

Integration of Science learning Apps based on Inquiry Based Science Education (IBSE) in enhancing Students Science Process Skills (SPS)

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Abstract—The teaching and learning process no longer has its focus on the classroom. There are various teaching methods which teachers can use these days. However, the traditional, passive and teacher-oriented methods of teaching Science are still being widely used and this has led to the deterioration of students' interest in Science. Thus, this study was conducted to examine the effectiveness of Inquiry Based Science Education (IBSE) learning through apps in improving the level of students' mastery and achievement in the Science Process Skills (SPS). The study involved a total of 30 Year-6 students from a school in the district of Johor Bahru selected based on their achievement in the Primary School Achievement Test. It took 5 weeks to complete the study which used quasi-experimental design of time series design followed by multiple repetitions of assessments before the post-test was given to the students. The results of the paired-samples t-test were found to be significant ($t = -11.119$, $df = 29$, $p < .05$) which showed that, there was a difference in the level of the students' performance in the pre- and post-tests. The quasi-experimental study of this series of time design used recurring measurements carried out on dependent variables and one-way ANOVA tests for repeated measures were used for the data analysis. The test results of Mauchly's Test of Sphericity showed that, there were significant differences in the three test scores $F(1.63, 47.4) = 344$, $p < .05$. The mean score values for test 2, test 3 and test 4 outweighed the mean of test 1. In addition, the graphical shape of plots profile shows that, teaching activities through apps enhanced students' Science Process Skills (SPS). Therefore, it can be concluded that, the integration of Inquiry-Based Science Education (IBSE) in Science learning through Apps is capable of improving students' mastery and achievement in their Science Process Skills (SPS)

Keywords—Mobile Learning; Science Process Skills (KPS); Inquiry Based Science Education (IBSE)

1 Introduction

The use of apps fulfils the requirements of Shift 7 in the Malaysian Education Development Plan (MEDP) 2013-2025 (Preschool to Post-Secondary Education), which leverages information technology (ICT) to improve the quality of learning in Malaysia. The optimum use of ICT in self-learning can be extended for access to high quality teaching, regardless of the location or level of students' skills [29]. As such, the implementation of new initiatives is highly anticipated by the society to continue its success and impact in making education in Malaysia well in tandem with that of other developed countries. Considering the needs of today's environment and technology, various forms of ICT integration, including apps have been introduced, where the learning process can be carried out by integrating it with mobile technology such as laptops, tablets and smartphones. The use of apps will revolutionize education in schools and transform conventional classrooms into interactive classrooms with applications which have the potential to enhance students' learning experience to explore, examine, investigate and conduct activities or experiments which they need to master [53]. Therefore, to help students think critically and build their confidence in problem solving, the hands-on approach and the minds-on approach in the inquiry-based learning environment need to be integrated [6].

Therefore, to continue its legacy as a rapidly developing country towards becoming a developed country, the education sector needs to be developed and a paradigm shift taken [30]. Accordingly, a research that supports the development of skills and the development of knowledge needs to be developed and implemented through the use of mobile technology to enhance student's mastery of the Science Process Skills (KPS) by integrating an inquiry-based approach which can support towards improving students' understanding and their subsequent mastery of skills [5], [16], [47], [55]. Overall, the use of apps in an inquiry-based learning environment is deemed capable of helping students in self-directed learning and exploration, which is considered as an important component of education in the 21st century. In support of this goal, the provision of apps helps teachers to design and implement learning outside of the traditional classroom [3]. The learning environment with the use of multimedia on mobile platforms and inquiry-based learning combined, can help enhance students' understanding, thereby supporting the mastery of Science Process Skills (SPS) in Science subjects [53].

1.1 Background of problems

A study by the Inspectorate and Quality Assurance Committee (IQAC) 2011 found that, only 13% of teachers in schools achieved good or excellent grades in teaching sessions delivered using pedagogical best practices, while the remaining 87% of them did not practice proper pedagogy when teaching and learning. Overall, it was found that, teachers' achievements are still at a low level and are a cause for concern, thus the need for them to improve their pedagogical skills [6], [7]. Meanwhile, in a report issued by the Teacher Education Division, the Ministry of Education (MOE) to the State Education Department, it was stated that the results of their study found that, 42.4% of

students stated that Science teachers use the lecture method almost all the time in the class. The study was conducted in a total of 113 schools across Malaysia and it was found that, the percentage of teachers surveyed who used creative teaching techniques, such as debate (24%), simulation (45%), games (45%), model building (52%), projects (53 %) and field studies (57%) were relatively low. The most notable finding was that, more than 89.29% of Science teachers used teaching techniques that did not impress students and involved only copying notes. This situation causes students to lose interests in studying Science as their main focus and objective are to memorize the content of the study and pass the examinations. Students only listen to explanations given by teachers and are not exposed to Science Process Skills (SPS), thus resulting in their cognitive levels to not fully develop. This consequently leads to their failure to construct and to get the grasp of the Science concept. Inaccurate interpretations of students' abilities cause students to not collaborate with each other resulting in less communication and less teamwork among them [45]. This situation contributes to the students' failure to master the concept of Science and this in turn causes them to become disinterested in the Science subjects. This factor causes a decline in their performance, rendering it difficult to produce high quality students.

The Primary School Science Curriculum in Malaysia focuses on the mastery of scientific skills in learning and understanding of nature [12], [39], [54]. These Scientific skills are an important part of the inquiry process and problem solving for conducting activities based on scientific methods. These Scientific Skills are divided into two components, namely, Science Process Skills (SPS) and Manipulative Skills (MS). Science Process Skills (SPS) is divided into two elements, namely Basic Science Process Skills and Integrated Science Process Skills, which enable students to be trained through activities and investigations, and these skills range from the simplest to the most complex [34]. Inquiry allows students to participate in Science activities and exercises as well as encouraging them to study Science [41], [3], [13]. Students should be actively engaged in teaching and learning activities and be able to voice their opinions easily. However, this is not the case, because students are passive and only wait for teachers' instructions in the classroom [24], [37], [44]. Therefore, to ensure that students gain optimum knowledge, the integration of mobile technology in teaching and learning should not be underestimated as a quality learning process is believed to be capable of producing knowledgeable and excellent students (58), [33]. However, no analysis or study of the effectiveness of mobile learning methods for Science subjects in Malaysia has been conducted. Mobile learning (apps) is a concept of learning that emphasizes on teachers' ability to carry out the learning process without being constrained by the physical locations of the learning process [28], [50].

1.2 Literature review

The Science teaching method in primary schools is one of the main causes for the failure listed in the Primary School Standard Curriculum, and it also causes students to lose interest in Science subjects in primary schools. Teachers rarely conduct learning activities such as simulation, project, inquiry, experiment, discussion, visit, use of external resources and the use of technology and this has contributed to the decline of

students' achievement in Science subjects [13]. Teachers' failure to apply constructivism as a method of learning has resulted in students not being able to form their own understanding in constructing analogies, examples and methods of digesting what they have learned in their own way [3]. Students are less interested in Science due to the teaching methods practised by teachers in the teaching and learning process of Science which are unable to draw their attention [1], [18], [27], [53], [57], [59]. Teachers only teach using traditional methods by giving descriptions and writing on the chalkboards. Although the concepts of contextual learning, mastery learning, inquiry and constructivism have been written in the Daily Lesson Plan, they are not fully implemented [48]. To address the problem of exam-based teaching and learning delivery methods, teacher-designed learning techniques should suit the various levels of the students' brainpower and be able to arouse their interest in learning Science topics easily and effectively [18], [27], [53], [57], [59]. Thus, it can be concluded that teaching methods and techniques play important roles in the teaching and learning process, where Science learning should be able to get students engaged in the teaching and learning process and even should enable them to identify problems, design problem solving methods and find solutions to such problems as in the Inquiry-Based Science Education (IBSE) strategy [25], [44], [46], [1], [23].

1.3 Inquiry-Based Science Education (IBSE)

An inquiry approach helps students think critically and build confidence in solving problems [3]. Referring to Table 1, the learning level of inquiry is divided into four types; verification inquiry, structured inquiry, guided inquiry and open inquiry. Verification inquiry is the first and the lowest level, where students verify a principle or law of Science, which final results are known. In structured inquiry, students investigate the questions raised by teachers based on the prescribed procedures. Students conduct investigations based on questions given by the teacher, but planning and procedures are determined by the students themselves through the third level of guided inquiry, while in the fourth level, namely, open inquiry, which is the highest level, students are required to ask questions and determine how the investigation should be conducted. Inquiry-based Science Education utilizes and promotes the use of Science Process Skills (SPS) in Science activities carried out, which simultaneously builds and nurtures students' curiosity and awe of the phenomena observed in everyday life [35], [56]. Ergül et al. (2011) in their study found that, teaching of Science based on inquiry enabled students to integrate Science Process Skills (SPS), scientific reasoning and critical thinking to build their understanding of scientific concepts [15]. Students engaged in the study of Science based on inquiry are able to build a deeper understanding including appreciating knowledge and discovery process in Science. The advantage of the Science inquiry approach is that, it is driven by the curiosity and desire to understand something or to solve problems, which in turn raises questions to be solved [48]. Inquiry learning emphasizes on the exploration of the environment and is able to stimulate students to explore further to enhance their understanding and achievements [56]. In addition, interesting inquiry activities can help develop skills in discussion, communications and recording learning [38], [4]. The integrated IBSE

approach coupled with the use of mobile applications will make Science learning more meaningful and effective.

Table 1. Four Levels of Inquiry Learning

Level	Types of Inquiry	Description
4	Open Inquiry	Students do research based on the questions and steps which they themselves create and determine according to specific topics.
3	Guided Inquiry	Students conduct investigations based on the questions which the teacher has prepared, and the selection of the exploration steps is determined by them.
2	Structured Inquiry	Students conduct research based on questions and steps which the teacher has determined.
1	Verification	Students verify certain principles based on the teacher's explanations and the results of the research are known in advance.

1.4 Mobile learning

Mobile learning generally uses technology components such as laptops, digital personal aids and mobile phones. It enables students to share information more easily, facilitates the process of assigning tasks faster and can build good co-operation among group members [11], [10], [36], [26], [51], [52]. Students can share notes via mobile devices, such as cell phones and smartphones and they no longer have to sit in front of a personal computer to download notes [32], [21]. Good acceptance of mobile learning among students enables them to use mobile learning platforms for communication, collaboration and self-learning opportunities [49], [17]. Educators need to be prepared in terms of pedagogy and approaches in applying the use of mobile technology during the teaching and learning process [17]. Teachers' skills in the use of mobile technology need to be enhanced, so that teachers can produce themselves, for example, software that are now readily available and can be developed using simple programming techniques to prepare quiz questions, and this can greatly enhance students' knowledge of Science Process Skills (SPS) [40]. In fact, mobile devices make teaching and learning easier because all relevant information can be implemented in a timely manner. Students understand Science learning better after using mobile technology compared to traditional learning. Mobile learning can also save time and make it easier for students and teachers to set their daily schedule without being limited to specific times.

1.5 Science Process Skills (SPS)

Science process skills (SPS) is a skill that encourages students to question Science problems which they encounter and to find the answers systematically [14], [20], [24], [9], [43], [19], [8]. Based on Diagram 1 below, Science Process Skills (SPS) can be divided into two types, namely, Basic Science Process Skills and Integrated Science Process Skills. Basic Science Process Skills include the skills of observing, classifying, measuring and using numbers, inferring, predicting, communicating and using space and time relationships. Meanwhile, Integrated Science Process Skills consists of skills in interpreting information, operating definitions, controlling variables, hypothesizing

and experimenting. Science Process Skills (SPS) are very useful in designing and constructing scientific facts in Physical science at the school level and scientific activities which involve a variety of methods, including such activities as observing phenomena, questioning, scrutinizing, examining books and also other sources of information to find out about the phenomenon [34], [42].

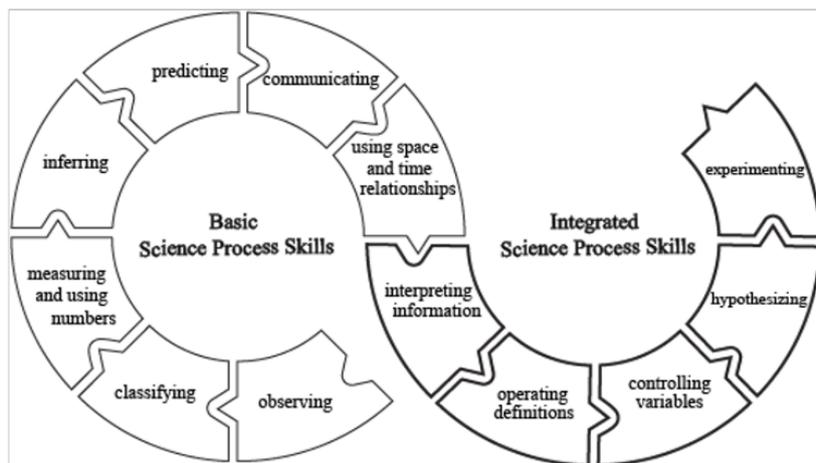


Fig. 1. Basic and Structured Science Process Skills

2 Objectives of the Study

The objectives of the study as outlined in the problem statement as which to study the impact of learning activities through apps based on the integration of Inquiry-based Science Education (IBSE) and the instructional scaffolding method in Science learning on:

- i. The level of students' achievement in Science learning.
- ii. The level of mastery of Basic and Integrated Science Process Skills.

3 Methodology

This study was conducted for 5 weeks using the quasi-experimental design of time series design. The study involved a total of 30 Year-6 students from a school in the district of Johor Bahru, selected based on the achievement in the Primary School Achievement Test. The quasi-experimental study of this series of time designs used recurring measurements which were carried out on dependent variables and one-way ANOVA tests for repeated measures were used for the data analysis.

4 Data Analysis and Results

The comparative analysis of the frequency of the content-based pre- and post-test scores as in Fig. 2 shows that, out of the total 30 students taking the test, there were 27 of them who showed an increase in test scores, 90% of the overall test scores.

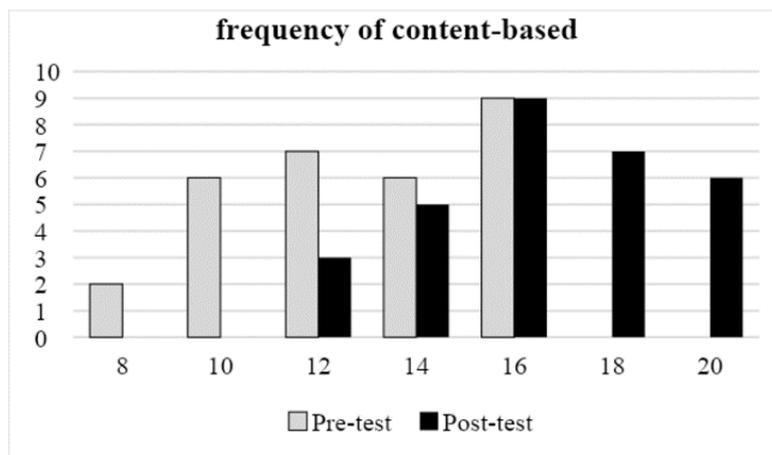


Fig. 2. Comparison of the frequency of content-based pre- and post- test scores

Table 2. Statistical results of paired-sample t test for pre- and post-tests

Pairs	Mean	Standard Deviation	t	Sig. (2-tailed)
Pre-Test	32.93	2.612	-11.119	.000
Post-Test	36.53	2.515		
Post-Test- Pre-Test	3.6			

To study the comparisons of the students' achievements, further analyses were performed using the t-test for repeated measures (paired-samples t test). Based on Table 2, the results of the study were significant ($t = -11.119$, $df = 29$, $p < .05$). This indicates that, there were significant differences in students' achievement in pre- and post-tests at 32.93 and 36.53, respectively. Higher mean scores in post-test with a difference of 3.6 indicate that, the use of apps in teaching and learning Science can improve students' achievement.

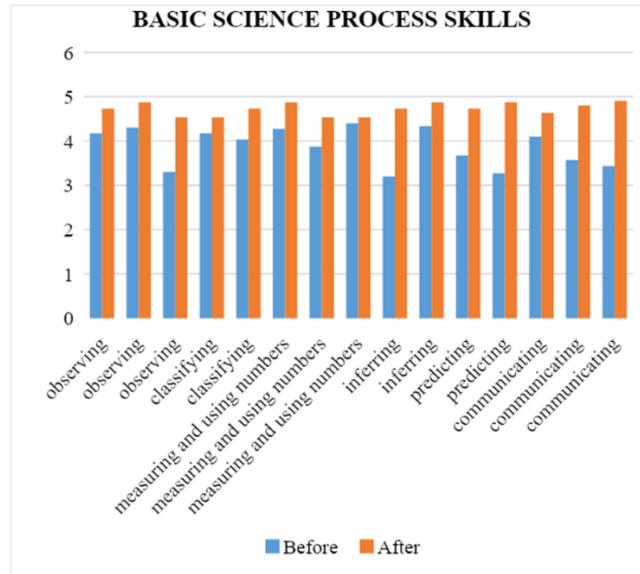


Fig. 3. Comparison of the means before and after the use of apps for the Basic SPS

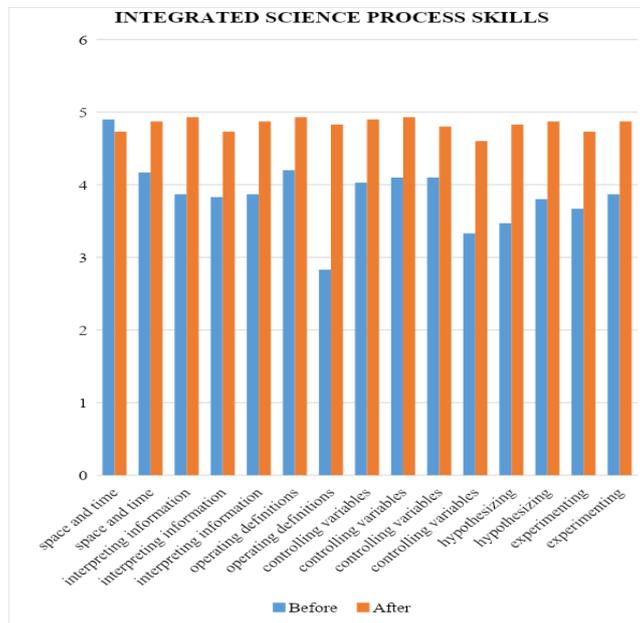


Fig. 4. Comparison of the means before and after the use of apps for the Integrated SPS

The subsequent analysis was to find the mean difference in students' achievement before and after they used the apps in the learning session.

Table 3. Comparison of students' achievement for Science Process Skills (SPS) test

STU-DENTS	SPS1	%	SPS2	%	SPS3	%	SPS4	%	TOTAL	PERCENT
S1	6	43	7	50	9	50	12	67	34	53
S2	7	50	7	50	12	67	15	83	41	64
S3	8	57	9	64	13	72	17	94	47	73
S4	7	50	9	64	13	72	17	94	46	72
S5	6	43	7	50	12	67	15	83	40	63
S6	9	64	10	71	14	78	17	94	50	78
S7	12	86	11	79	13	72	17	94	53	83
S8	6	43	7	50	11	61	15	83	39	61
S9	5	36	7	50	11	61	16	89	39	61
S10	6	43	7	50	11	61	15	83	39	61
S11	12	86	13	93	15	83	17	94	57	89
S12	9	64	9	64	14	78	17	94	49	77
S13	9	64	10	71	11	61	15	83	45	70
S14	9	64	11	79	11	61	16	89	47	73
S15	10	71	11	79	14	78	17	94	52	81
S16	6	43	7	50	9	50	13	72	35	55
S17	7	50	7	50	10	56	14	78	38	59
S18	9	64	10	71	12	67	15	83	46	72
S19	11	79	13	93	14	78	17	94	55	86
S20	10	71	11	79	13	72	17	94	51	80
S21	11	79	11	79	13	72	17	94	52	81
S22	13	93	14	100	13	72	17	94	57	89
S23	12	86	11	79	14	78	17	94	54	84
S24	6	43	7	50	10	56	15	83	38	59
S25	6	43	7	50	11	61	14	78	38	59
S26	9	64	10	71	14	78	17	94	50	78
S27	4	29	7	50	11	61	14	78	36	56
S28	6	43	7	50	11	61	15	83	39	61
S29	9	64	9	64	12	67	15	83	45	70
S30	4	29	7	50	11	61	14	78	36	56

The analysis on the Science Process Skills (SPS) test showed an increase in students' achievement, where all the four tests showed that 27% of them achieved higher than 80 marks, while 50% of them achieved scores in the range of 60-78.

Table 4. Mauchly's Test of Sphericity^b

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^a		
					Green-house-Geisser	Huynh-Feldt	Lower-bound
Tests	.236	40.066	5	.000	.520	.545	.333

For comparisons of the achievements of the SPS test, repeated measures of one-way ANOVA tests were conducted. The results of Mauchly's Test of Sphericity as shown in Table 4 are significant, so these need to be modified to adjust the new df values by the adjustment of the df values using Tests of Within-Subjects Effects, such as in Table 5,

with the new values (new df1 = 1.634, new df2 = 47,382). Based on the new df values, it clearly shows that there was a significant difference in the KPS test score [F (1.63,47.4) = 344, p <.05] overall among the four tests.

Table 5. Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Tests	Sphericity Assumed	1026.467	3	342.156	344.001	.000
	Greenhouse-Geisser	1026.467	1.561	657.554	344.001	.000
	Huynh-Feldt	1026.467	1.634	628.250	344.001	.000
	Lower-bound	1026.467	1.000	1026.467	344.001	.000
Error(test)	Sphericity Assumed	86.533	87	.995		
	Greenhouse-Geisser	86.533	45.270	1.911		
	Huynh-Feldt	86.533	47.382	1.826		
	Lower-bound	86.533	29.000	2.984		

Table 6. Estimated Marginal Means

Test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	8.133	.457	7.199	9.067
2	9.100	.396	8.289	9.911
3	12.067	.291	11.471	12.663
4	15.633	.260	15.101	16.166

The mean score values of the SPS tests for test 2 (Min = 9.10), test 3 (Min = 12.01) and test 4 (Min = 15.63) are higher than that for test score 1 (Min = 8.13), as shown in Table 6, indicating that the use of apps in teaching and learning is effective to enhance students' achievement and mastery of Science Process Skills in the study population. In addition, the graphical form of profile plots in Fig. 5 clearly indicates that, the integration of apps in teaching and learning activities has helped to improve students' achievement in the KPS 2, KPS 3 and KPS 4 tests.

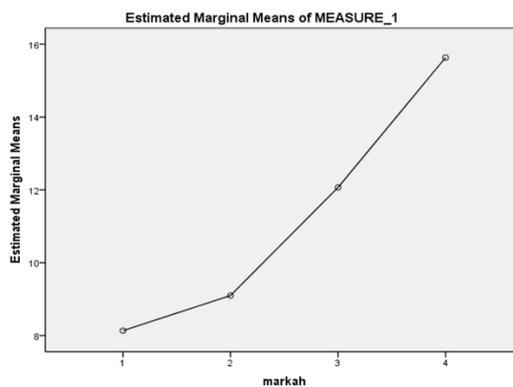


Fig. 5. Graphs of Profile plots

5 Discussion

Comparisons of the frequency of scores shown in Figure 1 and the means in Table 1, between the pre and post content-based tests show that, the majority of respondents recorded improved scores in post-tests. This proved the effectiveness of IBSE integration through apps, which has successfully enhanced the level of students' achievement after using the app. In fact, the increased means in the achievement of Basic SPS in Figure 3 and Integrated SPS in Figure 4 show that, the effectiveness of using mobile technology depends on good acceptance among students [49]. Therefore, the researchers recommend that educators be prepared in terms of pedagogy and approaches in applying the use of mobile technology in teaching and learning. The increase in scores also accentuates the facts that learning through mobile technology is more effective, efficient and is able to encourage students to learn [32].

From the comparative analysis of students' achievement for the Science Process Skills (SPS) tests shown in Table 3, the improvements in their achievements were significant, where the overall percentages for all the three tests showed that, the majority of the students achieved scores above 80 marks. Each student has different potentials, so learning using mobile technology is a motivation for the students to continuously improve their achievement in education and positively impact their Science learning [22]. In fact, the improved achievement and mastery of the students in SPS, as can be seen in Figure 5, proves that a more flexible mobile learning can make learning more individual and student-centred, as well as making them creative and critical, compared to traditional learning [2], [31].

6 Conclusion

In conclusion, learning through apps can have a positive impact as it enables students to understand Science learning better after using mobile technology compared to traditional learning [49]. Overall, it was found that, all of the respondents not only showed improvements in their understanding of Basic and Integrated Science Process Skills, but also in their overall achievements. Therefore, the integration of mobile technology through the IBSE approach in Science learning is highly recommended as it helps to increase students' mastery of Science Process Skills.

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