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Exploring Basic and Integrated Science Process Skills and Their Impact on Science Achievement among University Students

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Abstract

Learning science is important to gain a broader view and clear understanding of the complex world. This study aimed to examine the effect of the level of understanding of basic and integrated science process skills (SPSs) on student science achievement. The test instrument was administered to measure the level of understanding of basic and integrated SPSs from 73 students studying in the Science Foundation Studies Program. Findings: The findings of the study reveal level of understanding of basic science processes was satisfactory whereas integrated science process skill was poor. A moderate correlation was found between basic SPSs and integrated SPSs. A weak positive correlation was found between basic SPSs and science achievement. There was an insignificant correlation between integrated SPSs and science achievement. The level of understanding of SPSs among both females and males was fair with females and males. The results of the independent sample t-test indicated there were no significant differences in the level of understanding of SPSs between females and males. It is hoped that the findings provide insight into the ability level of students and would be useful to bring a positive change in the Foundation Studies Program.

Keywords: science process skills, basic science process skills, integrated science process skills, academic achievement

1. Introduction

Science, in the broadest senses, refers to a system of knowledge that attempts to model objective reality. It refers to a system of acquiring knowledge based on the scientific method, as well as the organized body of knowledge gained through research (Rocard, 2007). Education in the field of science has become more important than ever. As the world faces the new era of science and technological development introduced by the fourth industrial revolution, education needs to match the demands of the new world (Thuneberg et al., 2022). Learning science needs to engage students in activities that require higher-order thinking skills (Saido et al., 2018). Scientific knowledge is identified as two broad domains: content knowledge and science process skills (SPSs). The content knowledge constitutes facts, principles, laws, concepts, explanations, and theories that students are expected to understand and remember, whereas the SPSs s are the skills and techniques of scientific methods which are used to discover scientific knowledge (Af'idayani et al., 2018). Both domains are considered necessary for students to fully understand science concepts and be able to apply them (Uğur et al., 2020). Consequently, SPSs cannot be separated in practice from the conceptual understanding that is involved in learning and applying science (Irwanto & Prodjosantoso, 2019).

Around the globe, many studies have highlighted an alarming decline in young people's interest in science. This declining interest among young people in science studies is largely linked to how science is taught (Rocard, 2007). According to Jufrida et al. (2019), many students experience difficulty in science courses due to a lack of understanding of the methods of science which are the SPSs. For many years, science educators have argued the importance of the acquisition of SPSs as a major goal in science instruction (Jufrida et al., 2019). Emphasizing the importance of SPSs, Çelik (2022), states that these skills are not only needed by scientists but essential for every citizen to become scientifically literate to function in society and people are expected to use these skills in all aspects of their regular life.

SPSs are defined as a broad set of transferable abilities which are categorized into basic and integrated SPSs (National Research Council, 2000). These skills are essential for students to learn to think critically and use information creatively. Thus, understanding of science content knowledge is related to the extent of acquisition of both basic and integrated SPSs (Juhji & Nuangchalerm, 2020). Several studies have been conducted by researchers on the relationship between the acquisition of SPSs and students' achievement (Derilo, 2019). Tilakaratne and Ekanayake (2017), studied the relationship between the formal thinking abilities of students and SPSs of students in lower secondary to senior secondary. They found a strong correlation between the SPSs and thinking abilities. Even though the importance of SPSs in learning scientific knowledge has been emphasized at all levels including from primary to tertiary level, studies indicate that by the time students reach the undergraduate level, students lack full mastery of basic SPSs (Irwanto & Prodjosantoso, 2019). No study has been conducted to date, related to the FSP or teaching and learning approach utilized in teaching science at the Center for Foundation Studies (CFS) of the Maldives National University (MNU). Hence, to investigate the low achievement of students in the science FSP, there is a need to assess the level of understanding of the SPSs in learning science and how it relates to academic achievement.

2. Literature Review

2.1 Basic Science Process Skills

SPSs are defined as broad transferable skills which can be developed through myriad opportunities for hands-on experiences with scientific investigations. These are appropriate to many science disciplines and reflect the behavior of scientists (Kirimi et al., 2017). SPSs are not specific to any particular subject in science, nevertheless, they are necessary to foster specific subject knowledge. Moreover, these skills facilitate learning ability and develop the logical and rational thinking that is applied in the context of science that is used to understand and learn scientific knowledge (Susantia et al., 2018). Each of these skills is important to progress the level of thinking and developing learning skills necessary for the 21st century (Turiman et al., 2012). Basic SPSs play a significant role in teaching ways of reaching knowledge and learning with understanding. It is crucial to develop the basic SPSs which can connect prior understandings to new concepts thereby expanding understanding of scientific phenomena (Harlen, 1999).

2.2 Integrated Science Process Skills

Integrated SPSs are more complex involving higher-order thinking processes and are employed at higher levels of secondary and tertiary education (National Institute for Education, 2014). The integrated SPSs include identifying and defining variables, collecting and transforming data, constructing tables of data and graphs, describing the relationship between variables, interpreting data, manipulating materials, recording data, formulating hypotheses, designing investigations, drawing conclusions, and making generalizations (Gunawan et al., 2019). These skills are often combined with basic SPSs and can help to generate ideas, make predictions and synthesize information. The inadequate development of integrated SPSs is a problem in the understanding of science concepts and doing science at higher levels.

2.3 SPSs Development and Academic Achievement

Abungu et al. (2014) state that instruction based on SPSs improved the scores of secondary students significantly compared to students who were taught using a regular teaching approach. A study conducted by Aktamis and Ergin (2008) is consistent with these findings showing that exposing students to SPSs in teaching enhanced students' achievement and scientific creativities. Ekon and Eni (2015) conducted a study on junior secondary school students and observed that the overall performance of the acquisition of SPSs of the students was low. Despite this, those who acquired the SPSs showed better academic performance than those who did not acquire those skills. Parallel findings were reported by Oloyede and Adeoye (2012) on students' chemistry achievement. The findings showed that students' chemistry performance was higher for students who used SPSs compared to students who did not use the skills. In addition, students whose SPSs performance was higher had an enhanced reasoning and analytical capabilities leading to better understanding of concepts and increased performance.

2.4 Gender Differences in Understanding of SPSs

Inequity in the understanding of SPSs between genders would contribute to the disproportionation of interest and professional career choices made in society. Research on the level of understanding of SPSs among gender is inconclusive. Some studies are in favor of females whereas others are in favor of males and some studies have shown no significant difference between gender. A study conducted on Form four students in one of the states of Malaysia showed no significant difference in the level of acquisition of overall, basic, or integrated SPSs (Mohamad & Ong, 2013). A quasi-experimental study on secondary school students found no difference in gender (Abungu et al., 2014). For basic SPSs of high school students in Turkey, Gürses et al. (2015) found boys performed better than girls. Inconsistent with these, Zeidan and Jayosi (2014) investigating the level of SPSs of Palestinian secondary students found a significant difference in females performing better than males.

2.5 Theoretical Framework for This Study

The theoretical framework for this study is guided by the constructivist learning theory. The foundation for the contemporary understanding of constructivism relates to the pioneering work of educational theorists, Jean Piaget, Lev Vygotsky, and David Ausubel. The framework for this study is aligned with the cognitive and social constructivism perspective which can be used to improve achievement in science performance by integration of basic SPSs and integrated SPSs. Teaching and learning science based on constructivism constitute a paradigm shift in the focus of pedagogical design away from teacher-centered instruction and toward the design of learning environments that are learner-centered and knowledge-centered. Features of application of basic SPSs and integrated SPSs are used to improve the performance of students in science subjects. The SPSs are transferable thinking skills that when developed help to retain and process information to improve performance in the future.

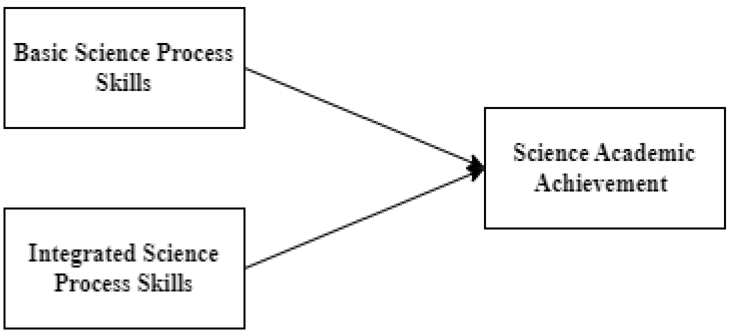

Figure1. The conceptual framework for this study

3. Method

3.1 Participants and Procedure

This study employs a quantitative descriptive correlational approach as the research design because the study aims to examine the level of understanding and relation between students' understanding of SPSs and their academic achievement, perhaps this design serves best to address the research questions.

A descriptive design is used as no other study has been conducted previously on the level of understanding of SPSs of the students at the CFS and a descriptive study would allow identifying the level of achievement of basic and integrated science process skills among the respondents (Fraenkel et al., 2018). In addition to the descriptive, correlational design was used in the study, to determine the association of the variables; basic SPSs, and integrated SPSs to science academic achievement. The correlation design used in the study was explanatory because it looks into the degree of association between the two variables.

The data for this study was collected from the CFS which is one of the centers at MNU. The CFS is located in Male, the capital of Maldives. Ages 16 and 18 are ages when students will usually sit for the lower secondary examination (Cambridge GCE O/Level) and higher secondary examination (Edexcel A/Level) respectively. The target population in this study comprised the students enrolled in the science Foundation Studies Program at the CFS which sums to a total of 92 respondents from three classes.

The sample size for this study is 73 which represents the respondents from the Science Foundation Studies Program of the CFS. For a small sample size, Cochran's (1977) correction formula is used to calculate the final sample size. The Cochran formula is:

$$n_0 = \frac{Z^2pq}{e^2}$$

Where:

- e is the margin of error, set at 5%
- p is the (estimated) proportion of the population estimated at 0.5
- q is 1 – p.
- Z is the significant level, the alpha level set at .10

Thus,

Sample size, n0 = [(1.645)2 x (0.5) x (0.5)]/(0.05)2

= 271

The final sample size, n, is calculated using Cochran's (1977) correction formula. These are the calculations (Bartlett et al., 2001):

$$n = \frac{n_o}{(1 + n_o / \text{Population})}$$

Where

population size = 92

no – required return sample size according to Cochran's formula = 271

Final sample size, n = 271/(1 + 271/92)

= 69

The minimum returning sample size from these procedures is 69. A total of 92 SPST questionnaires were distributed and 73 were completed and returned. The returned questionnaires are within the sample size calculated using Krejcie and Morgan's (1970) and Cochran's (1977).

3.2 Measures

Science Process Skills Test (SPST). Science Process Skills Test (SPST) was administered to measure students' understanding level of SPSs. The test measure students' level of basic SPSs and integrated SPSs (Zeidan & Jayosi, 2014). There are 10 items based on basic process skills and 15 items on integrated process skills, with a total of 25 multiple-choice items. At the end of the SPST questionnaire, demographic information and other basic characteristics of the respondents are included.

Science Academic Achievement Score. The second instrument which is the students' science academic achievement score was obtained from the CFS office. The science academic achievement score was the science score from the semester one result. The final score was 100 points, where the passing mark is 50 percent. The maximum score a student can achieve in the final examination is 100 whereas the minimum is 0.

4. Data Analysis

Descriptive and inferential statistics were used to examine the quantitative data gathered. All analysis was carried out using SPSS, version 26. A normality test was conducted using SPSS before the descriptive analysis was carried out. The descriptive quantitative statistical analysis calculated for the variables are the measures of central tendency and variability which includes mean, standard deviation, and percentage. Pearson correlation coefficient was used to find the association between the basic SPS and academic achievement of the respondents and how significant the correlation is between the two variables. A similar analysis was conducted for integrated SPS. The multiple regression analysis was used to find the influence of the basic and integrated SPS on science academic achievement. In this study, multiples regression is used to find the effect the independent variables; basic and integrated SPS can have on the science academic achievement which is the dependent variable.

5. Results

5.1 Demographic Findings

Out of the 73 respondents, 46 are females which makes up 63 percent of the respondent while 27 are males which account for 37 percent. Based on the questionnaires collected about two third of the respondents are female. A normality test was run to determine the distribution was normal with no outliers. Skewness and kurtosis measures were calculated to determine the normality of the distribution which was between ±1.96, suggesting that the data represents a normal distribution hence the number of respondents for this study remained at 73 (Pallant, 2016).

5.2 Level of Science Academic Achievement Among the Students in the FSP

Results show that the science academic achievement of the students in the FSP is fair (M= 53.93, SD = 12.14). The mean score corresponds to the fair from the grading criteria, implying that on average students obtained a percentage range between 50 to 64 which denotes a clear pass. The maximum score for science academic achievement is 82 while the minimum score remains very low with only 17 points. The highest percentage of students obtained a score range between 50 to 64 which denotes a clear pass.

5.3 Level of Understanding of Basic SPSs

Results show that the level of understanding of basic SPS is satisfactory (M= 7.34, SD = 1.59). The mean score corresponds to the score range of 6.5-7.4 out of the 10 items that are used in the SPST, implying that on average most have achieved between 65 to 74 percent of items correctly. Results show that 2.7 percent of students' understanding of basic SPS is poor, 32.9 percent score fair, 12.3 percent obtained satisfactorily, 20.5 percent achieved good and 31.5 percent demonstrated outstanding performance.

5.4 Level of Understanding of Integrated SPSs

Findings indicate the level of understanding of integrated SPS is poor (M= 6.19, SD = 3.03). The mean value is in the score range between 7.5-9.6 which demonstrates that on average respondents have not attained 50 percent of the items correct out of the 15 items on the integrated SPS. This indicates that on average most respondents were unable to reach a pass level for the items on integrated SPS. The maximum score obtained for this variable is 13 out of the 15 items suggesting no student was able to get all items correct.

5.5 Relationship Between the Student's Level of Understanding of Basic SPSs and Academic Achievement in Science

Pearson’s correlation was used to examine the relationship between the basic SPS (IV) and respondents’ science academic achievement score (DV). The result shows basic SPS had a statistically significant positive correlation with the science academic achievement score at $p < .01$ level. The Pearson correlation coefficient, $r(71) = 0.359$, $p < 0.01$ confirms a weak or moderate linear relationship exists between the two variables. The positive correlation indicates that an enhanced understanding of basic SPS tends to improve the academic performance of the respondents. A weak correlation between the variables indicates there is some association between students' basic SPS understanding level and their science academic achievement in the FSP, however, the association is not strong. Thus, the level of understanding of basic SPS is not strongly associated and does not necessarily indicate the understanding level of basic SPS fully determines the science's overall academic performance.

5.6 Relationship Between the Student's Level of Understanding of Integrated SPSs and Academic Achievement in Science

From the Pearson correlation analysis, it can be observed that there was not a statistically significant correlation between the integrated SPS and the science achievement scores of the students in the science FSP. The Pearson correlation coefficient, r(71) = 0.193 (p = n.s), is indicative of negligible correlation. The p-value between integrated SPS and students' science achievement scores is 0.101. Since the p-value is greater than the significance level of 0.05, there is inconclusive evidence about the significance of the linear relationship between the two variables.

5.7 Influence of Level of Understanding of Basic SPSs and Integrated SPSs on Science Academic Achievement

Multiple regression analysis was used to find if basic SPSs and integrated SPSs predicted the science academic achievement score of the students in the FSP. Using the enter method it was found that basic and integrated SPSs explain a significant amount of the variance in the science academic achievement ($F(2, 70) = 6.244$, $p<.05$, $R = .389$, $R2 = .151$). The analysis shows that integrated SPSs level did not significantly predict score of science academic achievement ($\beta = .009$, $t(70) = 0.073$, p = ns), however basic SPSs level did significantly predict score of science academic achievement ($\beta = .385$, $t(70) = 3.067$, $p<.05$).

Table 1. Multiple Regression analysis related to science academic achievement

	Unstandardized Coefficients		*Standardized Coefficients*		
	B	*Std. Error*	*β*	*t*	*Sig.*
(Constant)	32.435	6.236		5.202	.000
Basic SPS	2.859	.932	.385	3.067	.003
Integrated SPS	.037	.502	.009	.073	.942

Note. DV: Science Academic Achievement Score

5.8 Gender Difference in the Level of Understanding of SPSs Among Science Students

A descriptive analysis was carried out followed by an independent t-test to compare the means of females and males. Findings show both females (M= 13.9, SD = 4.2) and males (M= 13.3, SD = 3.9) showed a fair performance in terms of understanding of SPSs. As the mean value obtained for the level of understanding of SPSs is slightly higher among females compared to males, an independent sample t-test was carried out to find whether the difference is statistically significant. (Table 2).

The analysis of results showed the standard deviation for both the female and males in the performance of SPS is similar, equal variance assumed t-test results are taken. The results indicate there is not a statistically significant difference between the mean level of understanding of SPSs for females and males, t(71) = 0.593, p>0.05. Overall it can be inferred there is no significant difference between females and males in the understanding level of SPSs among science foundation studies program students.

Table 2. Independent sample t-test for gender

		t-test for equality of means				
		t	*df*	*Sig. (2-tailed)*	*MD*	*SED*
SPSs	Equal variances assumed	0.593	71.00	0.55	0.589	0.99
	Equal variances not assumed	0.605	58.50	0.55	0.589	0.97

6. Discussion

The findings from this study examining the level of understanding of basic SPSs revealed students have a satisfactory level of understanding. These findings are in line with Susantia, and Anwar's (2018) study on pre-service and in-service teachers and Raj and Devi's (2014) study on high school students showing acquisition of basic SPSs to be better than average. However, these findings are contradicting the findings in Jack (2018) suggesting that high school students also find most of the basic SPSs difficult.

This is also an issue for their development of integrated SPSs and academic performance. Considering the benchmark rule used in Ong et al. (2013) it can be concluded that students at the science Foundation Studies Program, in general, need to do more work to reach the mastery level in understanding basic SPSs. Thus, students preparing for tertiary higher levels education such as Foundation Studies need to demonstrate a higher level of performance in the basic SPSs as these are necessary to develop more complex integrated SPSs which are required the for the learning and understanding of the content at higher levels.

The results reveal a very low level of understanding of the integrated SPSs among the science students of the Foundation Studies Program. These findings suggest that a very large proportion of the students are unable to reach a level of attaining half of the items on the integrated process skills correctly. Even though the findings are distressing, previous studies on the level of understanding of integrated SPSs have shown very low performance. A study on high school students integrated science process skills showed that half of the students were not able to attain a good level of understanding (Beaumont-Walters & Soyibo, 2001). Jack (2018) also found that the integrated science process was difficult for students. However, Ongowo (2017) analyzing the level of mastery of integrated SPSs of lower secondary and upper secondary students found them to have achieved an average level of acquisition with the highest performance for the highest grade. Considering these research findings from other countries, it is important to emphasize that, although the level of understanding of integrated SPSs is average or low in most developing countries, the performance shown by the students in this study is immensely poor and of great concern in learning and understanding of science concepts. Hence it is important to explore the factors that resulted in this performance. As it is obvious from the findings and approaches suggested for teaching and learning in curriculum documents, the relevancy of basic SPSs for the development of integrated SPSs is undoubtable. Focusing on the development of the basic science process would enhance the development of integrated SPSs which are essential to become competent in future science programs and fields (Turiman et al., 2012).

The academic performance of the students undertaking the science foundation studies program shows in general a low performance in science. The correlation analysis between the level of understanding of basic SPSs and academic achievement shows a significant weak correlation. The multiple regression analysis showed that the basic SPSs had a greater influence on the science academic achievement of the students in the FSP compared to integrated SPSs. These results infer that students' understanding level of basic SPSs is to some extent related to the academic ability demonstrated by the students. A better understanding of basic SPSs may lead students to comprehend scientific knowledge. These findings are similar to Derilo (2019) showing a significant correlation between students' basic SPSs and the academic achievement of seventh-grade students. Explaining further Oloyede and Adeoye (2012) suggest that students who have well-developed SPSs tend to show higher reasoning ability leading to think analytically and critically and deal with problem situations more effectively leading to higher achievement.

When the relationship between students' level of understanding integrated SPSs and academic achievement is investigated, no significant relationship has been found. The multiple regression analysis revealed integrated SPSs are not significant to the performance of science academic achievement. These are in line with the findings of Derilo (2019) suggesting no significant relation between integrated SPSs and science achievement, even though an association exists between basic SPSs and science achievement. Raj and Devi (2014) also found no significant relation between SPSs and science achievements in high school students. However, the findings are contradictory to many other research findings, showing the level of understanding of integrated SPSs positively affects academic achievement (Abungu et al., 2014; Asabe & Yusuf, 2016; Ongowo, 2017).

As the understanding level of basic SPSs shows, a positive correlation to science academic achievement, and the findings also suggest that there is a positive correlation between the level of understanding of basic SPSs and integrated SPSs, there may likely be other factors cofounding this relationship. It could be related to the low representation of the integrated skills in the assessments that are used to determine the achievement. Siachibila and Banda (2018) examining the SPSs assessed in the Senior Secondary Examinations for chemistry in Zambia found that a large percentage of the questions was examining the basic SPSs and in which the representation of the integrated science process was found to be very less. Similar findings were observed for senior secondary physics examinations in Nigeria (Akinbobola & Afolabi, 2010).

Although the study showed no signs of integrated SPSs for achievement it is crucial to examine this further as the importance of integrated SPSs for learning and understanding science, especially at higher levels has been emphasized by researchers and curriculum frameworks (Akben, 2020). According to Çakiroğlu et al. (2020), students who performed well on integrated SPSs such as conducting open-ended experiments, constructing hypotheses, and interpreting experimental findings in the light of theoretical information were found to be showing high academic achievement.

Because a weak correlation has been observed between basic SPSs and academic achievement, the level of representation that is given for the basic and integrated SPSs in the assessment of the science foundation program needs to be analyzed in more detail. The low overall achievement in the assessment that is shown among the science students could be due to a lack of understanding of essential process skills. Furthermore, it could be that SPSs are not emphasized in the teaching of science content. Emphasizing the importance of SPSs for learning science content, Harlen (1999) states that if SPSs are not well developed, science learning becomes meaningless as learning science requires learning with understanding which requires SPSs.

As SPSs are considered transferable skills which implies that developing basic SPSs would enable students to use them in the future in a different area of learning and understanding of content knowledge. A thorough understanding of the basic SPSs would make students more prepared to handle integrated SPSs which a more prominent in higher levels of education. The level of understanding of basic SPSs was found to be on the low end and integrated process skills were very poor. Taking these factors together, it can be inferred that a drastic change needs to be adapted to the teaching and learning approach that is used in teaching science content.

The teaching approaches that are used in teaching science at the Foundation Studies Program need to be highly focused on developing the basic and integrated SPSs. Students' level of understanding of SPSs is at a lower level of expectation by international standards, in comparison with countries like Malaysia (Ong et al., 2013). Aligning the teaching of science with the constructivism theory as suggested in science in the national curriculum (National Institute for Education, 2014) would provide students to develop cognitive and social skills through interactions and reflections on the experiences. Constructivist learning actively engages students in the learning process where students can develop skills and knowledge by constructing their meaning through interactions and connections to modify prior conceptions and address content in a variety of contexts (Zajda, 2018).

The use of 5E instructional model can enforce strategies to develop the SPSs. Students get opportunities to develop SPSs through the different phases of the model. It aims to interest students in significant scientific problems, provide scientific explanations and assist students in connecting these to their ideas, and provide chances for students to investigate, apply, and evaluate what they have learned (Ong et al., 2020). Students may work cooperatively and collaboratively in groups to make learning more meaningful. Innovative instructional practices and strategies that can improve the thinking skills of students can be utilized to make science learning interesting and ensure the effective acquisition of science concepts and skills.

The science foundation program students are progressing for higher level science field courses such as engineering, architecture, medical field related or teaching of in secondary or higher secondary courses, it is important in this technologically advanced world to have a sound level of performance in these skills to meet the demands of the 21st-century workforce. For the students to demonstrate the thinking that is required for higher cognitive levels such as application, synthesis, and evaluation, poor levels of integrated SPSs in the science foundation will have consequences for future higher-level science courses. Students may lack the competency that is essential to apply knowledge at a higher level such as problem-solving, evaluation, interpreting, and analysis. The integrated SPSs are necessary because these skills are the thinking skills that are necessary for scientific understanding. Developing this higher level of skills is important for lifelong learning and also contribute to the development of critical thinking, problem-solving, reasoning, and communication skills (Harlen, 1999). Without these skills, students will lag behind in navigating successfully in this complex world of advanced science and technology.

The findings from the study reveal that the students' level of understanding of SPSs were slightly higher for females than males, however, there no significant gender difference was found to exist between females and males. These findings are consistent with previous findings on gender conducted for different levels of students. Jack (2018) found no gender differences exist in the students' difficulty level in the acquisition of SPSs in chemistry. While Ong et al. (2013), Beaumont-Walters, and Soyibo (2001) also found no significant gender differences in the performance of SPSs of secondary students.

7. Conclusion

This study examining the level of understanding of basic and integrated SPSs among the science foundation students showed their level of basic SPSs to be average. However, this is far from the expected standard for science students who are mature and expected to join the bachelor's level in the short future. As basic skills are the core skills, students at this level should have demonstrated complete mastery of these skills. These results are reflected in their academic performance. Overall academic performance of these students in science is low. The results of this study reveal students understanding level of basic SPSs is associated with their academic performance. A weak correlation was observed between the level of understanding of the basic science process and academic achievement. The findings also suggest that the level of performance on the basic SPSs is related to their performance on the integrated SPSs. Hence their level of understanding of basic skills affects their performance on higher skills such as problem-solving, reasoning, and critical thinking which are seen as essential for the understanding of the content at this level and important in their future for the demands of the 21st century.

The findings for integrated SPSs are more alarming compared with the basic SPSs. Overall, it can be seen that the performance of integrated SPSs is extremely poor. The poor performance has implications for students to demonstrate the higher level of thinking that is required in learning more abstract and complex science concepts at the foundation program as well as in future studies. The findings also revealed there is no relationship observed between the understanding level of students' integrated SPSs and academic achievement, unlike the findings of basic SPSs. The low representation of integrated SPSs in assessments could have led to finding a negligible correlation between the integrated SPSs' performance and academic achievement. These findings shine a limelight on concerns in instruction as well as assessment that is used in the program. Lack of competent performance in integrated SPSs limits students' application of higher level thinking necessary for scientific understanding and the future studies of the students.

In terms of gender, no significant difference was observed in the understanding of SPSs. These results are a positive sign for a developing country like the Maldives. These findings infer the scope for the equal participation of gender in education and the future workforce.

8. Recommendations

The science Foundation Studies Program should focus on instructional practices that are used in the teaching of science to go beyond lecture demonstration employing a variety of teaching strategies for students to engage their thinking and acquire the SPSs. As the performance of the integrated SPSs very poor, a great emphasis needs to be given to integrated process skills with basic skills incorporated. Teachers need to assess students on the different types of basic and integrated skills and design classroom activities to develop these skills. Additionally, learning outcomes need to include explicitly the skills and abilities that need to be achieved. Apart from focusing on the development of skills, instruction can be focused to create students' awareness and relevance on how science connects to their lives and society.

SPSs are the thinking skills that are essential to understanding and comprehending scientific content. It is important to use the technologies and resources that are available to provide factual information allocating more time for learning to be student-centered and active giving opportunities for students to get engaged in activities that have the potential to develop 21st-century skills, such as acquiring the ability to solve problems, creativity, and self-development.

The study showed that academic achievement which was determined by the assessment was not linked with the attainment of skills. Hence there is a need to analyze the assessments and achievement tests to find the representation of content and process skills in the assessment. As the current assessment was mainly on the achievement test, an alternative approach to assessment is needed to narrow the gap between the standard and competencies required by the students. The alternative assessment would help to focus on the knowledge and skills learned rather than focusing only on cognitive aspects.

As the study gives an analysis of the level of understanding of basic and integrated SPSs and their relation to academic achievement, future research could be conducted to explore and expand understanding of the low level of acquisition of SPSs and academic performance. A mixed-method approach that involves both quantitative and qualitative research methods would give insight into the issues encountered by teachers and students and it could guide in tailoring the foundation program.

9. Limitations

This study has its limitations. The study is focused only on science students from one campus of the center due to a lack of time and funding. Moreover, the data is collected from one semester of the academic year. In addition, academic achievement is based on science assessment which has a large percentage of the test score allocated for the achievement test that was given in the Foundation Studies Program. More factors can be considered in examining the importance of SPSs for academic achievement in the learning and teaching of science. A broad range of subject modules and a greater pool of students are essential. The study is limited to the collection of only quantitative data. A mixed-method approach would have enriched and given more insight into the problem.

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