
Title	Learning physics: The “Play-N-Learn” approach
Author(s)	Munirah Shaik Kadir and Yau Che Ming

Copyright © 2006 Natural Sciences and Science Education, National Institute of Education

This is the published version of the following conference paper:

Munirah Shaik Kadir, & Yau, C. M. (2006). Learning physics: The “Play-N-Learn” approach.
In Y. J. Lee, A. L. Tan, & B. T. Ho (Eds.), *Proceedings of ISEC 2006: Science education: What works* [CD-ROM] (pp. 757-771). National Institute of Education (Singapore).

LEARNING PHYSICS: THE “PLAY-N-LEARN” APPROACH

Munirah Shaik Kadir

Chung Cheng High School, Singapore

Yau Che Ming

National Institute of Education, Nanyang Technological University

Abstract:

The science curriculum in Singapore promotes innovation in teaching and learning to encourage children to develop curiosity and the spirit of inquiry. It hopes to build the development of thinking and reflection into the everyday classroom processes and sets to understand the complexities and relate learning to application and alternatives. The end goal is pupils who enjoy and value science.

In the area of physics, pupils find it difficult to enjoy and appreciate the subject because they are intimidated by the terminologies, calculations and concepts that require higher- order thinking. Teachers are always looking for new ways to make physics more appealing to the pupils.

Past research has shown that when pupils play with concrete models and toys, it arouses curiosity and interest because it is a fun learning experience. Curricula in early childhood education programs throughout the world are built around play because young children respond very well to it and play has shown to contribute to the many aspects of a child's psychological development.

If the level of difficulty of the play activities is raised for older pupils, will play still be a stimulant for their learning and will the learning be effective? Will the pupils respond well to play or find the play experience too childish? These are some of the questions and concerns that have been addressed in the study. This paper reveals how the “play-n-learn” approach was implemented on a group of secondary three pure physics pupils and their response to the experience.

INTRODUCTION

Many pupils have commented that physics is a difficult subject because they are not able to visualize some physics concepts and encounter difficulties relating theories to real life. Some develop a fear for the subject over time. The Curriculum Planning and Development Division (CPDD) of MOE promotes innovation in teaching and learning to encourage children to develop curiosity and spirit of inquiry. It hopes to build the development of thinking and reflection into the everyday classroom processes and sets to understand the complexities and relate learning to application and alternatives. The end goal is pupils who enjoy science and value science, not those who fear the subject. Teachers are expected to facilitate and role model the inquiry process, and help pupils overcome difficulties. The ideal teaching and learning approaches are those which centre around the student as an inquirer. In this study, the play-n-learn approach was taken to motivate and get the pupils interested in the physics learning experiences in order to facilitate the inquiry process. As play is often without strict rules, the level of achievement and accomplishment are often self-set. When pupils are able to acquire what they aim to in their play, they will attain a level of satisfaction which will then lead to their interest for continual learning in the subject, so asking questions and acquiring concepts may come naturally. Findings described in this paper support this assertion.

THEORETICAL BACKGROUND AND LITERATURE REVIEW

Play-n-Learn

Although a definition of play is difficult to derive; there is a consensus on the common characteristics of play behaviours (Rubin, Fein, & Vandenberg, 1983). Play is intrinsically motivated rather than extrinsically motivated. One aspect of play that reveals the importance of process over results

is its non-literality. In play, the activities are not to be taken at face value, for what they literally are, but as a medium for play (Chance et al., 1979).

Sutton-Smith (1979) stated that play gives us permission to make mistakes. The freedom to fail and the permission to explore and fiddle with the absurd, allow the child the opportunity to explore the outer limits of his skill, thereby gradually extending those limits. Usually children may function at a higher level of sophistication in their play than at other times. It is not just that children talk more during play, but that their language is more complex, more sophisticated. They also use skills that, in other settings, they simply do not seem to possess.

It is not unusual to identify tangible instances in which children learnt or realized something new in their play. Clearly both processes and outcomes are important indicators of the value of play (Wood & Attfield, 1996). Children benefit through play by constructing competencies in all areas of development (Fromberg & Bergen, 1998; Jones & Reynolds, 1992; VanHoorn, Nourot, Scales, & Alward, 1999).

Play is known to be a stimulus for effective learning when the level of difficulty of the play activity is not too high and not too low. According to Chance (1979), activities that are either too difficult or too easy seldom qualify as play. In order to be play, an activity must ordinarily be difficult enough to be interesting, but not so difficult that it is impossible. The challenge is open ended, as much up to the player as is the solution.

Play is known to be the natural medium through which youngsters explore their environment, solve problems (Garvey, 1990; Rubin, Fien & Vandenberg, 1983), and develop their motor skills and cognitive abilities (Piaget, 1966). When students play with concrete models and toys, it will arouse curiosity and interest in the subject and thus will stimulate motivation in learning the concepts; some made visual by the 'toy', others formed by filling in the gaps in their cognitive maps as they explore further because of the excitement of self-discovery. Extensive literature that is grounded in the constructivist theories of Piaget and Vygotsky (DeVries & Kohlberg, 1987; Vygotsky, 1962) covers play in the educational setting with a focus on learning through play.

Learning

More recent work in brain studies indicates that learning is something that happens through the connections made within the brain as a result of external stimuli received through the senses (Sylwester, 1997; O'Shea, 2002; Greenfield, 2004). Learning does not happen in a social vacuum but is an interactive event that helps children construct their own meanings through activities supported by adults (Moyses, 2005).

The learner is said to be active in shaping knowledge when he or she connects the new concepts to the real world and to prior knowledge, participates in the activity as a group and is involved in feedback and interactions. Probing prior knowledge in the student learner can be verbal, visual, graphic or dramatic. Probes seek to elicit the different understandings of concepts and the two main designs of probes are using questionnaires and drawings (CPDD, 2005).

Learning is both recursive and incremental so that children gradually develop flexibility and transfer-ability. Creativity, imagination and fantasy are important elements in this process as they encourage divergent ways of thinking and reasoning and help to make novel connections and interconnections between areas of the brain and different domains of learning (Wood & Attfield, 1996).

Learning Science in a Play-Centred Curriculum

In our educational context, the quality of the learning environment, the role of play in the planned curriculum and the role of adults are all influential factors in developing a clearer relationship between play and pedagogy. Whilst some of this learning will be spontaneous, educators need to be able to utilize

play as a window into the child's developing mind in order to understand the learning patterns, characteristics and needs of the individual children (Wood & Attfield, 1996; Yau, 2002).

How can our observations of young children's natural interests as expressed through play lead us to the formation of a balanced curriculum? If we analyze the nature of science, we recognize that central to all scientific inquiry and discovery are certain dispositions: curiosity, a drive to experiment, and a desire to critically assess the validity of answers. Children's spontaneous play shows us the children's interests, what they are curious about and how they attempt to solve problems. We believe that a developmentally appropriate science program is based on the similarities between scientists involved in science and children involved in play – an interest plus the energy, knowledge, and skills to pursue that interest. (Judith et al., 2003)

Approaches to the teaching of science illustrate the changes that are occurring. The sciences are deeply involved with the amassing of facts, data and specifics. But scientists are now concerned as much with the process and the means of gathering information as they are with the information itself. The proponents of science education are working to develop attitudes of curiosity and interest in experimentation (Rosberg, 2003).

Role of the science teacher in a Play-Centred Curriculum

Just with other disciplines, it takes the trained eye of the educator to see the science processes, concepts, and content that the children are involved as they play. Children are engaged in scientific processes whenever they are observing, comparing, and exploring. (Judith et al., 2003)

The teacher's role becomes a critical component when play is at the centre of a curriculum in an educational setting. The role of the science teacher is to promote the interest in learning science, and play seems to be one avenue that could be explored to motivate and help pupils acquire scientific concepts (Jones & Reynolds, 1992).

Teachers can begin with an environment that invites children to explore their physical world through spontaneous play. Drawing upon the children's expressed interests, teachers can introduce science activities related to children's play. Generally, pupils prefer the hands-on approach to traditional teaching, so the pupils will most surely welcome play-n-learn as a mode of learning in their curriculum. However, pupils' perceptions of the play-n-learn workshop and a test on the effects of such workshops on the pupils' performance in a subject area are still necessary to ensure that the pupils are able to enhance their learning when they play with models, 'toys' and hands-on play kits which are selected for their cognitive level.

Figure 1 shows a model created by the authors. The model summarizes their ideas on how play can enhance learning in pupils.

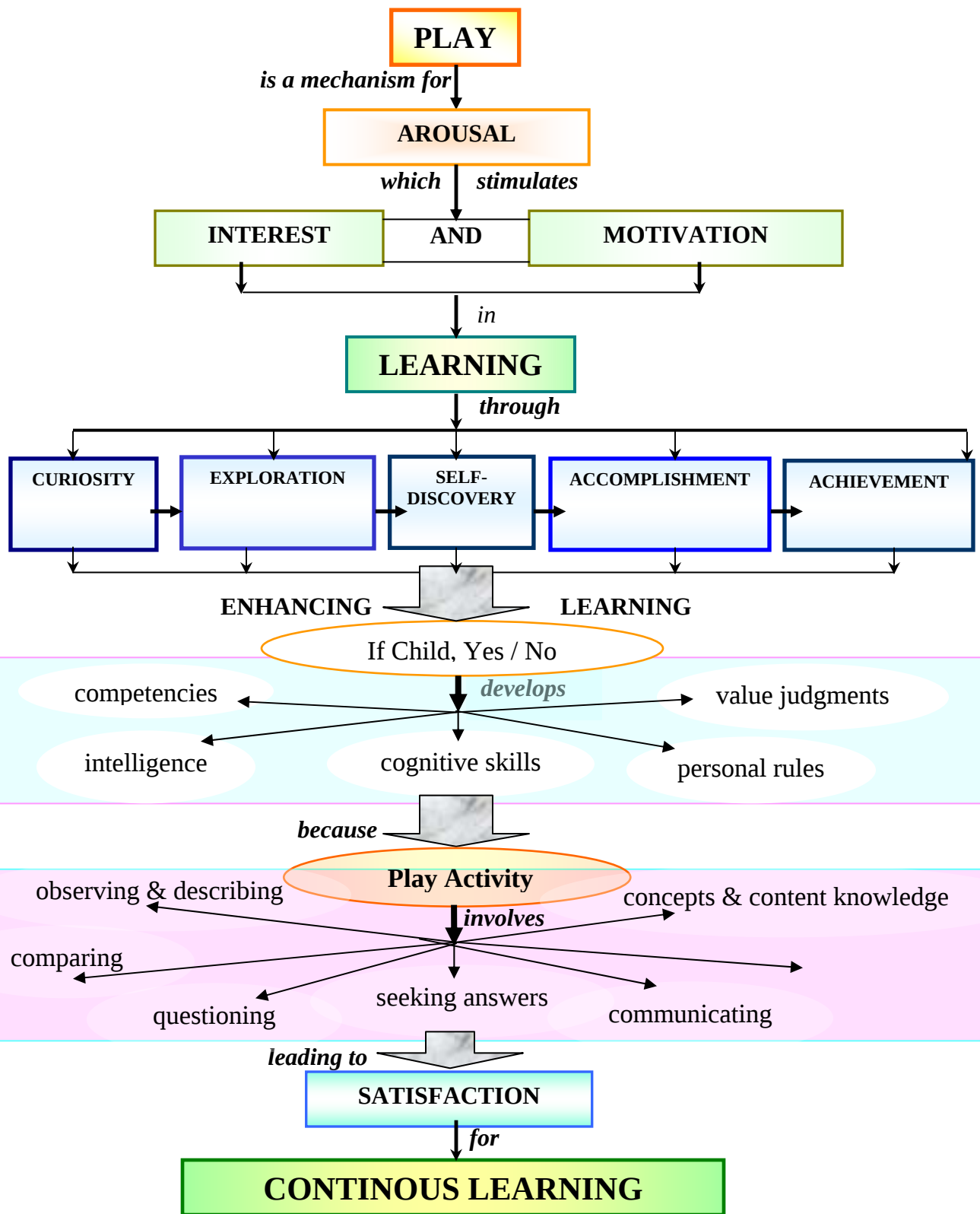


Figure 1

A Model on how Play can enhance Learning

A sample size of 100 Secondary Three pupils (whose average age is 15 years) was selected for the study. The sample was taken from the pupils in the express stream reading pure physics in the school curriculum in Chung Cheng High School (Main) (CCHMS). The percentage of male and female pupils involved in the study is 45% and 55% respectively, which was a close representation of the population of a co-ed school with a relatively even distribution of male and female pupils. The student sample was of mixed ability in their competencies in physics. Their ability level was categorized into three groups, High Ability (HA), Middle Ability (MA) and Low Ability (LA). Most of the pupils were in the middle ability range (46%). Twenty percent (20%) of the sample fell in the high ability category and the remaining 34% was in the low ability category.

They were grouped into these categories based on their Secondary Three Overall Examination results in Physics. The high ability pupils were those who scored As (A1 and A2; with marks ranging from 70-100) in their Physics examinations. The middle ability pupils were those who scored Bs (B3 and B4; with marks ranging from 60-69) and C5 (55-59 marks). Pupils in the low ability category (C6, D7, E8 & F9; with marks ranging from 0-54) formed 34% of the cohort.

Research Plan

The purpose of the study is use a play-n-learn approach to give the secondary school pupils learning experiences in physics and then establish the perceptions of the pupils towards the learning experience and also measure their performance in a diagnostic physics test to study if the play-n-learn approach has, in any way, helped them acquire the intended physics concepts thus benefiting them academically.

The subjects were grouped for the purpose of the structured play segment of the workshop such that each group comprised three to five pupils of mixed ability and gender. Figure 2 illustrates the flow chart of the methodology employed for the study.

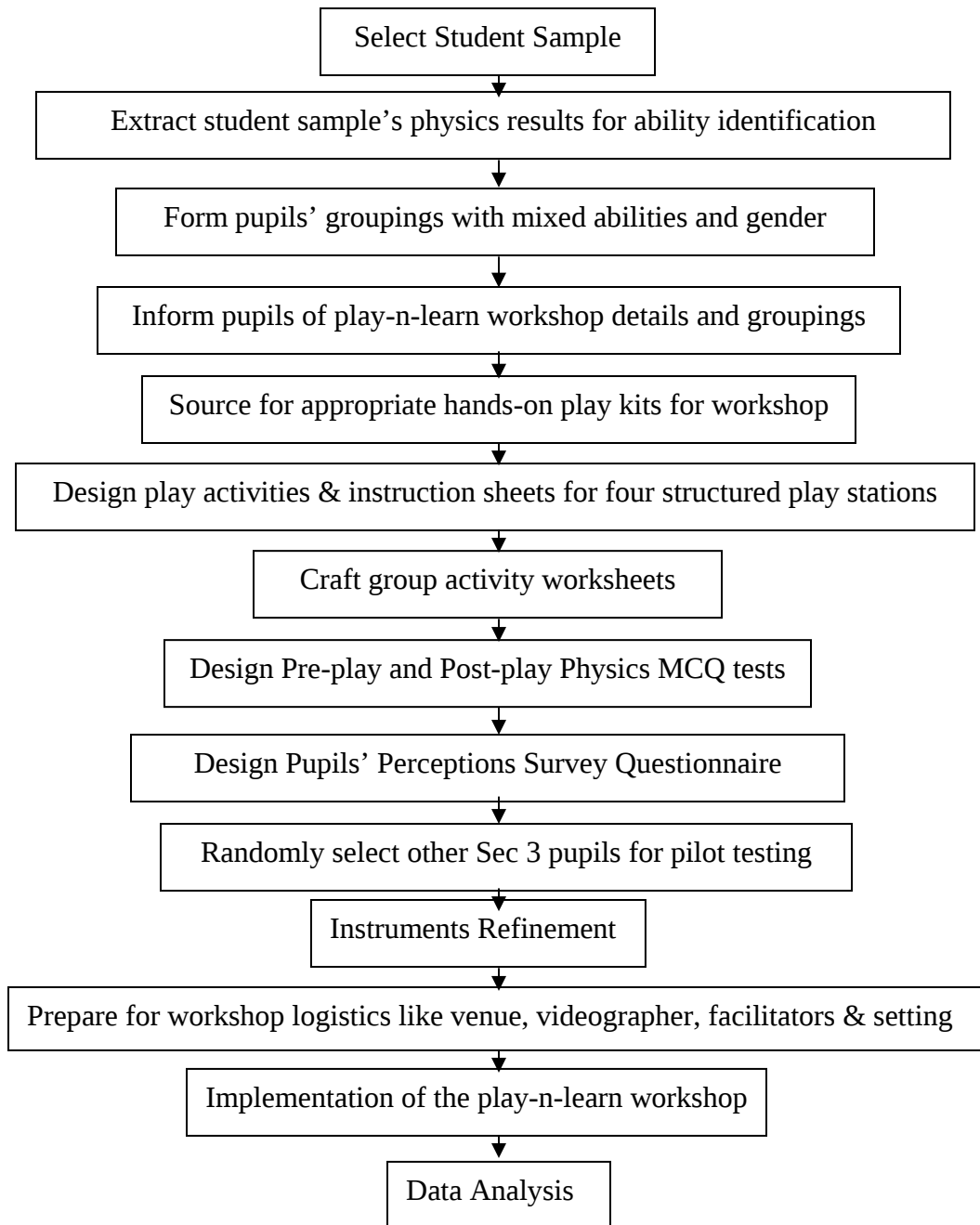


Figure 2

Flowchart of Research Methodology

SURVEY INSTRUMENTS

The measuring instruments used to collect data in this survey approach were two sets of questionnaires, the group activity worksheet and video clippings of the pupils during the play-n-learn physics workshop.

The questionnaire

Two sets of questionnaires were developed, one for pre-play and the other for post-play.

A pre-play questionnaire was administered prior to the commencement of the workshop. This pre-play physics MCQ test was designed to assess the conceptual knowledge of the pupils before they attend the play-n-learn workshop. Another set of questionnaire was administered at the end of the workshop. This post-play questionnaire comprised the same concept questions in the pre-play physics MCQ test and an additional twelve survey statements which were set to investigate the pupils' perceptions of the play-n-learn physics workshop. The pupils' perceptions survey (in the post-play questionnaire) included rating scales (Strongly Agree, Agree, Disagree and Strongly Disagree) and open-ended formats. It consisted of both negative and positive statements in order to have a more balanced and fair response. The open-ended questions at the end of the survey provided an opportunity for self-expression, an avenue which was important in the survey.

Group Activity Worksheet

The group activity worksheet was designed to accompany the pupils throughout their play-n-learn experience at the structured play segment. This group activity worksheet served both as a guide as well as a record of the pupils' learning as a group at the four structured play stations. The pupils were reminded to discuss their findings as a group and to take turns to record them in the group activity worksheet.

Video Clippings

The video clippings served as a supplement to the questionnaires, the main and major method of approach in this study. The day to day proceedings of the seven-day workshop were recorded to observe the pupils' interactions with one another, their mood and behaviour as they experience the structured as well as the free play segments of the workshop. Their comments and conversations as well as their body language and behaviour were assessed against the responses from the questionnaires to obtain a clearer and richer understanding of the subject researched on.

RESULTS

Pupils' Perceptions

The pupils' perceptions showed that they enjoyed the play-n-learn workshop, with 98% considering the workshop as fun and interesting. They also believed that the play kits helped them to learn. Ninety-four percent (94%) of them agreed that play helped reduce their fear of physics. The same percentage of pupils also felt that they learnt physics better through play than theory lessons. As mentioned by Elkind (1981), play has a therapeutic effect of helping young adolescents release stress and built-up tension. Table 1 shows the survey statements, their grouping, whether they are positively or negatively worded, and the results from the pupils' responses. The ranking column shows how popular the statement is with the pupils with Rank 1 being the best (highest percentage of pupils who agreed with the positive statement and disagreed with the negative statement) and Rank 12 being the worst (highest percentage of pupils who disagreed with the positive statement and agreed with the negative statement).

Table 1 Results of Pupils' Perceptions Survey

	Survey statements	+ positive / - negative	Grouping	Ranking	% Agree	% disagree
1	This is a fun and interesting play - n - learn workshop.	+	1	2	98	2
2	I learn easily by playing with hands-on kits.	+	2	5	96	4
3	Now, after this workshop, I like physics more.	+	6	9	88	12
4	I prefer to carry out activities by myself than in groups.	-	3	10	13	87
5	I learn better when I carry out activities in a group.	+	3	8	89	11
6	I think I do not learn anything from this workshop.	-	2	3	3	97
7	I learn better from such 'play' activities than just theory lessons.	+	4	3	97	3
8	I learn better when there are worksheets to guide me.	+	5	12	84	16
9	The activity worksheets restrict my creativity so I cannot learn.	-	5	11	14	86
10	I cannot concentrate and learn when I am having fun.	-	1	6	7	93
11	Theory lessons make me learn better than such activities.	-	4	7	10	90
12	The activities make me tense and increase my fear of physics.	-	6	1	1	99

The results of the pupils' perceptions survey show an overall positive response to the play-n-learn workshop. The pupils agreed with the positively structured statements and disagreed with the negatively structured statements.

Pupils' open-ended perceptions on free play versus structured play

At the end of the 12-statement survey questionnaire, there was an open ended segment in which the pupils were given the freedom to write anything that they wanted about the play-n-learn workshop. Most of them chose to write about their preferred experience between free play and structured play. Table 2 shows a comparison between free play and structured play as perceived by the pupils.

Table 2 Comparison between Free Play and Structured Play

Free Play	Structured Play
• No time limit • No restrictions, rules and regulations • Freedom to choose any play activity • No worksheets • Freedom playing individually or in groups • A lot of room for innovation and creativity • No guidance unless requested • Open ended, learning is left to the individual	• With time limit • Instructions and steps to follow • Play activities are pre-determined • Worksheets to guide learners • Playing in pre-determined groups to facilitate cooperative learning • Innovation and creativity are bound by rules of play activity • Guidance provided to meet learning objectives of play • Need to make sense of the activity and draw conclusions to streamline learning

Pupils' Performance

Figure 3 represents the data to show whether there is any improvement in the pupils' test results after attending the play-n-learn workshop.

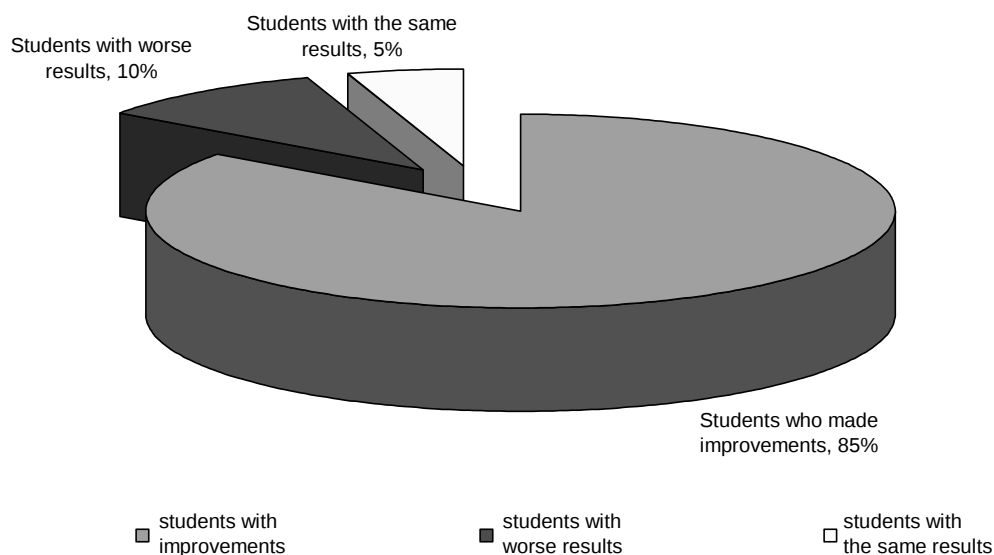


Figure 3 Percentage of Pupils who improved in the post-play test

Eighty-five percent (85%) of the pupils improved in their performance in the physics MCQ test after attending the workshop. Ten percent (10%) of them, however, scored worse results and a minority (5%) of the participants scored the same results in the pre-play and post-play test. The majority of the pupils who obtained worse results in their test after attending the workshop was in the middle ability (MA) range (7 pupils). Only one high ability (HA) student and two low ability (LA) pupils scored likewise in the post-play test. The student who obtained the worst result (worsen by 3 marks) in the post-play test was a low ability male student from Class B who was typically weak in the subject.

An interesting finding is that the majority of the pupils who got lower scores were boys (i.e. three girls and seven boys worsen their scores). As for the boys who obtained lower scores, the majority (5 boys) was from Class B, a class that was competitive when it came to Physics theory tests. One boy who obtained lower score came from Class A and another from Class C. As for the girls, all of them who obtained lower scores came from the same class, Class C.

The two girls with zero improvement score were from the same class, Class C. Another similar trend was that most of the pupils who scored the same results in both tests were boys, and this time all three were from Class B. An interesting observation was that two of them were High Ability (HA) pupils. They were from the same group, Group 9, the only all-boys group in the play-n-learn workshop. There was no middle ability student amongst the five of them.

Pupils' overall performance in each Physics Multiple Choice Question

The pupils' performance for each question in the Physics MCQ test was compiled and comparisons were made between the pre-play and post-play test results to determine whether the play-n-learn workshop experience had caused any significant difference in their performance. Having a higher percentage of pupils who got the question correct in the post-play test than the pre-play test could imply that the pupils had acquired or improved in the physics concepts within that scope after going through the play-n-learn workshop.

Table 3 shows the percentage of pupils who got the question correct or wrong for each of the twelve physics concept questions in the pre-play and post-play test. The '% Improvement' was derived from taking the '% Correct' data in the post-play test and subtracting the '% Correct' data in the pre-play test. Zero ('0') showed that there was no improvement made for the question before and after the play-n-learn workshop and positive values for '% Improvement' showed that more pupils got the question correct after attending the play-n-learn workshop than before.

Table 3 Pupils' Performance for each Physics Conceptual Question

<u>MCQ CONCEPT</u> <u>QUESTIONS RESULTS</u> (12 MCQ)						
		<i>PRE- PLAY</i>		<i>POST- PLAY</i>		
		% Correct	% Wrong	% Correct	% Wrong	% <i>Improvement</i>
Topic 1:	<u>Magnetism</u>					
	Question 1	97	3	97	3	0
	Question 2	84	16	95	5	11
	Question 3	89	11	95	5	6
		<i>Total Improvement points = 17</i>				
		<i>PRE- PLAY</i>		<i>POST- PLAY</i>		
Topic 2:	<u>Electronics (function of the LDR)</u>	% Correct	% Wrong	% Correct	% Wrong	% <i>Improvement</i>
	Question 1	7	93	70	30	63
	Question 2	15	85	69	31	54
	Question 3	19	81	89	11	70
		<i>Total Improvement points = 187</i>				
		<i>PRE- PLAY</i>		<i>POST- PLAY</i>		
Topic 3:	<u>Hydrometer</u>	% Correct	% Wrong	% Correct	% Wrong	% <i>Improvement</i>
	Question 1	59	41	90	10	31
	Question 2	34	66	63	37	29
	Question 3	26	74	47	53	21
		<i>Total Improvement points = 81</i>				
		<i>PRE- PLAY</i>		<i>POST- PLAY</i>		
Topic 4:	<u>Electricity</u>	% Correct	% Wrong	% Correct	% Wrong	% <i>Improvement</i>
	Question 1	62	38	75	25	13
	Question 2	67	33	88	12	21
	Question 3	25	75	62	38	37
		<i>Total Improvement points = 71</i>				

The 'Total Improvement points' were derived from taking the sum of the '% Improvement' data for each of the three questions. This value, though arbitrary, gave an idea of the degree of improvement made by the pupils for each topic after going through the play-n-learn workshop.

A study of the results in Table 4.10 shows that the pupils' performance for each of the MCQ was better after attending the play-n-learn workshop than before because more pupils got the MCQ correct in the post-test (after going through the play-n-learn workshop) than in the pre-test (before going through the play-n-learn workshop). This fact is easily reflected as positive values in the '% Improvement' column.

Observations and Comparisons among the high, middle and low ability pupils

The results revealed that the middle and low ability pupils had benefited more from this play-n-learn workshop than the high ability pupils. A higher percentage of the pupils within these groups improved on their Physics MCQ test scores after the workshop.

Figure 4 shows the percentage of pupils in each ability group who made improvement, scored worse scores in the post-play than in the pre-play test and equaled the scores in both tests.

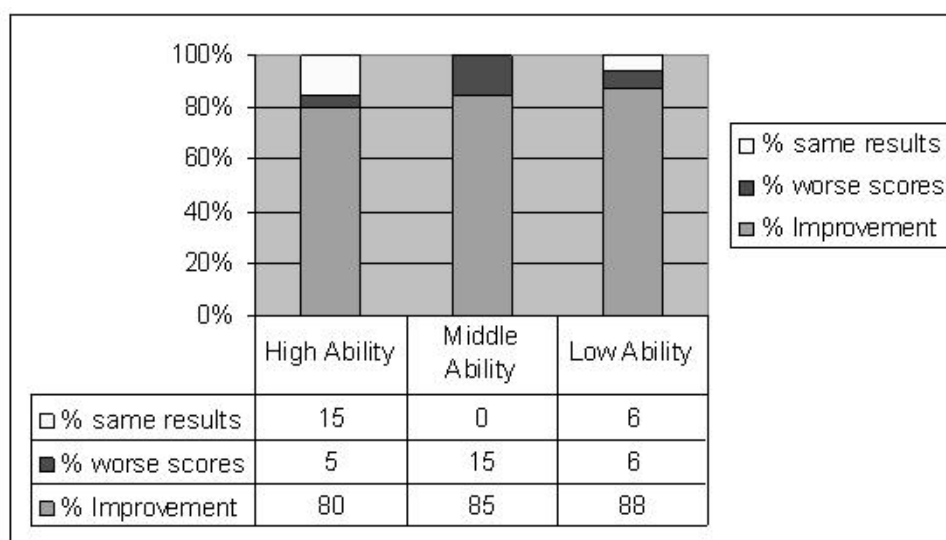


Figure 4 % of Different Ability Pupils' Performance in Physics MCQ test

Figure 4 shows that each of the high, middle and low ability groups had more than 80% of its pupils making improvements in their physics test scores after attending the play-n-learn workshop. The low ability (LA) group of pupils was top with 88% of its pupils who had made improvements.

Observations and Comparisons between male and female pupils

What is surprising to note is the finding that the female pupils seemed to have benefited more from this play-n-learn workshop than the male pupils. A high level of 93% of the female pupils improved on their Physics MCQ test scores after going through the workshop and the marks by which they improved exceeded those of the male pupils.

An all-female group scored 11.00 marks in the post-play test, making their improvement level higher than the all-male group. A look at the video footages showed that the all-female group had worked well together and every member was actively participating in the play. They figured out how to solve problems themselves and commented on each other's play and worked and guided one another. In terms of improvement level as a whole (compared with the other groups), the all-male group was ranked 21st (out of 26 groups) while the all-female group was ranked 2nd. This showed that the all-female group had a high level of improvement that was not only more than the all-male group but also more than the other groups.

An analysis was done on the performance of the male and female pupils in the Physics Concepts MCQ test. The mean marks of their pre-play and post-play tests were calculated by first grouping the pupils according to their gender, and then summing up their scores for the pre-play and post-play tests before dividing the sum by the total number of male or female pupils. The male and female pupils' mean improvement marks were also averaged out. Figure 5 shows the summary of the mean marks of each gender and it illustrates a higher improvement level of the female pupils.

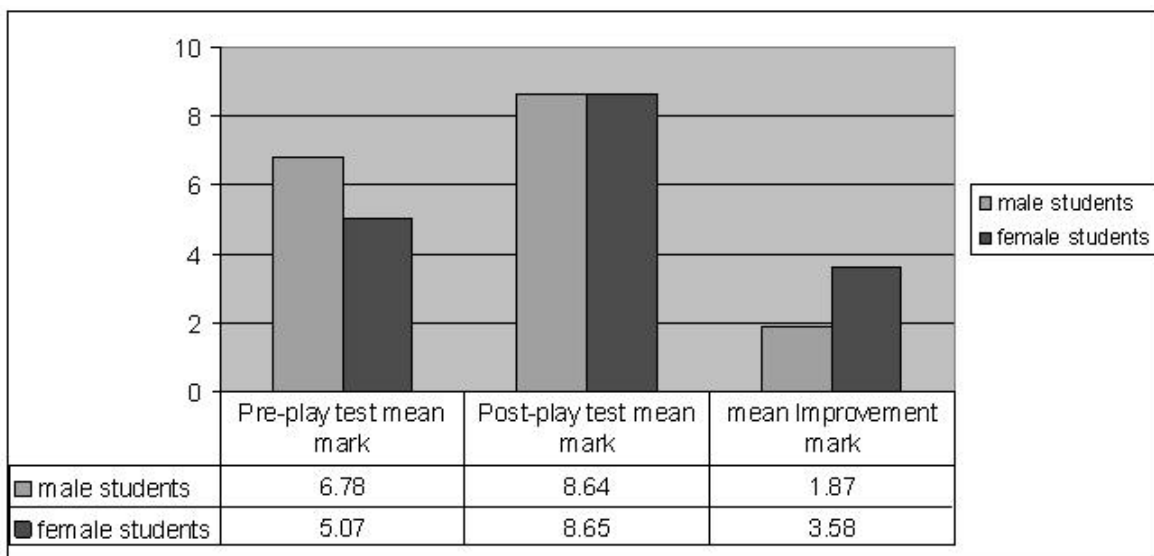


Figure 5 Male and Female Pupils' Mean Marks for the Physics MCQ test

Another analysis was done on the male and female pupils. Figure 6 shows the percentage of pupils in each gender who had made improvement, scored worse scores in the post-play than in the pre-play test and equaled the scores in both tests.

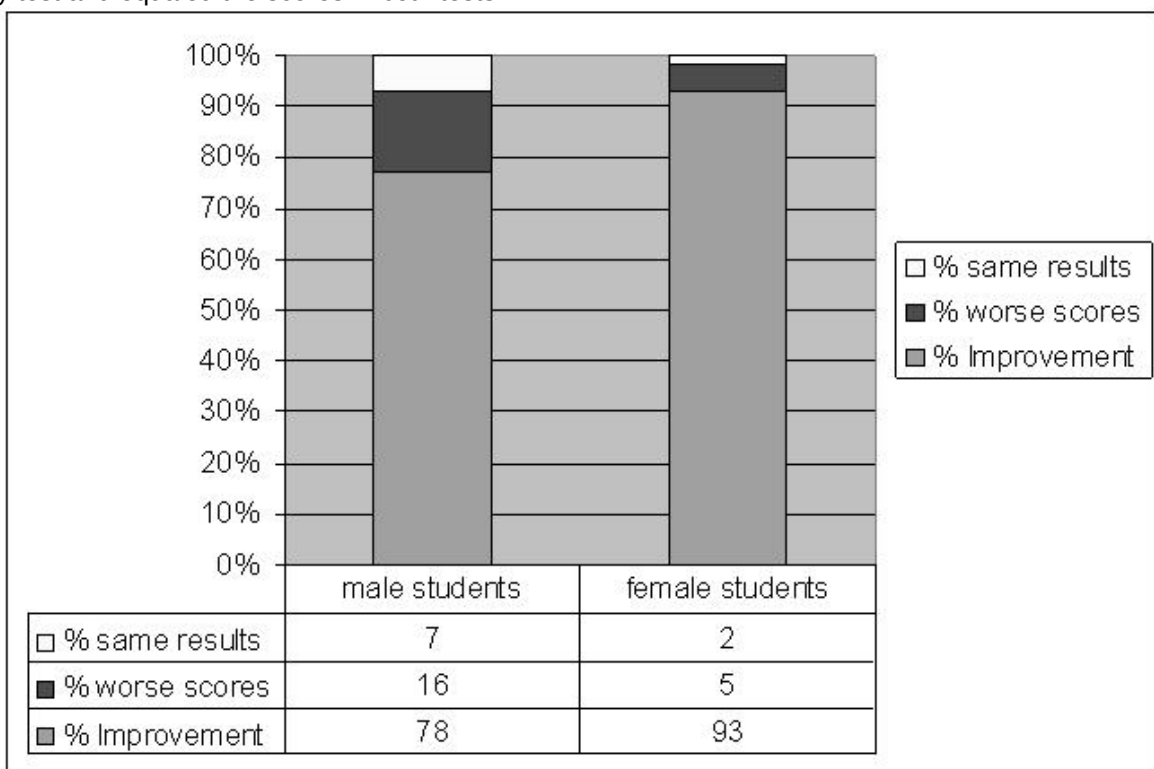


Figure 6 % of Male and Female Pupils' Performance in the Physics MCQ test

It is clear from Figure 6 that 93% of the female pupils had made improvements in their test scores after attending the play-n-learn workshop. Only 5% of them scored worse results in the post-play and 2% scored the same results. As for the male pupils, although the majority of them (78%) still made

improvements in their test scores after the workshop, 16% of them got worse results in the post-test while 7% had the same results in both tests.

There were also other observations (from the video footages) of the male and female pupils' attitudes and behaviour during the play-n-learn workshop. The boys were more analytical and seemed to analyze what caused the effects they saw from play. They made accurate judgments. They solved problems very well and were enthusiastic and excited over their discoveries. They were also very creative and loud! The girls were more passive and tend to hold back their feelings of excitement. They were very careful with the play-kits that they explored and were less adventurous but they were more meticulous in carrying out the activities. The girls were less expressive and tend to discuss more softly among themselves but both genders laughed loudly frequently throughout the session. Another interesting observation is that the same gender groups are more comfortable with one another, thus they were more expressive and tend not to hold back any of their ideas. They also tend to be more creative and each member has equal opportunities to explore with no one member passively taking a back seat.

Part of these gender differences can be explained by social learning (Moyles, 2005). As emphasized by Maccoby (1998), boys and girls have clear ideas of what is gender appropriate behaviour, and peer pressure will increase the tendency to conform to those.

Observation of children gives some indication of why play might be such a powerful learning medium (Moyles, 2005). During play children are usually totally engrossed in what they are doing. Two further elements that have been highlighted by psychological research and theory also contribute to an understanding of its vital significance in learning and creativity. These relate to its role in children's developing sense of control and self-regulation of their own learning and to their developing powers of symbolic representation. Both emerge from the influential theoretical writing of the Russian psychologist Vygotsky (1978).

DISCUSSION

The positive results of this study has led to the establishment of the conceptualization of a framework of ideas on how the play-n-learn approach has made the learning of physics fun, interesting and meaningful for the secondary school pupils.

The pupils had expressed their interest in having play-n-learn in their curriculum to help them learn physics better. The word "fun" was widely used by the pupils to describe their play-n-learn experiences in the workshop. The results from the pupils' perceptions survey were positively overwhelming. They agreed that playing with the hands-on kits helped them to learn and they could learn while having fun at the same time. They also expressed that the play experience helped them to reduce their fear for physics. These showed that pupils welcomed the play-n-learn concept as a mode of learning physics.

The analysis of results from the physics tests that they sat for before and after going through the play-n-learn experience also showed a high percentage of pupils who had improved in their physics performance. Apart from the tangible benefits that we could measure using instruments that lead to data analysis, there were also intangible benefits that the play-n-learn experience had given the pupils and these were realized from observations from the video footages of the workshops and informal interactions with the pupils which showed their joy in learning physics during the workshop. It had also brought out their natural curious, "need-to-know" nature to find out what the play kits could do, and made them ask questions like "How does it work?", "What makes it work that way?", "Will it still work if ...?" Such questions made the pupils look for answers and trigger alternative ways of making things work. Learning was not forced upon, it occurred naturally in that setting. It created learning gaps for the pupils to fill, either with the help of their peers, facilitators or by their own self-discoveries. Play-n-learn had helped to develop interest in the subject, and physics no longer appears complex and intimidating to the pupils. Being innovative and seeking for alternative answers in play-n-learn also comes naturally without the stress factor.

Teachers and educators could take advantage of the play-n-learn approach as an incentive to stimulate the pupils' inquisitive spirit. It could be considered as a mode of introduction of 'intimidating' topics to the pupils. Play is able to make the concepts appear simple and less intimidating for the pupils to make learning fun. The play-n-learn approach is not here to replace all other modes of physics pedagogy but as an added mode of pedagogy to the current practices to make the teaching and learning of physics more interesting, meaningful and holistic.

REFERENCE

Chance, P., et al. (1979). *Learning Through Play*. United Square West, NY: Gardner Press, Inc.

CPDD (2005). Curriculum Planning & Development Division, Ministry of Education. [on-line] Available: <http://www.moe.gov.sg/cpdd/doc/Science.pdf>

DeVries, R., & Kohlberg, L. (1987). *Constructivist early education: Overview and comparison with other programs*. Washington, DC: National Association for the Education of Young Children.

Elkind, D. (1981). *The hurried child*. Reading, MA: Addison-Wesley.

Fromberg, D. P., & Bergen, D. (Eds.) (1998). *Play from birth to twelve and beyond: Contexts, perspectives, and meanings*. New York: Garland.

Garvey, C. (1990). *Play*. Cambridge, MA: Harvard University Press.

Greenfield, S. (2004). *The Human Brain: A Guided Tour*. Phoenix, AZ: Phoenix Mass Marker Publications.

Jones, E., & Reynolds, G. (1992). *The play's the thing: Teachers' roles in children's play*. New York: Teachers College Press.

McManus, S.M., & Gettinger, M. (1996). Teacher and Student Evaluations of Co-operative Learning and Observed Interactive Behaviours. *The Journal of Educational Research*, 90(1), 13-22.

Maccoby, E.E. (1998). *The Two Sexes: Growing Up Apart, Coming Together*. Cambridge, MA: Harvard University Press.

Moyles, J. (2005). *The Excellence of Play* (2nd Edn). England: McGraw-Hill Education, Open University Press.

O'Shea, M. (2002). *The Brain: A Very Short Introduction*. Oxford: Oxford Paperbacks.

Piaget, J. (1966). *The moral judgement of the child* (M. Gabois, Trans.). New York: Free Press

Rosberg, A.M. (2003). Work and Play: Are They Really Opposites? *Opinion Papers* (120), ED 473 151.

Rubin, K. H, Fein, G. G., & Vandenberg, B. (1983). *Play*. In P. H, Mussen (Ed.) *Handbook of child psychology* (Vol. 4). New York: Wiley.

Sutton-Smith, B., et al. (1979). *Play-n-learning*. United Square West, NY: Gardner Press, Inc.

Sylwester, R. (1997). *A Celebration of Neurons: An Educators' Guide to the Human Brain*. Alexandria, VA: Association for Supervision and Curriculum Development.

VanHoorn, J., Nourot, P., Scales, B., & Alward, K.R. (1999). *Play at the center of the curriculum*. Upper Saddle River, NJ: Merrill.

Vygotsky, L.S. (1978). *Mind in Society: The Development of Higher Psychological Processes* (translated by M. Cole, V. John-Steiner, S. Scribner and E. Souberman). Cambridge, MA: Harvard University Press.

Yau, C.M. (2002). Play-n-learn in Teaching Electronics in the Subject Design and Technology (D&T) for Secondary One Pupils in Singapore. *Paper, Science and Technology Education Conference Proceeding 2003*, Hong Kong, 388-396.