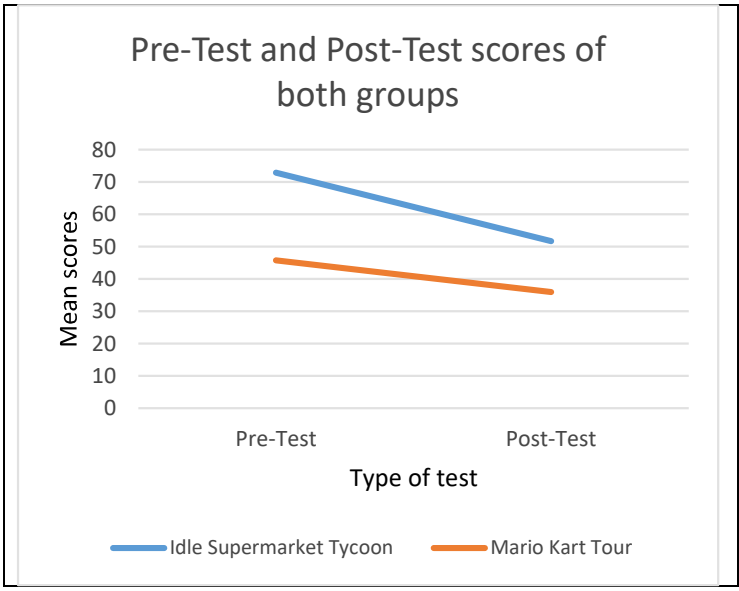
4. Findings and discussion

The average is calculated from the pre-test and post-test scores of the participants. A lower average would indicate better problem-solving performance as it indicates lesser time is used to complete the task/achieve the goal. According to the data collected, those who play *Mario Kart Tour* have a much better performance in pre-test with a mean score of 49.67 and a standard deviation of 13.02. Those who play *Idle Supermarket tycoon* have a pre-test mean score of 73.60 with a standard deviation of 26.17.

During the post-test, the group which play *Mario Kart Tour* once again exhibit better performance with a mean post-test score of 39.23 and a standard deviation of 11.07. The group who play *Idle Supermarket Tycoon* have a post-test mean score of 49.78 and a standard deviation of 16. The difference in pre-post-test mean for *Mario Kart Tour* is 10.44 with a reduction in standard deviation of 1.94. The difference in pre-post-test mean for *Idle Supermarket tycoon* however, is 23.82 with a reduction in standard deviation of 10.17. Hence, though students who play *Mario Kart Tour* consistently perform better in pre-post-tests, those who play *Idle Supermarket Tycoon* improve much more than those who play *Mario Kart*

Tour. This finding is consistent with Emihovich's (2017) on the comparative strengths of role-playing games vs. brain training games.

Figure 4 illustrates the pre-test and post-test mean scores and standard deviation of each group.



Mario kart tour		
Participant no.	Pre-test score	Post-test score
2	66.00	31.50
4	35.00	31.00
6	39.83	33.00
8	43.17	35.33
10	45.00	49.25
12	49.67	34.50
14	69.00	60.00
Mean	49.67	39.23
Std dev	13.02	11.07

Idle supermarket tycoon		
Particpant no.	Pre-test score	Post-test score
1	64.43	38.58
3	59.00	70.13
5	129.50	35.42
9	51.00	75.00
11	60.60	39.50
13	75.50	45.25
15	75.17	44.55
Mean	73.60	49.78
Std dev	26.17	16.00

Figure 4. Mean and standard deviation for time taken to complete *Idle Supermarket Tycoon* and *Mario Kart Tour* in pre-post-tests

Furthermore, *Mario Kart Tour* is more similar to the *Tower of Hanoi* with lesser number and types of variables to consider. In addition, the lesser number and types of variables to consider if viewed in terms of Shute, Lubin, Greiff, Zhao and Moore's (2016) competency model's 4 facets, i.e., "analyzing givens and constraints," "planning a solution pathway," "using tools and resources effectively and efficiently" and "monitoring and evaluating progress," may provide hints/insights as to why time taken to complete is faster.

It is interesting that players are able to manage the increased cognitive load integral in strategy and role-playing games to problem-solve faster. This may indicate rule formulation/rule activation through multiple attempts. These findings confirm the possibility that increased multivariate variation and complexity do not necessarily reduce problem-solving performance, if there are frequent practices and reasoning based on these practices. The greater learning gain may also have resulted from greater motivation to develop rule formulation/activation when the problem is personally relevant/simulates real life challenges. If so, then the findings support that of Lee and Hughes' (2019) earlier study on cognitive load theory with seniors; built on prior work with young adults.

5. Conclusion

This is an exploratory study intended to reconfirm Emihovich's (2017) findings with a sample group of Malaysian students, using two different games. We have reconfirmed Emihovich's (2017) findings on the comparative strengths of role-playing games vs. brain training games. Though cultures are different, findings are consistent. Furthermore, findings reveal that practice alone may not be sufficient to improve learning outcomes (problem-solving performance). Motivation to activate rule formulation and refinement in problem-solving, plays a key role too. There are however, limitations to the study. Due to MCO, the sample size is small and monitoring of participants is not carried out. Furthermore, there are limitations to self-report. Hence, we can only conclude that there are positive indications that more attention should be given to strategy and role-playing games, while interspersed with speed and brain training games, corresponding to the context and learning gaps at the point in time.

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Appendix 1

The Pre-Test

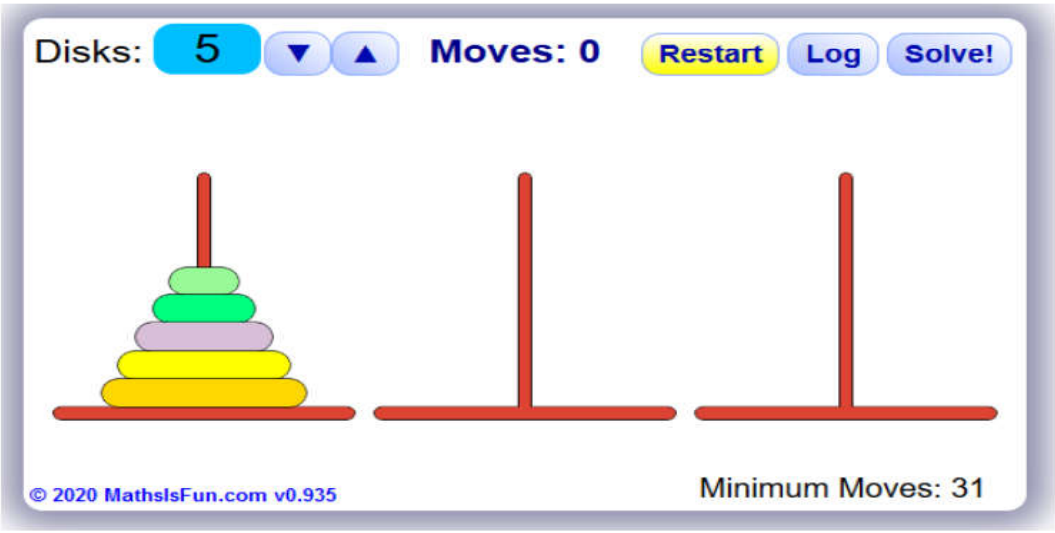
Pre-test

Before you start to play your assigned video game, you are required to first play a game called "Tower of Hanoi" which you can find online on the internet. A picture of "Tower of Hanoi" can be found below. You are required to play it for 20 minutes so be sure to time yourself when you are playing it, you can play as many time as you want so long as it falls under 20 minutes. Be sure to record the number of moves you managed to complete the game at each attempt.

If you have any questions about the experiment, you may email me at lingyulung50@gmail.com

* Required

A picture of "Tower of Hanoi"



Rules of "Tower of Hanoi"

players are tasked with transferring all the disks from tower 1(the first tower on the left) to tower 3 (the third tower on the right) in the order that they were in the first tower before any moves were made. However, players can only move the topmost disk once at a time and the larger disk cannot be placed on top of the smaller ones. The number of moves it takes for players to complete the game are tracked at the top.

What is your participant number *

Choose

How often do you played games in a week(including smartphone games, computer games and consoles games)? *

	1	2	3	4	5	
Never	○	○	○	○	○	Very Often

How often do you played games like "Idle Supermarket" or others of its genre(resource management games e.g Simcity)? *

	1	2	3	4	5	
Never	○	○	○	○	○	Very Often

List down the number of moves you managed to complete each "Tower of Hanoi" attempt. Use a new line for every number of moves at each attempt (an example is provided below). *

List down the number of moves you managed to complete each "Tower of Hanoi" attempt. Use a new line for every number of moves at each attempt (an example is provided below). *

40
50
60
70
80
31

Your answer

Submit

Appendix 2

The Post-Test

Post-test

You are required to play "Tower of Hanoi" again once you had finish playing your assigned game. Like before, you are required to play "Tower of Hanoi" for 20 minutes, you may do as many attempts as you wish so long as it does not cross the 20 minutes limit mark. Be sure to record the number of turns you managed to complete the game after each attempt.

If you have any inquiries, you may email me at lingyulung50@gmail.com

* Required

What is your participant number *

Choose

Choose your reward. *

- ◯ RM10 GrabFood voucher
- ◯ RM10 Steam Wallet Code
- ◯ I don't want any

Enter in your email address. (you are required to enter your email address for the collection of your reward, you reward will be given out by July 12. Please ensure your email address is entered correctly or your reward will be forfeited.)

Your answer