ARTICLE

The Effect of In-Class Educational Group Games (EGGs) on Student Motivation and Academic Achievement for Pharmaceutical Science Students

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Recommended Citation:

Ng, A. Y. N., Liew R. S., & Phoon C. W. (2020). The effect of in-class educational group games (EGG) on student motivation and academic achievement for pharmaceutical science students. *Asian Journal of the Scholarship of Teaching and Learning, 10*(2). 134-152.

ABSTRACT

An in-class Educational Group Game (EGG) is defined as a face-to-face educational game which aims to motivate students to learn through interaction and collaboration with peers. Many teachers have used EGG to facilitate their teaching. However, most research conducted on EGG activities thus far were either derived from case studies or only focused on students' perceptions of EGGs. In addition, the literature indicates that not many of such studies were conducted in tertiary institutions.

To address these research gaps, this study aimed to investigate the effectiveness of in-class EGGs on students' learning motivation and academic achievement by applying a quasi-experiment method in a tertiary setting. The participants were Year 1 (n=88) and Year 2 (n=54) students of Nanyang Polytechnic taking the Diploma in Pharmaceutical Sciences.

The results for Year 1 and Year 2 students in this study were analysed separately as different EGGs were administered with different learning objectives and different game mechanics. A mixed ANOVA was conducted to examine the mean differences between pre- and post-tests conducted among the control as well as experimental groups A and B of Year 1 and Year 2 students. A paired sample t-test was conducted on data collected from the questionnaire to compare the difference between the levels of motivation of students towards the EGG and the worksheet. Students in both years demonstrated a significant increase of interest (intrinsic motivation) and perceived choice towards the EGG compared to the worksheet. Interestingly, a decrease in both direct and indirect performance-related extrinsic motivation were also observed in both years. In conclusion, the EGG provides an affective learning environment for students to learn by eliciting their intrinsic motivation.

Keywords: Educational games, learning motivation, game-based learning, peer learning, collaborative learning, pharmaceutical science

INTRODUCTION

The traditional learning method where students learn passively through listening and interpreting content delivered by the teacher remains prevalent in many higher education institutes as it is a convenient way to teach and introduce basic concepts (Smith & Valentine, 2012). However, students are not engaged in a passive-learning classroom. Although educators have facilitated active learning activities in their classrooms, such as team-based learning, problem-based learning, small group discussions and presentations, they are only able to engage a small group of vocal and highly intellectual students. The majority of students may find the activities boring, challenging and daunting. Hence, there is a need to make classroom lessons lively and less pressurised, yet ensure that students can still achieve the course's intended learning outcomes and enhance their academic achievements.

In-class Educational Group Games (EGGs) may offer a good solution. In fact, psychologists have long acknowledged the importance of play in physical, social, emotional, and cognitive development and learning. Piaget (1962) described play as a way for children to unify experiences, knowledge, and understanding. Vygotsky (1967) proposed that when a learner is playing with an adult or a more capable peer, he or she is likely to succeed at things that are beyond his or her current ability. In a high school setting, Fine (2014) attempted to create awareness of intellectual playfulness, which describes the ability to learn through play. Intellectual play not only nurtures problem solving, independence and perseverance, learners have the opportunity to develop greater independence and demonstrate competency. The tasks given to students could be open-ended, absorbing, and comprise elements of intellectual risk taking, which are exemplified by educational games.

According to a study by Koh et al. (2012) on teachers' perceptions of games in Singapore schools, while the majority of teachers believe that games can lead to better student learning outcomes, they rarely incorporate games in teaching. The main obstacles cited include not only the time and effort spent in games development and delivery, but also the level of support from their school administration and parents' reactions towards games-based learning (Koh et al., 2012). Therefore, this study aims to find out 1) whether in-class EGGs can help enhance students' learning motivation and academic achievement, and 2) whether in-class EGGs could serve as a complementary mechanism or replace pen-and-paper worksheets in improving students' academic achievement. The successful implementation of in-class EGGs in the polytechnic setting highlights a good example of games being an effective and engaging mode of teaching and learning. This should encourage more educators from institutes of higher learning to adopt EGGs.

MATERIALS AND METHODS

The in-class Educational Group Games (EGGs)

Two in-class EGGs, 1) "Guess the Terms", and 2) "Game of Truth", were conducted in April and May 2018. Details of the EGGs are as follows:

"Guess the Terms"

a) **Objective**. This EGG uses an app called Charades® to help Year 1 Diploma of Pharmaceutical Science (DPS) students learn the terminology of different dosage forms.

b) **Key learning outcomes**. Upon completing this EGG, students are able to:

- Describe the different dosage forms of pharmaceutical products.
- Relate the different dosage forms in their daily use.
- Communicate and articulate their ideas.

c) **Mode of delivery**. "Guess the Terms" was delivered via a tablet. The terminology of different dosage forms was stored in the app Charades®, which is pre-installed in the tablet. A class would form four teams comprising five to six students in each team. One representative from each team would be the 'guesser'. The instructor would then hold the tablet on top of the guesser's head and the rest of the team members had to describe or enact the clues without saying the exact word. Each team had two minutes to play one round. After playing the games, all the definitions of dosage forms (whether correct or incorrect) which appear in Charades® were explained by the instructor. This served as a revision for the class. The team which guessed the most number of terms correctly was declared the winner.

d) **Rationale for applying "Guess the Terms" as an in-class activity**. The EGG "Guess the Terms" made rote learning and the memorising of definitions of dosage forms more engaging and interesting. Students could describe or act out the clues in order to guess the term. During the game, they could use the explanations they learnt during the lecture or from their personal experience about dosage forms as clues. This would help them relate the course content to their daily life experiences, which would enable them to remember the terminology better.

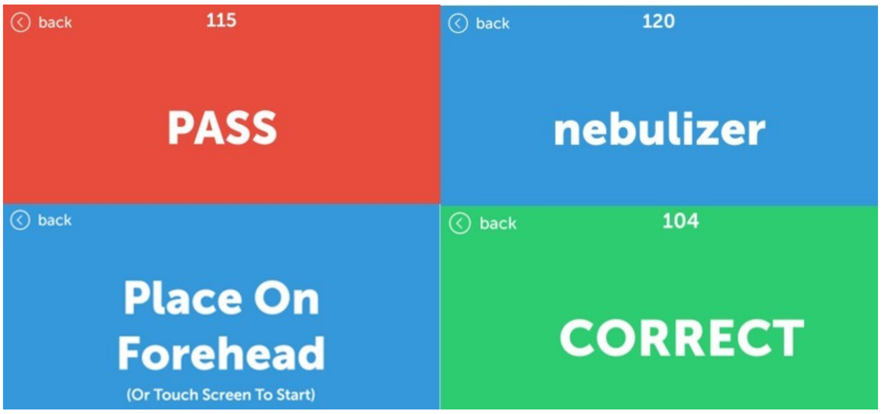

Figure 1. An example of the interface for the EGG "Guess the Terms".
The various screens in the app Charade® will be displayed when students are playing the game.

"Game of Truth"

a) **Objective**. "Game of Truth" was an EGG developed to help Year 2 DPS students learn about the brief history and theories of Traditional Chinese Medicine (TCM). Being a traditional practice of medicine with 5000 years of history, TCM consists of many theories and concepts which students need to memorise.

b) **Key learning outcomes**. Upon completing this EGG, students are able to:

- State the theories of "blood" and "qi".
- Describe the Five Elements theory in TCM.
- Describe the Meridian theory in TCM.
- Describe some applications of TCM in modern medicine.

c) **Mode of delivery**. "Game of Truth" was delivered in class using four different sets of 10 True-False (T/F) questions. A class would form four teams comprising five to six students in each team. All students would be given one set of T/F questions. The selected team would attempt one set of 10 T/F questions in 100 seconds. This selected team had an additional 30 seconds to choose five (out of 10) questions to answer. The remaining three teams could challenge the selected team's answers. Points would be given for each correctly challenged answer, otherwise points would be deducted.

If the first team answers all five selected questions correctly, their awarded points would be doubled. The team would then have to answer the remaining five questions within 30 seconds after the instructor reveals the answers of the first five questions. Similarly, the remaining three teams could challenge the answers given by the first team; points would be given if the answer is correct and deducted otherwise. The game would be repeated until all the teams have answered all four sets of T/F questions. The team with the highest points would be declared the winner.

Rationale for applying "Game of Truth" as an in-class activity. The EGG "Game of Truth" incorporates a gamification element into the session, which aims to get students excited about learning TCM. There are many TCM theories and concepts students would need to memorise. It is hoped that the game's fast and exciting pace would enable students to stay alert and competitive during the lesson, and also help them remember the many TCM theories and concepts embedded in the game.

Figure 2. Photo of the students and instructor playing "Game of Truth" during a tutorial.

Research design

Data collection methods

All Year 1 and Year 2 DPS students (n=144) participated in this study, and had given their consent to participate. To ensure consistency, all students were taught by the same instructor, who also conducted the study. To reduce transition time and ensure smooth running of the lesson, pre-, post-tests and the questionnaire were also administered and collected by the same instructor.

This study employed a quasi-experiment approach, which involved grouping the students based on their pre-existing tutorial groups. The tutorial groups were based on their existing class, which was randomly assigned when they enrolled into the polytechnic. Figure 3 provides an overview of the research design.

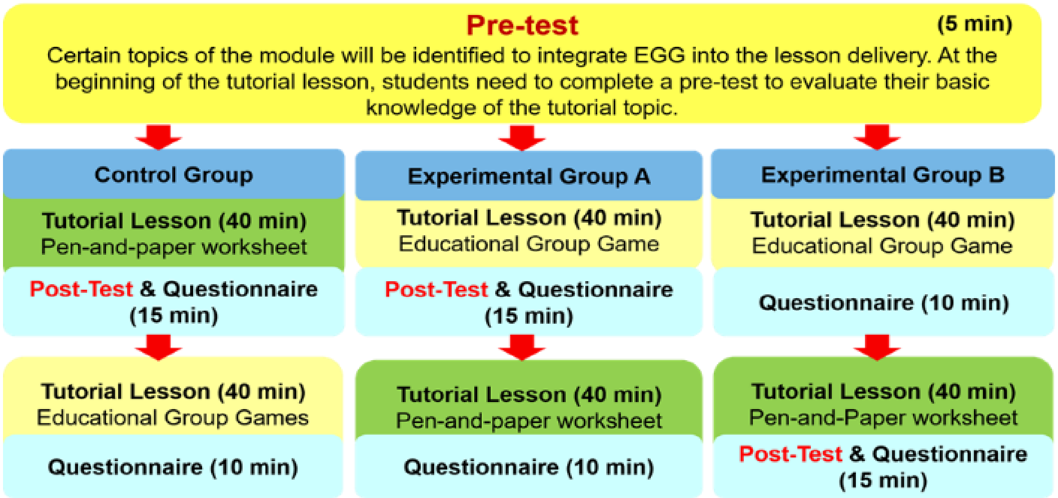

Figure 3. Overview of the research design to study the effectiveness of in-class Educational Group Games (EGGs).

During the two-hour tutorial, all students did the pre- test, went through the traditional pen-and-paper worksheet, played the EGG, attempted the post-test, and completed questionnaires for both the EGG and worksheet. This was done to ensure fairness across the three groups, so that no student would be at a disadvantage in terms of missing out on the lesson content. However, the sequence of content delivery was different. The difference between the pre- and post-tests after administrating the intervention(s) indicated the academic achievement for that intervention. Through this research design, we can understand: (1) from control group data—the effectiveness of the pen-and-paper worksheet, (2) from Experimental Group A data—the effectiveness of the game, and (3) from Experimental Group B data—whether a combination of the two activities can better enhance students' academic achievement.

Items in the pre- and post-tests

A pre- and post-test evaluation was adapted in this study as a parameter to measure the academic achievement and overcome constraints imposed by the quasi-experiment approach. A pre-test was administered at the beginning of the lesson, and the post-test was administered at different timing, based on the research design shown in Figure 3. There were ten questions in each set of the pre- and post-tests, and served as a direct evaluation of student learning. All the questions were identical without randomisation, and crafted based on the lecture topic. Samples of the pre- and post-tests used in both Year 1 and Year 2 are shown in Appendix A.

The questionnaire

A validated instrument (Intrinsic Motivation Inventory, or IMI) as well as questions measuring their extrinsic motivation (direct or indirect performance-salient incentive) were used in the questionnaire to capture students' personal attributes, motivation and demographic data.

The questionnaires were administered at the end of each activity to understand students' perceptions on both the pen-and-paper worksheet and EGGs. Most of the quantitative questions used in the questionnaires were adapted from the IMI, a multi-dimensional validated measurement device created by Ryan and Deci (2000) to assess participants' subjective experience related to a target activity.

The definition and sources of the various variables are summarised in Table 1.

Table 1
Definition and sources of variables in the questionnaire for in-class EGG and pen-and-paper worksheet

Factors	Variables	Definition	Source
Demographic Data	Gender	Students' gender, i.e., male or female	Researcher's self-constructed item
	Age	Students' age	Researcher's self-constructed item
Motivation	Interest	Interest and inherent pleasure when doing an activity, it assesses intrinsic motivation directly. (Deci & Ryan, 1985)	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
	Direct Performance-salient Incentive	Incentives that link directly to the individual's performance, e.g., immediate reward, grade improvement and avoidance of immediate punishment. (Cerasoli et al., 2014)	Researcher's self-constructed item based on the publication by Cerasoli et al. (2014).
	Indirect Performance-salient Incentive	Incentives that link indirectly to the individual's performance, e.g., teacher's recognition, peer's recognition (Cerasoli et al., 2014).	Researcher's self-constructed item based on the publication by Cerasoli et al. (2014).
Personal Attributes	Perceived Competence	Competence based on students' understanding and perception of themselves (Ryan & Deci, 2001)	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
	Effort	Effort that measures the investment of a person's capacities in what he/she is doing. (Fredricks et al., 2004)	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
	Pressure	Pressure experienced by students during the activities. (Fredricks et al., 2004)	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
	Value	Perceived value or usefulness of the activities (Deci et al, 1994)	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
	Perceived Choice	Effectiveness as perceived by individuals feels when they are performing a task (Ryan & Deci, 2000)	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
	Relatedness (in-class EGG only)	Perception of personal connection with others (Teixeira et al., 2012) and it is used to measure the impact of peers' interaction in the EGG only	Intrinsic Motivation Inventory IMI (CSDT, n.d.)
Academic Achievement	Pre-Test	10 MCQ questions were asked about the topic content before the administration of the intervention	Researcher's self-constructed items based on the topic content
	Post-Test	10 MCQ questions were asked about the topic content after the administration of the intervention. It is the same questions as the Pre-test.	Researcher's self-constructed items based on the topic content

There were 37 constructs measuring seven domains in the IMI, which includes "Interest", "Perceived Competence", "Effort", "Value", "Pressure", "Perceived Choice", and "Relatedness". The domain of "Interest" was captured as participants' intrinsic motivation, while the other six domains were captured as participants' personal attributes. The EGG questionnaire incorporated all seven domains of the IMI. However, the domain "Relatedness" was not included in the worksheet questionnaire. This was because no communication was allowed while students were doing the worksheet. All items from the IMI were modified slightly to fit the specific activities. There were five items in all domains except "Interest" (which had seven items) as this is the direct self-reported measurement of intrinsic motivation.

The questions on extrinsic motivation (direct or indirect performance-salient incentive) were developed based on the meta-analysis on motivation by Cerasoli et al. (2014). All the questions were randomised and subjected to a 4-point, instead of 7-point Likert scale as suggested in the IMI. This was to prevent respondents from adopting a neutral perspective and forcing them to make a viewpoint (Brown, 2000). Three open-ended questions were included to obtain respondents' perceptions about the activities since they were useful in obtaining in-depth information, like opinions and suggestions, which the instructor might otherwise not be able to obtain by using the IMI alone. Besides, it helped the instructor obtain detailed information about students' feelings towards both activities (Singer & Couper, 2011). Samples of the questionnaires for the EGG and worksheet can be found in Appendix B.

Data analysis methods and tools

The study employed IBM SPSS (version 23) data analysis software to examine the effectiveness of in-class EGG in enhancing students' learning motivation and academic achievement. A mixed ANOVA was conducted to examine the mean differences between pre- and post-tests among the control group as well as experimental groups A and B of Year 1 and Year 2 students. The results for Year 1 and Year 2 students would be analysed separately since different EGGs were conducted. The two EGGs conducted in different years were different in terms of the mode of delivery and learning objectives. The dependent variable for this analysis is academic achievement, the within-subject factor is time, measured by the pre- and post-test, and the between-subject factor would be the intervention groups, namely the control groups and experimental groups A and B.

An independent sample T-Test was used to determine the mean differences of the attributes and motivations between the worksheet and EGG based on students' responses in both surveys.

RESULTS

There were 88 Year 1 students who participated in the study, of which 24 of them were male and 64 were female. Similarly, of the 56 Year 2 students who participated in the study, there were 19 male and 37 female students.

Mean differences between pre- and post-tests for the control groups, and experimental groups A and B of Year 1 and Year 2 students

The one way repeated measure ANOVA with a Greenhouse Geisser correction determined that the mean difference between the pre- and post-test was statistically significant for both Year 1 $(F=(1, 86) = 22.628), p < 0.001)$ and Year 2 $(F=(1, 54) = 165.244), p < 0.001)$ students. Figures 4 and 5 show the mean score differences between pre- and post-tests among the control groups, and experimental groups A and B for Year 1 and Year 2 students.

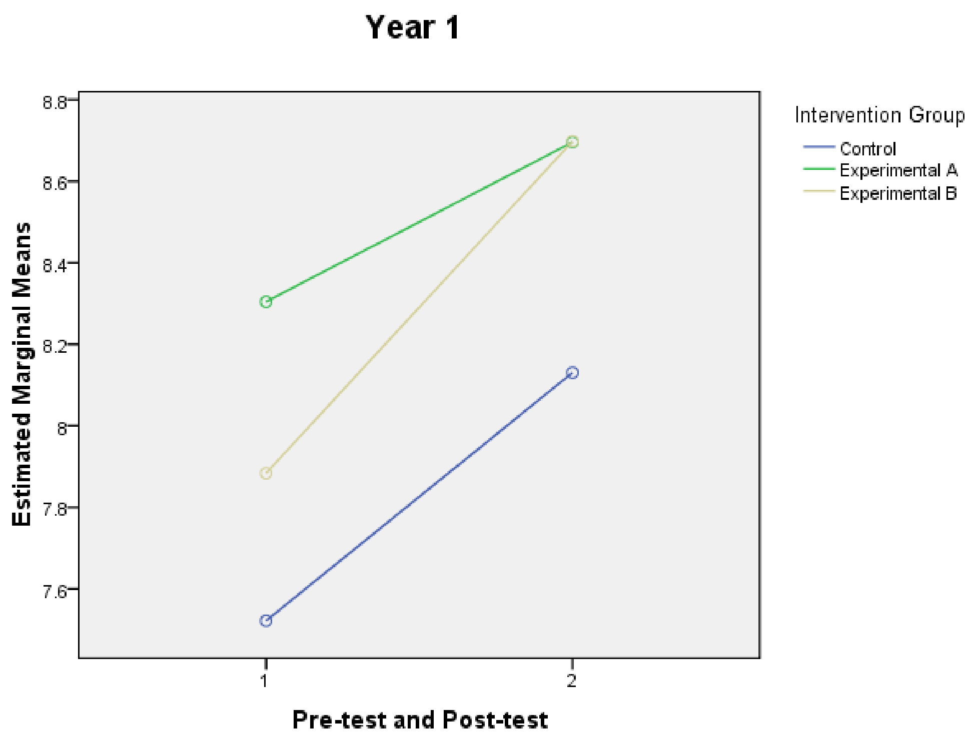

Figure 4. Line graph of the pre- and post-test results in Year 1.

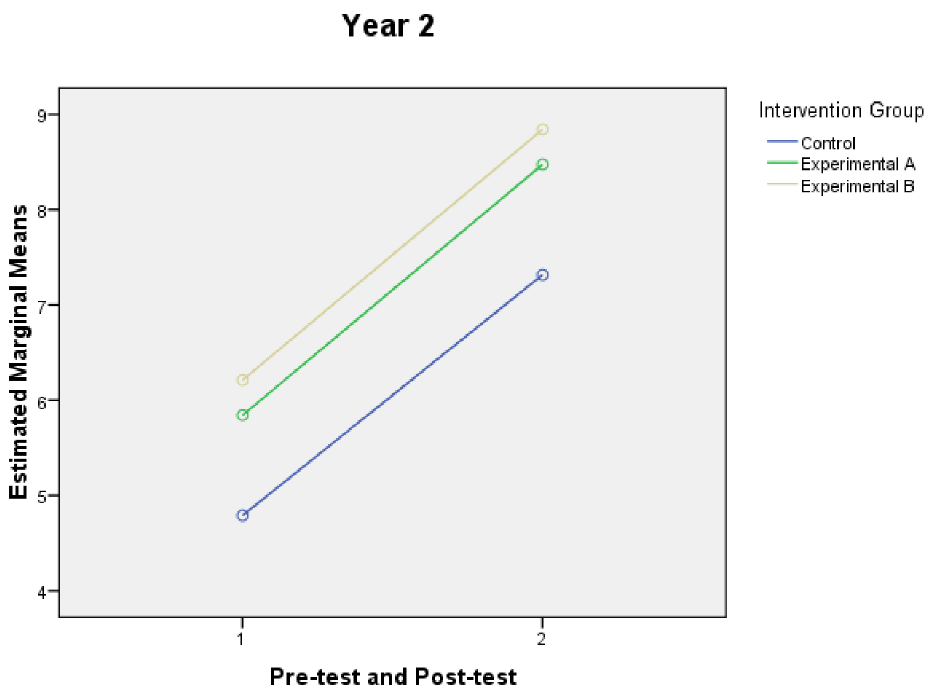

Figure 5. Line graph of the pre- and post-test results in Year 2.

Based on Figure 4, the mean scores of the post-test in all three Year 1 groups were higher than the pre-test. The students in Experimental Group A had the highest mean score (*M = 8.30, SD = 1.06)* in their pre-test compared to Experimental Group B *(M = 7.88, SD = 1.37)* and the control group *(M = 7.52, SD = 1.81)*.

Like the result in Year 1, all three groups in Year 2 achieved higher post-test results compared to the pre-test. Figure 5 showed that the control group *(M = 4.79, SD = 1.84)* had the lowest pre-test score as compared to Experimental Group A *(M = 5.84, SD = 1.77)* and Group B *(M = 6.21, SD = 1.58)*.

Intervention groups and mean differences in pre- and post-tests of Year 1 and Year 2 students

An examination on whether the mean differences in the pre- and post-tests depended on the intervention group was also conducted. The results show that there was no statistically significant interaction between time (i.e. pre-test and post-test) and intervention groups (i.e. control, Experimental Group A and Experimental Group B) with the value of $F(2,86) = 1.03, p = .36$ for Year 1, and $F(2,54) = .03, p = .97$ for Year 2. Therefore, post-hoc tests were conducted focusing on the significant main effects of the within-subject and between-subject factors to better understand where differences between the groups within the factors lay.

Table 2

Group	**Post-Test**		**Pre-Test**		**Mean Difference (Post – Pre)**	**t**	**df**	$p^{\#}$
	Mean	**SD**	**Mean**	**SD**				
Year 1								
Control	8.13	1.49	7.52	1.81	0.61	2.61	22	0.02*
Experimental A	8.70	0.97	8.30	1.06	0.40	1.99	22	0.06
Experimental B	8.70	1.19	7.88	1.37	0.82	4.24	42	<0.001*
Year 2								
Control	7.32	1.38	4.79	1.84	2.53	7.93	18	<0.001*
Experiment A	8.64	0.91	5.84	1.77	2.63	6.99	18	<0.001*
Experiment B	8.84	1.07	6.21	1.58	2.63	7.47	18	<0.001*

*Variable that shows significant difference between pre- and post-Test with p < .05

The p-value is adjusted by using Bonferroni

The within-subject factors were shown in the Table 2, which presents the mean scores, standard deviations, and the mean difference of the test results in the three groups of both years which demonstrate. For the Year 1 students, the worksheet approach (control) significantly improved students' scores by 0.61 (8.11%) with $t(22) = 2.61, p = .02$. Similarly, the combination of worksheet and the EGG approach (Experimental Group B) significantly improved students' scores by 0.82 (10.41%) with $t(42) = 4.24, p = <0.001$. However, the difference between the pre- and post-test scores for Experimental Group A was 0.40 (4.82%), with $t(22) = 1.99, p = .06$, and it implied that the EGG approach alone did not improve students' scores significantly.

For Year 2 students, the EGG-alone approach (Experimental Group A) significantly improved students' scores by 2.63 (45%) with $t(18) = 7.93, p < 0.001$. Similarly, the combination of worksheet and EGG approach significantly improved students' scores by 2.63 (42.35%) with $t(18) = 6.99, p < 0.001$. There was also a significant improvement in the worksheet-only approach by 2.53 with $t(18) = 7.93, p < 0.001$). In both years, both the combination approach and control groups achieved a significant improvement in students' scores.

Table 3
ANOVA summary table for the mean difference between the pre- and post-test among the intervention groups for both years

Source	df	SS	MS	F	p
Year 1					
Between-group	2	5.59	2.79	1.95	0.15
Within-group	86	123.42	1.44		
Total	88	129.01			
Year 2					
Between-group	2	22.35	11.18	7.15	0.02*
Within-group	54	84.71	1.57		
Total	56	107.06			

Table 3 demonstrates the between-subject factors of the intervention groups by showing the mean difference of the pre- and post-tests among the intervention groups for both years. Based on the results shown, there were no significant differences between the intervention groups in Year 1 *(F (2, 86) = 1.95, p = .15).* However, Table 3 also showed a significant mean difference between the pre- and post-tests among the intervention groups in Year 2 (*F(2, 54) = 7.15, p = .02)*. Post-Hoc analyses using Bonferroni test indicated that the mean score was lower in the control group than for Experimental Group A *(MD = 1.11, SE = .41, p = .03).* Similarly, the control group also obtained a significantly lower mean difference than for Experimental Group B *(MD=1.47, SE= .41, p=<0.01).*

Mean differences for perceived attributes and motivation towards the worksheet and the EGG of Year 1 and Year 2 students

Year 1 students' motivation and attributes towards the worksheet and EGG approaches were collected via survey questionnaires and the scores were summarised in Table 4.

Table 4
The mean scores and standard deviations (SD) of students' motivations and attributes towards the worksheet and EGG in Year 1 students

	EGG		Worksheet		n
	Mean	**SD**	**Mean**	**SD**	
Perceived Attribute					
Value	15.86	2.10	15.86	2.01	88
Effort *	13.08	1.55	14.65	1.68	85
Pressure	11.84	2.92	12.78	3.13	87
Perceived Choice *	14.92	2.38	12.51	2.92	84
Perceived Competency	12.86	2.15	12.95	2.15	87
Relatedness	16.64	2.16			
Motivation					
Interest Δ*	23.26	2.72	18.88	3.44	85
Direct Performance *	12.79	1.70	14.56	1.70	87
Indirect Performance *	13.69	2.53	14.58	1.70	88

Δ The base mark of the interest variable is 28. The rest of the motivation and attribute variables have a base mark of 20.

* Variable that shows significant difference between worksheet and game based on the independent sample T-test with $p < 0.05$.

For "Perceived Attribute", there was a significant mean difference in the "Effort" and "Perceived Choice" of EGG compared to the pen-and-paper worksheet. For "Effort", the mean score in the EGG *(M = 13.08, SD = 1.55)* was lower than the worksheet *(M = 14.65, SD = 1.68), t(86) = 7.18, p = .037*, suggesting that students perceived that they spent less effort to play the EGG. On the other hand, a higher mean score of "Perceived Choice" was observed in the EGG *(M=14.92, SD=2.38)* than in the worksheet *(M = 12.51, SD = 2.92), t(84)= 7.42, p < 0.001*. This implies that students felt that they had more choices and felt more effective when they were playing the EGG as compared to worksheet.

For "Motivation", there was a significant increase of interest (intrinsic motivation) when students played the EGG *(M = 23.26, SD = 2.72)* compared to doing the worksheet *(M = 18.88, SD = 3.44)*, *t(84) = 11.25, p < 0.001*. However, there was a significant reduction in extrinsic motivation when students played the EGG as compared to doing the worksheet. This was shown by the results in "Direct Performance" and "Indirect Performance" in Table 4. For "Direct Performance", the mean score in EGG *(M = 12.79, SD = 1.70)* was lower than the worksheet *(M = 14.56, SD = 1.70), t(86) = 8.31, p = .027*. Similarly for "Indirect Performance", the mean score for EGG *(M = 13.69, SD = 2.53)* was also lower than the worksheet *(M = 14.58, SD = 1.7), t(87) = 3.08, p = .032.*

The results of students' motivation and attributes towards the worksheet and the EGG for Year 2 students were summarised in Table 5.

Table 5.
The mean scores and standard deviations (SD) of students' motivations and attributes towards the worksheet and EGG in Year 2 students

	EGG		Worksheet		n
	Mean	**SD**	**Mean**	**SD**	
Perceived Attribute					
Value	15.39	2.21	15.73	1.89	56
Effort	13.35	1.93	13.92	1.33	52
Pressure *	13.37	2.81	9.87	2.38	54
Perceived Choice *	13.89	2.70	13.11	2.66	54
Perceived Competency	13.31	2.45	14.02	2.08	57
Relatedness	15.61	3.18			
Motivation					
Interest Δ*	22.70	3.14	19.07	3.20	57
Direct Performance *	12.60	2.07	14.25	1.67	55
Indirect Performance *	12.42	3.01	13.22	2.57	55

Δ The base mark of the interest variable is 28. The rest of the motivation and attribute variables have a base mark of 20.

** Variable that shows significant difference between worksheet and game based on the independent sample T-test with p < 0.05.*

Similar to Year 1, there was a significant increase in "Perceived Choice" toward playing the EGG (*M = 13.89, SD = 2.70*) as compared to doing the worksheet *(M = 18.88, SD = 3.441), t(53) = 2.90, p = .02*. Unlike the Year 1 students, Year 2 students felt more pressure to play the EGG than doing the worksheet, as indicated by the significant increase in students' mean scores in EGG (*M = 13.37, SD = 2.81*) than in the worksheet (*M = 9.87, SD = 2.38*), *t(53) = 7.42, p < 0.001*.

Similar results for students' motivation were observed in the Year 2 students, as shown in Table 5. There was a significant increase of interest (intrinsic motivation) when students played the EGG *(M = 23.70, SD = 3.14)* as compared to doing the worksheet *(M = 19.07, SD = 3.20), t(56) = 6.14, p < 0.001*. Similarly, there was a significant reduction in extrinsic motivation when students played EGG as compared to doing the worksheet.

DISCUSSION

Traditional worksheet, EGG and a combination of both approaches

For Year 1 students, both the worksheet-only approach, and a combination of worksheet and EGG approach significantly improved students' scores by 0.61 and 0.82 respectively. The EGG-only approach (Experimental Group A) failed to achieve significant improvements in student academic achievement.

Unlike the result in Year 1, the Year 2's Experimental Group A (EGG-only approach) achieved the same significant improvement as Experimental Group B (combination of worksheet and EGG approach), i.e. both approaches improved students' result by 2.63. Experimental Group A (EGG-only approach) even achieved a higher percentage increase than the combination approach (42.35% versus 45%). This was probably due to the lower pre-test score obtained by students in Experimental Group A.

The control group achieved the highest significant improvement (52.82%) in Year 2. It could be a result of the low pre-test score in the control group (worksheet-only approach) compared to the two experimental groups. The hypothesis was confirmed by the significantly lower mean difference of the pre- and post-test scores in the control group compared to Experimental Groups A and B.

However, those improvements in test scores do not depend on the types of interventions, based on the non-significant results obtained in the repeated ANOVA measure for both years. Hence, the result of improvements in academic achievement by using EGG is not conclusive in this study.

Significant improvements were observed in the intrinsic motivation (interest) of the EGG approach compared to the worksheet approach for both Year 1 and Year 2 students. On the other hand, significant reductions of extrinsic motivation (direct performance and indirect performance) of the EGG to the worksheet approach were observed for both years. The results indicated that students had an increase in intrinsic motivation and a decrease in extrinsic motivation while they were playing the EGG. Hence, the EGG enabled students to generate motivation from within. They were participating and performing well in an activity for their own sake, rather than the desire for external rewards (Lee et al., 2012).

Based on the results, the EGG is shown to be a better method than using the worksheet to create an environment that enabled students to cultivate intrinsic motivation without excessive extrinsic rewards. Much of the literature also support the perspective that active learning strategies and techniques help create a more stimulating and enjoyable classroom environment (Miller & Grocchia, 1997; McCathy & Anderson, 2000; Kern, 2012). The EGG approach, like many other active learning strategies, helps create a more appealing environment which would motivate students.

Furthermore, Kim et al. (2009) concluded that students experience the pleasure while playing the game, and this made them grasp the new concept more easily and subconsciously. Students felt that it was more effective as less effort was spent to complete the EGG compared to the worksheet. This was demonstrated by the questionnaire results for Year 1 students as they felt they had more perceived choices, and less effort was required to play the EGG compared to doing the worksheet.

Year 2 students responded similarly to their Year 1 counterparts. However, the former felt more pressurised to play the EGG. This finding opposes the suggestion by Deci and Ryan (1985) that a reduction in pressure helps promote intrinsic motivation. This could be due to the excitement in playing the highly competitive and time-restrictive EGG "Game of Truth", which led to students feeling more pressured.

The use of the EGG is further supported by the overwhelmingly positive responses recorded in the open-ended question about students' perceptions of the EGG. Students indicated that they loved to participate in the EGG as they found that the game helpful in terms of training their thinking, improving their communication skills, and promoting teamwork. These positive responses were consistent with observations made in various studies (Seow, 2016; Wang, 2015; Sandford, 2014).

Limitations and recommendations

An examination on whether the mean differences in the pre- and post-tests depended on the intervention group was conducted through mixed ANOVA. There was no statistically significant interaction between time (i.e. pre-test and post-test) and the intervention groups (i.e. control group, Experimental Group A and Experimental Group B). However, a within-subject factor analysis showed that the post-test scores were significantly higher compared to pre-test scores in the combination approach for both years. The inconclusive result in the demonstration of effectiveness of the EGG in academic achievement could be due to the small population size. Hence, a more generic EGG could be used and administered to a larger population in a subsequent research study.

This study was undertaken by one researcher who not only conducted both the EGG and pen-and-paper worksheet during the lesson, but also administered and collected the pre- and post-tests and questionnaires. Hence, bias might be introduced in the research as the students might want to gain recognition from the instructor (Cerasoli et al., 2014). However, the bias was reduced since the questionnaire was fully anonymous, and no student would be able to gain recognition by submitting good feedback.

This study also provides some guidance for further research. As the pen-and-paper worksheet is a traditional learning method which is more intellectually engaging compared to the EGG activity which is more fun. Future research can be done to compare students' motivation of in-class EGG with other active learning strategies, like case-based learning or problem-based learning, which are intellectually engaging (Edward, 2015).

This study only investigated the impact of EGGs on Year 1 and Year 2 DPS students in Nanyang Polytechnic. The result gathered from this research is encouraging. This may propel more educators involved in the teaching of sciences-related diplomas to adopt EGGs.

CONCLUSION

Two simple and low-cost EGGs were developed and tested in a study which involved 144 Year 1 and Year 2 students taking the Diploma of Pharmaceutical Science at Nanyang Polytechnic. The study shows that the game provides an affective learning environment for students to learn in a playful and interactive way. The components of excitement and entertainment while playing the game appealed to the new millennial learners.

Such results from the study might encourage educators in institutes of higher learning to consider designing and adopting in-class EGGs more frequently and enthusiastically. Hence, more support can be sought and more resources may be allocated to develop interesting in-class EGGs in the future. Lastly, the findings from this study could provide some direction for future research to measure the effectiveness of in-class EGGs in diploma programmes in other institutes of higher education.

ACKNOWLEDGEMENTS

The authors are grateful to all the students and parents who agreed (or allowed their children) to participate in this research project. The authors are also thankful to Dr Lye Che Yee who provided great support in terms of statistical analysis and advice for this paper. This work was supported by the Ministry of Education-Tertiary Education Research Fund (MOE-TRF), Singapore.

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REFERENCES

Brown, J. D. (2000). What issues affect Likert-scale questionnaire formats? *Shiken: JALT-testing & Evaluation SIG Newsletter, 4*(1), 18-21. http://hosted.jalt.org/test/bro_7.htm

Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychological Bulletin, 140*(4), 980. http://dx.doi.org/10.1037/a0035661

CSDT (n. d.). *Intrinsic Motivation Inventory (IMI)*. https://selfdeterminationtheory.org/intrinsic-motivation-inventory/

Deci, E. L., Eghrari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: The self-determination theory perspective. *Journal of Personality, 62*(1), 119-142. http://dx.doi.org/10.1111/j.1467-6494.1994.tb00797.x

Deci, E. L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of research in personality, 19*(2), 109-134.

Edwards, S. (2015). Active learning in the middle grades: This article offers examples of developing students' participation as a central tenet of ideal middle level education that is intellectually active, socially active, and physically active. *Middle School Journal, 46*(5), 26-32. http://dx.doi.org/10.1080/00940771.2015.11461922

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of educational research, 74*(1), 59-109. http://dx.doi.org/10.3102/00346543074001059

Fine, S. M. (2014). "A slow revolution" Toward a theory of intellectual playfulness in high school classrooms. *Harvard Educational Review, 84*(1), 1-23. http://dx.doi.org/10.17763/haer.84.1.qtr193464843n334

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education, 80*, 152-161. http://dx.doi.org/10.1016/j.compedu.2014.08.019

Kern, B. (2012). Using role play simulation and hands-on models to enhance students' learning fundamental accounting concepts. *Journal of the Scholarship of Teaching and Learning, 1*(1), 8-24. https://scholarworks.iu.edu/journals/index.php/josotl/article/view/1581

Keller, C. L., Bucholz, J., & Brady, M. P. (2007). Yes, I can! Empowering paraprofessionals to teach learning strategies. *Teaching Exceptional Children, 39*(3), 18-23. http://dx.doi.org/10.1177/004005990703900303

Kim, B., Park, H., & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education*, *52*(4), 800-810. http://dx.doi.org/10.1016/j.compedu.2008.12.004

Koh, E., Kin, Y. G., Wadhwa, B., & Lim, J. (2012). Teacher perceptions of games in Singapore schools. *Simulation & Gaming*, *43*(1), 51-66. http://dx.doi.org/10.1177/1046878111401839

Lee W, Reeve J, Xue Y, & Xiong J. (2012). Neural differences between intrinsic reasons for doing versus extrinsic reasons for doing: an fMRI study. *Neurosci Res., 73*(1), 68-72. http://dx.doi.org/10.1016/j.neures.2012.02.010

Leng, E. Y., Baki, R., & Mahmud, R. (2010). Stability of the intrinsic motivation inventory (IMI) for the use of Malaysian Form One students in ICT literacy class. *Eurasia Journal of Mathematics, Science & Technology Education, 6*(4), 215-226. https://doi.org/10.12973/ejmste/75242

Lucangeli, D., & Scruggs, T. E. (2003). Text anxiety, perceived competence, and academic achievement in secondary school students. In *Advances in learning and behavioural disabilities* (pp. 223-230). Emerald Group Publishing Limited.

Malaquias, R. F., Malaquias, F. F. D. O., JUNIOR, D. M. B., & Zambra, P. (2018). The use of a serious game and academic performance of undergraduate accounting students: An empirical analysis. *Turkish Online Journal of Distance Education, 19(*2), 117-127. http://dx.doi.org/10.17718/tojde.415825

McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport, 60*(1), 48-58. http://dx.doi.org/10.1080/02701367.1989.10607413

McCarthy, J. P., & Anderson, L. (2000). Active learning techniques versus traditional teaching styles: Two experiments from history and political science. *Innovative Higher Education, 24*(4), 279-294. http://dx.doi.org/10.1023/b:ihie.0000047415.48495.05

Miller, J. E., & Groccia, J. E. (1997). Are four heads better than one? A comparison of cooperative and traditional teaching formats in an introductory biology course. *Innovative Higher Education 21*, 253-273. http://dx.doi.org/10.1007/BF01192275

Piaget, J. (1962). *Play, dreams and imitation in children*. New York: Norton.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57*, 749-761. http://dx.doi.org/10.1037/0022-3514.57.5.749

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78. http://dx.doi.org/10.1037/0003-066X.55.1.68

Sandford, R. (2014). Teachers as game designers: using a game in formal learning in a Singapore primary school. *Educational Media International, 51*(1), 66-78. http://dx.doi.org/10.1080/09523987.2014.889410

Seow, P. S., & Wong, S. P. (2016). Using a mobile-gaming app to enhance accounting education. *Journal of Education for Business, 91*(8), 434-439. http://dx.doi.org/10.1080/08832323.2016.1256264

Singer, E., & Couper, M. P. (2011). Ethical considerations in web surveys. In M. Das, P. Ester, & L. Kaczmirek (Eds.), *Social Research and the Internet (pp. 133-162). New York: Taylor and Francis.*

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology*, *64*(2), 289-558. https://doi.org/10.1111/j.1744-6570.2011.01190.x

Smith, D. J., & Valentine, T., (2012). The use and perceived effectiveness of instructional practices in two-year technical colleges. *Journal on Excellence in College Teaching*, *23*(1), 133-161. https://eric.ed.gov/?id=EJ972560

Teixeira, P. J., Silva, M. N., Mata, J., Palmeira, A. L., & Markland, D. (2012). Motivation, self-determination, and long-term weight control. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 22. http://dx.doi.org/10.1186/1479-5868-9-22

Vygotsky, L. S. (1967). Play and its role in the mental development of the child. *Soviet Psychology*, *5*(3), 6-18. https://doi.org/10.2753/RPO1061-040505036

Wang, A. I. (2015). The wear out effect of a game-based student response system. *Computers & Education, 82*, 217-227. http://dx.doi.org/10.1016/j.compedu.2014.11.004

Wouters, P., Van Nimwegen, C., Van Oostendorp, H., & Van Der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of educational psychology*, *105*(2), 249-265. http://dx.doi.org/10.1037/a0031311

Zhang, X., & Venkatesh, V. (2013). Explaining employee job performance: The role of online and offline workplace communication networks. *MIS Quarterly*, *37*(3), 695-722. http://dx.doi.org/10.25300/misq/2013/37.3.02 ■

APPENDIX A. SAMPLES OF THE QUESTIONS FOR THE PRE- AND POST-TESTS

APPENDIX B. SAMPLES OF THE QUESTIONNAIRES FOR THE EGG AND THE WORKSHEET