Self-Explanation Prompts in *i*Fractions: The Effect on Students with Different Levels of Ability

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Abstract
The purpose of this study is to evaluate the effectiveness of the help element that is the self-explanation prompts in *i*Fractions educational game software, on the achievement of students with different levels of ability. A total of 40 students from a school in Pulau Pinang participated in this survey. The study was conducted using quasi - experimental with a 3 x 2 factorial design where the questionnaires involved were the pre-test and post-test. The self-explanation prompts was developed using the cartoon concept. The study data was analysed using SPSS version 20 software with the t-test parametric comparison analysis. The findings of the study indicate that the self-explanation prompts in *i*Fractions has helped to improve the students' achievements when compared to MyCD software without the self-explanation prompts. High ability students and low ability students who used the self-explanation prompts showed significantly better achievements. Students with different levels of ability who used *i*Fractions with self-explanation prompts found that it has helped them make the fractions abstract concept concrete and facilitate the proper construction of fractions schema. Therefore, the design of any educational software must be constructive in parallel with the combination of scaffolding element which is the self-explanation prompts.
Keywords: Self- explanation prompts; high ability; low ability

1. Introduction

Fractions is a very difficult topic for school children (Gabriel et.al., 2013; Forgues, Tian and Siegler 2015; Tian and Siegler 2016;Emily Sharp and Dennis, 2017). This occurs since students cannot construct a proper fractions schema due to the confusion that arises when learning the topic of Round Numbers. Hence, previous researchers have developed various teaching aids to solve problems that arose in learning fractions.

One of the teaching aids developed by previous researchers was an educational software in the form of games and non-games. However, the software developed had many weaknesses in terms of assistance to low ability students. Md Salleh and Napiah (2010) have developed a fractions educational software to improve students' performance in fractions. However, this software was not flexible for students with different levels of ability because the help element was not available. Wan Fatimah and Nurul Hidayah (2010) have also developed the fractions educational game software that contained tutorials on fractions. The help element was also not provided in this software.

The Ministry of Education Malaysia(MOE) has also distributed the educational software, that is the MyCD course software for Year 1 to Year 4 students; containing text, animation, audio, video, interactive activities and interactive tests to support and enhance text book contents (Muhammad, 2009). However, MyCD did not provide scaffolding elements or help to students to assist low ability students to construct fractions schema. According to Adams and Clark (2014), the current education world still has no clear principles for designing an effective educational game for students.

Helping students learn new information is very important especially for low ability students. There are various methods to achieve this goal but not all methods are proven effective. One of the methods is the explanation approach, that is the self-explanation prompts (Durkin, 2011). According to Killingsworth and Clark (2015), self-explanation prompts is a very effective approach to enhance learning in educational game software. This statement is supported by O'Neil et. al. (2014), where the self-explanation prompts is a very effective teaching method to help in strengthening the learning schema.

2. Self-Explanation Prompts

The self-explanation prompts is defined as generating self-explanations in order to understand the information learned (Johnson, Loehr and Durkin, 2017; Chi, 2000). According to Chi, Olfman and Berger (2017), self-explanation is an effective metacognitive strategy that can help students develop deeper understanding since the self-explanation prompts emphasises on production of conclusions to bridge the information gap in learning materials (Sern lai, Spottl and Straka, 2011) and can be used to support multimedia learning (Lijia Lin et. al, 2014). Studies show that students who are often motivated to carry out self-explanation related to learning materials perform better than students who are not motivated to do self-explanation (Chi, Olfman and Berger, 2017; Rittle-Johnson and Loehr, 2016; Mayer, Dow and Mayer, 2003; Wong, Lawson, and Keeves, 2002). Most students do not do self-explanation spontaneously but begin to self-explain when guided (Bielaczyc, Pirolli, and

Brown, 1995) or when motivated to do so (Chi, DeLeeuw, Chiu, and LaVancher,1994). According to Rittle-Johnson (2006), students who are not motivated to do self-explanation will return to using their wrong procedure or understanding. Self-explanation prompts can be carried out through 'thinking-aloud' (talking) or covertly (thinking). According to Roy and Chi (2005), Chi et al. (1989) and Nokes, Hausmann and VanLehn (2011), self-explanation prompts can play a role in two forms, that is generating conclusions to fill up the missing information (gap-filling) and the mental-model revision. Gap-filling is designed to fill in the information gap in such learning while mental-model revision is the driving force that focuses on students to review their existing knowledge.

Studies done by Lijia Lin et. al (2014) found that self-explanation prompt can improve students' performance while reducing the students' cognitive burden. This statement is supported by O'Neil et. al. (2014) where he found that self-explanation prompt could help students in the process of playing educational software games. Figure 1 shows examples of self-explanation prompts used in learning mathematics.

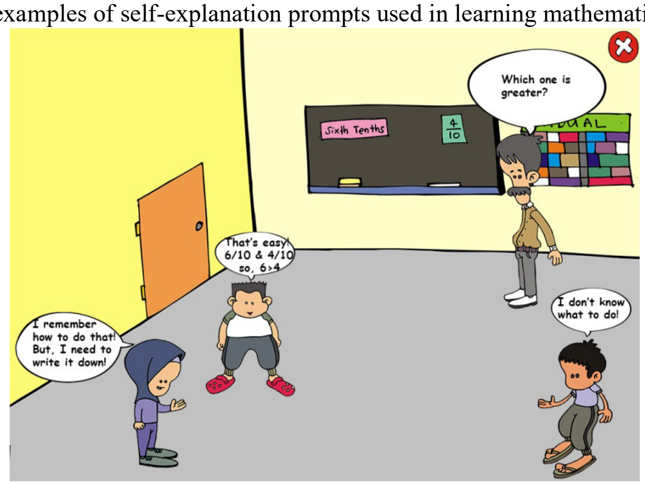

Figure 1. The use of self-explanation prompt in Mathematics

2.1 Self-Explanation Prompts in Educational Game Software

The design of an educational software for example educational game software must emphasise on the ability of students (Allen, 2007). For high ability students with strong existing knowledge, it is highly likely that they do not need help in learning. High ability students can construct their own mental model or schema through existing knowledge and new knowledge gained without being driven by external help (Clark, 2008; Mayer, 2001). Therefore, the element of assistance or scaffolding in the design of an educational software for high ability students need not be emphasised. Whilst low ability students need help in learning since their existing knowledge is not strong to build the schema (Hannafin, 1997; Mayer, 2001). Students need to be driven by external help to construct a proper educational schema to improve their achievements. Most educational games software developed by previous researchers did not contain help elements like self-explanation prompts. According to Jonker et al (2009), educational games software that do not provide help or tips will make it especially difficult for low ability students.

3. Conceptual Framework

Figure 2 shows the conceptual framework that has been developed in this study. Referring to this conceptual format, the construction of self-explanation prompts in *i*Fractions educational software helps students in building the correct fractions schema.

Coding and Schema Design

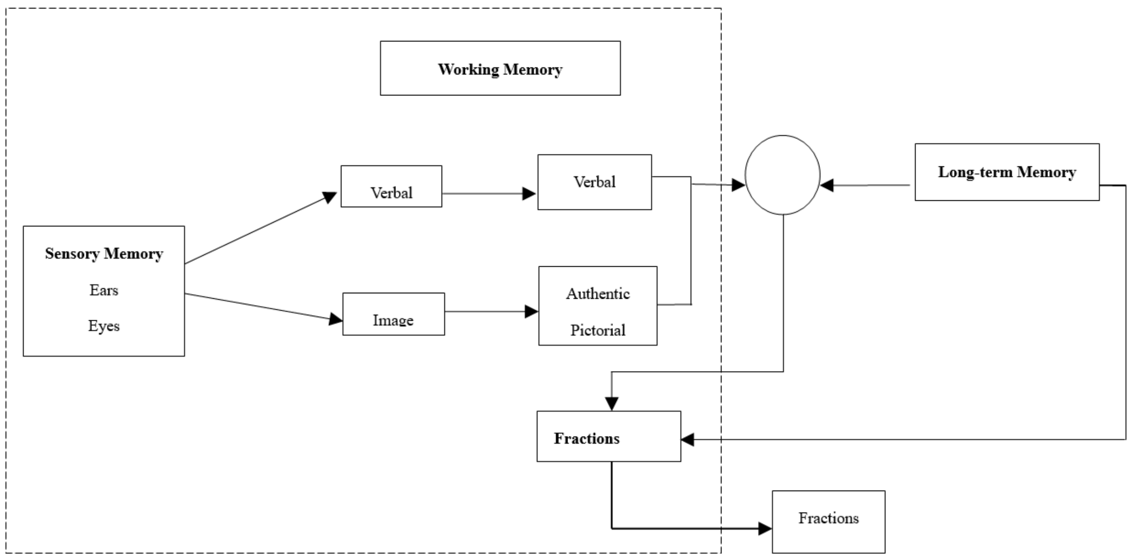

Figure 2. Study Conceptual Framework

In the development of the self-explanation prompts, coding and schema formation occurred when there were two presentations i.e words and audio which penetrate the eyes and ears. All of this content is via sensory memory as well as the selection of critical word and image which subsequently, enters the working memory. In the working memory, word and image compilation into the appropriate representation takes place, i.e verbal model and authentic pictorial model. Finally, the process of integrating verbal models and authentic pictorial models with the students' existing knowledge to accommodate the schema formation. For high ability students who have strong existing knowledge, they can form schema without the help of self-explanation prompts. On the other hand, for low ability students who are in a proximal developmental zone and with weak existing knowledge, they need the help of self-explanation prompts to enable them to form the correct fractions mental model. With this breakthrough, the achievements of fractions can be improved.

4. Methodology

This study uses experimental designs as per Figure 3 with the aim of investigating the relationship of cause and effect between variables (Hashim, 2011). This design is capable of producing strong evidence of cause and effect relationships (Gay and Airasian, 2003).

O_1	MyCD	O_2
O_3	*iFractions*	O_4

with

O_1, and O_3 are pre-tests

O_2, and O_4 are post-tests

MyCD is course software for KPM

iFractions is educational games software with self-explanation prompts

Figure 3. Experimental design of the study

The factorial 2 x 2 design as shown in Figure 4 is used to enable researchers to study the effects of interactions between two or more independent variables against dependent variables on each moderator variable (Beins, 2009; Gay and Airasian, 2003).

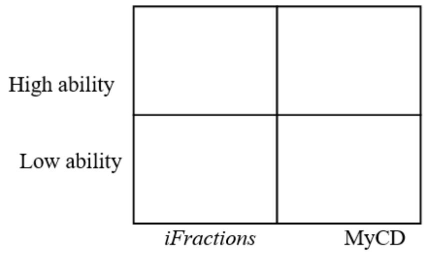

Figure 4. Experimental design with 2 × 2 factorial

The experimental design used was the quasi-experimental design. The type of quasi-experimental design chosen in this study was the non-equivalent control group design since the random distribution of students as subject of groups could not be done (Chua, 2006). Each group of students in a class was used as one group rather than randomly distributing the students into groups.

4.1 Study Instruments

The study instruments used in this research were the pre-test and post-test which will be used to measure the students' fractions achievements before and after treatment was given. The pre-test and post-test were subjective questions consisting of 10 items. These tests were done in writing. The pre-test and post-test items were the same in terms of contents but they were randomly arranged. The pre-test was aimed at determining the existing knowledge of students for Year 4 fractions subject and was conducted prior to the learning treatment. This is important to control the uniformity of the academic level of the selected students. The purpose of the pre-test was to investigate and to extract the problems and difficulties faced by the students in learning fractions. While post-test was given after the learning treatment to see the actual achievements of the students.

The topic chosen for the learning treatment covers the Fractions syllabus in Year 4 Mathematics. The items in these tests are related to comparing fractions, equivalent fractions and simplifying fractions. The items in the pre-test and post-test have been prepared by the researcher. These test items were refined after the pilot study. In the development of the Fractions items for the pre-test and post-test, the items were classified according to the cognitive level of Bloom's Taxonomy.

Based on the pilot study conducted, the reliability of Cronbach's Alpha as the instrument for pre-test and post-test was determined using SPSS version 20 software. Reliability was conducted to illustrate the stability and consistency of the instrument and to determine whether or not the instrument built can be used in the research.

The maximum value of the reliability coefficient is 1.0. If the coefficient value is less than 0.6, then the instrument used has a low reliability value. Table 1 shows the Cronbach's Alpha value for each pre-test and post-test.

Table 1. Cronbach's Alpha Value For Each Test

	Dimension	Number of Items	Alpha Coefficient Value
1	Pre-Test	16	0.97
2	Post-Test	16	0.99

Based on Table 1, the Cronbach's Alpha reliability value for the pre-test and post-test is 0.97 and 0.99 respectively. This reliability value exceeds 0.6 and this indicates that the pre-test and post-test have satisfactory reliability values and can be used in this research.

4.2 Data Analysis

Data collected from all respondents were analysed using the Statistical Package for Social Science(SPSS) software. The analysis provides empirical data about the relationship between educational software that has self-explanation prompt and educational software without the self-explanation prompts, with the students' achievements for high-ability students and low ability students.

To answer the questions of the study which comprises "Is there no significant difference in the achievement of fractions for high ability students who use *i*Fractions with self-explanation prompts and MyCD without self-explanation prompts" and "Is there no significant difference in the achievement of fractions for low ability students who use *i*Fractions with self-explanation prompts and MyCD without self-explanation prompts"; the researcher has conducted t-test to determine whether there are differences in the achievement of fractions between educational software which are different in terms of self-explanation prompts design.

5. Findings and Discussions

5.1 T-test analysis on Educational software with Self-Explanation Prompts

T-test was conducted to determine whether there are differences in the achievement of fractions between educational software which are different in terms of self-explanation prompts design. The first hypothesis i.e

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'there is no significant difference in the achievement of fractions by high ability students who use *i*Fractions with self-explanation prompt and MyCD without self-explanation prompts', was examined. Based on t-test, the study result was significant at ($t = 23.229$, $df = 18$, $p < 0.05$). In terms of achievement, there was a significant difference between high ability students who used software that contains self-explanation prompts and software without self-explanation prompts.

The mean difference of 60.300 indicates that students using *i*Fractions with self-explanation prompts have improved in their achievements when compared to students using MyCD without self-explanation prompts. This means that the null hypothesis was rejected and *i*Fractions supported by self-explanation prompts helps to improve student achievement.

T-test was also conducted to determine whether there were differences in the fractions achievement between educational software which was different in terms of the design of self-explanation prompts, for low ability students. The second hypothesis i.e 'there is no significant difference in the achievement of fractions by low ability students who use *i*Fractions with self-explanation prompts and MyCD without self-explanation prompts', was examined. Based on t-test, the result of the study was significant at ($t = 18.466$, $df = 18$, $p < 0.05$). In terms of achievement, there was a significant difference between low ability students who used software containing self-explanation prompts and software without self-explanation prompts. The mean difference of 34.300 indicates that low ability students using *i*Fractions with self-explanation prompts have improved in their achievements when compared to students using MyCD without self-explanation prompts. This means that the null hypothesis was rejected and *i*Fractions supported by self-explanation prompts helps to improve the achievements of low ability students.

Table 2. T-Test For High Ability Students Using *I*fractions With Self-Explanation Prompts And Mycd Without Self-Explanation Prompts

		Levene's test for equal variance		T-test for mean equality						
									Confidence interval difference 95%	
		F	Sig.	t	Degree of freedom	Sig. (2-way)	Mean difference	Standard error difference	Bottom	Top
Achievemnt	**Equal variances assumed**	8.499	.009	23.229	18	.000	60.300	2.596	54.846	65.754
	Equal variances not assumed			23.229	11.414	.000	60.300	2.596	54.612	65.988

Table 3. T-Test For Low Ability Students Using *I*fractions With Self-Explanation Prompts And Mycd Without Self-Explanation Prompts

		Levene's test for equal variance		T-test for mean equality						
									Confidence interval difference 95%	
		F	Sig.	t	Degree of freedom	Sig. (2-way)	Mean difference	Standard error difference	Bottom	Top
Achievemnt	**Equal variances assumed**	4.103	.058	18.466	18	.000	34.300	1.857	30.398	38.202
	Equal variances not assumed			18.466	14.048	.000	34.300	1.857	30.318	38.282

6. Conclusions

The findings of the study indicate that the achievements of students using the self-explanation prompts are significantly better than the achievements of students who do not use the self-explanation prompts elements in educational software. High ability students who use *i*Fractions with self-explanation prompts show significantly better achievements in fractions when compared to students who use MyCD without the self-explanation prompts, while low ability students who use self-explanation prompts show significantly better achievements in fractions when compared to students who use MyCD. These suggest that *i*Fractions with self-explanation prompts is more effective especially for low ability students in improving their fractions achievements. Low ability students who use self-explanation prompts obtain better scores in post-test. This finding is parallel with the study of Ainsworth and Loizou (2003) and Hausmann and Chi (2002) where students gave better answers in post-test after being exposed to self-explanation prompts. Low ability students have a weak existing knowledge and this compels the students to require self-activation prompts to guide them to construct proper fractions schema. This is in line with the theory of proximal development zone where students in this zone need help in learning.

The *i*Fractions educational game software can trigger self-explanation among students as a software environment that encourages and assist students to begin their own self-explanation process among themselves. This is because according to Bielaczyc, Pirolli, and Brown, (1995), most students do not begin the self-explanation process spontaneously unless they are assisted to begin the process of self-explanation or are encouraged to do so (Chi, DeLeeuw, Chiu, & laVancher, 1994). Due to the weak existing knowledge of low ability students, self-explanation prompts helps activate existing knowledge of students by creating a phenomenon that can trigger conceptual conflicts through different perceptions (Clark, 2008). Different perceptions can create dissatisfaction with the old concept existing in the cognitive structure. In accommodating this, students will alter the concept of inaccuracy with the new phenomenon encountered. The self-explanation prompts developed in this game software helps students in constructing the correct fractions schema by creating perceptions different from the students' perceptions.

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