Learning Styles and Information Processing Patterns of Science, Technology and Engineering (STE) Students

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Abstract

This study entitled "Learning Styles and Information Processing Patterns of Science, Technology, and Engineering (STE) Students", investigated the diverse learning styles and information processing patterns of STE students. A population of 261 students was examined, revealing a predominantly adolescent respondent (44.4% aged 13-14) with a higher proportion of female participants (65.1%). Enrollment has a relatively balanced distribution across grades 7th up to 10th. Academic performance was generally high, with 86.6% of students garnering a General Weighted Average of 91-95. This study found that STE students favor a blend of learning styles. A strong inclination towards the Theorist style with a mean score of 3.35 indicates a strong agreement for theoretical understanding. The Reflector style with a mean score of 3.30 also got a suggesting strong agreement for observation and reflection. Information processing patterns revealed an existence for both top-down processing and bottom-up processing with a mean score of 4.14; demonstrating an ability to often make connections between new information and their existing knowledge, and focus on details. This is complemented by a sequential processing pattern with a mean score of 4.11 and parallel processing with a mean score of 4.14, reflecting a need for structured learning and attention to detail, and handling multiple information sources simultaneously. Significant relationships were identified between student profiles and their learning styles and information processing patterns. Female students demonstrated a greater likelihood of exhibiting an Activist learning style and a Sequential information processing pattern. Higher academic performance was associated with increased Activist and Theorist learning styles, as well as Parallel, Top-Down, and Bottom-Up processing patterns. Additionally, significant interrelationships were also found between learning styles and information processing patterns, suggesting a connection between how students prefer to learn and how they process information in learning science. This study highlights the diversity of learning approaches within STE programs and underscores the importance of understanding how individual differences impact student learning experiences. Findings suggest that science teachers should consider incorporating varied instructional strategies to cater to the broad spectrum of learning styles and information processing patterns commonly found in STE classrooms. This approach may further enhance student engagement and success in the special program of STE.

Keywords: Learning styles; Information processing; STE students; Academic performance; Instructional strategies; Science education

1. Introduction

In the modern global education landscape, the demand for competent Science, Technology, and Engineering (STE) professionals is constantly growing. The important role that STE fields play in generating new ideas and growing the economy suggests that there is a need to improve teaching students who excel in these subjects. As countries strive to prepare the workforce for the rapidly evolving technological era, it is critical to understand the learning styles of the students that influence their cognitive pathways.

Meanwhile, in the Philippines, the Department of Education (DepEd) has demonstrated its readiness to advance science, technology, and engineering learning. It is important to note that the STE program has been in existence since 1994 and has greatly influenced basic education. This assists students in achieving success in college and in obtaining decent employment. Nevertheless, even if the program is effective, the research is still lacking in a thorough understanding of how Filipino students acquire knowledge in science, technology, and engineering.

The theoretical framework upon which this research is based is the cognitive theory that focuses on the differences in learning styles and information processing strategies. Based on the theories of learning style and information processing patterns, there are Honey and Mumford's Learning Styles Theory and the Information Processing Patterns Models include Sequential Processing, Parallel Processing, Top-Down Processing, and Bottom-Up Processing.

When reviewing previous research studies, it can be observed that there is limited knowledge about the precise information processing patterns of STE students. Although many researchers have looked at overall learning styles and their effect on academic performance. This research seeks to address this gap by investigating specific information processing patterns of STE students.

In this manner, this study can be useful in augmenting the existing literature by presenting a comprehensive analysis of information processes in the STE program. Based on the findings of the study regarding the relationship between learning styles and information processing patterns, it will be feasible to gain a better understanding of the STE students' learning styles and how they process information, and possible implications for instructional practices and curriculum.

The purpose of this research was to examine the learning characteristics of STE students in learning science. In particular, it focused on the extent of learning styles and information processing patterns. Furthermore, the following research questions were posed in the study: To what extent does an STE student's profile correlate with the student's preferred learning style and information processing style? Last but not least, it investigated whether students' learning styles were in any way related to their information-processing patterns.

The researcher, being a student of Masters of Arts in Science Education and as a dedicated educator in the Special Program in Science, Technology, and Engineering (STE), the researcher's direct involvement in teaching STE subjects qualified him as an authority in this research. The researcher undertook this study to contribute to body of knowledge that can help STE students enhance their learning strategies, help the teachers to better understand and facilitate their students' needs, assist curriculum developers in designing a better learning curriculum for inclusive STE students, and create a framework for future research on learning strategies of inclusive STE students.

2. Review of Related Literature

Looking into the diverse and existing literature and studies, students have their own learning styles and information processing patterns.

Learning styles, as a theory that addresses an individual's preferences for receiving, interpreting, and communicating knowledge, has attracted a considerable amount of interest in the field of education. Several researchers have explored the learning styles and their effectiveness in the classroom, and how they may affect the academic achievements of the students as well as the choice of teaching methods.

Learning styles are not fixed but may change with context and content (Litzinger et al., 2013). This adaptability requires the use of teaching methods that can accommodate the students' individual differences. Thus, the learning-teaching process in cooperative group work is effective for many students, but not for all of them as some prefer individual work, which indicates a great need for differentiated instruction (Gillies, 2014).

Several instruments have been employed in the measurement of learning styles such as the Learning Style Inventory and Honey and Mumford's model (Yousef, 2019; Parham, 2022). These assessments can help educators in organizing learning experiences according to students' preferences, increase their interest, and achieve better results.

There are also cultural differences that might affect the learning styles. Sharing the above study by Pereyra (2020), the researcher noted that Filipino students preferred collaborative and kinesthetic learning activities which are in line with Filipino culture. This insight is in line with the concept of culturally relevant teaching practices.

The use of technology in education has raised questions on its efficiency and as a result, there have been researches done. Goroleo (2024) stated that through computer-aided instruction which is best suited for visual learners, there is enhanced learning. However, there are some complications which have to be solved, for example, hardware availability and teacher's attitudes.

Information processing theory which originated from the premise that people engage in active processing of information is another perspective that can be used to explain learning. Cuncic (2023) described the basic premises of this theory focusing on how knowledge is acquired, stored, and used.

Several new investigations have been published in the last few years, covering different aspects of information processing at the neural level (Musslick et al., 2016), in working memory (Cowan, 2017), and self-regulated learning (Winne, 2017). In the Philippine setting, studies have been conducted on how Filipino students think and the correlation to academic performance (Bernardo et al., 2020; Aldossari & Jadou, 2021).

Learning styles and information processing patterns have also been considered in the literature. In his 2014 article, Ünal Çakıroğlu stressed the need for students to be aware of the learning styles to enhance their level of motivation and learning. Other researchers have examined the learning style preferences of certain populations for example Saudi Arabian EFL learners (Al-Seghayer, 2021)

Therefore, this analysis of literature emphasizes the complexity of learning styles and information processing patterns. All these ideas are not only useful to explain the learning process of students but also to design the appropriate teaching methods. Through understanding and embracing the different learning styles among students, the teachers are in a position to deliver education that empowers the learners to the maximum.

The interaction between learning styles, cognitive styles, and academic performance is a topical issue in current research. Based on the study of the learning styles, Nazemi et al. (2016) established four learning styles which include Divergent, Convergent, Assimilative, and Accommodative and their relationship with the brain quadrants. This fact highlights the differences in students' information processing and their interaction with the environment.

The study on learning styles and information processing has recently started to emerge in the Philippines. Holmes et al. (2013) explored the correlation between the children's thinking styles, their preferences of play, and their academic achievements; the study showed that both are related and are affected by cultural factors. In the study by Catingub (2020), the author explored the relationship between learning style preferences, motivational level, and academic achievement, indicating that matching educational methods with the learners' preferences increases the chances of success at school.

The concepts of learning styles and information processing patterns remain active areas of research that provide useful information for teachers, educational leaders, and curriculum specialists. While technological development and changes in education environments are progressing, it is essential to focus on how people learn and acquire information. Thus, it is crucial to apply these findings in educational practices to make the learning process more individualized, interesting, and efficient for every learner.

In addition, the study reveals that education should not be solely a one-dimensional process that focuses on the differences, the culture and the use of technology in the society. To this end, understanding the interdependence of learning styles, information processing, and other contextual factors will help educators adopt holistic and context-sensitive approaches to meet the needs of learners.

Summing up, the further investigation of learning styles and information processing patterns is a prospect of changing the educational practices and helping students achieve their academic success. By understanding the intricate interplay between learning styles and information processing patterns of the students, it will be possible to make the school system more effective and welcoming for every learner and to prepare them for the future.

3. Methodology

This study used descriptive correlational research design among 261 Science, Technology, and Engineering (STE) students enrolled in the STE program from grades seven to ten at Julia Ortiz Luis National High School and Sto. Domingo National Trade School. All of the students within this population were included in the study. A semi-structured survey questionnaire based on the "Honey and Mumford Learning Styles" and "Information Processing Patterns" from the "Sequential Processing Model," "Parallel Processing Model," "Bottom-Up Processing Theory," and "Top-Down Processing Theory" was utilized to collect data. The questionnaire's validity was assessed through content and face validity, while reliability was determined using Cronbach's alpha, with coefficients of 0.87 for "Learning Styles of STE Students" and 0.85 for "Information Processing Patterns of STE Students." Data analysis included frequency counts, percentages, weighted means, and Spearman's rho for correlation to examine relationships between students' profiles, learning styles, and information processing patterns.

4. Result and Discussion

The student respondents in the Science, Technology, and Engineering (STE) program at Julia Ortiz Luis National High School and Sto. Domingo National Trade School during the School Year 2023-2024 were mostly 13-16 years old (85%), with a higher percentage of females (65.1%) than males (34.9%). The majority of students were enrolled in Grade 7 (27.2%), followed by Grades 8 and 10 (24.5% each), and Grade 9 (23.8%). Most students (86.6%) had a General Weighted Average (GWA) of 91-95, indicating high academic performance.

Table 1. Frequency Distribution of STE Students in terms of Age, Sex, Grade Level, and General Weighted Average

Profile of the Respondents	Frequency	Percent
Age		
11-12	38	14.6
13-14	116	44.4
15-16	106	40.6
17 and above	1	.4
Total	**261**	**100.0**
Sex		
Male	91	34.9
Female	170	65.1
Total	**261**	**100.0**
Grade Level		
Grade 7	71	27.2
Grade 8	64	24.5
Grade 9	62	23.8
Grade 10	64	24.5
Total	**261**	**100.0**
General Weighted Average		
75-79	0	0.0

80-85	2	.8
86-90	21	8.0
91-95	226	86.6
96-99	12	4.6
Total	**261**	**100.0**

These findings align with Chan et al. (2020), who found that early to mid-adolescents have a higher tendency to express STEM major aspirations, and emphasize the need for STEM programs tailored to their needs and interests. The high female enrollment reflects a positive trend towards gender balance in STEM education, supported by initiatives like Girls Who Code (GWC) and research by Dedicatoria (2024) and Guenaga et al. (2022). The balanced distribution of students across grade levels suggests consistent student interest and retention, aligning with research by Starr et al. (2020) on the importance of authentic science practices and Argaw et al. (2016) on problem-based learning (PBL) in enhancing student motivation. The high GWAs achieved by STE students support the program's effectiveness in fostering academic achievement and readiness for STEM careers, while also highlighting areas for improvement to accommodate diverse learning abilities, as suggested by López et al. (2022) and Bayanova et al. (2023).

Table 2. Weighted Mean and Verbal Description of Learning Styles of STE Students

Learning Styles	Wm	Verbal Description
Activist Style		
In learning science…		
1. I enjoy trying new things and solving problems through action.	3.32	Strongly Agree
2. I learn best by doing and participating in activities.	3.38	Strongly Agree
3. I prefer to get things done quickly and efficiently.	3.15	Agree
4. I can be impatient with explanations and prefer to learn by experience.	2.97	Agree
5. I am often described as enthusiastic, outgoing, and adventurous.	2.95	Agree
Average wm	**3.15**	**Agree**
Theorist Style		
6. I like to understand how things work and why they happen.	3.59	Strongly Agree
7. I am naturally curious and enjoy analyzing information.	3.41	Strongly Agree
8. I prefer to gather facts and data before taking action.	3.38	Strongly Agree
9. I learn best through structured learning and clear explanations.	3.48	Strongly Agree
10. I am often described as logical, analytical, and detail-oriented.	2.92	Agree
Average wm	**3.35**	**Strongly Agree**
Pragmatist Style		
11. I am focused on practical applications and getting things done.	3.16	Agree
12. I prefer to learn skills that I can use in real-world situations.	3.56	Strongly Agree
13. I am a problem-solver and enjoy finding practical solutions.	3.02	Agree
14. I am not interested in theories or ideas that are not practical.	2.32	Disagree
15. I am often described as reliable, efficient, and results-oriented.	3.00	Agree
Average wm	**3.01**	**Agree**
Reflector Style		
16. I need time to process information and think things through before taking action.	3.49	Strongly Agree
17. I prefer to observe and listen before participating in discussions.	3.50	Strongly Agree
18. I am good at picking up on the nuances of situations and people.	3.06	Agree
19. I value reflection and introspection to make sense of my experiences.	3.29	Strongly Agree
20. I am often described as thoughtful, insightful, and empathetic.	3.14	Agree
Average wm	**3.30**	**Strongly Agree**

Legend: 1.00-1.74 – Strongly Disagree; 1.75-2.49 – Disagree; 2.50-3.24 – Agree; 3.25-4.00 – Strongly Agree

A survey conducted for the STE program indicated that students demonstrated a diverse range of learning styles in learning science. While the Theorist and Reflector styles were particularly prominent, elements of Activist and Pragmatist approaches were also evident.

Activist Style

The data from Table 2 reveal that the STE students “agree” with the statements on the Activist learning style with an average weighted mean of 3.15. This means that students tend to be more proactive in their learning, preferring practical activities and solving problems through direct action. Students also “strongly agree” to statements from activist style like "I enjoy trying new things and solving problems through action" and "I learn best by doing and participating in activities".

This qualitative description of “agree” for the Activist style indicates that, although STE students appreciate practical or hands-on approaches, they appreciate the role of systematized explanations and theoretical orientations as well. This balance is important in science and technology education to acquire both the practical skills and knowledge to apply in the field.

This finding is in line with the research done by Kolb and Kolb (2018) and McLeod (2017) on experiential learning, and it shows that this type of learning enhances the motivation of students and helps them retain more knowledge and develop critical thinking skills. The preference for the Activist learning style aligns with active learning benefits shown in Freeman et al. (2014), particularly in STEM courses. This preference is echoed in Rubrica's (2019) findings on Project-Based Learning (PBL) enhancing science achievement. The STE student preference for active learning and hands-on activities indicates the potential of PBL and active learning to improve learning outcomes and foster 21st-century skills. Incorporating active learning approaches, such as experiments, simulations, and project assignments, into STE science teaching strategies can address the Activist learning style, increasing student engagement and satisfaction, and preparing them for future science and technology careers.

Theorist Style

The findings of the survey reveal that students in the STE program “strongly agree” with learning science by grasping the concepts that govern science. With an average weighted mean of 3. 35, STE students strongly agreed a lot with the statement that it is important to understand why and how things occur in science.

This desire for theory indicates that STE students are not content with rote learning; instead, they are eager and want to know how scientific principles work. They wish to make connections between all the concepts that they learn in science and therefore have a broader view of science.

This is supported by a student's statement:

“I am always motivated to understand science concepts because I am not satisfied with just memorizing facts when I am studying science topics. I enjoy breaking down every detail in our science lessons and to fully understand the lessons, I want to first form my interpretations and explanations about a science topic.

“For example, when I am studying the Organ Systems of the human body, I learn it better when I first explain to myself the different functions of the organs and how they connect. In this way, I gain a more solid foundation in a science topic.”

The teacher's observations further confirm this:

“From my experience, STE students are naturally curious about the deeper reasons behind scientific ideas. This shows in how they interact in class, asking thought-provoking questions that go beyond basic facts. They want to understand the core workings of things, how different ideas link together, and the logic behind scientific events.

This curiosity makes them eager to participate in discussions and activities. They do well in organized lessons where they can first learn the basics, and then carefully explore more complex science topics. Clear explanations and well-structured information help them analyze and connect ideas effectively.

I've also seen how good they are at analyzing things. They're skilled at breaking down problems, spotting patterns, and coming to logical answers. They like activities that challenge them to use what they know in new ways, which helps them learn even more."

This aligns with the growing emphasis on inquiry-based science education (IBSE) and the need for scaffolding that caters to students' curiosity and desire for connected knowledge (Petersen, 2022). STE students, like field-independent learners, thrive in environments that build a strong conceptual framework before tackling complex scenarios (Fatemi et al., 2014).

These findings imply that science teachers should adapt their instructional approaches to cater to STE students' Theorist learning style. This could involve incorporating activities that promote problem-solving using scientific concepts, inquiry-based learning, and the development of evidence-based explanations. Recognizing and accommodating this learning style can enhance students' engagement and performance in science.

Pragmatist Style

Table 2 reveals that there is a presence of a Pragmatist learning style among STE students with a weighted mean of 3.01, which falls within the "agree" verbal description. STE students displayed a Pragmatist learning style, preferring practical applications and real-world problem-solving (Pritchard, 2017). This aligns with their agreement with statements like "I prefer to learn skills that I can use in real-world situations" and "I am a problem-solver and enjoy finding practical solutions." However, they showed less interest in theoretical concepts without practical applications. This preference for practicality is an asset in the STE program, fostering innovation and problem-solving.

This finding supports the characteristics of Pragmatist learners as effective, productive, and outcome-oriented (Pritchard, 2017). In science education, this translates to a desire to apply scientific concepts to real-life situations. Science teachers can leverage this by incorporating real-life examples, project work, case studies, and simulations into their teaching approaches.

The presence of Pragmatist learners in the STE program necessitates the use of diverse teaching methods, combining theoretical background with practical examples (Widya et al., 2019). This approach enhances learner interest and comprehension. STEM education, with its focus on both cognitive intelligence and skills, aligns with this preference for linking science content to practical applications, boosting motivation.

The diverse learning styles of STE students underscore the need for differentiated instruction, addressing individual needs and preferences. Understanding these learning styles can aid in curriculum design, incorporating various teaching-learning strategies.

Reflector Style

Based on Table 2, the analysis of the learning style revealed that the STE students "strongly agree" with the Reflector learning style with an average weighted mean of 3.30, which suggests that the student is cautious and would prefer to take time and think before participating in the practical aspect of learning science. This reflective thinking is well illustrated in their agreement with statements like; "I need time to process information and think things through before taking action (item 16)" and "I prefer to observe and listen before participating in discussions (item 17)".

One STE student expressed during data gathering: "I believe that one of my learning styles or approaches to learning is that I prefer to thoroughly study our topic before engaging in performance tasks. At times, I have many questions for my teacher before conducting experiments because I want everything to be crystal clear before proceeding. I need time to process what I'm learning before taking action. I also prefer to observe and listen first before joining discussions."

A science teacher observed that STE students often think carefully and analyze before acting, taking in information before joining discussions. The teacher fosters a reflective learning environment, encouraging discussions, sharing ideas, and group projects. This aligns with the student's statement, as the teacher emphasizes understanding and provides time for reflection.

A study in Shanghai (Pei et al., 2020) found that technology-enhanced learning (TEL) with reflection prompts improved students' mastery of concepts and recall of information, particularly benefiting students with a Reflector learning style. This suggests that incorporating reflective techniques within TEL settings can enhance learning outcomes.

Promoting the students' preferred learning styles, such as the Reflector style, can make the learning environment more effective and accommodating. Science teachers can cater to reflective learners by providing opportunities for observation, analysis, and discussion, thereby strengthening their scientific knowledge.

Table 3. Weighted Mean and Verbal Description of Information Processing Patterns of STE Students

Information Processing Patterns	wm	Verbal Description
Parallel Processing		
In learning science…		
1. I can easily handle multiple sources of information simultaneously and process them effectively.	3.69	Often
2. I prefer learning environments that are open-ended and allow for exploration and experimentation.	4.18	Often
3. I am able to see connections and patterns between different pieces of information quickly.	3.81	Often
4. I am good at understanding and responding to complex situations that require rapid decision-making.	3.73	Often
5. I often multitask and can switch between tasks quickly and easily.	3.82	Often
Average wm	**3.85**	**Often**
Sequential Processing		
In learning science…		
1. I prefer to complete tasks one step at a time, focusing on each detail before moving on.	4.03	Often
2. I enjoy working on tasks that have a clear beginning, middle, and end.	4.36	Always
3. I follow instructions and procedures closely, ensuring I don't miss any steps.	4.32	Always
4. I find it helpful to make lists and to-do notes to organize my thoughts and actions.	4.07	Often
5. I am easily distracted by new information or interruptions when working on a task.	3.79	Often
Average wm	**4.11**	**Often**
Top-down Processing		
In learning science…		
1. When I am presented with a new problem, I usually start by thinking about how it relates to things I already know.	4.20	Always
2. I find it helpful to organize information into categories or groups based on my existing knowledge.	4.15	Often
3. I often use my prior knowledge to fill in information gaps or to understand things that are ambiguous.	4.01	Often
4. I am able to use my understanding of general principles to solve specific problems.	4.05	Often
5. I find it easier to learn new information when it is presented in a way that connects to my existing knowledge.	4.31	Always
Average wm	**4.14**	**Often**

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Bottom-up Processing			
In learning science…			
1.	I tend to focus on individual details and facts before forming an overall understanding.	4.13	Often
2.	I find it easier to learn by starting with specific examples and then working towards general principles.	4.21	Always
3.	I often break down complex information into smaller, more manageable parts.	3.98	Often
4.	I rely on my senses to gather information and form impressions of the world.	4.01	Often
5.	I feel more confident when I have a solid foundation of facts and details to build upon.	4.39	Always
	Average wm	**4.14**	**Often**

Legend: 1.00-1.79 – Never; 1.80-2.59 – Rarely; 2.60-3.39 – Sometimes; 3.40-4.19 – Often; 4.20-5.00 – Always

The data of STE students showed a rich variety of information processing patterns in learning science. Notably, the two categories of processing strategies, namely top-down and bottom-up, were rated highly with the former receiving slightly higher average scores than the latter.

Parallel Processing

The data reveal that STE students "often" have parallel processing when learning science, with an average weighted mean of 3.85, demonstrating the ability to handle multiple sources of information simultaneously, identify connections between ideas, and thrive in adaptable environments. This capacity for parallel processing is valuable in scientific work, as many problems require integrating knowledge from various fields (Vinney, 2023). STE students' preference for open-ended learning environments, which encourage exploration and experimentation, aligns with the nature of scientific inquiry.

This finding supports the concept of parallel processing, wherein individuals absorb multiple pieces of information concurrently. STE students exhibit this skill by managing diverse information sources, seeking relationships between ideas, and excelling in flexible learning environments. Their ability to engage in parallel processing makes them well-suited for addressing complex scientific problems that demand the integration of information from various fields. Furthermore, their preference for open-ended learning aligns with scientific practices, enhancing their capacity for parallel learning.

Although parallel processing is not the most preferred style among STE students, their inclination towards it highlights their cognitive flexibility. This adaptability in thinking, problem-solving, and responding to change is crucial in the dynamic field of science and technology. This aligns with Saputra et al. (2023), who emphasized the importance of cognitive flexibility as a professional competency for STEM graduates.

Sequential Processing

The data reveals the findings of the study, STE students "often" process information in a sequential pattern, with an average weighted mean of 4. 11. This implies that these students often use a systematic approach when learning science, and prefer tasks that are well defined with clear starting and ending points. They appreciate order and tidiness and prefer such elements as lists and to-do notes to arrange their ideas and tasks. This methodical way of learning is also reflected in their desire to solve a problem step by step, paying attention to each aspect of the process. Also, these learners are well oriented in terms of following instructions and procedures in order to achieve precision and comprehensiveness in their work.

The results of this study showing that STE students preferred sequential processing are in line with the study by Veselinovska (2014) on the effect of teaching methods on students' performance in Biology class. Veselinovska's research revealed that STE students, learn sequentially and systematically with much emphasis on order and structure. This is evidenced by the kinds of tasks they like, their reliance on tools to help them organize, and their ability to follow specific instructions. Although sequential processing is not the only learning strategy among STE students, it is relevant to the students' learning processes. Knowing this preference can help educators adapt to the learning preferences of the STE students and perhaps improve their performance and interest in scientific subjects.

Further, the findings of this study are supplemented by the study done by Lkama and Musa (2023) on the impact of successive teaching methods on achievement and interest in automobile technology. Based on their study, students often follow a sequential pattern, which is characterized by systematic learning. This preference is manifested in their approach to tasks with defined procedures, their utilization of tools that help in organizing their work, and their ability to work according to a set procedure. As pointed out by Lkama and Musa (2023), this logical approach might be one of the reasons for their success in academics especially those technical disciplines that require progressive mastering of theories and techniques. Knowing this preference can help educators to adjust their approaches and make them more suitable to the learning styles of STE students and therefore, improve their attitude and results in these subjects.

Top-down Processing

From the data presented above, it is apparent that STE students have a top-down processing based on their average weighted mean score of 4.14, with a verbal description of “often”. This information processing pattern is characterized by using previous knowledge and concrete scientific material for further understanding of the received information. All the STE students were always able to express how they use prior knowledge to tackle new problems, group information and fill in for missing information. They indicated their understanding when knowledge is presented in a way that is linked to what is already familiar to them, which enables the elaboration of prior knowledge. This implies that STE students are quite able to assimilate new information with the existing knowledge structure they have by using the prior knowledge as a framework for reconstructing new information.

One STE student stated:

“I learn better when I can relate the things I have been taught and learned before to the lessons that our teachers will teach, especially in science. For example, when we were studying how to solve Speed and Acceleration, I learned it better after I remembered how to solve division and multiplication. In this way, I also feel that the information in my mind is more organized.”

The STE students’ learning style is characterized by the integration of new information with prior knowledge to construct a more comprehensive knowledge structure that enables efficient categorization, prediction, and gap-filling. This ability to relate information with what they have learned in the past not only improves their understanding but also shows that they have a knack for constructing knowledge networks.

A science teacher observed:

“In my classes, STE students often come in with a good grasp of basic ideas. They like to connect what they're learning to things they already know. For example, if I'm teaching a new idea in physics, they'll start comparing it to other science stuff they've learned.

“These students are also good at using what they already know to figure out tricky parts or ask smart questions. They like to build on their knowledge, and I often see them making diagrams or charts to connect new ideas to old ones. This helps them learn better.”

This active integration of prior knowledge suggests that STE students are not passive learners but actively construct new knowledge.

This study's findings align with constructivist learning theory (Halpern, 2017) and cognitive theory, emphasizing the importance of top-down processing in learning (Oh & Lee, 2014).

Bottom-up Processing

From the bottom-up processing analysis, the research findings suggest that STE students favor the "often" choice as represented by the average weighted mean of 4.14. This means that STE students often learn through the accumulation of facts and details that are then pieced together to come up with a coherent understanding. For that reason, they often turn to case studies and numbers as their building blocks for creating more general categories.

This approach implies that STE students can learn better when they start by focusing on details and facts as if they were learning with building blocks and then trying to see the big picture. They would rather work with real-life examples that can be seen or felt to be able to understand concepts. In case of finding a task complex, they tend to divide the information into chunks that are easier to handle. Also, they rely on senses to obtain information and come up with feelings about the surrounding environment.

This bottom-up approach is evident in a student's statement: "To me, every detail in a lesson is very important... I need concrete examples first to understand things. It's like building a house – we need a strong foundation made of each piece of hollow block before the whole house can be built." The student's emphasis on foundational knowledge and the use of tangible examples aligns with the characteristics of bottom-up learners.

A science teacher's observations further corroborate this finding: "These STE students also love hands-on activities and real-life examples... It's also helpful to teach them step-by-step, explaining one concept at a time." The teacher's emphasis on practical applications and incremental learning resonates with the preferences of STE students.

The bottom-up approach is particularly beneficial for scientific learning, which often involves intricate and integrated structures best explained through reductionist methods. However, it is important to acknowledge that this approach may present challenges in problem-solving scenarios requiring predictions or deductions from limited information.

These findings resonate with Cherry's (2023) assertion that bottom-up processing enhances scientific thinking skills by emphasizing empirical observation and data analysis. Furthermore, Mayer's (2014) handbook supports instructional methods that introduce concepts through concrete examples before progressing to abstract notions, mirroring the pedagogical approaches employed by the science teacher to cater to STE students' learning styles.

Overall, the identification of diverse information processing patterns, including bottom-up processing, allows science teachers to better accommodate the varied learning preferences of STE students, thereby optimizing their educational experience and fostering their potential as future scientists, technologists, and engineers.

Table 4. Significant Relationship Between Students' Profile and their Learning Styles and Information Processing Patterns

		Age	Sex	Grade Level	GWA
Learning Style					
	Correlation Coefficient	.062	**.223****	.033	**.169****
Activist	Sig. (2-tailed)	.321	.000	.591	.006
	N	261	261	261	261
	Correlation Coefficient	.023	.038	-.018	**.154***
Theorist	Sig. (2-tailed)	.714	.543	.777	.012
	N	261	261	261	261
	Correlation Coefficient	.023	.053	-.006	.095
Pragmatist	Sig. (2-tailed)	.709	.392	.922	.126
	N	261	261	261	261
	Correlation Coefficient	.034	.109	.059	.120
Reflector	Sig. (2-tailed)	.588	.078	.345	.052
	N	261	261	261	261

Information Processing Patterns					
	Correlation Coefficient	-.029	.084	-.010	**.215****
Parallel	Sig. (2-tailed)	.635	.178	.871	.000
	N	261	261	261	261
	Correlation Coefficient	-.009	**.178****	-.009	.087
Sequential	Sig. (2-tailed)	.883	.004	.883	.163
	N	261	261	261	261
	Correlation Coefficient	-.025	-.034	-.032	**.204****
Top-down	Sig. (2-tailed)	.693	.579	.604	.001
	N	261	261	261	261
	Correlation Coefficient	-.086	.052	-.059	**.154***
Bottom-up	Sig. (2-tailed)	.166	.401	.342	.013
	N	261	261	261	261

*****Correlation is significant at the 0.01 level (2-tailed)***
****Correlation is significant at the 0.05 level (2-tailed)***

Profile of Students and Learning Styles

The data from Table 4 revealed a significant relationship between students' gender and the activist learning style in learning science. Female students are most likely to manifest an activist style in learning science concepts, as evidenced by the positive correlation (.223, significant at 0.01 level) between their gender and the activist learning style. There is also a significant relationship between students' general weighted average and activist style (.169, significant at 0.01 level) and theorist style (.154, significant at 0.05 level) in learning science. The higher the general weighted average, the more they display activist and theorist styles in learning science concepts. These findings rejected the null hypothesis, which stated that there is no significant relationship between student profiles in the STE program and their learning styles. On the other hand, age and grade level of students are not significantly related to learning styles as to activist, theorist, pragmatist, and reflector styles in learning science.

The results of this study align with Wang et al. (2023), highlighting the complexity of gender and learning styles in STEM education, particularly the positive relationship between female students and the activist learning style in science (O'Leary et al., 2020). This preference for practical activities and group work among female students necessitates gender-specific educational methodologies for inclusive STEM classrooms.

The findings are consistent with Freiberg-Hoffmann (2017), suggesting that aligning teaching strategies with preferred learning styles, such as the activist style prevalent among female students, can enhance knowledge acquisition. The positive relationship between the general weighted average (GWA) and activist/theorist learning styles implies the effectiveness of a combined hands-on and conceptual approach in teaching science.

Furthermore, this study supports Bernard et al. (2019) and Bernacki et al. (2021), emphasizing the need for personalized learning strategies responsive to learners' needs and styles to improve STEM academic achievements. The lack of correlation between age/grade level and learning styles reinforces the importance of differentiated instruction in science education.

Overall, this research contributes to the growing body of evidence advocating for the consideration of individual learning styles in science education, promoting inclusivity, and tailoring teaching approaches to enhance student success in STEM fields.

Students' Profile and Information Processing Patterns

The analysis of Table 4 shows that there are relationships between the STE students' profiles and information processing patterns. The sex of students is significantly related to sequential information processing patterns. Female students are most likely to manifest sequential information processing patterns.

Additionally, the General weighted average is significantly related to information processing patterns of students as to parallel, top-down, and bottom-up.

As for gender, a notable relationship between the female students and the sequential information processing was established (.178, significant at 0. 01 level). This seems to imply an inclination among female students to learn science concepts in a sequential pattern. Furthermore, the study revealed a significant relationship between a student's GWA and their preference for parallel (.215, significant at 0. 01), top-down (.204, significant at 0. 01 level), and bottom-up (.154, significant at 0.05 level) processing. This means that students who perform well academically in science might be in a better position to deal with multiple sources of information simultaneously, use both conceptual and detailed information, and be more flexible in dealing with science tasks. These findings rejected the null hypothesis, which stated that there is no significant relationship between student profiles in the STE program and their information processing patterns.

García-Holgado et al. (2020) highlighted a significant gender gap in STEM participation, particularly in Latin America and Europe. To address this, a study examining gender parity deficits in STEM courses was proposed, focusing on attraction, access, retention, and guidance. The study aligns with suggestions by García-Holgado et al. (2020) to consider gender in implementing learning preferences. Adopting sequential learning approaches preferred by many female learners could create a more inclusive learning environment, potentially encouraging more women to pursue STEM fields.

The study found a strong correlation between GWA (Grade Weighted Average) and different information processing styles, suggesting that incorporating diverse learning modalities in science education is beneficial. Utilizing interactive visualizations and multimodal tools can facilitate parallel, top-down, and bottom-up processing, positively impacting students' overall comprehension and performance.

The study provides insights into the complex ways students learn and process information in science. While significant relationships were identified, insignificant ones also exist, highlighting the diversity and uniqueness of student learning preferences. Science teachers can design more inclusive and effective learning environments by understanding these diverse learning styles and information processing approaches.

Recent research by Onyejiaku (2015) further emphasizes the importance of tailoring instructional approaches to students' information processing patterns, demonstrating a positive impact on mathematics performance. This underscores the need for teachers to develop diverse teaching methods to cater to different learning styles.

In sum, these findings highlight the importance of considering student characteristics in science education. Understanding students' varied information processing patterns allows for the development of more inclusive learning environments. By employing a combination of instructional methods, science teachers can effectively engage learners with different processing styles, enhancing students' interest, understanding, and performance in science.

Table 5. Significant Relationship Between Students' Learning Styles and Information Processing Patterns

				Information Processing Patterns		
	Learning Style		**Parallel**	**Sequential**	**Top-down**	**Bottom-up**
Spearman's rh	Activist	Correlation Coefficient	**.463****	**.354****	**.345****	**.394****
		Sig. (2-tailed)	.000	.000	.000	.000
		N	261	261	261	261
	Theorist	Correlation Coefficient	**.518****	**.376****	**.482****	**.431****
		Sig. (2-tailed)	.000	.000	.000	.000
		N	261	261	261	261
	Pragmatist	Correlation Coefficient	**.399****	**.285****	**.427****	**.342****
		Sig. (2-tailed)	.000	.000	.000	.000
		N	261	261	261	261

o	Reflector	Correlation Coefficient	**.477****	**.449****	**.497****	**.497****
		Sig. (2-tailed)	.000	.000	.000	.000
		N	261	261	261	261

****. Correlation is significant at the 0.01 level (2-tailed).***

Table 5 shows the correlation between students' learning styles and their modes of information processing, based on Spearman's rho. The data reveals that there are significant interrelationships between students' learning styles and their information processing patterns in learning science. This means that STE students show a complex and integrated approach to their science learning. Contrary to the traditional students, STE students show preferences of learning styles for the specific task or environment. They can be reflective and analytical, apply theory to practice, take a hands-on approach, and be pragmatic in problem-solving. Similarly, they can break down information, process it in a linear fashion, make connections to prior knowledge, and even handle multiple things at once. These findings rejected the null hypothesis, which stated that there is no significant relationship between student learning styles and information processing patterns.

The study's findings align with the existing literature on the complexity of learning styles and information processing patterns. STE students' ability to switch to a context-based approach indicates their capacity for self-regulated learning (Miller & Manderfeld, 2021). Theorist learners' emphasis on theoretical aspects correlates strongly with top-down processing, supporting their focus on the "why" behind scientific occurrences (Saunders & Wong, 2020), aligning with the K to 12 curriculum (DepEd, 2021). Pragmatist learners, valuing practical application, also correlate with top-down processing, suggesting they prioritize comprehension before application (Magolda, 2023). This finding aligns with Magolda's research on how graduates construct meaning in their lives and work, highlighting the importance of an internal compass for informed choices (Magolda, 2023). These insights can guide Filipino science teachers in tailoring instructional strategies to diverse learning styles and information processing patterns, enhancing learning experiences and fostering scientific and technological advancement in the Philippines (CHED, 2022).

5. Conclusions

Based on the findings of the study, the following conclusions were drawn:

1. STE students are generally adolescents (13-14 years old) with a nearly even gender distribution and consistent enrollment across STE junior high school grades. Most students performed well academically.
2. STE students exhibit a blend of learning styles in learning science, with a strong agreement for Theorist style and Reflector style. However, there are also students who learn best through Activist style and Pragmatist style.
3. STE students often process information in a way indicating their ability to relate new information to prior knowledge (Top-Down Processing), focusing on details (Bottom-Up Processing), alongside a comfort with a step-by-step approach (Sequential Processing), and handling multiple information sources simultaneously (Parallel Processing).
4. There is a significant relationship between the profiles of STE students and their learning styles and information processing patterns. In particular, STE female students are more likely to exhibit an activist learning style and sequential information processing pattern in learning science concepts. Additionally, STE students who have higher general weighted averages are more inclined towards the activist and theorist learning styles, as well as parallel, top-down, and bottom-up information processing patterns.

5. Significant interrelationships exist between students' learning styles and their information-processing patterns in learning science. This underscores a connection between how students prefer to learn and how they process information in learning science.

6. Recommendations

Based on the drawn conclusions, the study suggests the following for future researchers:

1. School administrators should establish partnerships with education researchers to investigate and track changes in motivations, interests, and learning preferences among STE students as they progress from early adolescence to late adolescence. This cooperation can help to obtain valuable information for more effective advancement of interventions, which help diverse students to engage, persist, and succeed in the STE program.
2. Future researchers should utilize the findings of this study to develop assessment tools that adaptably capture students' experiences and personal views regarding learning styles in the STE context. These tools can help in understanding the ways the students learn in the STE program, ultimately leading to more effective instructional strategies and personalized learning experiences.
3. Science teachers should investigate how the incorporation of technology in both learning contexts and everyday life influences STE students' information processing patterns, ensuring that educational strategies remain relevant and effective within the present technological environment.
4. Science teachers should design and incorporate science activities that intentionally promote gender equality and cater to diverse learning styles and information processing patterns. These activities should foster collaboration, showcase diverse role models in science, and connect with all real-world applications relevant to all genders. Additionally, teachers must consider teaching students about different learning styles and information processing patterns and encourage them to reflect on their preferences to enhance metacognitive skills and academic performance. This approach has the potential to increase students' engagement, enhancement of their mastery of concepts, and sense of belonging in the STE classroom.
5. Science teachers should design, implement, and evaluate the effectiveness of integrating various educational technologies, such as gamified learning platforms, virtual laboratories, and adaptive learning systems, into their teaching methods to cater to STE students with diverse learning styles and information processing patterns.

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