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Development and evaluation of a self-learning module for mastering basic science process skills

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ABSTRACT

This study developed and validated a self-learning module designed to help Grade 8 Junior High School students acquire basic science process skills independently. The module, containing adapted and modified activities, was tested at Cesar E. Vergara Memorial High School using a pretest–posttest control group design. While both groups showed low initial scores, students who used the module achieved significantly higher posttest results than those taught through traditional instruction, indicating its effectiveness in improving knowledge and application of science process skills. Validation by science teachers confirmed the module's clear objectives, logical organization, appropriate illustrations, safety measures, and accessible materials, as well as the adequacy of its evaluation tools. Overall, the module effectively enhanced students' skills and promoted independent, confident learning.

1. Introduction

Since the introduction of the Secondary Education Curriculum, which followed the Basic Education Curriculum, there has been little emphasis on teaching basic science process skills in secondary schools. These skills include observing, inferring, estimating, measuring, classifying, predicting, and communicating, as well as integrated process skills such as identifying relationships among variables, formulating hypotheses, organizing and interpreting data, and drawing conclusions. It is generally assumed that students have already mastered these skills in elementary school, since they are part of the Elementary Science curriculum (Ješková et al., 2022; Pozuelo-Muñoz et al., 2023). The same assumption is present in the current K–12 Curriculum of the Philippine education system, where more learner-centered activities are required in secondary school. Because of this, students are expected to apply these skills in their lessons.

In reality, many students enter high school without a strong mastery of the basic process skills. This creates difficulties in performing science activities and in applying the skills as required. As a result, science teachers often spend a considerable amount of time reteaching these skills, which prevents them from completing all the lessons covered by the curriculum. This situation has led the researcher to develop a self-learning module designed to reinforce the knowledge and mastery of basic science process skills. The module aims to help students recall, practice, and apply these skills not only in science activities but also in other subjects and in everyday life. When used properly, it has the potential to improve students' ability to work independently, since it is designed for learning and practice even without direct teacher assistance. In this way, teachers can continue with scheduled lessons while providing students with an alternative means of strengthening their skills (Morris, 2025; Tsaliki et al., 2024).

The module was evaluated by secondary science teachers in the Division of Cabanatuan City, with approval from the appropriate authorities. The study focuses on describing the students' knowledge of science process skills before and after using the module, comparing test results between groups of students who did and did not use the module, examining differences in performance across gender, and gathering teachers' evaluations of the module in terms of clarity of objectives, content and organization, methods of evaluation, clarity of presentation, and relevance to students' understanding and application of science process skills (Sofianidis and Kallery, 2021; Georgiou and Kyza, 2023).

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From these inquiries, the study proposes the following assumptions. There is no significant difference between the pretest results of students in the control and experimental groups before using the module. There is no significant difference between the pretest and posttest results of the experimental group after using the module. There is no significant difference between the posttest results of the control and experimental groups. There is also no significant difference in the knowledge of science process skills between male and female students.

2. Literature survey

Effective science instruction requires that students grasp basic science process skills (SPS), which foster critical thinking and problem-solving skills and empower them to carry out scientific investigations. SPS fosters scientific literacy, which is necessary to build a society that is informed by science and technology, by enabling students to interact with the outside world, develop ideas, and acquire intellectual control (Libata et al., 2023; Tejero, 2025). Additionally, they support, one of the core components of science literacy is knowing scientific techniques.

Constructivist philosophy, which stresses active student participation, group collaboration, and the teacher's role as facilitator, supports effective education through science process skills. It has been demonstrated that inquiry-based learning techniques, such as computer simulations and group investigations, improve SPS in elementary and secondary education. The social production of knowledge is fostered by verbalization and discussion, which further improve collaborative learning situations. Therefore, mastering SPS involves not only acquiring scientific material but also cultivating cognitive skills necessary for understanding the world, solving problems, and critical thinking.

The development of SPS includes both teaching and assessment, which often occur together during learning. These skills can be taught as key elements of scientific literacy, for example, by using tasks such as reading and interpreting data from maps, graphs, and tables (Libata et al., 2023). Assessing SPS requires tracking students' performance over time. Cooperative learning strategies, such as the Jigsaw and Group Investigation methods, as well as technology-based tools, can help students better understand scientific concepts and processes.

Effective teaching strategies include hands-on and experiential learning activities, which encourage active participation and enactment of process skills during investigations. Assessment of SPS can be conducted separately or embedded within instructional programs to diagnose learning gaps and inform teaching (Tejero, 2025).

Instructional materials designed and developed specifically for students can foster better skill development compared to generic textbooks. Teachers should engage in the process of designing, try-outs, evaluation, and revision to optimize instructional materials and assessments, thereby enhancing scientific skills and achieving science teaching goals (Libata et al., 2023).

Self-learning modules are particularly effective in fostering SPS due to their inherent characteristics of self-education and individualized learning. These modules incorporate specific objectives, logically sequenced learning experiences, and activities that allow learners to progress at their own pace (Alelaimat and Ghoneem, 2012). Well-designed modules are self-contained, motivating, and aligned with learners' developmental levels, providing opportunities for interaction and mastery of targeted skills (Libata et al., 2023).

The structured nature of modules- featuring clear objectives, content descriptions, learning tools, and activity sheets facilitates comprehensive learning experiences. Modular programs offer advantages such as organizing experiments, identifying student deficiencies, and assessing progress, while reducing routine tasks and enabling teachers to provide personalized support.

Despite challenges like the need for learner self-discipline and resource availability, the adaptability of self-learning modules and their potential to incorporate various pedagogical styles make them valuable tools for mastering SPS. Recent studies affirm that teacher-made materials adapted to specific student needs, coupled with iterative development processes, significantly enhance learning outcomes and promote scientific skills (Libata et al., 2023; Tejero, 2025).

Literature has emphasized the importance of applying theories in teaching basic SPS, which are essential for carrying out scientific activities and supporting inquiry-based learning. These skills serve as building blocks for the development of critical thinking necessary for problem-solving and scientific inquiry, making SPS the fundamentals of "doing" science. The development of a Self-Learning Module for mastering these skills is therefore anticipated to benefit both teachers and learners. Since most activities included in the module involve hands-on experiences, it provides authentic learning opportunities that reinforce students' knowledge and understanding of SPS.

Instructional materials prepared by teachers themselves are often more effective than textbook materials because they are tailored to the specific needs of their students. Teacher-made modules adopt principles of self-education and individualized learning, including specific objectives and logically sequenced activities that help learners progress at their own pace. The developed self-learning module in this study was carefully designed to be adaptive to the specific group of Grade 8 learners involved, with activities selected and evaluated for their suitability to learners' mental aptitude.

Recent international research supports the use of modular and inquiry-based instruction to enhance SPS. Libata et al. (2023) demonstrated that a constructivist-based 7E-inquiry integrated module

significantly improved junior secondary students' SPS across cognitive levels, highlighting the adaptability of such modules. Similarly, Tejero (2025) found that Science Investigatory Project Instruction markedly increased SPS proficiency among senior high STEM students, especially in higher-order skills like synthesizing scientific information. These findings align with constructivist learning theory, which emphasizes active engagement and experiential learning as key to mastering scientific processes.

Globally, interactive approaches such as computer simulations have been shown to improve students' scientific reasoning and process skills. Inquiry-based learning fosters critical SPS, including hypothesis formulation, data collection, and interpretation. These approaches reflect a global trend toward learner-centered, scaffolded instruction that promotes autonomy and critical thinking. However, some studies report challenges in SPS mastery despite positive attitudes toward innovative instructional methods. For example, Rusmini et al. (2021) found that during the COVID-19 pandemic, students' SPS mastery remained low despite favorable perceptions of project-based learning, suggesting that factors like learning environment and resource availability influence effectiveness. This contrasts with Barut and Yüce (2025), who observed significant positive relationships between scientific process skills and academic achievement (e.g., Barut's $r \approx 0.39$ for middle school science), highlighting how the effectiveness of SPS development depends strongly on educational context and conditions.

These mixed findings highlight the need for carefully designed contextually relevant modular instruction. The self-learning module developed in this study aims to address these needs by providing a structured, learner-centered resource tailored to Filipino secondary students, contributing to both local and international efforts to improve SPS instruction.

3. Methodology

This study employed a mixed-methods approach combining descriptive and experimental research designs. The descriptive method guided the development and validation of the Self-Learning Module, while the experimental method evaluated its effectiveness.

The Self-Learning Module in Mastering the Science Basic Process Skills was developed based on a review of science textbooks and relevant online activities, modified to suit Grade 8 learners' age and competency levels. Content validity was ensured by aligning the module with desired learning competencies and through critical evaluation by Secondary Science teachers in the Division of Cabanatuan City, who assessed the module using a structured questionnaire.

Students in Grade 8 at Cesar E. Vergara Memorial High School participated in a quasi-experimental design to examine the module's efficacy. Either the experimental group, which used the Self-Learning Module, or the control group, which received conventional lecture-discussion training, was given to the participants. After a two-week intervention session, both groups finished a pretest to gauge their baseline knowledge and a posttest to gauge their learning progress.

To further establish the module's usefulness, Secondary Science teachers evaluated it through a questionnaire/checklist focusing on its relevance, clarity, and instructional value. Fig. 1 further summarizes the methodology of this study.

4. Results and discussions

This section discusses the findings and the output of the study. This study addressed three questions.

4.1. Knowledge of student-respondents before and after using the self- learning module

The results of the study revealed that both the control and experimental groups began with similarly low levels of mastery in science process skills, as reflected in their pretest scores in Table 1. Table 2 shows that there was no significant difference between the two groups at the outset ($t = 0.408$, $p = 0.685$), indicating that they possessed comparable baseline knowledge prior to any intervention. The pretest scores between the experimental and control groups did not differ significantly ($t(58) = 0.408$, $p = 0.685$), with a very small effect size (Cohen's $d = 0.11$), indicating comparable baseline performance.

Following the instruction, the control group, which received traditional teaching, showed modest improvement with a posttest mean of 18.87, as displayed in Table 3. In contrast, the experimental group, which utilized the developed self-learning module, achieved a significantly higher posttest mean of 25.67. The statistical analysis confirmed a significant difference between the posttest scores of the two groups ($t = 5.843$, $p < 0.01$), favoring the group exposed to the self-learning module. The posttest scores showed a significant difference ($t(58) = 5.843$, $p < 0.001$), with a very large effect size (Cohen's $d = 1.51$), indicating that the intervention had a substantial impact on students' science process skills. Furthermore, the increase within the experimental group from their pretest mean of 12.73 to a posttest mean of 25.67, as displayed in Table 4, was also found to be highly significant ($t = 12.212$, $p < 0.01$), underscoring the module's effectiveness in enhancing students' mastery of basic science process skills.

Lastly, the computed t-value of 0.330, which was displayed in Table 5, indicated no significant difference in the scores of male and female students, suggesting that gender was not a factor in the acquisition and mastery of science process skills. While existing literature acknowledges cognitive differences between boys and girls (Voyer and

Voyer, 2014; Mayer and Massa, 2003), these are often influenced by both learner-related and environmental factors. However, since the self-learning module emphasized skill mastery through uniform, hands-on activities and was used by both genders under the same conditions, it can be inferred that gender did not affect the students' performance in this context.

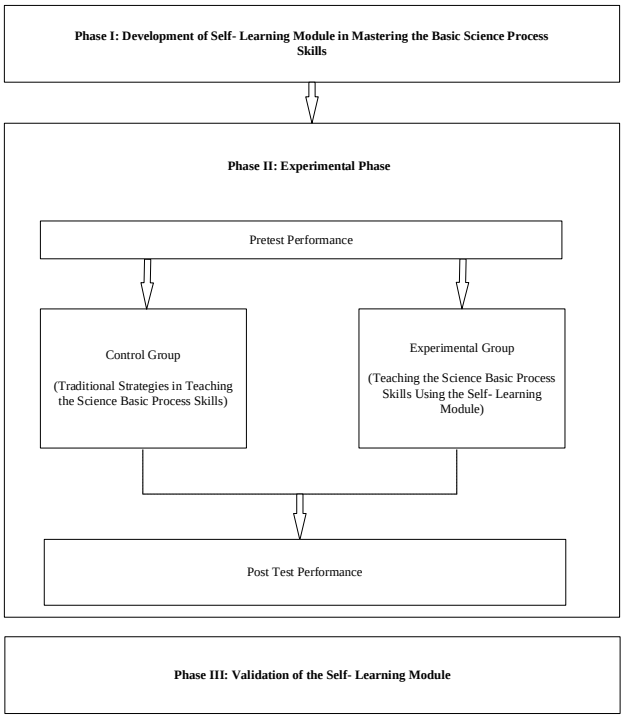

Fig. 1: Methodology of the study

Furthermore, qualitative feedback from students further supported these findings, highlighting that the hands-on, activity-based learning embedded in the module allowed them to apply skills in practical contexts. This approach not only improved their understanding but also made the learning process more enjoyable and engaging.

4.2. Validation of the self-learning module in mastering the basic science process skills

The evaluation of the self-learning module by secondary science teachers from Cabanatuan City Division yielded highly favorable results across all key areas. Teachers strongly agreed that the learning objectives were specific, measurable, attainable, relevant, and time bound as displayed in the overall weighted mean of 4.67 in Table 6, making them effective in guiding students toward mastering basic science process skills. The content and organization of the module were also rated very positively (Weighted mean (WM) = 4.63), with activities described as manageable, well-sequenced, relevant, and sufficient to aid comprehension and application of the skills. Moreover, teachers also noted that the module encouraged logical and critical thinking while requiring minimal teacher assistance. In terms of evaluation, the guide questions and assessment items were aligned with the behavioral objectives, reinforcing key concepts effectively (WM = 4.61). The clarity of ideas presented in the module also earned high ratings (WM = 4.50), with teachers affirming that the language and discussions were appropriate for Grade 8 learners.

Lastly, the module was found to be highly relevant and suitable to students' mental development and learning needs (WM = 4.67), promoting independence and confidence. These findings suggest that the self-learning module is a well-designed, functional, and pedagogically sound tool for teaching science process skills, and it holds strong potential for use even among learners at risk of dropping out.

Due to the unavailability of item-level data from the original administration of the assessment instruments, it was not possible to calculate reliability coefficients such as Cronbach's alpha for this study. The researcher acknowledges this as a limitation and recommends that future research include reliability analysis to further establish the consistency of the instruments.

Nevertheless, to ensure the validity of the assessment tools, a systematic test blueprinting process was conducted to align test items with the targeted science process skills based on curriculum standards and learning objectives. Additionally, the instruments underwent pilot testing with a sample of 30 students to assess item clarity, difficulty, and appropriateness. Experts in science education reviewed the instruments to evaluate content relevance and face validity. Feedback from both the pilot testing and expert review was incorporated to refine the instruments and enhance their overall validity.

Future studies are encouraged to replicate this validation process and compute reliability statistics to strengthen the psychometric evidence for these assessment tools.

Table 1: Summary of scores before and after the application of the self-learning module

Scores	Control group				Experimental group			
	Pretest		Posttest		Pretest		Posttest	
	F	%	F	%	F	%	F	%
0-10	15	50	-	-	12	40	-	-
11-20	15	50	17	56.7	18	60	2	6.7
21-30	-	-	13	43.3	-	-	25	83.3
31-40	-	-	-	-	-	-	3	10.0
41-50	-	-	-	-	-	-	-	-
Total	30	100.0	30	100.0	30	100.0	30	100.0

Cohen's d effect size for the pretest comparison between experimental and control groups was 0.11, indicating a very small effect size

Table 2: Significant difference in the pretest scores of controls and experimental groups

	Respondents	N	Mean	T	Sig (2-tailed)
Pretest	Experimental group	30	12.7333	.408	.685
	Control group	30	12.2000		

Table 3: Significant difference in the posttest scores of the control and the experimental groups

	Respondents	N	Mean	T	Sig (2-tailed)
Posttest	Experimental group	30	25.6667	5.843**	.000
	Control group	30	18.8667		

**: Significant at the 0.01 level (2-tailed); Cohen's d effect size for the posttest comparison between experimental and control groups was 1.51, indicating a very large effect size and a substantial impact of the intervention

Table 4: Significant difference in the pretest and posttest scores of the experimental group

	Mean	N	T	Sig (2-tailed)
Pretest	12.7333	30	12.212**	.000
Posttest	25.6667	30		

**: Significant at the 0.01 level (2-t)

Table 5: Significant difference in the students' knowledge of basic science process skills across gender

Gender	N	Mean	T	Sig (2-tailed)
Scores- male	16	24.9375	-.990	.330
Female	14	26.5000	-.982	

Table 6: Teacher respondents' evaluation of the self-learning module

Statement of learning objectives	WM	Verbal description
1. The objectives are specific, measurable, attainable, reliable, and time-bound.	4.66	Strongly agree
2. The stated objectives are relevant to the student's need.	4.69	Strongly agree
Average WM	4.67	Strongly agree
Content and organization of ideas		
1. The experiments/activities provided in the module are manageable.	4.66	Strongly agree
2. The module helps learners to think logically and critically	4.63	Strongly agree
3. The illustrations used are simple, correct and make the procedure more understandable.	4.72	Strongly agree
4. The writing style of the module makes it enjoyable to read.	4.53	Strongly agree
5. Proper safety measures for performing the activities were clearly explained.	4.66	Strongly agree
6. The organization of the lesson is logical and properly sequenced.	4.63	Strongly agree
7. The experiments are useful in helping the students understand and apply the Science basic process skills.	4.66	Strongly agree
8. The experiments/activities are relevant in understanding and applying the Science basic process skills.	4.75	Strongly agree
9. The experiments/activities provided are sufficient to understand and apply the Science basic process skills.	4.59	Strongly agree
10. The materials used in the activities are available and relevant to the student's need.	4.50	Strongly agree
Average WM	4.63	Strongly agree
Evaluation		
1. The guide questions at the end of each activity reinforced the basic concepts for each of the Science basic process skills.	4.59	Strongly agree
2. The operations in the tests reflect the behavioral objectives of the module.	4.63	Strongly agree
Average WM	4.61	Strongly agree
Clarity of ideas presented		
1. The language of the module is clear.	4.56	Strongly agree
2. The discussion of the lesson is simple and clear.	4.44	Strongly agree
Average WM	4.50	Strongly agree
Learners and the module		
1. The lesson is relevant and suited to the learners' level of mental development.	4.59	Strongly agree
2. The activities provided are enough to enable the students to understand and apply basic process skills.	4.66	Strongly agree
3. The module is functional and relevant for mastering the Science basic process skills.	4.72	Strongly agree
4. Through the module, students can observe independence and self confidence in understanding and applying the basic process skills.	4.72	Strongly agree
Average WM	4.67	Strongly agree

WM: Weighted mean; 1.00-1.79: Strongly disagree; 1.80-2.59: Disagree; 2.60-3.39: Undecided; 3.40-4.19: Agree; 4.20-5.00: Strongly agree

5. Conclusions

The study concluded that the self-learning module developed for mastering basic science process skills is an effective tool in enhancing students' understanding and mastery of these skills. Initial findings showed that students had relatively low levels of knowledge based on pretest results, indicating the need for an intervention. With no significant difference between the control and experimental groups before the module's implementation, the posttest comparisons were reliable. The significant improvement observed in the experimental group's posttest scores, compared to their pretest scores and the control group's performance, confirms the module's effectiveness over traditional teaching methods. Additionally, gender was found to have no significant effect on students' performance, indicating that the module is equally beneficial to all learners regardless of gender.

Teachers who evaluated the module strongly agreed that it was pedagogically sound and student-centered. They found the module's objectives to be specific, measurable, and relevant, with activities that were manageable, logically sequenced, engaging, and aligned with the intended learning outcomes. The materials used were accessible, the illustrations clear, and the safety procedures well explained. The module also fostered independent learning, critical thinking, and confidence among students. Its structure and content were suited to the learners' developmental levels, providing a functional and enjoyable platform for acquiring and applying science process skills effectively.

However, several limitations should be acknowledged. First, the study's sample was limited to Grade 8 students from a single school, which may restrict the generalizability of the findings to other grade levels, schools, or educational contexts. Second, the module focused specifically on selected basic science process skills and did not encompass the entire range of science competencies, which may limit its applicability to broader science curricula. Third, data collection relied on pre-, and posttests and teacher evaluations conducted over a relatively short intervention period, which may not capture long-term retention or transfer of skills.

Future research should address these limitations by involving larger and more diverse samples, expanding the module content to cover additional science skills and topics, and employing longitudinal designs to assess sustained learning outcomes. Incorporating qualitative data could also provide deeper insights into learner experiences and instructional effectiveness.

Despite these limitations, this study contributes valuable evidence supporting the use of self-learning modules as an effective instructional strategy for developing science process skills. The findings underscore the potential of modular, learner-centered approaches to enhance science education and promote critical thinking skills necessary for scientific inquiry.

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Compliance with ethical standards

Ethical considerations

This study was conducted in accordance with ethical standards for research involving human participants. Approval to conduct the research was obtained from the Division of Cabanatuan City, Department of Education, and permission was granted by the administration of Cesar E. Vergara Memorial High School. Since the participants were minors, informed consent was secured from their parents/guardians, and assent was obtained from the students. Participation was voluntary, and students were informed that they could withdraw at any time without penalty. All data collected was kept confidential and reported anonymously to protect the identity of the participants.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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