Self- and Teacher-Assessment of Science Process Skills

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Abstract This study aimed to assess both basic (BSPS) and integrated science process skills (ISPS) level of proficiency among selected grade ten technical-vocational students. The study also examined the feasibility and value of utilizing the developed SPS assessment tool that supports the "assessment for learning" in teaching science. To measure the SPS level of proficiency, an instrument was developed based on the performance-based indicators of process skills (Miller 2006). After participating in science laboratory activities, the students assessed their SPS level of proficiency individually. Data were collected from the students' activity outputs, worksheets and self- and teacher-SPS score sheets. Findings revealed that the performance of subjects in the overall SPS was "average". When categorized into basic and integrated process skills, the subjects showed "proficient" basic SPS (BSPS) and "average" integrated SPS (ISPS). There was no significant difference between the student and teacher assessment on both basic and integrated SPS. The results support the feasibility and value of utilizing an SPS score sheet as an assessment tool in addition to the performance rubrics for formative assessments. It was observed that the disclosure of students' progress and SPS level of proficiency made the students more focused in improving their SPS skills rather than their numerical grades. Based on these findings, the researchers advocate daily assessment of SPS and the use of both teacher and self-assessment of SPS

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as alternative or adjunct strategies in the assessment of SPS.

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Introduction

Simultaneous with the beginning of the ASEAN Integration in 2015, the Philippine educational system introduced the K to 12 Basic Education Curriculum. This curriculum change calls for a paradigm shift in the policy and practice of classroom assessment, emphasizing the importance of formative assessment. This type of assessment intends to help teachers in improving their instruction and facilitate student reflection on their own progress. (DepEd Order 8, s.2015).

In teaching and learning science, "hands-on" performance tasks require students to manipulate objects, measure outcomes and observe results of their experimental manipulations. These hands-on tasks are essential to capture the process skills needed to perform certain tasks. Martin et al. (2006) suggested that it is more important for the learner to master the process skills and "do" science than to merely learn the facts, concepts and theories of science. In an inquiry based hands-on science learning, "doing" science means applying the process. Science process skills pertain to a "set of broadly transferable abilities, appropriate to various science disciplines and reflective of the behaviour of scientists" (Padilla, 1990). Students are practicing these process skills to understand how scientists investigate and answer their own questions.

Science process skills (SPS) are divided into basic and integrated processes. Basic processes are the fundamental activities required in scientific inquiry and they are the key skills that underlie all scientific investigations. The integrated science processes skills (ISPS) are the complex activities that form the method of actual inquiry and extend beyond the basic processes into problem-based scientific explanations. The basic process skills (BSPS) consist of observing, classifying, communicating, measuring, predicting and inferring while the integrated science process skills (ISPS) include identifying and controlling variables, formulating and testing hypothesis, interpreting data, defining operationally, experimenting and construction of models (Miller, 2009).

In this action research, the researchers advocate the need to assess science process skills and designed a plan to implement the use of an emerging approach of assessment involving performance indicators that determine the SPS level of proficiency. These performance indicators were set and measured in order to accurately describe and qualify the details of each process skill. Martin (2006) suggested this type of observation because it enables the researcher to monitor the student's track and the logical and proper methodology of scientific operations during laboratory activities. Moreover, Rauf (2013) emphasized the necessity to make the students aware of the SPS that are to be acquired through guided exploration questioning.

This action research also emphasized the assessment of process skills as part of science teaching. The question of process versus content as the focus of assessment was inherently examined as the action research was implemented. Using the checklist approach, process skills were assessed and evaluated quantitatively. This type of assessment was employed as a formative assessment to provide accurate and specific feedback with the aim of supporting student's learning. Cahppuis and Stiggins (2002) recommended "assessment for learning" as something that teachers can use everyday in classroom assessment activities to involve students directly and deeply in their own learning. Thus, this action research also advocated the use of innovative assessment strategies to assess students' science process skills.

Purposes of the Research

This action research aimed to examine the use of an SPS assessment tool in assessing the basic (BSPS) and integrated science process skills (ISPS) level of proficiency among grade ten students. It sought to determine the feasibility and value of utilizing self- and teacher-assessment on science process skills (SPS) using performance-based indicators. Specifically, this study sought answers to the following questions:

1. What is the level of proficiency of grade ten technical vocational students in terms of:
   1.1. Basic Science Process Skills (BSPS)?
      1.1.1. measuring
      1.1.2. predicting
      1.1.3. inferring
   1.2. Integrated Science Process Skills (ISPS)
      1.2.1. interpreting data
      1.2.2. making scientific models
2. Is there any significant difference between the self- and teacher- assessment on the SPS level of proficiency of grade ten technical vocational students?
3. How do the grade ten students respond to the self-assessment of science process skills?

Methodology

Research Design and Participants

The study used the descriptive method of research. The participants of the study were sampled from a Grade 10 class consisting of 48 technical vocational students during academic year 2015-2016. From this class, 23 students were purposively selected to serve as participants of the study. The participants were selected by the researchers based on their capability of providing necessary laboratory materials. Of the 23 participants, 10 (43%) were male and 13 (57%) were female. The participants' age ranges from 14 to 16 years old.

Instruments

BSPS and ISPS were identified during the performance of earth science laboratory activities: measuring, predicting, inferring, interpreting data and model making. Two forms of self-administered SPS score sheets were developed for the study: score sheet A for the self-assessment and score sheet B for the teacher- assessment. Performance indicators were adapted from Martin (2006) which provided the accurate descriptions of each science process skill. The performance indicators served as the indicators in which the students' SPS level of proficiency was assessed. They were arranged according to hierarchy, from basic to advance level of process skills. The score sheets were validated by selected experts in science education. Test development and revisions were made based on the expert's comments and suggestions. After revision, the score sheets were pilot tested to three (3) science teachers and 10 grade 10 students. Revisions on the score sheets were further made based on the comments and suggestions of the teachers and the students and the observations made by the main researcher during the pilot testing.

Data Collection

The instrument was administered to the research participants right after the laboratory part of the earth science lessons for the first quarter. Teacher observations and interviews were employed to assess the learner's mastery of the process skills. The main researcher performed informal observations and checked the student's activities from group to group. After the assessment activities, the students were interviewed to get their reactions about self-assessment of SPS.

Data Analysis

To determine the level of SPS proficiency, interpretation of the mean scores of the students on the SPS report sheets was based on the following standard (Table 1).

Table 1. Table of interpretation of the mean scores on the level of science process skills proficiency

Verbal Interpretation	Rating
Proficient	2.51-3.00
Average	1.51-2.50
Poor	1.00-1.50

Quantitative data were processed using SPSS. Descriptive statistics (frequencies, percentages, standard deviations, means) and t-test for dependent means were performed. Data from the interviews with students were analyzed through content analysis.

Results and Discussion

Students' Reactions on Self-assessment of SPS

When the student-respondents were asked about their reactions about performing self-assessment of their SPS, 80% of them showed positive responses and recommended that the teacher should continue assessing science process skills using student self-assessment. Only one student showed negative response and disapproval about self-assessment. That lone student expressed that grading student performance is an exclusive task of the teacher. Below are the common positive verbatim responses of the students that made the researchers believe that assessing SPS helped the students to reflect on their own learning.

- “I see the actual results of my own level of process skills.”
- “I become aware of how to develop my own process skills.”
- “ I learned the level of my science process skills.”
- “I became aware of the my strengths and weaknesses.”
- “I learned to share my process skills in science to my classmates.”
- “I gave myself a deserving score.”
- “I had to be real and honest with myself.”
- “I scored high in the levels of process skills.”
- “I realized myself-capability and skills in science.”
- “It challenged my honesty as a student to give a well deserved score.”
- “I realized that I’ve learned a lot from the science subject.”
- “My score reflects what I have learned in science subject.”
- “My score is strong evidence of my learning.”

Teachers’ Reflections on Assessing Science Process Skills

After the assessment of the science process skills (SPS) of the participants, the researchers gained insights on the need for teachers to emphasize the SPS in teaching science. Assessment of SPS gained positive responses among the student-respondents because it encouraged them to reflect on their own learning. Self-reflection allowed the students to realize the inadequacy of their skills that lead to greater self-awareness. By allowing them to monitor their level of SPS mastery, students became more responsible of their own learning and more active in the learning process.

Self- assessment of SPS among the students will most likely develop self-directed learners as they are encouraged to contemplate on their strengths and weaknesses and eventually take action to improve least their mastered skills.

Table 2. Self- and Teacher- Assessment of Basic Science Process Skill in Terms of Measuring

Measuring process performance indicators		**Student Mean**	**Verbal Interpretation**	**Mean Difference**
selects appropriate type of instrument	Self	2.83	Proficient	.00
	Teacher	2.83	Proficient	
selects appropriate units of measurement	Self	2.70	Proficient	.75
	Teacher	2.75	Proficient	
uses measurement instruments properly	Self	2.78	Proficient	.03
	Teacher	2.75	Proficient	
applies measurement techniques appropriately	Self	2.57	Proficient	.01
	Teacher	2.58	Proficient	
uses standard units	Self	2.26	Average	.50
	Teacher	2.83	Proficient	
uses measurements as evidence	Self	2.35	Average	.11
	Teacher	2.46	Average	
uses measurement to help explain conclusions	Self	2.13	Average	.20
	Teacher	2.33	Average	
Overall	**Self**	**2.52**	**Proficient**	**.13**
	Teacher	**2.65**	**Proficient**	

Table 2 shows the self-and teacher- assessment of students' SPS in terms of the measuring process. The results reveal that the students' SPS level of proficiency was rated by the teacher and by the students as **proficient** in the first 4 indicators of measurement while rated as **average** in the last 2 indicators. Interestingly, the students have been proven to be **proficient** in selecting appropriate type of instrument and units of measurement, using of instrument, and applying measurement techniques and **average** in using of measurements as evidence, and using measurement to help explain conclusions. The overall means are **2.52** and **2.65** which signify that the students were **proficient** in the measurement process.

Table 3. Self- and Teacher-assessment of Basic Science Process Skill in Terms of Predicting Process

Predicting process performance indicators		**Mean**	**Verbal Interpretation**	**Mean Difference**
forms patterns/ extend patterns	Self	2.74	Proficient	.14
	Teacher	2.88	Proficient	
applies the process of predicting appropriate situations	Self	2.57	Proficient	.18
	Teacher	2.75	Proficient	
checks the accuracy of predictions	Self	2.35	Average	.14
	Teacher	2.21	Average	
Overall	Self	**2.55**	**Proficient**	.06
	Teacher	**2.61**	**Proficient**	

Table 3 illustrates that the two indicators of the predicting process were given ratings interpreted as **proficient**. The students were rated **proficient** in forming patterns, applying predicting process to appropriate situations. While the last indicator was given a rating interpreted as **average** with a resulting means of 2.35 and

2.21 from self and teacher assessment, respectively. The students seemed to neglect to check the accuracy of their predictions in science laboratory activities.

Table 4. Self-and Teacher- Assessment of Basic Science Process Skill in Terms of Inferring

Inferring process performance indicators		Mean	Verbal Interpretation	Mean Difference
describes relationships among events observed	Self Teacher	2.26 2.38	Average Average	.12
utilizes information in making inferences	Self Teacher	2.57 2.71	Proficient Proficient	.14
separates appropriate from non essential information	Self Teacher	2.22 2.29	Average Average	.07
applies the process of inferringin appropriate situations	Self Teacher	2.74 2.83	Proficient Proficient	.09
interprets graphs, tables and other experimental data	Self Teacher	2.61 2.63	Proficient Proficient	.02
Overall	Self Teacher	**2.48** **2.57**	**Average** **Proficient**	**.09**

Table 4 reveals that three indicators of the inferring process were rated as **proficient** while two indicators were rated as **average**. Students were **proficient** in utilizing information in making inferences, applying the process of inferring in appropriate situations and interpreting tables, graphs, and other experimental data. On the other hand, results show that the students had an **average** proficiency in describing relationships among events observed and in separating appropriate from non-essential information.

Table 5 presents the average level of proficiency in all the six indicators of the process of interpreting data process. The students had an average proficiency in identifying the data needed, planning collection of qualitative and quantitative data, collecting data as usable evidence, constructing tables, interpreting data and making valid conclusions. Both student- and teacher- assessment were consistent in rating all the indicators of interpreting data as **average** with an overall mean of 2.28 and 2.20, respectively. These results imply that the students' skill in interpreting data needs to be improved.

Table 5. Self- and Teacher- Assessment of Integrated Science Process Skills in Terms of Interpreting Data

Interpreting data indicators		**Mean**	**Verbal Interpretation**	**Mean Difference**
identifies data needed and how to measure it	Self	2.17	Average	.06
	Teacher	2.11	Average	
plans collection of qualitative and quantitative data	Self	2.17	Average	.01
	Teacher	2.16	Average	
collects data as usable evidence	Self	2.22	Average	.01
	Teacher	2.21	Average	
constructs tables	Self	2.50	Average	.18
	Teacher	2.32	Average	
interprets data	Self	2.50	Average	.24
	Teacher	2.26	Average	
makes valid conclusion	Self	2.11	Average	.05
	Teacher	2.16	Average	
Overall	Self	**2.28**	**Average**	.08
	Teacher	**2.20**	**Average**	

Table 6 shows that three indicators of the process making models were rated as **average** while one indicator was rated as **proficient**. The students were **proficient** in developing accurate and appropriate models and had an **average** level of proficiency in differentiating between a model and the real thing, indentifying needs for the model and interpreting models in terms of real things.

Table 6. Self-and Teacher- Assessment of Integrated Science Process Skills in Terms of Making Models

Making models indicators		**Mean**	**Verbal Interpretation**	**Mean Difference**
differentiates between a model and the real thing	Self	2.43	Average	.35
	Teacher	2.08	Average	
identifies needs for models	Self	2.35	Average	.19
	Teacher	2.54	Proficient	
interprets models in terms of real thing	Self	2.17	Average	.08
	Teacher	2.25	Average	
develops accurate and appropriate models	Self	2.61	Proficient	.27
	Teacher	2.88	Proficient	
Overall	Self	**2.39**	**Average**	.05
	Teacher	**2.44**	**Average**	

The data presented in Table 7 show that the students were **proficient** on the basic SPS: measuring, predicting and inferring and **average** in the integrated SPS: interpreting data and making models. It can be deduced from the data that overall, the students had an **average** rating in terms of their SPS level of proficiency.

Table 7. Summary of Self- and Teacher- Assessment of Basic and Integrated Science Process Skill

Science Process Skills		Mean	SD	Verbal Interpretation	Composite Mean	Verbal Interpretation	Rank
Measurement	Self	2.52	.26	Proficient	2.59	Proficient	1
	Teacher	2.65	.46	Proficient			
Predicting	Self	2.55	.28	Proficient	2.58	Proficient	2
	Teacher	2.61	.43	Proficient			
Inferring	Self	2.48	.23	Average	2.53	Proficient	3
	Teacher	2.57	.48	Proficient			
Interpreting data	Self	2.28	.53	Average	2.24	Average	5
	Teacher	2.20	.51	Average			
Making models	Self	2.39	.23	Average	2.42	Average	4
	Teacher	2.44	.29	Average			
Overall SPS mean					**2.47**	**Average**	

In general, the results of the self and teacher assessment of the students SPS show that the students seem capable of coming up with honest and accurate assessment of their current science process skills. This particular finding is welcome as it indicates that self-assessment can indeed be promoted in the classroom and that it is an effective tool to allow students to be more responsible in monitoring and evaluating their own performance or skills. In addition to with the positive comments of students regarding the use of self-assessment of SPS, it seems that the use of the self-assessment is also able to help the students become more reflective.

Table 8 presents the results of the difference-tes for dependent means which indicate that there is no significant difference between self- and teacher- assessment on the SPS level of proficiency of grade 10 technical-vocational students across all indicators. This means that the student self-assessment of their SPS level of proficiency was consistent with the teacher assessment. This consistency between self and teacher assessment is in consonance with the students' comments during the interview that they practiced honesty and showed importance of giving truthful SPS self-assessment

Table 8. Significance of the Difference Between Self- and Teacher- Assessment of SPS (N=20)

Process skills		Mean	SD	Computed t-value
Measurement	Self	2.52	.26	.35
	Teacher	2.65	.46	
Predicting	Self	2.55	.28	.17
	Teacher	2.61	.43	
Inferring	Self	2.48	.23	.24
	Teacher	2.57	.48	
Data Interpretation	Self	2.28	.53	.16
	Teacher	2.20	.51	
Model Making	Self	2.39	.23	.19
	Teacher	2.44	.29	

**significance at 0.05*

The finding that the students' self-assessment and teacher assessment were consistent further supports the value of using self-assessment as an innovative approach of assessing students' SPS. The findings of the study are supported by the study conducted by Fagel et al. (2011), highlighting the advantage of emphasizing learning by deemphasizing grades. Fegel explained that developing focus on personal learning growth and improvement would make the students less likely to fail and more likely to accept responsibility for their own learning. Thus, the researchers think that the use of both self and teacher assessment of SPS is a useful and effective approach in the assessment of SPS which should be used as supplemental assessment strategy to the use of teacher-made tests and other performance-based assessment tasks.

Conclusion and Recommendations

The findings from the assessment of students' level of proficiency and interview seem to have led students to aspire for higher levels of proficiency on basic and integrated SPS. Consistent to findings of Rauf et al. (2013), the use of the inquiry method and continuous discussion in teaching science is recommended by the researchers to promote the inculcation of SPS inside the classroom. Both self- and teacher- assessment SPS score sheet are recommended as alternative strategies to the performance rubrics in assessing specific tasks. The researchers suggest the inclusion of science laboratory activities which engage the students in designing and conducting experiments and controlling variables. Rauf et al. (2013) also recommends the use of various teaching approaches in a single lesson which could provide opportunities for the inculcation and acquisition of science process skills in the classroom. Disclosure of the students' mastery on the process skills provides the learners an opportunity to determine their strengths and weaknesses and to assist them in monitoring their own learning. Emphasizing SPS in science teaching also requires alignment of achievement tests questions to include both "content" and "process skill" types of questions. The school administration should support the teacher's initiative of conducting science inquiry skill stest (SIST) and process skills inventory. Results of the inventory could be used as baseline data for the teacher to adjust their instructional strategies and give emphasis to the students' least mastered process skill. Moreover, topics concerning SPS assessment should also be included in the school and division in-service trainings to enhance the teacher *skills* in evaluating students SPS. Several researches, including those conducted by Karamustafaoğlu (2011) and Yakar (2014)underscore the significance of developing and assessing SPS levels among science students and pre-service teachers. More importantly, science teachers should begin to adapt alternative and adjunct strategies or tools in assessing their students level of SPS proficiency . The findings of the present action research have given the researchers the insight that students should not only experience being active learners in the classroom, they must also experience becoming and being active assessors or appraisers of their own learning. Hence, the researchers strongly suggest that science teachers provide students with a supportive environment where they can effectively experience self-assessment of their SPS. Moreover, the researchers are advocating the inclusion of a day-to-day SPS assessment and to use the results of these assessments to modify teaching strategies based on the identified students' strengths and weaknesses.

Personal Reflections

Given our insights that teachers need to emphasize the SPS in teaching science, there is a need for the first researcher/ author to continue and advocate the use of SPS in teaching science subjects in the basic education level. While integrating SPS in science classes seem to be challenging task, there is a need for the researchers and other teachers to practice it on a wider scope in order to provide more evidence of its usefulness. The first researcher also commits to practice and advocate the use of both self- and teacher-assessment as supplemental or adjunct strategies in assessing students' SPS. The researchers believe that the use of both self- and teacher-assessment would not only allow a more comprehensive and holistic assessment of students' SPS but also allows students to acquire personal insights about their own strengths and limitations and allows them to experience self-awareness and even self-regulation. The researchers also commit to advocate the need for science teachers to adapt alternative and adjunct strategies or tools in assessing their students' level of proficiency of SPS. More specifically for the first researcher/author, he commits to both the use of these alternative assessment strategies and in adjusting his instructional strategies based on such assessment results. The researchers hopes that there will be more initiatives among teachers in advocating alternative assessment strategies, not only in science classes but in other subjects or areas. In this way, teachers can have more options to choose from when deciding on how they would assess their students' learning.

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