Jurnal Pendidikan Malaysia 46(1) Isu Khas (2021): 33-45
DOI: http://dx.doi.org/10.17576/JPEN-2021-46.01SI-04

Effects of Discovery Learning on Year Two Pupils' Achievement in Learning Fractions

(Kesan Pembelajaran Penemuan terhadap Pencapaian dan Motivasi Murid Tahun Dua dalam Pembelajaran Topik Pecahan)

ONG PEI WEN* & CHEW CHENG MENG

ABSTRACT

Understanding fractions is one of the important skills that need to be developed in Mathematics curriculum as it is essential for understanding algebra, geometry as well as other aspects of Mathematics. However, pupils around the world face difficulties in learning fractions. This quasi-experimental study examined the effects of Discovery Learning on pupils' achievement in fractions. 66 Year Two primary school pupils in Kedah were assigned into experimental (Discovery learning) and control (conventional instruction) groups. Data was collected using pre-test and post-test. Independent samples t-test and paired-samples t-test were used to analyze the data. Results indicated that: 1) there is no significant difference in pupils' achievement in fractions (pre-test) between the groups; 2) there is a significant difference in pupils' achievement in fractions (post-test) between the groups; 3) there is a significant difference in pupils' achievement in fractions between the pre-test and post-test of the experimental group; and 4) there is a significant difference in Year Two pupils' achievement in fractions between the pre-test and post-test of the control group. This concludes that Discovery Learning was effective in improving Year Two pupils' achievement in learning fractions. Therefore, it can play a role as a starting milestone for educators in Malaysia to implement Discovery Learning in daily teaching life especially in fractions.

Key Words: Discovery Learning; Achievement in fractions; Primary pupils

ABSTRAK

Memahami pecahan merupakan salah satu kemahiran yang perlu dikuasai dalam kurikulum Matematik di mana ia penting dalam pemahaman algebra, geometri dan aspect lain dalam Matematik. Namun demikian, murid-murid seluruh dunia menghadapi masalah dalam pembelajaran pecahan. Kajian eksperimen kuasi ini mengkaji kesan Pembelajaran Penemuan terhadap pencapaian murid dalam pembelajaran topik pecahan. Seramai 66 orang murid Tahun Dua sekolah rendah dari Kedah telah dibahagikan kepada dua kumpulan, iaitu kumpulan eksperimen (Pembelajaran Penemuan) dan kawalan (pembelajaran konvensional). Data dikumpulkan menggunakan ujian pra dan ujian pasca. Ujian t sampel bebas dan ujian t sampel berpasangan digunakan untuk menganalisis data. Keputusan kajian menunjukkan bahawa: 1) tiada perbezaan yang signifikan dalam pencapaian (ujian pra) murid antara kumpulan; 2) terdapat perbezaan yang signifikan dalam pencapaian (ujian pasca) murid antara kumpulan; 3) terdapat perbezaan yang signifikan dalam pencapaian murid kumpulan eksperimen antara ujian pra dan ujian pasca; dan 4) terdapat perbezaan yang signifikan dalam pencapaian murid Tahun Dua kumpulan kawalan antara ujia pra dan ujian pasca. Kesimpulannya, Pembelajaran Penemuan dapat meningkatkan pencapaian murid Tahun Dua dalam pembelajaran pecahan.Oleh itu, Pembelajaran Penemuan boleh bermain peranan sebagai tanda pemulaan bagi pendidik Malaysia untuk menlaksanakan Pembelajaran Penemuan dalam pengajaran seharian terutamanya dalam pecahan.

Key Words: Pembelajaran Penemuan; Pencapaian dalam Pecahan; Murid Sekolah Rendah

INTRODUCTION

Pupils from different countries around the world face difficulties in learning fractions especially low and average achievers who do not gain conceptual knowledge of fractions (Brown & Quinn 2006; 2007; Idris & Narayanan 2011; National Mathematics Advisory Panel 2008; Noordin et al. 2010; Razak et al. 2012; Sarwadi & Shahrill 2014; Shin & Bryant 2016; 2017; Siegler et al. 2010; Singh et al. 2010;

Valarmathy 2004). Even majority of students from countries such as Japan and China who achieve good conceptual understanding in Fractions also considered fractions as a difficult topic (Fazio & Siegler 2011). In the Malaysian Education system, Primary School Standard Curriculum (KSSR) introduced fractions learning to primary school pupils from Year 1 to Year 6 (Kementerian Pelajaran Malaysia 2011).

Trends in International Mathematics and Science Study (TIMSS) showed that Malaysia's performance has kept falling from 1999, 2003 and to 2011; meanwhile, the Programme for International Student Assessment (PISA) 2009 also indicated that Malaysia was ranked in the bottom third of 74 participating countries, below the international and OECD average when students answered questions which involved knowledge of Fractions in Mathematics (Hassan et al. 2016; Ministry of Education 2013; Mullis et al. 2012; Salleh 2009). In fact, Malaysia was ranked the last in the Southeast Asia countries (Bahagian Perancangan dan Penyelidikan Dasar Pendidikan Kementerian Pendidikan Malaysia 2016a; Hassan et al. 2016).

Students face difficulties in their first lesson of fractions as many properties are true of whole numbers but are not true for all numbers (Fazio & Siegler 2011). There are too many students who struggle with fractions concept, even after studying fractions for several years and it limits students' ability to solve problems with fractions and to learn and apply computational procedures involving fractions (Shin & Bryant 2016; Siegler et al. 2010). In addition, elementary students find difficulties in understanding concept of fractions as traditional teaching methods are focused on procedures and algorithms, hence students who are frustrated in learning fractions ends in failure and they would memorize algorithm to cope with anxiety (Brown & Quinn 2007; Clark 2010). Maybe fractions are meaningless symbols for many pupils because they view numerator and denominator as separate number rather than a unified whole (Fazio & Siegler 2011). There are students who are having unstable understanding in comparing fractions with different denominators and some learners took longer time in comparing fractions in common numerator (Meert et al. 2010; Razak et al. 2012). Lack of fraction concepts limits students' ability in solving problems with fraction which are related to application of computational procedure of fractions. (Siegler et al. 2010).

Therefore, it is essential to teach fractions in a meaningful way since primary school level (Idris & Narayanan 2011). Without solid foundation, students will continue to struggle with higher level of mathematics (Shin & Bryant 2016). Instead, teachers should focus on establishing deep understanding of concepts of fractions among students (Clark 2010). Siegler et al. (2011) suggested teachers to develop effective strategies to improve learners' knowledge in fractions. Teacher should show magnitude of fractions concretely to build fraction concept among learners (National Mathematics Advisory Panel 2008). Siegler et al. (2010) suggested to introduce fractions by building on students' informal understanding of sharing and help students in recognizing that fractions are numbers and that they expand the number system beyond whole numbers. He also suggested to use number lines as a central representational tool in teaching fractions. Fazio and Siegler (2011) suggested that teachers can use hands-on activities to measure objects such as fraction strips and also sharing activities in order to help students to understand the relative size of fractions. For example, $\frac{1}{4}$ is less than $\frac{1}{3}$, which is less than $\frac{1}{2}$.

In Jerome Bruner's book, 'Towards A Theory of Instruction', in the concept of discovery learning, Bruner (1966) proposed that a learner constructs his or her own knowledge for themselves by discovering rather than to be told about something. In the learning process, the teacher plays the role as a facilitator by developing lessons that provide the learner with the information that they need without organizing it for them. The learners focus on their ideas and contributions to their own learning by playing roles as active collaborators (Hoffman 2013). The idea of discovery learning is often referred to as an inquiry-based and constructivism, whereby learner is building understanding by own with past and new knowledge and making sense of information actively in a problem-solving situation (Bruner 1961). Students interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments to remember concepts and knowledge discovered on their own (Bruner 2009). Discovery Learning encourages active engagement and promotes motivation in learning. Bruner (1978) promoted scaffolding to help learners acquire skills where scaffolding refers to the steps taken to reduce the degrees of freedom in carrying out some tasks. The effects of Discovery Learning in the pupils' achievement in learning fractions are still not widely studied in Malaysia. Nevertheless, Discovery Learning is a widely used teaching approach in United States of America, Turkey, Indonesia and Nigeria (Anyafulude 2014; Balim 2009; Herdiana et al. 2017; Kartikasari 2012; Tokada et al. 2017; Uside et al. 2013). The related studies on Discovery Learning showed that it brings positive effect on achievement in learning towards learners. Due to the limited studies of Discovery Learning in Malaysia, therefore this study was implemented to examine the effects of Discovery Learning on pupils' achievement in learning fractions.

The main objective of this study was to determine the effects of Discovery Learning on Year Two pupils' achievement in learning fractions. The specific objectives of this research include:

1. To determine if there is a significant difference between the experimental and control groups' pre-test scores
2. To determine if there is a significant difference between the experimental and control groups' post-test scores
3. To determine if there is a significant difference between the pre-test and post-test scores of the experimental group
4. To determine if there is a significant difference between the pre-test and post-test scores of the control group

To answer the above research questions, the following null hypotheses were evaluated:

$H_0 1$: There is no significant difference in Year Two pupils' achievement in fractions (pre-test) between the experimental group and control group.

$H_0 2$: There is no significant difference in Year Two pupils' achievement in fractions (post-test) between the experimental group and control group.

$H_0 3$: There is no significant difference in Year Two pupils' achievement in fractions between the pre-test and post-test of the experimental group.

$H_0 4$: There is no significant difference in Year Two pupils' achievement in fractions between the pretest and post-test of the control group.

DISCOVERY LEARNING CONCEPT

Bruner (1961) introduced Discovery Learning to help children learn actively. Children make hypotheses by themselves as the intellectual potency increased which will lead to enactive learning. Hence, the enactive learning will become a heuristic of discovery by itself to make material more readily accessible in children's memory. Learners can construct their own knowledge through Discovery Learning (Tokada et al. 2017). Bruner's Discovery Learning includes three modes of representation to form one's learning, which are enactive, iconic and symbolic. There are three modes of representation in Bruner's Discovery Learning, which are enactive, iconic and symbolic. Modes of representation refers to information or knowledge stored and encoded in memory (Mcleod 2012). These three modes are essential in learner's learning which help the learner to understand the reason behind.

Bruner believed that learning should begin with direct manipulation of objects. Enactive, refers to the representation of knowledge through actions. This mode involves the encoding and storage of information with direct manipulation of objects and without internal representation. Iconic is the visual summarization of images which involves an internal representation of external objects visually in the form of a mental image or icon. After a learner has the opportunity to manipulate the objects directly, they should be encouraged to construct visual representations, such as drawing a shape or a diagram. The last mode refers to symbolic representation, which is the use of words and other symbols to describe experiences. The symbolic mode happens when information is stored in the form of a code or symbol such as language. Each symbol has a fixed relation to something it represents. Symbols can be classified and organized, unlike mental images or memorized actions. Most information is stored as words, mathematical symbols, or in other symbol systems in this mode. Lastly, a learner associates the understanding of the symbols with what they represent.

Assisted or guided discovery which uses scaffolding to elicit explanation instructions is able to help weak and low achievers (Alfieri et al. 2011; Okwute 2015). In order to solve the pupils' problem of learning fractions, Bruner's Discovery Learning was applied in this study as the teaching method. Bruner (1961) postulated that Discovery Learning will increase one's intellectual potency besides motivate learners from extrinsic to intrinsic. He also stated that Discovery Learning is heuristic, and it aids one's memory processing. Learners can discover mathematics concept and learn to express ideas through Discovery Learning (Tokada et al. 2017). Discovery Learning promotes active learning and arouse learners' curiosity in increasing motivation in learning Mathematics (Kartikasari 2012; Kistian et al. 2017).

DISCOVERY LEARNING IN THE TEACHING OF MATHEMATICS

There are some past studies of Discovery Learning in teaching and learning show the relation between Discovery Learning and learners' achievement (Aini 2016; Anyafulude 2014; Balim 2009; Kristin & Rohayu 2016; Uside et al. 2013). These past studies indicate that Discovery Learning is helpful and able to benefit the learners in order to improve learners' understanding and achievement academically in various topics, subjects and different academic levels of learners. Anyafulude (2014) that Discovery Learning was able to improve learners' knowledge and Aini (2016) found that Discovery Learning was able to achieve the learning outcomes. It is also consistent with Balim's (2009) finding that Discovery Learning was able to increase students' success and Kristin and Rohayu's (2016) study which involved quasi-experimental research design found that Discovery Learning was effective to achieve Year Four pupils' learning outcomes. Uside et al. (2013) also concluded that Discovery learning had significant effect on secondary students' achievement by enhancing knowledge retention.

Additionally, there are some past studies that implemented Discovery Learning in teaching and learning academically, especially in Mathematics. These past studies are related to Mathematics learning (Kartikasari 2012), Mathematics achievement (Okwute 2015; Sari et al. 2017) and Mathematics literacy (Kusumadhani et al. 2015; Tokada et al. 2017). These past studies concluded that Discovery Learning are able to improve and enhance learners' Mathematics learning generally.

Furthermore, Discovery Learning was also used in some past studies in the teaching and learning of Mathematics specifically in some Mathematics topics and Mathematics thinking skills. There are some past studies that applied Discovery Learning in teaching and learning of Space and Building (Kistian et al. 2017) and Trigonometry (Arifudin et al. 2016). There are some past studies that applied Discovery Learning in Mathematics teaching and learning specifically to Mathematics thinking skills such as problem solving (Herdiana et al. 2017), adaptive reasoning (Arifudin et al. 2016) and critical thinking (Kristianti et al. 2017). These past studies show that Discovery Learning is effective and able to improve learners' knowledge besides developing learners on the topics and skills. These studies involved learners from different levels, where Kistian et al. (2017) and Sari et al. (2017) involved primary school pupils and Arifudin et al. (2016), Herdiana et al. (2017), Kristianti et al. (2017), Kusumadhani et al. (2015), Okwute (2015) and Tokada et al. (2017) involved high school students as samples of the study.

Arifudin et al. has found significant difference in adaptive reasoning in students who learned in the topic of Trigonometry by Discovery Learning among 65 secondary students in quasi-experimental study while Herdiana et al. concluded that the problem-solving competency of students who learned by Discovery Learning was high among 70 Form 1 students and Discovery Learning was able to improve mathematics problem solving. Kristianti et al. found that students who received Discovery Learning were better in developing mathematical critical thinking among Form 2 students. Kusumadhani et al. found that Discovery Learning was a good quality teaching and learning where it can improve students' achievement in Mathematics Literacy among students in Form 1. Okwute found that Discovery Learning can help low achievers in mathematics performed better in mathematics among 207 secondary students after eight weeks of treatment. Tokada et al. found significant difference in Mathematics Literacy of Form 2 students with Discovery Learning in Mathematics in quasi-experimental study and concluded that Discovery Learning provided opportunity for students to construct their own knowledge.

Moreover, these past studies on Discovery Learning also showed that there is no significant difference in (pre-test) between the experimental group and control group (Arifudin et al. 2016; Balim 2009; Herdiana et al. 2017; Kistian et al. 2017; Kristin & Rohayu 2016; Okwute 2015; Tokada et al. 2017; Uside et al. 2013) in determining the equivalent ability level in learning between experimental and control group. In addition, these past studies on Discovery Learning also indicated that there is a significant difference in (posttest) between the experimental group and control group (Aini 2016; Arifudin et al. 2016; Balim 2009; Herdiana et al. 2017; Kristianti et al. 2017; Kristin & Rohayu 2016; Tokada et al. 2017; Okwute 2015; Sari et al. 2017; Uside et al. 2013). Conversely, there is only a past study related with Discovery Learning which showed there is a significant difference between the pre-test and post-test of the experimental group in learning outcome (Aini 2016).

However, only limited past studies showed that there is a significant difference between the pretest and post-test of the control group (Ishak et al. 2009; Periasamy et al. 2016) which used conventional instruction in teaching and learning of Mathematics. These studies also indicated that conventional instruction or traditional teaching method which is teacher-centred learning also had a positive effect on learners' learning. These past studies involved topic of fractions among primary school pupils (Periasamy et al. 2016) and Mathematics learning among at-risk students (Ishak et al. 2009). Ishak et al. (2009) stated that conventional teaching instruction or traditional teaching method can also bring significant effect on at risk pupils in mathematics after 10 weeks of intervention. Therefore, the conventional teaching instruction is suitable for weak pupils too in long hours of teaching. Periasamy et al. (2016) also discussed that the traditional teaching method had positive impact on the learning of fractions among the pupils in Year 5. Hence, the traditional teaching method is suitable to teach Year 5 pupils with an average ability in Mathematics too.

METHODOLOGY

RESEARCH DESIGN

This study used quasi-experimental research design to investigate the effects of Discovery Learning on Year Two pupils' achievement in fractions. Non-equivalent control group design was used as the researcher randomized the assignment of intact groups to treatments. The inability to assign individuals to treatments randomly would add validity threats. For example, regression and interactions between selection, maturation, history and testing (Gay et al. 2012, p.270). Moreover, the groups may not even be aware that they are involved in a study. In this study, the pupils were divided into two groups, which are control group and experimental group. The control group learned fractions using conventional instruction while the experimental group learned fractions using Discovery Learning. This research has obtained ethical approval by the Universiti Sains Malaysia and permission has been granted by the school administration where this study is conducted.

POPULATION AND SAMPLING

The population consisted of Year Two pupils from Sekolah Jenis Kebangsaan Cina (SJKC) in Kedah. The district and the schools for this study were chosen based on cluster sampling method, where the intact group of the population members has similar characteristics.

Overall, two out of four SJKC schools were randomly selected for the purpose of this study. The schools had the same characteristics; they had the same school average scores for the 2017 Primary School Assessment (UPSR). Then, one out of three classes from each of the two schools was randomly assigned to be the experimental group and control group. The two chosen classes shared the same criteria; the pupils are of mixed ability, and they have average achievement in the school examination. To simplify, 32 Year Two pupils (15 boys and 17 girls) in school A were selected as the experimental group, while 34 Year Two pupils (16 boys and 18 girls) in school B were selected as the control group. Both groups are average achievers of Mathematics. In addition, they were only introduced to the concept of fractions in Year One.

INSTRUMENTATION

This study used the Fractions Achievement-test developed by the researcher to collect the data. The items in the Fractions Achievement-test were built according to Year Two Mathematics Document Standard which is provided by the Ministry of Education. According to the Document Standard, the pupils are required to learn naming and writing the fractions, shading the fractions and comparing the fractions. Hence, the items in the test were developed according to the learning standards and a test specification table. The levels of difficulty of the test which are easy, moderate, and difficult, were included in the test specification table. The Fractions Achievement-test was validated by two Mathematics expert teachers who are experienced in teaching Mathematics for 10 years and piloted at School C for its reliability. The value of Cronbach's alpha for the Fraction Achievement-test is 0.819. Teacher C who has more than 10 years of teaching experience in Mathematics and the researcher graded the pre-test and post-test with the scoring rubric provided by the researcher. The pre-test and post-test scores of pupils which were graded by Teacher C and the researcher reached 96.97% of agreement indicating a high degree of inter-rater reliability.

The test consisted of 12 items: 5 items on writing fractions in numerals or words, 3 items on shading fractions, 3 items on comparing fractions and 1 item on writing fractions in numerals and comparing fractions. The total score of the Fractions Achievement-test is 23. The sum of the scores determines the pupils' achievement in fractions, where higher scores represent higher achievement in learning fractions. The test was given to both the control and experimental groups as pre-test and post-test. In the post-test, the number content of the test items was changed so that it is parallel with the pre-test.

RESEARCH PROCEDURE

For the experimental group, the teachers used Discovery Learning and the lessons were based on the Year Two Mathematics Document Standard KSSR (Kementerian Pelajaran Malaysia 2011). Before the study was conducted, a workshop was conducted in the experimental group school to train the Year 2 mathematics teacher to teach fractions using Discovery Learning. The teachers were briefed on the procedures in carrying out the study and Bruner's Discovery Learning in learning. The researcher and teacher participant planned the lessons based on Bruner's Discovery Learning and was incorporated into the lesson in order to promote pupils' interest towards learning fractions. Teaching and learning were done in group activities and student-centred. A variety of teaching materials was used such as concrete materials, real-life materials and pictorial representation. Instructions were scaffolded to follow Bruner's modes of representation to ensure that pupils explore and develop their learning actively. The lesson plans on Discovery Learning were reviewed by two Mathematics expert teachers who are experienced in teaching Mathematics for more than 10 years.

For the control group, the teacher participant used conventional instruction in teaching fractions. The lessons were based on the Year Two Mathematics Document Standard KSSR (Kementerian Pelajaran Malaysia 2011) and Year Two Mathematics Textbook which is provided by the Ministry of Education Malaysia 2011. The teacher participant was briefed on the procedures in carrying out the study by using conventional instructions. The researcher and teacher participant planned the lessons. The lesson plans were reviewed by two Mathematics expert teachers who are experienced in teaching Mathematics for more than 10 years. The lessons were modified into three weeks based on Teaching and Learning Mathematics Module which is provided by Ministry of Education Malaysia 2011 to fit practical school situation.

TABLE 1. Teaching schedule of experimental group (Discovery Learning)

Day	Learning Outcomes of Discovery Learning
Lesson 1 Teaching: 60 minutes	Identify fractions with 1 as numerator and denominator up to 10 with concrete materials. (Enactive)
Lesson 2 Teaching: 60 minutes	Identify fractions with 1 as numerator and denominator up to 10 with folding papers and diagram (Enactive and Iconic)
Lesson 3 Teaching: 60 minutes	Name fractions with one over two, one over three, one over four, one over five, one over six, one over seven, one over eight, one over nine and one over ten. (Enactive, Iconic and Symbolic)
Lesson 4 Teaching: 60 minutes	Name fractions with numerator up to 9 and denominator up to 10. (Enactive)
Lesson 5 Teaching: 60 minutes	Shade diagram with given fractions. (Enactive and Iconic)
Lesson 6 Teaching: 60 minutes	Write fractions with numerator up to 9 and denominator up to 10 according to diagram. (Iconic and Symbolic)
Lesson 7 Teaching: 60 minutes	Compare two fractions with 1 as numerator and denominator up to 10 with fraction bars. (Enactive)
Lesson 8 Teaching: 60 minutes	Compare two fractions with 1 as numerator and denominator up to 10 with folding paper and diagram. (Enactive and Iconic)
Lesson 9 Teaching: 60 minutes	Compare two fractions with 1 as numerator and denominator up to 10 with folding paper and diagram. (Iconic and Symbolic)

TABLE 2. Teaching schedule of control group (conventional instruction)

Day	Learning Outcomes of Conventional Instruction
Lesson 1 Teaching: 60 minutes	Identify fractions with 1 as numerator and denominator up to 10 with concrete materials, diagrams.
Lesson 2 Teaching: 60 minutes	Identify fractions with 1 as numerator and denominator up to 10 with folding papers.
Lesson 3 Teaching: 60 minutes	Name fractions with one over two, one over three, one over four, one over five, one over six, one over seven, one over eight, one over nine and one over ten.
Lesson 4 Teaching: 60 minutes	Name fractions with numerator up to 9 and denominator up to 10.
Lesson 5 Teaching: 60 minutes	Shade diagram with given fractions.
Lesson 6 Teaching: 60 minutes	Shade diagram with given fractions
Lesson 7 Teaching: 60 minutes	Write fractions with numerator up to 9 and denominator up to 10 according to diagram.
Lesson 8 Teaching: 60 minutes	Compare two fractions with 1 as numerator and denominator up to 10 with folding paper, fraction bars and diagram.
Lesson 9 Teaching: 60 minutes	Compare two fractions with 1 as numerator and denominator up to 10 with folding paper, fraction bars and diagram.

At the start, both the control and experimental groups were administered the Fractions Achievement pre-test in this study. After the pre-test, the experimental group learned fractions using the Discovery Learning while the control group learned fractions through conventional instructions for three weeks. The pupils were given assignments from the textbooks or exercise books provided by the Ministry of Education. Both control and experimental groups used the same duration of time to complete the unit. At the end, the Fractions Achievement post-test was administered to the Year 2 pupils in both the experimental and control groups. The pre-test and post-test are parallel in order to compare the pupils' fractions achievement before and after the teaching method that had been carried out.

The lessons were implemented where each group of pupils completed the topic of Year Two Fractions in 9 days (nine hours, three hours per week), which is one hour per lesson. Table 1 shows teaching schedule of the experimental group (Discovery Learning) and Table 2 shows teaching schedule of the control group (conventional instruction).

DATA ANALYSIS METHOD

The data collected were analysed descriptively and inferentially using the Statistical Package for the Social Sciences (SPSS) version 22 to answer the four research questions. Independent samples t-test was applied first to examine whether there is a significant difference in the mean score of pre-tests between the experimental and control group pupils. If there was no significant difference, the independent sample t-test was used to analyze the mean score of the post-test score between the experimental and control groups. Paired-samples t-test was used to examine if there is a significant difference in the mean score of the pre-test and post-test of the experimental group who learned fractions through Discovery Learning. Paired-samples t-test was also used to examine if there was a significant difference in the mean score of the pre-test and post-test the control group who learned fractions through the conventional instruction.

RESULTS AND DISCUSSIONS

PRE-TEST AND POST-TEST SCORES OF EXPERIMENTAL AND CONTROL GROUPS

Table 3 below shows the mean and standard deviation for the pre-test and post-test scores of the control and experimental group pupils.

From the table, the mean and standard deviation of the experimental group's pre-test score are (M=11.69, S.D= 8.03) and the mean and standard deviation of the control group's pre-test score are (M=10.82, S.D= 6.65). It can be seen that both the mean of the experimental (M=20.66) and control (M=18.09) groups' post-test scores show an increase compared to the mean of their respective pre-test scores.

DIFFERENCE BETWEEN EXPERIMENTAL AND CONTROL GROUPS' PRE-TEST SCORES

To determine whether there is a significant difference between the experimental and control groups' pre-test scores, independent samples t-test was carried out. The Kolmogorov-Smirnov normality test (Table 4) and the Levene's test (Table 5) were carried out to ensure that the experimental and control groups' pre-test scores fulfil the assumptions of the independent samples t-test.

Based on Table 4, as p=0.08(>0.05), therefore the pre-test scores for the experimental group were normally distributed in the population; similarly, as p=0.14(>0.05), therefore the pre-test scores for the control group were normally distributed in the population. Therefore, both groups' pre-test scores were normally distributed in the population.

Based on Table 5, the Levene's test shows that p=0.53 (>0.05), therefore the pre-test scores for both the experimental and control groups had equal variances in the population and the first row of the independent samples t-test (equal variances assumed) was referred to make the decision. Based on Table 5, as p=0.64 (>0.05), thus, the null hypothesis is failed to be rejected. Therefore, there was no significant difference in the mean of the pre-test scores between the experimental and control groups in the population, t(64)=.48, p>0.05.

The result shows that the experimental and control groups are having equivalent achievement and it is consistent with the findings of the studies of Arifudin et al. (2016), Balim (2009), Herdiana et al. (2017), Kistian et al. (2017), Kristin and Rohayu (2016), Okwute (2015), Tokada et al. (2017) and Uside et al. (2013). This finding is consistent with the findings of Balim (2009), Kristin and Rohayu (2016) and Uside et al. (2013) which showed homogenous groups in achievement are used in the studies. This finding is also consistent with the findings of Arifudin et al. (2016) which used equivalent groups in the ability of adaptive reasoning in the topic of Trigonometry, Kistian et al. (2017) in the aspect of Mathematics achievement in the topic of Space and Building, Herdiana et al. (2017) in Mathematics problem solving, Okwute (2015) in Mathematics achievements among low achiever learners and Tokada et al. (2017) in Mathematics literacy.

TABLE 3. Descriptive analyses of the experimental and control groups' pre-test and post-test scores

	Experimental Group (Discovery Learning) N=32		Control Group (Conventional Instruction) N= 34	
	Pre-test	Post-test	Pre-test	Post-test
Mean	11.69	20.66	10.82	18.09
Standard Deviation	8.03	3.57	6.65	5.01

TABLE 4. Kolmogorov-Smirnov Normality Test on the experimental and control groups' pre-test scores

		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Pre-test	Experimental Group	.15	32	.08
	Control Group	.13	34	.14

TABLE 5. Independent samples t-test on the experimental and control groups' pre-test scores

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-test	Equal variances assumed	.41	.53	.48	64	.64	.86	1.81	-2.75	4.48
	Equal variances not assumed			.48	60.32	.64	.86	1.82	-2.78	4.51

TABLE 6. Kolmogorov-Smirnov Normality Test on the experimental and control groups' post-test scores

		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Post-test	Experimental Group	.26	32	.00
	Control Group	.19	34	.00

TABLE 7. Independent samples t-test on the experimental and control groups' post-test scores

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post-test	Equal variances assumed	2.87	.10	2.39	64	.02	2.57	1.08	.42	4.72
	Equal variances not assumed			2.41	59.74	.02	2.57	1.07	.44	4.70

DIFFERENCE BETWEEN EXPERIMENTAL AND CONTROL GROUPS' POST-TEST SCORES

To determine whether there is a significant difference between the experimental and control groups' post-test scores, independent samples t-test was carried out. The Kolmogorov-Smirnov normality test (Table 6) and the Levene's test (Table 7) were carried out to ensure that the experimental and control groups' post-test scores fulfil the assumptions of the independent samples t-test.

Based on Table 6, for the experimental group, as p=0.00 (<0.05), therefore the post-test scores for the experimental group were not normally distributed in the population. Although it is not normally distributed, for large sample size (32>30) it was large enough to compensate for non-normality (Yockey 2008). Meanwhile, for the control group, as p=0.00 (<0.05), therefore the post-test scores for the control group were not normally distributed in the population. Although it is not normally distributed, for large sample size (34>30) it was large enough to compensate for non-normality (Yockey 2008).

Based on Table 7, the Levene's test shows that p=0.10 (>0.05), therefore the post-test scores for both the experimental and control groups had equal variances in the population and the first row (equal variances assumed) of the independent samples t-test was referred to make the decision. Based on Table 7, as p=0.02 (<0.05), thus, the null hypothesis was rejected. Therefore, there was a significant difference in the mean of the post-test scores between the experimental and control groups in the population, t(64)= 2.39, p<0.05.

From the comparison between the mean scores of the post-test of the experimental and control group, it shows that the mean score of the post-test of the experimental group (M=20.66) was higher than the mean score of the post-test of the control group (M=18.09). This indicates that pupils who learnt fractions by Discovery Learning have more improvement in achievement of fractions. The teaching theory that applied in this study is based on Jerome Bruner's Discovery Learning. Bruner (1966) explained that pupils learned through three modes of representation in Discovery Learning, which are enactive, iconic and symbolic where the modes of representation refer to information or knowledge stored and encoded in memory (Salleh 2009). In Discovery Learning, learners learn through active engagement with concepts and principles during the teaching and learning process (Balim 2009; Kistian et al. 2017).

The result of this study shows that pupils in the experimental group learned fractions by Discovery Learning have better achievement. It concurs with the findings of several other studies (Aini 2016; Anyafulude 2014; Balim 2009; Kristin & Rohayu 2016; Uside et al. 2013). These past studies applied Discovery Learning in teaching and learning and indicate that Discovery Learning is helpful and able to benefit the learners in order to improve learners' understanding and achievement in various topics, subjects and different academic levels of learners.

The finding of this study is also consistent with the studies of Kistian et al. (2017) and Sari et al. (2017) which found that Discovery Learning had positive effect on Year 5 pupils' learning in Mathematics. The study of Kistian et al. only involved 18 Year 5 pupils in teaching and learning of Space and Building while the study of Sari et al. involved 79 Year 5 pupils in teaching and learning of mathematics.

The finding of this study also agrees with the studies of Arifudin et al. (2016), Herdiana et al. (2017), Kristianti et al. (2017), Kusumadhani et al. (2015), Okwute (2015) and Tokada et al. (2017) although the sample of their studies involved secondary school students which found that Discovery Learning had improve students' learning in mathematics.

In this study, Discovery Learning brings significant difference in Year Two pupils' achievement in fractions (post-test) between the experimental group and control group, in naming fractions, writing fractions and comparing two fractions. Generally, Discovery Learning is able to improve pupils' achievement in fractions where this study applied Discovery Learning in teaching and learning of fractions.

DIFFERENCE BETWEEN THE PRE-TEST AND POST-TEST SCORES OF THE EXPERIMENTAL GROUP

To determine whether there is a significant difference between the pre-test and post-test scores of the experimental group, paired samples t-test was carried out. The Kolmogorov-Smirnov normality test (Table 8) was carried out to ensure that the pre-test and post-test scores of the experimental group fulfil the assumptions of the paired samples t-test.

Based on Table 8, the pre-test scores for the experimental group were normally distributed in the population (p=0.08) and the post-test scores for the experimental group were not normally distributed in the population (p=0.00). Although the post-test scores for the experimental group were not normally distributed, for large sample size (32>30) it was large enough to compensate for non-normality (Yockey 2008).

Based on Table 9, there was a significant difference between the pre-test and post-test scores of the experimental group (t(31)=-5.74, p<0.05). Thus, the null hypothesis was rejected.

From the comparison between the mean scores of the pre-test and post-test of the experimental group, it shows that the mean score of the post-test of the experimental group (M=20.66) was higher than the mean score of the pre-test of the experimental group (M=11.69). This indicates that pupils who learnt fractions by Discovery Learning had improvement in achievement of fractions. This result is the same with the study of Aini (2016). Aini used paired-samples t-test which showed that Discovery Learning had a significant effect on the pupils' achievement.

DIFFERENCE BETWEEN THE PRE-TEST AND POST-TEST SCORES OF THE CONTROL GROUP

To determine whether there is a significant difference between the pre-test and post-test scores of the control group, paired samples t-test was carried out. The Kolmogorov-Smirnov normality test (Table 10) was carried out to ensure that the pre-test and post-test scores of the control group fulfil the assumptions of the paired samples t-test.

Based on Table 10, the pre-test scores for the control group were normally distributed in the population (p=0.14) and the post-test scores for the control group were not normally distributed in the population (p=0.00). Although the post-test scores for the control group were not normally distributed, for large sample size (34>30) it was large enough to compensate for non-normality (Yockey 2008).

Based on Table 11, there was a significant difference between the pre-test and post-test scores of the control group (t(33)=-5.91, p<0.05). Thus, the null hypothesis was rejected.

From the comparison between the mean scores of the pre-test and post-test of the control group, it shows that the mean score of the post-test of the control group (M=18.09) was higher than the mean score of the pre-test of the control group (M=10.82). This indicates that pupils who learnt fractions by conventional instruction also improved their achievement of fractions significantly. However, the difference between the mean scores of the pre-test and post-test of the experimental group (8.97) was higher than that of the control group (7.27). This result is the same with the findings of two studies, namely Ishak et al. (2009) and Periasamy et al. (2016).

TABLE 8. Kolmogorov-Smirnov Normality Test on the experimental group's pre-test and post-test scores

	Kolmogorov-Smirnov[a]		
Group	Statistic	df	Sig.
Pre-test	.15	32	.08
Post-test	.26	32	.00

TABLE 9. Paired samples t-test on the experimental group's pre-test and post-test scores

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Experimental Group	Pre-test-Post-test	-8.97	8.84	1.56	-12.16	-5.78	-5.74	31	.00

TABLE 10. Kolmogorov-Smirnov Normality Test on the control group's pre-test and post-test scores

	Kolmogorov-Smirnov[a]		
Group	Statistic	df	Sig.
Pre-test	.13	34	.14
Post-test	.19	34	.00

TABLE 11. Paired samples t-test on the control group's pre-test and post-test scores

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Control Group	Pre-test Post-test	-7.26	7.17	1.23	-9.77	-4.76	-5.91	33	.00

CONCLUSION

The objective of this study was to determine the effects of Discovery Learning on Year Two pupils' achievement in learning fractions. In conclusion, the findings of this study show that there is a significant difference between Year Two pupils' achievement in fractions who learnt using Discovery Learning compared to the pupils who learnt using conventional instruction. Therefore, it can play a role as a starting milestone for educators in Malaysia to implement Discovery Learning in daily teaching life especially in fractions. In addition, Discovery Learning can be one of the choices of teaching approach to help pupils to understand the conceptual knowledge of fractions especially in comparing fractions with one as numerator and different denominators. Discovery Learning can be also a teaching approach to be used in helping remedial class pupils in developing and understanding concept of fractions. The findings of this study can be used as a reference for teachers to promote Discovery Learning in school especially in teaching fractions. Peer teaching or lesson study can be implemented in school among the teachers to promote Discovery Learning too. The findings of this study can help curriculum specialists in considering to integrate Discovery Learning in development of the Mathematics curriculum. A well-planned Discovery Learning could be developed as one of the teaching approaches suggested in teachers' guidebook in order to achieve the learning objectives. The findings of this study also contribute to the Ministry of Education. Primary School Department in the Ministry of Education can make evaluation and improve its suitability in enhancing Discovery Learning to improve pupil's understanding in mathematics especially in fractions. It is suggested to have further study at higher level of fractions topic such as operations in fractions by using Discovery Learning to examine the suitability of this teaching approach in the topic of fractions and to categorize sample based on pupils' mathematics achievement level to be the sample in future study in order to examine the best target for the Discovery Learning to be implemented. Besides that, it is suggested to involve gender differences in future study to examine the effects of Discovery Learning and gender on achievement in fractions. Due to some constraints, this study was only carried out in Chinese primary schools. In order to make the findings more comprehensible and able to generalize to all the primary school pupils, it is suggested that future research include pupils from National and Tamil primary schools.

REFERENCES

Aini, I. M. 2016. Pengaruh penggunaan model pembelajaran Discovery Learning (DL) terhadap hasil belajar tematik siswa Kelas V SD negeri 2 Labuhan Ratu Bandar Lampung. Laporan penyelidikan, Fakultas Keguruan dan Ilmu Pendidikan Bandar Lampung.

Alfieri, L., Brooks P. J., Aldrich, N. J., & Tenenbaum, H. R. 2011. Does discovery-based instruction enhance learning?. *Journal of Educational Psychology*, *103*(1), 1-18.

Anyafulude, J. 2014. Impact of discovery-based learning method on senior secondary school physics. Journal of Research & Method in Education, 4(3), 32-36.

Arifudin, M., Wilujeng, H., Utomo, R. B. 2016. Pengaruh metode discovery learning pada materi Trigonometri terhadap kemampuan penalaran adaptif siswa SMA. *Jurnal Pendidikan Matematika Universitas Muhammadiyah Tangerang, 1*(2), 129-140.

Bahagian Perancangan dan Penyelidikan Dasar Pendidikan Kementerian Pendidikan Malaysia, 2016. *Laporan TIMSS 2015*. Putrajaya, Malaysia: Kementerian Pendidikan Malaysia.

Balim, A. G. 2009. The effects of discovery learning on students' success and inquiry learning skills. *Eurasian Journal of Educational Research, 35*, 1-20.

Brown, G., & Quinn, R. J. 2006. Algebra Students' Difficulty with Fractions: An Error Analysis. Australian Mathematics Teacher, 62(4),28-40.

Brown, G., & Quinn, R. J. 2007, Investigating the relationship between fraction proficiency and success in algebra. Australian Mathematics Teacher, 63(4), 8-15.

Bruner, J. S. 1961. The act of discovery. Harvard Educational Review, 31, 21-32.

Bruner, J. S. 1966. Toward a theory of instruction, Cambridge, Mass.: Belkapp Press.

Bruner, J. S. 1971. The relevance of education. New York: Norton.

Bruner, J. S. 1978. The role of dialogue in language acquisition. In A. Sinclair, R., J. Jarvelle, & W. J.M. Levelt (Eds.) The Child's Concept of Language (pp. 19). New York: Springer-Verlag.

Bruner, J. S. 2009. The process of education. Harvard University Press.

Clark, B. 2010. Running Head: Eliminating Fraction Frustration. Theses, University of Florida.

Fazio, L., Siegler, R. 2011. *Teaching fractions*. Vol. 22 of Educational practices series, Geneva: International Academy of Educational-International Bureau of Education.

Gay, L. R., Mills, G. E. & Airasian, P. W. 2012. *Educational Research: Competencies for Analysis and Applications.* 10th Edition, Pearson, Upper Saddle River.

Hassan, S. R., Rosli, R., & Zakaria, E. 2016. The use of I-Think map and questioning to promote higher-order thinking skills in Mathematics. *Creative Education, 7*, 1069-1078. Scientific Research.

Herdiana, Y., Wahyudin, & Sispiyati, R. 2017. Effectiveness of discovery learning model on mathematical problem solving. *AIP Conference Proceedings, 1868*, 050028.

Hoffman, S. K. 2013. Instruction for discovery learning: levels of implementation exhibited by a sample of algebra I teachers. Theses, University of Texas.

Idris, N., & Narayanan, L. M. 2011. Error patterns in addition and subtraction of fractions among form two students. *Journal of Mathematics Education, 4*(2), 35–54.

Ishak, A., Kasa, Z., Selamat, M. H., & Samah, B. A. 2009. Perbandingan pengajaran berasaskan multimedia dan tradisional ke atas pencapaian Matematik dan sikap matematik di kalangan pelajar berisiko. *Jurnal Teknologi Maklumat & Multimedia, 5*, 79 -89.

Kartikasari, I. 2012. Pengaruh metode discovery learning terhadap motivasi dan hasil belajar matematika siswa pada Pokok Bahasan Kubus dan Balok (studi eksperimen di Kelas VIII MTS Kiarapayung Kabupaten Ciamis). Laporan penyelidikan, Institut Agama Islam Negeri (Iain) Syekh Nurjati Cirebon.

Kementerian Pelajaran Malaysia 2011. *Dokumen standard sekolah rendah Matematik tahun dua.* Putrajaya, Malaysia: Kementerian Pendidikan Malaysia, Bahagian Pembangunan Kurikulum.

Kementerian Pelajaran Malaysia 2011. *Kurikulum Standard Sekolah Rendah Modul pengajaran dan pembelajaran Matematik nombor dan operasi tahun dua.* Putrajaya, Malaysia: Kementerian Pendidikan Malaysia, Bahagian Pembangunan Kurikulum.

Kistian, A., Armanto, D., & Sudrajat, A. 2017.The effect of discovery learning method on the Math learning of the V SDN 18 students of Banda Aceh, Indonesia. *British Journal of Education 5*(11), 1-11.

Kristianti, Y., Prabawanto, S., & Suhendra, S. 2017. Critical thinking skills of students through mathematics learning with ASSURE model assisted by Software Autograph. *Journal of Physics*, 895, 012063. doi :10.1088/1742-6596/895/1/012063

Kristin, F., & Rohayu, D. 2016. Pengaruh penerapan model pembelajaran discovery learning terhadap hasil belajar IPS pada siswa Kelas 4 SD. *Scholaria, 6*(1), 84-92.

Kusumadhani, D. N., Waluya, S. B., & Rusilowati, A. 2015. Mathematics literacy based on adversity quotient on the discovery learning and Guilford approach. *International Conference on Mathematics, Science, and Education,* 18-23.

McLeod, S. 2012. Bruner. *Simply Psychology.* Retrieved October 20, 2017, from http://www.simplypsychology.org/bruner.html

Meert, G., Gregoire, J., & Noel, M. P. 2010. Comparing the magnitude of two fractions with common components: which representations are used by 10-and 12-year-olds?. *Journal of Experimental Child Psychology*, 107(3), 244-59. doi: 10.1016/j.jecp.2010.04.008

Ministry of Education Malaysia 2013. *Preliminary Report Executive Summary Malaysia Education Blueprint 2013-2025*. Putrajaya, Malaysia: Kementerian Pendidikan Malaysia.

Mullis, I. V. S., Martin, M. O., Foy, P., & Drucker, K. T. 2012. *TIMSS & PIRLS International Result in Reading*. Boston: Boston College, International Study Center.

National Mathematics Advisory Panel, 2008. *The Final Report of the National Mathematics Advisory Panel 2008*. Washington, DCU. S. Department of Education.

Noordin, N., Razak, F. A., Dollah, R., & Alias, R. 2010. Identifying equivalent pictorial representation of a fraction & a whole. *Jurnal Pendidikan Malaysia, 34*(1), 131–153.

Okwute, O. A. 2015. Effect of guided discovery method on Mathematics performance of low and high averted secondary school students in FCT Abuja, Nigeria. Theses, Ahmadu Bello University.

Periasamy, D., Bakar, K. A., & Ayub, A. F. M. 2016. The effects of MATAS Hopscotch technique in the learning of fractions among year 5 pupils. *Malaysian Journal of Mathematical Sciences 10*(S), 201–210.

Razak, F.A., Noordin, N., Alias, R., & Dollah, R. 2012. How Do 13-year Olds in Malaysia Compare Fractions?. *Procedia -Social and Behavioral Sciences, 42*, 100-105.

Salleh, F. 2009. Strategi bagi membantu murid sekolah rendah menguasai Matematik. *Pendidikan Matematik DP, 9*(2), 56-65.

Sarwadi, R., Shahrill, M. 2014. Understanding students' Mathematical errors and misconceptions: the case of year 11 repeating students. *Mathematics Education Trends and Research*, 1-10. doi:10.5899/2014/metr-00051

Shin, M., & Bryant, D. P. 2016. Fraction interventions for students struggling to learn mathematics: a research synthesis. Remedial and Special Education, 1–14. doi: 10.1177/0741932515572910

Shin, M., & Bryant, D. P. 2017. Improving the fraction word problem solving of students with Mathematics learning disabilities. SAGE Journal, 38(2), 76-86.

Siegler, R. S., Carpenter, T., Fennell, F., Geary, D., Lewis, J., Okamoto, Y., Thompson, L., Wray, J. 2010. *Developing effective fractions instruction for kindergarten through 8th grade: A practice guide* (NCEE Paper No. 2010-4039). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Siegler, R. S., Thompson, C. A., & Schneider, M. 2011. An integrated theory of whole number and fractions development. *Cognitive Psychology 62*(4), 273-96. doi: 10.1016/j.cogpsych.2011.03.001

Singh, P., Rahman, A. A., & Teoh S. H. 2010. Languages and Mathematics achievements among rural and urban primary four pupils: a Malaysian experience. *Journal of Science and Mathematics Education in Southeast Asia 33*(1), 65-85.

Tokada, D., Herman, T., & Suhendra 2017. Discovery learning for Mathematical literacy ability. *Journal of Physics: Conference Series, 895*(1). doi :10.1088/1742-6596/895/1/012077

Uside, O. N., Barchok, K. H., & Abura, O.G. 2013. Effect of discovery method on secondary school student's achievement in Physics in Kenya. *Asian Journal of Social Sciences & Humanities, 2*(3), 351-358.

Valarmathy, M. 2004. Proses menyelesaikan masalah dalam matematik oleh murid tahun lima. Laporan penyelidikan, Universiti Malaya.

Yockey, R. D. (2008). *SPSS demystified: A step-by-step guide to successful data analysis*. Upper Saddle River, NJ: Pearson Education.

Ong Pei Wen
School of Educational Studies
Universiti Sains Malaysia
Email: gtongpw@hotmail.com

Chew Cheng Meng
School of Educational Studies
Universiti Sains Malaysia
Email: cmchew@usm.my

*Author for correspondence, email: gtongpw@hotmail.com

Submitted: 15 Mei 2019
Reviewed: 21 August 2019
Accepted: 3 September 2021
Published: 26 October 2021