METACOGNITIVE APPROACHES AND LEARNING MODALITIES TO IMPROVE INTEGRATED SCIENCE PROCESS SKILLS

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ABSTRACT

The study was an attempt to determine the effects of metacognitive strategies on integrated science process skills. The learning modalities of the respondents as accommodators, convergers, divergers, and assimilators and their initial level of Integrated Science Process Skills were identified. The Integrated Science Process Skills were controlling variables, defining operationally, formulation of hypotheses, interpretation of data, experimentation, and formulation of models. Using an experimental design of research, it involved the 72 Grade 11 students in San Bartolome Integrated High School, San Pablo City during the Academic Year 2019-2020. Survey questionnaires for learning modalities, integrated science process skills test and metacognitive instructional plans were utilized to gather the data. Results revealed that there was a significant difference in the pre and post-test scores within the PLAN group in terms of all the integrated science process skills of the learners while controlling variables and formulation of hypotheses were not significantly different for the RT group. For the difference of pretest scores between groups, no significant differences were noted and all skills were different except for controlling variables and formulation of models for the post-test scores difference.

Keywords: learning modalities, integrated science process skills, metacognition

INTRODUCTION

Globally, science education has led many countries into development and the lack of it to stagnation. Its quality has been the top priority of many internationally acclaimed schools. Specifically, it has affected the lives of people in terms of medicine, engineering, and other forms of development. Which is the very reason why the development of science education has been set as one of the top priorities. (Chetty, 2012). No best teaching strategy exists; the best teaching strategy is the one that works. However, it also has to be considered that optimum learning is achieved by most learners. Making these meetings has always been a challenge for most educationists. The individual characteristics of learners and their environment must be emphasized so that appropriate teaching instructions, which also entail the correct content, can be applied (Alkan, 2016).

Through direct instruction, not being permitted to fully think by themselves has revealed that students in the classroom setting were not given the chance to develop their Science Process Skills. Theories and their concepts were already provided to them through textbooks. Deductive methods of teaching, a setting where lectures about a concept are first presented by the teacher before the conduct of applications in experiments impedes the development of SPS among learners – the exact opposite of what is required by the Science education Framework.

As a result, the Philippines' ranking in the Trends in International Mathematics and Science

Studies (TIMSS), as reported by the Department of Education has proved that SPS among students has significantly declined. In the secondary level, the Philippines ranked 42nd out of 46 countries and among 25 countries, 23rd for the elementary level. These have caused alarm to most education reformists. Moreover, in the Advanced TIMSS, specifically the Advanced Sciences Category, the Philippines ranked last among all other participating Asian countries that joined the assessment in 2008, even with only Science High Schools participating.

Subsequently, results of the National Achievement Test likewise reveal a declining image of the quality of Science Education in the country. DepEd – NETRC also recorded that secondary school students did get average to low Mean Percentage Scores (MPS) in science from 2006 to the year 2015.

Alarming as the results may seem, the Department of Education (DepEd) has come up with an educational reform known as Republic Act 10533 or the Enhanced Basic Education Act of 2013. This is more popularly known as the K to 12 Basic Education Act which is primarily geared to develop Filipino students to be 21st Century Skill masters, entrepreneurs, possess middle school level skills, and are ready for employment after basic education employable after graduation in higher education. However, after its implementation for five academic years, there are claims of second–rate lifelong scientific literacy among secondary students which demands a thorough review and a wide range of assessments of the program to ensure the attainment that framework objectives are met, and competencies developed.

The performance ratings of San Bartolome National High School in its school-based achievement tests for the five previous consecutive years also reveal that there is a decline in science performance. A mean percentage score of 62.75 has been recorded for the school year 2016 – 2017. An increase was later documented after a year, 2017 – 2018 with a mean percentage of 64.55 for the end of the school year mean percentage score. After one school year, it declined to 61.90 which is a notable decrease in the mean performance of students in science. Although an increase was logged and verified, still, it is not a continual increase as far as the performance of students in science is concerned.

OBJECTIVES OF THE STUDY

The study was an attempt to find the effects of metacognitive teaching strategies on the development of Integrated Science Process Skills (ISPS) in students. Specifically, this study aimed to 1) describe the learning modalities of the students for their profiling, 2) determine the level of each ISPS before and after the use of different metacognitive strategies as to controlling variables, defining operationally, formulation of hypotheses, interpretation of data, experimentation, and formulation of models.

METHODOLOGY

A two-group experimental pretest-posttest research design was adopted for this research. Experimental research is one where variables are treated uniquely and compared after the different treatments. It also involves the manipulation of variables, and teaching strategies, in the sense that their manifestations have recurred or that they show manipulative and minimally influenceable properties.

This study was conducted by means of the Science Process Skills Test and the use of a survey questionnaire for learning modality inventory. Two classes were taught through the use of two different teaching strategies. The first group used a traditional lecture design and supplemented it with reading materials while the second group was exposed to an intervention program having the same content as that of the traditional.

The respondents for this research were the seventy-two (72) Grade 11 students who are officially enrolled in the Physical Science course for the academic year 2019 – 2020, therefore, the entire population was used. They were grouped into two and each group was exposed to a specific metacognitive strategy covering the same lesson content. In terms of characteristics, they are heterogeneously grouped and were matched–paired in terms of their pretest scores. Two research instruments were used in the conduct of this study including the Kolb Learning Modality Category Test and the Science Process Skills Test.

According to Kolb's Learning Modalities Theory, learners' experiences are reflected in their learning modality. Different learning experiences and thus, unique learning modalities. One learner can have more than one learning modality but it is highly theorized that among these, one should be most developed. The Kolb standardized test is composed of forty (40) situations. Each situation was originally aligned to measure perceptions of individuals but it was made adapted to the classroom setting. Questions were chosen and were slightly reconstructed to make those relatable to students. They put a checkmark if they are more likely to do what is stated. From their responses, their most prominent learning modality was then identified.

This research focused on the effect of using metacognitive teaching strategies, and the possible development of Integrated Science Process Skills in students. In terms of lesson content, the two classes discussed the same lessons and were assessed through the same assessment methods.

RESULTS AND DISCUSSION

1. Level of Preferred Learning Modalities of the respondents

Table 1
Level of Preferred Learning Modalities

Modalities	PLAN		Interpretation	RT		Interpretation
	F	%		f	%	
Accommodator	12	33.3	Low Preference	16	44.4	Moderate Preference
Converger	13	36.1	Moderate Preference	11	30.6	Very Strong/Moderate Preference
Diverger	14	38.9	Moderate Preference	11	30.6	Strong Preference
Assimilator	19	52.8	Very Strong Preference	16	44.4	Strong Preference

The results showed that the students from the PLAN (Predict, Locate, Add, Note) Group had a very strong preference for being Assimilators, meaning they try to collaborate with their fellow students most of the time. They tried to integrate and relate different concepts and ideas. While the RT (Reciprocal Teaching) Group had a very strong preference as convergers. As observed by the researcher, they tend to be highly skilled in practical work and they prefer to work independently.

2. Level of performance of the respondents in Physical Science in terms of their Integrated Science Process Skills

2.1. In terms of Controlling Variable

From the pretest scores of the two groups, they acquired a very low performance for *controlling variables*. Since the assessment procedures – and the subject itself, was more focused on mathematical concepts, students had more difficulty answering the questions.

The poor foundation of mathematical ideas is one of the reasons why students find it hard to understand facts that were involved in scientific generalizations.

Table 2
Controlling Variables

Performance	PLAN				RT			
	Pretest		Posttest		Pretest		Posttest	
	F	%	F	%	F	%	f	%
90 and above	1	2.8	6	16.7	2	5.6	15	41.7
85 – 89	2	5.6	6	16.7	-	-	2	5.6
80 – 84	5	13.9	3	8.3	2	5.6	-	-
75 – 79	9	25.0	11	30.6	4	11.1	2	5.6
74 and below	19	52.8	10	27.8	28	77.8	17	47.2
Total	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**

Legend: 90-100 – Outstanding (O);85-89 – Very Satisfactory (VS);80-84 – Satisfactory (S);75-79 – Fairly (F); Below 75 – Did Not Meet Expectations (DNME)

Before the use of the metacognitive teaching strategies, most of the respondents performed below expectation levels, but after they were exposed to the teaching techniques, most of the respondents in the PLAN (Predict, Locate, Add, Note) group from the below 74-mark performance level have gained scores that already fall under *Fair*. The percentage of respondents' performance that are classified as *Satisfactory*, *Very Satisfactory,* and *Outstanding*, has increased. Likewise, the same observation can be made for the RT (Reciprocal Teaching) group. From the "*Did Not Meet Expectations*" Level, a portion of the respondents were able to perform *Outstandingly*.

2.2. In terms of Defining Operationally

Table 3
Defining Operationally

Performance	PLAN				RT			
	Pretest		Posttest		Pretest		Posttest	
	f	%	F	%	F	%	f	%
90 and above	-	-	16	44.4	-	-	8	22.2
85 – 89	-	-	5	13.9	-	-	1	2.8
80 – 84	1	2.8	4	11.1	-	-	1	2.8
75 – 79	6	16.7	6	16.7	2	5.6	1	2.8
74 and below	29	80.6	5	13.9	34	94.4	25	69.4
Total	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**

With respect to the pretest scores, more than half of the respondents performed *"Did Not Meet Expectations*" for the PLAN (Predict, Locate, Add, Note) Group, with no recorded "*Very Satisfactory*" and "*Outstanding*" levels of performance. For the RT group, levels of performance that fell under "*Satisfactory*," "*Very Satisfact*ory" and "*Outstanding*" were not observable. This may be due to the consideration that the K – 12 Learning Curriculum is an educational framework that promotes activity-based learning. This may be attributed to the less emphasis that is given to the literal definition of words and terms because the highlight of K – 12 is anchored on skills development. However, after the use of the teaching strategies, performance levels "*Very Satisfactory*" and "*Outstanding*" have been filled drastically for both groups. Students with levels of performance of "Satisfactory" have been identified for the RT (Reciprocal Teaching) group too.

2.3. In terms of Formulation of Hypothesis

Table 4
Formulation of Hypothesis

Performance	PLAN				RT			
	Pretest		Posttest		Pretest		Posttest	
	F	%	F	%	F	%	f	%
90 and above	-	-	7	19.4	2	5.6	4	11.1
85 – 89	-	-	3	8.3	-	-	3	8.3
80 – 84	4	11.1	1	2.8	1	2.8	1	2.8
75 – 79	6	16.7	17	47.2	4	11.1	10	27.8
74 and below	26	72.2	8	22.2	29	80.6	18	50
Total	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**

Given a situation, one may make a temporary answer to what is happening. This is termed a hypothesis. A hypothesis may be warranted or unwarranted, but the latter is not widely used. Being able to warrant certain observations and draw meaningful hypotheses is the main mechanism of science. A hypothesis that is well thought of is essential in identifying what is most likely to happen and permits the time preparation in solving a problem. A hypothesis does not only temporarily answer the question or inquiry, it also serves as an avenue for highlighting guidelines on achieving empirical evidence. It serves as a guide in starting an inquiry into new knowledge or to a new observation.

2.4. In terms of Interpretation of Data

Table 5
Interpretation of Data

Performance	PLAN				RT			
	Pretest		Posttest		Pretest		Posttest	
	f	%	F	%	F	%	f	%
90 and above	-	-	13	36.1	-	-	4	11.1
85 – 89	1	2.8	4	11.1	-	-	3	8.3
80 – 84	2	5.6	-	-	-	-	1	2.8
75 – 79	1	2.8	13	36.1	3	8.3	10	27.8
74 and below	32	88.9	6	16.7	33	91.7	18	50.0
Total	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**

In many fields of basic, pure, and applied Sciences, data is always present. Their valid interpretation through appropriate representation is always vital in hypothesis testing, predicting outcomes, addressing a scientific concern, and many more. Interpretation of data is one of the many ways how a student implies meaning and draws conclusions based on specific trends, pertinent ideas, and general observations which can primarily be done on one's own.

Initially, most of the scores for both of the groups are clumped at *"Did Not Meet Expectations"*. From the same table above, the data shows that scores have been recorded as *"Outstanding"* and *"Very Satisfactory"* from the PLAN (Predict, Locate, Add, Note) Group while the same can be said for the RT (Reciprocal Teaching) Group, after the use of the metacognitive strategies. This implies that students have difficulty interpreting data. Students find it confusing as to how to verbalize data presented graphically as it is highly mathematical and analytical. One remedy he suggested is to provide learners with data, let them construct their own graphical representation, and try to have it explained.

2.5. In terms of Experimentation

Table 6
Experimentation

Performance	PLAN				RT			
	Pretest		Posttest		Pretest		Posttest	
	f	%	F	%	F	%	f	%
90 and above	-	-	3	8.3	-	-	2	5.6
85 – 89	-	-	1	2.8	-	-	1	2.8
80 – 84	-	-	8	22.2	4	11.1	4	11.1
75 – 79	1	2.8	16	44.4	4	11.1	6	16.7
74 and below	35	97.2	8	22.2	28	77.8	23	63.9
Total	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**	**36**	**100.0**

Before the use of PLAN (Predict, Locate, Add, Note), 97.2% of the respondents' scores are interpreted as *"Did Not Meet Expectations"*, while after its use, a number of scores were then distributed to the other score brackets, with some scores even interpreted as *"Outstanding"* and *"Very Satisfactory".* For the RT (Reciprocal Teaching) Group, no score was recorded for *"Very Satisfactory"* and *"Outstanding",* before its use. After employing the strategy, some of the scores were then found to be *"Very Satisfactory"* and *"Outstanding".*

Students nowadays find Science a difficult subject just like Mathematics. This may be the reason why students find it hard to study Science as compared to other subjects. On the other hand, they value Science and enjoy doing the experiments simply because learners of today's generation learn more when they are experiencing, doing, and conceptualizing the concepts in science on their own and relating them to their experiences as a person. In experimenting, students try to dig into their previous learning. However, the pretest scores of the two groups did reflect that the students still lack the necessary experience to come up with better experimentation schemes.

It is also said that in order to increase the level of interest in the science of the students there's a must to highlight the importance of science and its relevance to our lives. He further suggested that students be given experimental problems which they would try to answer on their own as this is one of the effective ways to develop experimenting skills (Mendoza, 2018).

2.6. In terms of Formulation of Models

A model is a graphical representation of a phenomenon, situation, or condition. It makes take the form of a paradigm, a flowchart, or a simple illustration. A model may be formulated by a step–by–step procedure. First, all variables must be identified as well as their relationships revealed. As such, the variables are placed in proper and logical order and sequence. The primary purpose of formulating a model is for easier discussion and better learning which in turn results in a highly scientific process and relevant conclusions (Lynch 2016).

Table 7
Formulation of Models

Performance	PLAN				RT			
	Pretest		Posttest		Pretest		Posttest	
	f	%	F	%	F	%	f	%
90 and above	-	-	3	8.3	-	-	12	33.3
85 – 89	-	-	16	44.4	1	2.8	4	11.1
80 – 84	1	2.8	16	44.4	-	-	7	19.4
75 – 79	-	-	-	-	3	8.3	3	8.3
74 and below	35	97.2	1	2.8	32	88.9	10	27.8
Total	36	100.0	36	100.0	36	100.0	36	100.0

The results show that the PLAN (Predict, Locate, Add, Note) and RT (Reciprocal Teaching) groups both *"Did Not Meet Expectations",* before the use of metacognitive strategies. In fact, 97.2% of the scores from the PLAN and 88.9% of the scores from the RT were categorized as such.

3. Differences in Performance of the respondents in Physical Science in terms of their Integrated Science Process Skills

3.1. Difference in RT

RT is an individual metacognitive strategy that encourages students to question what they already know.

Table 8
Difference within RT

Integrated Science Process Skills	Test	Mean	SD	Mean	SD	95% CI of the Diff.		T	Sig.
						Lower	Upper		
Controlling Variables	Pretest	70.00	7.75	6.25	18.80	-0.111	12.611	1.995	0.054
	Posttest	76.25	19.21						
Defining Operationally	Pretest	64.17	4.86	6.11	16.57	0.506	11.716	2.213	0.033
	Posttest	70.28	15.12						
Formulation of Hypothesis	Pretest	66.39	9.90	5.00	15.68	-0.304	10.304	1.914	0.064
	Posttest	71.39	11.31						
Interpretation of Data	Pretest	61.53	7.15	5.28	15.16	0.147	10.408	2.088	0.044
	Posttest	66.81	12.20						
Experimentation	Pretest	66.39	8.59	4.72	13.83	0.042	9.403	2.048	0.048
	Posttest	71.11	8.87						
Formulation of Models	Pretest	64.17	7.61	14.17	14.76	9.173	19.161	5.759	0.000
	Posttest	78.33	13.26						

Legend: p > 0.05Not Significant; p < 0.05 Significant

With this, it is expected that it will develop skills that are promoted through individualized instruction. With this, no significant differences were recorded for Controlling Variables and Formulation of models, meaning, these skills were not improved.

RT (Reciprocal Teaching) is able to develop skills that do not require collaboration such as Defining Operationally, Interpretation of Data, Experimenting, and Formulation of Models, despite the fact that they also have a strong preference for collaborative learning. The stagnation in Controlling Variables 54 Formulating Hypothesis skills cannot be attri to their learning modalities but to the nature of the strategy. Therefore, RT (Reciprocal Teaching) develops individual skills but cannot develop skills that require collaboration, even if students are more inclined toward group work. They did not improve because they were not given the chance to collaborate and increase the level of their collaborative skills, controlling variables, and formulating hypotheses.

3.2. Difference within PLAN

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Table 9
Difference within PLAN

Integrated Science Process Skills	Test	Mean	SD	Mean	SD	95% CI of the Diff.		T	Sig.	Interpretation
						Lower	Upper			
Controlling Variables	Pretest	72.78	6.81	4.44	13.03	0.037	8.852	2.047	0.048	Significant
	Posttest	77.22	9.82							
Defining Operationally	Pretest	66.67	6.09	17.08	12.27	12.932	21.235	8.354	0.000	Significant
	Posttest	83.75	10.65							
Formulation of Hypothesis	Pretest	69.72	5.85	7.04	10.99	3.922	11.356	4.172	0.000	Significant
	Posttest	77.36	9.30							
Interpretation of Data	Pretest	64.86	7.22	15.42	14.11	10.642	20.191	6.555	0.000	Significant
	Posttest	80.28	11.46							
Experimentation	Pretest	62.92	6.25	12.50	7.88	9.833	15.167	9.514	0.000	Significant
	Posttest	75.42	7.87							
Formulation of Models	Pretest	60.97	6.95	21.81	8.63	18.885	24.726	15.158	0.000	Significant
	Posttest	82.78	4.70							

Legend: $p > 0.05$ Not Significant; $p < 0.05$ Significant

PLAN (Predict, Locate, Add, Note) is a metacognitive strategy wherein students are allowed to express their ideas more freely, allowing them to engage more actively in learning. As a result, they are able to develop their Integrated Science Process Skills better, as shown in the table. This may be due to the fact that integrated science process skills and higher-order thinking skills are logical and rationally learned and may be enhanced by previous knowledge.

All integrated science process skills scores after the use of PLAN are significantly different from the pretest as reflected by the mean scores, in favor of the post-test results. It is therefore assumed that the strategy was effective. The enhancement in the levels of integrated science process skills is because of the use of the metacognitive strategy, PLAN. Considering that it is a strategy wherein discussion and collaboration are highly promoted through performing in pairs or in small groups, added to the consideration that most of the learners in the group have very strong preferences as assimilators who were previously described as learners who prefer to work actively and in harmony with others. This match between the learning modality and the teaching strategy has enabled the students to be aware of their cognitive operations. Consequently, the learners have set their mental abilities in analysis and acquired mental functioning skills through facts and relating has become more efficient.

It is therefore further implied that PLAN being a collaborative strategy develops all Integrated Science Process Skills, including those that were developed individually, of course, with the consideration that the strategy and Learning Modes of the learners are matched. The metacognitive strategy used also served as an avenue for the students to think freely and gave them more interaction during class activities causing more manifestations of different ideas and thinking. This awareness has equipped them with the skills necessary to identify what thinking process is most appropriate. As observed by the teacher, the students found it more interesting to work with others rather than learning specific concepts on their own.

3.3. Difference of Post-tests

The test for difference between the PLAN and RT groups revealed that there were skills that were significantly different after the use of metacognitive strategies and there were also skills that were not, with the mean scores from the PLAN Group being higher. Significant differences were noted for Defining Operationally, Formulation of Hypothesis, Interpretation of Data, and Experimentation. These are the skills that require one to question what and why, encouraging collaboration with one another, which is the main feature of PLAN. No significant differences were noted for Controlling Variables and Formulation of models, which were described as skills that require one to think how.

Table 10
Difference of Posttests

Integrated Science Process Skills	Group	Mean	SD	t	Sig.	Mean Diff.	95% CI of the Diff.		Interpretation
							Lower	Upper	
Controlling Variables	PLAN	77.22	9.82	0.270	0.788	0.972	-6.199	8.144	Not Significant
	RT	76.25	19.21						
Defining Operationally	PLAN	83.75	10.65	4.372	0.000	13.472	7.326	19.618	Significant
	RT	70.28	15.12						
Formulation of Hypothesis	PLAN	77.36	9.30	2.447	0.017	5.972	1.105	10.840	Significant
	RT	71.39	11.31						
Interpretation of Data	PLAN	80.28	11.46	4.830	0.000	13.472	7.909	19.036	Significant
	RT	66.81	12.20						
Experimentation	PLAN	75.42	7.87	2.178	0.033	4.306	0.363	8.248	Significant
	RT	71.11	8.87						
Formulation of Models	PLAN	82.78	4.70	1.896	0.062	4.444	-0.230	9.119	Not Significant
	RT	78.33	13.26						

Legend: $p > 0.05$ Not Significant; $p < 0.05$ Significant

Considering that the PLAN Group was mostly Assimilators, the strategy was able to develop certain skills that were better understood through sharing of ideas such as defining operationally, formulation of hypothesis, interpretation of data, and experimentation, better than RT. However, the Reciprocal Teaching Strategy was also able to develop certain skills that can be learned both by collaboration and individual analysis such as controlling variables and formulation of models, which reason for no significant differences to be recorded.

It is therefore concluded that since the skill level of Controlling Variables was developed in the PLAN Group and was not developed in the RT group, it requires collaboration among learners.

After the use of Metacognitive strategies, they were of the same level as reflected by the insignificant difference.

This leads to the implication that before the use of Metacognitive strategies, the RT group already has a high level of skill, and the PLAN group was able to catch up after the use of the strategies. This development may be attributed to the kind of strategy, they may be able to improve the skill too, considering that they are collaborators, however, an individual strategy was used. Further, the Formulation of Models was developed for both groups. It is a skill that ca 56 developed by a group or individually.

The rate at which the skill is developed is the same for both groups as shown by the table, leading to a not significant interpretation of the computed values. This development is largely anchored on the type of learner because it was improved even with different approaches.

CONCLUSIONS

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In the light of the findings, the follow conclusions are hereby drawn:

1. The scores of the respondents from the two groups in the pretest are not significantly different. It is therefore implied that before the use of any strategy, the students from both groups are of the same skill levels.
2. All the posttest scores of all skills are significantly different from the pretest scores for the PLAN, while differences were recorded for RT for defining operationally, interpretation of data, experimentation, and formulation of models. This leads to the conclusion that PLAN, as a collaborative strategy, develops all skills while RT as an individual strategy, only develops skills that are improved by individual instructions such as defining operationally, interpreting data, experimentation, and formulation of models.
3. PLAN Strategy is more effective in developing skills in defining operationally, formulation of hypothesis, interpretation of data, and experimentation. However, RT also develops skills in controlling variables and formulation of models at par with that of PLAN.

RECOMMENDATIONS

Based on the findings and conclusions drawn, the following are hereby offered:

1. Since the focus of the study is about integrated science process skills, it is recommended that instead of using pen and paper tests, a performance-based assessment or other forms of assessment such as authentic assessments may be employed with the aid of rubrics. This will also give the students the chance to explore scientific concepts on their own which was observed as a point for improvement based on the results of the integrated science process skill experimentation. Such skills that may be assessed through performances are experimentation, formulation of hypothesis, and formulation of models.
2. The use of Learning Modalities in this study is limited to profiling as a result of a very small population. In another research, a larger population may also be used to determine what metacognitive strategy works best on what learning modality.
3. The use of metacognitive teaching strategies has been noted to be effective in developing integrated science process skills, as supported by the results of the tests for the difference within the groups, to name some, when used properly with well-identified students. It is highly suggested that the strategies be used and tried to develop other skills as well.

REFERENCES

Aktamis, H., & Ergin, O. (2008). The effect of scientific process skills education on students scientific creativity, science attitudes and academic achievements. https://eric.ed.gov/?id=EJ832103

Alkan, F. (2016). Experimental Learning: Its effects on Achievement and Scientific Process Skills. https://www.researchgate.net/publication/307569599_Experiential_Learning_Its_Effects_on_Achievement_and_Scientific_Process_Skills

Freudenberg, B., Brimble, M., & Cameron, C. (2011). WIL and generic skill development: The development of business students ' generic skills through work-integrated learning. *Asia- Pacific Journal of Cooperative Education*, 12(2), 79–93.

Gottfried, A. E., Preston, K. S. J., Gottfried, A. W., Oliver, P. H., Delany, D. E., & Ibrahim, S. M. (2016). Pathways from parental stimulation of children's curiosity to high school science course accomplishments and science career interest and skill. *International Journal of Science Education*, 38(12), 1–23. https://psycnet.apa.org/record/2017-04825-005

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Englewood Cliffs, N.J: Prentice-Hall.

Lynch, M. (2016). Philosophies of education: 3 types of student-centered philosophies. The Advocate. http://www.theedadvocate. org/philosophies-education-3-types-student-centered-philosophies/

Osborne, J., Simon, S., Collins, S., (2010). Attitudes towards science: A review of the literature and its Implications. https://www.tandfonline.com/doi/abs/10.1080/0950069032000032199

Ramlawati, R., Liliasari, L., Martoprawiro, M. A., & Wulan, A. R. (2014). The effect of electronic portfolio assessment model to increase of students generic science skills in practical inorganic chemistry. *Journal of Education and Learning (EduLearn)*, 8(3), 179–186.

Republic Act No. 10533. An act enhancing the philippine basic education system by strengthening its curriculum and increasing the number of years for basic education, appropriating funds therefor and for other purposes. https://www.officialgazette.gov.ph/2013/05/15/republic-act-no-10533/

Sevilay, K. (2011). Improving the science process skills ability of science student teachers using I diagrams. https://www.ijpce.org/index.php/IJPCE/article/view/99

Van Schijndel, T. J. P., Jansen, B. R. J., & Raijmakers, M. E. J. (2018). Do individual differences in children's curiosity relate to their inquiry-based learning? *International Journal of Science Education,* 40(9), 1–20. https://www.tandfonline.com/doi/full/10.1080/09500693.2018.1460772

Virtanen, A., & Tynjälä, P. (2018). Factors explaining the learning of generic skills: a study of university students' experiences. Teaching in Higher Education, 24(7), 1–15. https://www.tandfonline.com/doi/full/10.1080/13562517.2018.1515195

Weible, J. L., & Zimmerman, H. T. (2016). Science curiosity in learning environments: developing an attitudinal scale for research in schools, homes, museums, and the community. *International Journal of Science Education*, 38(8), 1235–1255. https://www.tandfonline.com/doi/abs/10.1080/09500693.2016.1186853

Yohana, I., Sudarmin, S., Wardani, S., & Norashikin, S. (2018). The generic science skill profile of fourth grade students on acid and base topic in guided inquiry learning model. *International Journal of Active Learning,* 3(2), 110–116. https://journal.unnes.ac.id/nju/index.php/ijal/article/view/13485

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