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Profiling Gender-Based Disparities in Scientific Literacy Among STEM Students in the Division of Eastern Samar: Insights for Targeted Educational Interventions

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Abstract: *This study investigated scientific literacy among Senior High School STEM students in the Division of Eastern Samar (rural area in the Philippines) which is also an adapted study from an international perspective, focusing on gender and grade level differences. Using validated questionnaires, four dimensions of scientific literacy were assessed that includes: (i) habits of mind, (ii) character and values, (iii) science as a human endeavor, (iv) metacognition/self-direction, and two categories in terms of: (i) methods of inquiry and (ii) interpreting quantitative data. Results revealed significant deficiencies in inquiry and data analysis skills, with most students scoring low. Grade 11 students outperformed Grade 12 students, suggesting a decline in literacy levels. Males slightly outperformed females, though both groups demonstrated inadequate overall performance. These findings highlight critical gaps in inquiry-based learning and data analysis instruction within the STEM curriculum. Recommendations include integrating technology-enhanced learning, project-based approaches, and gender-sensitive pedagogies to improve scientific literacy outcomes, bridge gender disparities, and enhance critical competencies among STEM students in the rural settings.*
Keywords: *Scientific Literacy, STEM Students, Gender Differences, Inquiry-Based Learning, Data Analysis Skills*

INTRODUCTION

Background of the Study

Hung et al. (2012), Jackman and Morrian-Webb (2019), Morita et al. (2016), and Sparks-Wallace (2007) revealed that gender differences significantly impact the academic performance of STEM students. Ullah and Ullah (2019) agreed, noting that males performed academically better than females. Despite these findings, disparities are persistent in various domains, including scientific literacy. Therefore, this study, entitled "Gender-Based Differences in Scientific Literacy Levels Among Grades 11 and 12 STEM Students in the Schools Division of Eastern Samar: Basis for Crafting an Innovative Teaching-Learning Activity," seeks to explore these disparities during a critical and formative period of secondary education.Gender-based differences in educational outcomes, particularly in scientific literacy, have become a growing concern among educators and researchers. Scientific literacy, as defined by Utami et al. (2016), refers to an individual's scientific knowledge and their ability to use this knowledge to identify questions, acquire new information, explain scientific phenomena, and draw evidence-based conclusions about science-related issues. It also involves understanding the characteristic features of science as a form of human knowledge and inquiry, being aware of how science and technology interact with intellectual and cultural environments, and demonstrating a willingness to engage with science-related issues and ideas as a reflective citizen. However, research indicates that gender disparities in scientific literacy can significantly impact students' academic trajectories, often leading to the underrepresentation of certain genders in STEM fields. These disparities reflect broader societal biases and stereotypes, underscoring the need for targeted educational interventions to address and mitigate these differences. By examining the specific ways in which gender influences scientific literacy, educators can develop more effective and inclusive teaching methods that support all students in reaching their full potential in science and technology.Scientific literacy is essential for all students, equipping them with the skills to navigate and engage with the increasingly complex world of science and technology. It encompasses not only knowledge of scientific concepts but also the ability to apply scientific thinking to real-world problems. The importance of fostering scientific literacy among high school students cannot be overstated, as it lays the foundation for future academic and career pursuits in STEM fields. However, emerging evidence suggests that gender-based differences in scientific literacy may hinder equitable educational outcomes, potentially perpetuating gender imbalances in STEM professions. Understanding students' scientific literacy levels can provide a benchmark for improving learning competency standards, the curriculum, teaching models, and an evaluation of learning outcomes in science.This study is crucial for several reasons. First, it addresses a gap in localized research specific to Eastern Samar, an educational hub where resources and outcomes can vary significantly from national trends. By focusing on Grades 11 and 12 STEM students, the study targets a pivotal stage where students are making critical decisions about their future academic and career paths.

Understanding the extent and nature of gender-based differences in scientific literacy at this stage can inform targeted interventions that support both male and female students equitably.

Second, the study's findings will serve as a foundation for crafting a structured differentiated teaching-learning activity. Differentiated instruction, which involves tailoring educational approaches to meet the diverse needs of learners, is an effective strategy for addressing individual differences in educational settings. By identifying specific areas where male and female students diverge in their scientific literacy, educators can develop tailored instructional methods that promote a more inclusive and supportive learning environment.

Lastly, this research aligns with broader educational and societal goals of promoting gender equity and empowering all students to achieve their full potential. By systematically assessing and addressing gender-based differences in scientific literacy, this study contributes to the ongoing efforts to create a more equitable and just educational system. The insights gained from this research will not only benefit the STEM students of Schools Division of Eastern Samar but can also provide valuable implications for other regions with similar educational contexts.

Objectives of the Study

This study assessed the Scientific Literacy (SL) levels of Senior High School STEM students of DepEd Eastern Samar division.

Specifically, this study sought to:

describe the demographic profile of senior high school STEM students in terms of:

gender,

grade level,

examine the levels of scientific literacy among senior high school STEM students in terms of the four (4) dimensions (using GSLQ instrument), namely:

habits of mind,

character and values,

science as human endeavor,

metacognition and self-direction, and

in terms of two (2) categories (based on the TOSLS instrument), as follows:

understand methods of inquiry that lead to scientific knowledge,

rganize, analyze, & interpret quantitative data & scientific information; and

determine whether there is a significant difference in scientific literacy levels between Grades 11, and 12;

verify whether there is a significant difference in scientific literacy levels between males and females Senior High School STEM students.

Scope and Delimitation of the Study

This study focused is on gender-based differences in scientific literacy levels of SHS – STEM students. In literature reviews conducted by Coppi et al., (2023), it is found out that there are many research instruments that can be used to assess scientific literacy such as the TBSL (Laugksch and Spargo, 1996a; 1999), TACB-R (Nascimento-Schulze, Camargo and Wachelke 2006), Scientific Vocabulary Instrument (Brossard and Shanahan, 2006), ScInqLiT (Wenning, 2007), TACB (Nascimento-Schulze, 2006; Coppi and Sousa, 2019), SLiM (Rundgren, Rundgren, Tseng, Lin and Chang, 2010), Scientific Literacy Assessment (Koedsri and Ngudgratoke, 2018), SToSLiC (Jufri, Hakim and Ramdani,2019), TOSLS (Gormally et al., 2012; Waldo, 2014; Gomes and Almeida, 2016; Souza, 2019; Utami and Hariastuti, 2019; Shaffer, Ferguson, and Denaro, 2019), ScInqLiT (Innatesari, Sajidan and Sukarmin, 2019), and GSLQ (Mun et al., 2015; Pramuda, Mundilarto, Kuswanto and Hadiati, 2019). However, this study will use the GSLQ (Mun et al., 2015; Pramuda, Mundilarto, Kuswanto and Hadiati, 2019) questionnaire instrument as it is based on the theoretical framework of scientific literacy suggested by Choi, Kim, Lee, Mun, Choi, Krajcik and Shin (2011) and Choi, Lee, Shin, Kim and Krajcik (2011) for citizenship education in the 21st century, and purposely evaluates students' overall scientific literacy along four dimensions: habits of thought; character and values; science as a human activity; and metacognition and self-direction.

Further, for data consistency verification and comparison, this study also used the TOSLS as this research instrument is based on the National Research Council, Project 2061, findings from a Biology teacher survey, evaluations by expert Biology educators, student interviews, and statistical analyses for the purpose of assessing students' proficiency in the use of 9 scientific literacy skills, distributed into two categories: Category 1-skills related to recognizing and analyzing the use of research methods that lead to scientific knowledge (Skill 1: identify a valid scientific argument; Skill 2: evaluate the validity of sources; Skill 3: evaluate the uses and misuses of scientific information; Skill 4: understand the elements of a research project and how they impact scientific findings/conclusions); and Category 2-skills related to the organization, analysis, and quantitative interpretation of scientific data and information (Skill 5: create an appropriate graph from data; Skill 6: read and interpret graphical representations of data; Skill 7: solve problems using quantitative skills, including basic statistical analysis; Skill 8: understand and interpret basic statistics; Skill 9: justify inferences, predictions, and conclusions based on quantitative data).

Although the questionnaire instruments mentioned were used in this study to assess STEM students' scientific literacy levels, they can still accurately measure other populations, including those in other countries as proven by the available related studies in the online journal sites. Additionally, this study only revealed comparability between samples in terms of gender. Other variables such age, type of school, and lower grade levels (Grades 7 to 10) in secondary school will not be explored.

Moreover, the study was conducted only among Secondary Senior High Schools offering STEM strand in DepEd Eastern Samar Division, specifically in the second district of Eastern Samar.

Siginificance of the Study

This research provides bases for crafting innovative teaching-learning activities.

With this, the results provide additional information and insights to different people in the educational community as discussed hereunder:

To the Science Teachers. This study may help science teachers understand gender-based differences in scientific literacy among STEM students. It may enable them to adjust their teaching strategies to support both male and female students more effectively and meaningfully.

To the Principals. The School Principals may gain insights to better support science teachers in addressing gender disparities. This knowledge may help them allocate resources and promote initiatives that enhance scientific literacy for all students.

To the Division Science Program Specialist/Coordinator. The study may provide a foundation for developing division-wide policies and programs to address gender-based disparities. It will guide the creation of innovative strategies to ensure equal opportunities in STEM education.

To the Students. Students may benefit from a more equitable learning environment that supports both male and female learners. The study aims to remove barriers and foster an empowering educational experience.

To Future Researchers. This study may serve as a valuable resource for those exploring gender differences in education. It may contribute to the body of knowledge and provide a foundation for further research in this area.

Definition of Terms

The terms that follows were used in the study as defined conceptually and operationally:

Character. Refers to the development of an individual's ethical and moral qualities that enable them to function as responsible global citizens. This includes the cultivation of values and traits that foster sensitivity to global issues, respect for other human beings and the environment, and the ability to take responsible actions in addressing and resolving these issues (Berkowitz & Simmons, 2003; Hodson, 2003; Lee, Chang, Choi, Kim, & Zeidler, 2012; Zeidler, Sadler, Simmons, & Howes, 2005).

Gender-Based Differences. Refers to the variations in experiences and psychological consequences perceived by different genders, particularly regarding issues like gaps in academic performance and cyberbullying among others. These differences can produce divergent cultural narratives and impacts on individuals (Tost, et al. 2022).

Habits of the Mind. Involve skills essential for exploring scientific issues and solving various problems, including effective communication, collaboration, systematic thinking, non-routine problem-solving, and evidence-based reasoning (Choi et al., 2011). This concept requires individuals to interpret and use information from diverse sources while engaging with others to develop shared understandings (AAAS, 2007; Dillenbourg, 1999).

Human Endeavor. In the scientific concept, it refers to the socially-driven pursuit of knowledge that influences decision-making and problem-solving. It encompasses the application of scientific understanding in making informed choices about the limits and capabilities of science (Aikenhead, 1985; Zeidler et al., 2002). Scientific practices are inherently social, making scientific knowledge provisional, subjective, and intertwined with human life (Abd-El-Khalick, 2001; Lederman, 1992).

Innovative Learning. Is an educational approach that fosters continuous exploration and independent idea generation among students. It leverages technologies such as augmented reality and deep learning, alongside practical activities like DIY projects, to enhance understanding through hands-on experience. This method also emphasizes collaborative learning, aiding in the development of teamwork and leadership skills essential for future roles in creative leadership, UNext (2020).

Innovative Teaching. Refers to the application and integration of creativity and novel approaches by educators, resulting in changes to teaching methods and styles (Kalyani & Rajasekaran, 2018). It involves the integration of new ideas, methodologies, and technology to enhance student learning outcomes.

Metacognition. Defined as the active engagement of cognitive resources by an individual to regulate and improve their own thinking processes, thereby enhancing their capacity to comprehend and apply knowledge (Brown, 1987; Leahey & Harris, 1997). This concept is fundamental to lifelong learning, as it plays a crucial role in navigating the complexities of modern life, where continual learning and adaptation are necessary due to constant scientific and technological advancements (Fischer, 2000). Metacognition enables individuals to assess their understanding of specific content, evaluate the relevance and sufficiency of evidence in supporting arguments, and consider how different perspectives align or differ from their own (Choi et al., 2011).

Self-direction. Refers to an individual's ability to autonomously plan, monitor, and evaluate their learning and problem-solving processes to achieve a deeper understanding and successful task completion (Collins, 1994; Leahey & Harris, 1997; Maitland, 2000). It encompasses three critical aspects: self-directed planning, self-directed monitoring, and self-directed evaluating (Brown, 1987; Leahey & Harris, 1997). Self-directed planning involves determining the necessary steps to accomplish a task (Voss, Lawrence, & Engle, 1991), while self-directed monitoring pertains to the awareness of one's comprehension and task performance during the execution of that task (Nietfeld, Cao, & Osborne, 2005). Finally, self-directed evaluating involves reflecting on the task process and assessing the appropriateness and effectiveness of the decisions made (Sinnott, 1989). These components are vital for continuous learning and adaptation, enabling individuals to respond effectively to personal, societal, and global challenges (Choi et al., 2011).

Science. Is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence (International Science Council, 2022).

Scientific Literacy. Defined as the set of competencies required for individuals to critically assess and address societal issues influenced by advancements in science, technology, and information. This construct includes a comprehensive understanding of the nature of science, adeptness in information management, and the ability to engage in effective communication and collaboration (Ke et al., 2021). It necessitates the integration of these competencies into science standards, curricula, and pedagogical materials (Mun et al., 2015). Scientific literacy is characterized as a socially constructed and context-dependent construct, with variations influenced by sociocultural factors and temporal changes (Laugksch, 2000; Yuenyong & Narjaikaew, 2009).

Teaching-Learning Strategy. A teaching-learning strategy is a systematic approach employed by educators and students to enhance the educational process. It involves the design and implementation of innovative methods and forms of teaching, as well as examination and evaluation practices, aimed at fostering and maximizing student creativity (Le Thuy Hang & Vu Hong Van, 2021).

Values. In the context of global citizenship research, are principles that guide individuals to be responsive to global issues, respect others and the environment, and take responsible actions (Berkowitz & Simmons, 2003; Hodson, 2003; Lee et al., 2012; Zeidler et al., 2005). These include an ecological worldview, which acknowledges the interconnection between humans and nature (Smith & Williams, 1999), moral and ethical sensitivity, reflecting empathy for those affected by socio-scientific issues (Ruiz & Vallejos, 1999), and socio-scientific accountability, emphasizing a shared responsibility to address global challenges (Boyes et al., 2009; Elmose & Roth, 2005; Mueller & Zeidler, 2010; Roth & Lee, 2004).

Acronyms

DepEd – Department of Education
GSLQ - Global Scientific Literacy Questionnaire
OECD - Organization for Economic Co-operation and Development
PISA – Program for International Student Assessment
ScInqLiT - Scientific Inquiry Literacy Test
SGDs – Sustainable Development Goals
SHS – Senior High School
SLA - Scientific Literacy Assessment
SLiM - Scientific Literacy Measurement
STEM – Science, Technology, Engineering, and Mathematics
SToSLiC - Test of Scientific Literacy Integrated Character
TACB - Test of Basic Scientific Literacy
TACB-R: Reduced Test of Basic Scientific Literacy
TBSL - Test of Basic Scientific Literacy
TOSLS - Test of Scientific Literacy Skills
UNESCO - United Nations Educational, Scientific and Cultural Organization

METHODS AND METHODOLOGY

This chapter presents the procedure of how the study was conducted. This includes the research design, respondents of the study, the instruments that were used in the data collection, the procedure, and the statistical tools in analyzing the data gathered.

Research Design

Quantitative research was the design of this study. Specifically, the process of conducting the descriptive-correlational approach to verify correlations between gender differences and scientific literacy levels of STEM senior high school students was followed. Descriptive-correlation research design is used to investigate variables of interest and examine whether relationships exist between or among them. In thin design type, the primary area of interest under investigation is not manipulated by the researcher. Researchers investigating descriptive-correlational research questions commonly use survey methods to gather data (Miksza et al., 2023). Surveys are an efficient method for gathering large amounts of information about such things as in this study the STEM students' gender and scientific literacy levels.

Locale of the Study

This study was conducted in all Secondary Senior High Schools offering STEM Strand, located in the different municipalities in the Second District of Eastern Samar.

Table 1: Table 1, Secondary Schools (Senior High School) in the Second District of Eastern Samar

Municipalities (where schools are situated)	Secondary Schools (locale of study)
Gen. McArthur, Eastern Samar	Gen. McArthur National Agricultural School
Salcedo, Eastern Samar	Salcedo National High School
Guiuan, Eastern Samar	Guiuan National High School

Table 1. shows the secondary schools offering STEM Strand.

Research Respondents and Sampling Procedure

The respondents of this study were the senior high school students specifically, those enrolled in the STEM Strand. They were obtained through purposive sampling technique. A total of three hundred sixty-four (364) STEM students in Grades 11 and 12 were purposely identified as respondents of this study.

Table 2: Table 2, Respondents in the Secondary Senior High Schools

Secondary Schools (locale of study)	Number of Respondents (STEM Students)	
	Grade 11	*Grade 12*
1. Gen. McArthur National Agricultural School	28	45
2. Salcedo National High School	53	78
3. Guiuan National High School	84	76
Subtotal	165	199
TOTAL	364	

Table 2 summarized the number of respondents in each identified school offering STEM Strand based on the pre-survey.

Research Instrument

GSLQ developed by Mun et al., 2015; Pramuda, Mundilarto, Kuswanto and Hadiati (2019) research instrument with established validity and reliability based on the theoretical framework of scientific literacy for citizenship education in the 21st century will be used in this study. Also, for data consistency verification and comparison, this study will also use the TOSLS as this research instrument is based on the National Research Council, Project 2061, purposely developed to assess students' proficiency in the use of nine (9) scientific literacy skills. This instrument likewise underwent validity and reliability testing and both research instruments were already used by many schools in different countries assessing scientific literacy among students.

The first survey instrument (GSLQ) has two parts. Part 1 will ask the student-respondents their demographic profile such as gender, grade level, and their school. Part 2 will assess their scientific literacy in four dimensions, namely: habits of thought; character and values; science as a human activity; and metacognition and self-direction. The later survey instrument (TOSLS) is composed of multiple-choice questions that students need to answer to assess their scientific literacy distributed into two categories: Category 1-skills related to recognizing and analyzing the use of research methods that lead to scientific knowledge (Skill 1: identify a valid scientific argument; Skill 2: evaluate the validity of sources; Skill 3: evaluate the uses and misuses of scientific information; Skill 4: understand the elements of a research project and how they impact scientific findings/conclusions); and Category 2-skills related to the organization, analysis, and quantitative interpretation of scientific data and information (Skill 5: create an appropriate graph from data; Skill 6: read and interpret graphical representations of data; Skill 7: solve problems using quantitative skills, including basic statistical analysis; Skill 8: understand and interpret basic statistics; Skill 9: justify inferences, predictions, and conclusions based on quantitative data).

Data Gathering Procedure

With the permission from the school authorities, researchers asked the STEM students their most convenient time to answer the survey questionnaires which were given to them personally. A short orientation about the survey was conducted first assuring them at the same time confidentiality of their responses and identity as respondents in the study. The survey questionnaires were retrieved after a one and half hour time limit of answering. While answering the TOSLS instrument, student-respondents were not allowed to use calculators, tablets, smartphones, or any information sources, including books and websites. For each of the 28 multiple-choice questions, students were instructed to choose 1 correct answer from four possible options. One point was counted for the correct answer in each item, while no points were given for choosing distractors or incorrect answers.

Ethical Considerations

Communication letters were sent to the DepEd Eastern Samar Division Superintendent asking permission to conduct the study among the secondary senior high schools located in the second district of Eastern Samar. With the approval of the superintendent, consent letters were sent also to the district supervisors and the school heads/principals. Upon approval, letters seeking permission and convenient time for the distribution of the questionnaires were sent to advisers of the student-respondents. Consent letters were also sent to the identified STEM student-respondents respectfully asking them to be part of this study.

With the permission of the respondents, data were gathered through questionnaires. The data were kept in strictest confidentiality and used solely for the study. Free will and voluntary participation among the respondents were encouraged, especially during the data gathering.

Data Analysis

Analysis, presentation, and organizing of the numerical data obtained from the questionnaires were through the use of statistical techniques. To analyze quantitative data, descriptive statistics were used to determine the mode, mean, variance, maximum and minimum scores, ranges, and standard deviations, of the levels of scientific literacy and gender. Welch's ANOVA in inferential statistics was used to determine whether statistically significant differences exist between levels of scientific literacy among the three grades, and Mann-Whitney U test was used to investigate potential differences between two genders in terms of scientific literacy levels.

RESULTS

This chapter presents the data gathered using quantitative approach and the corresponding analysis and interpretation considering the research questions.

Profile of the Senior High School STEM Student-Respondents

Using a survey questionnaire, data about the profile of the STEM student-respondents in terms of school they are enrolled, grade level and gender were gathered, and after which, were analyzed. Table 3, 4, and 5 respectively show the results of the analyses.

School. There are only three (3) schools offering senior high school STEM in the second district of Eastern Samar: General McArthur National Agricultural School, Salcedo National High School, and Guiuan National High School. Table 1 shows the total number of STEM student-respondents of the mentioned schools. Guiuan National High School has the highest number (160 or 46.2%) of STEM students, Salcedo National High School of 131 or 37.9%, and Gen McArthur National Agricultural School with 55 or 15.9%. The data infers that there are only few senior high schools offering STEM strand in Eastern Samar division, and this count is similar to other schools' division across the country. According Alvarez (2024), there are many reasons why few schools in the Philippines offer STEM strands. Among the reasons are: low enrollment (DepEd 2023), low completion rates, socioeconomic factors, personal goals, and parental influence (Madriaga et al 2022), low scientific literacy (Rogayanan 2021), negative perceptions, and grade requirements (Andrada 2019), teachers who are pedagogically prepared (Hasim et al 2022), and limited resources, inadequate facilities, and insufficient learning materials (Bullo et al 2023).

Table 3: Table 3, Senior High School STEM Student-Respondents

School	Frequency	Percent
Gen. McArthur National Agricultural School	55	15.9
Salcedo National High School	131	37.9
Guiuan National High School	160	46.2
Total	346	100.0

Table 3 shows the distribution of STEM students per school and its corresponding percentage per school.

Table 4: Table 4, Gender of the STEM Student-Respondents

Gender	Frequency	Percent
Male	130	37.6
Female	216	62.4
Total	346	100.0

Table 4 illustrates most of the STEM student-respondents are female (216 or 62.4%), and below half (130 or 37.6%) of the total number are male.

The data is a manifestation that female students nowadays are already getting interest in STEM-related courses, and as preparation greater number of them enroll in senior high school STEM strand. These opposes the findings of Wang et al., (2023) that male students' interest in STEM careers is significantly higher than that of female students, and to the idea of Meinck & Brese (2019) stating that for career aspirations, boys are often seen in professions related to STEM in contrast to girls, who prefer trades in the social sciences.

Table 5: Table 5, STEM student-Respondents Based on Grade Level

Grade Level	Frequency	Percent
Grade 11	165	47.7
Grade 12	181	52.4
Total	346	100.0

Table 5 shows that there is a greater number of students enrolled in STEM Grade 12 (181 or 52.3%) than those admitted to Grade 11 (165 or 47.7%) as depicted in Table 3. The data implies that there is a decrease of senior high school students enrolling in STEM strand.

This result may be attributed to personal goal, future career choices and aspirations similar to the findings of Nazareno et al (2021) stating that the intended course in college is strongly associated with SHS track/strand choice. This is further confirmed by Madriaga et al (2022) adding that personal preference, parental influence and socioeconomic factors which include access and cost of STEM education are found to be among the aspects that impact students' decisions to choose STEM track.

STEM Student-Respondents Level of Scientific Literacy Using GSLQ & TOSLS

Using the Global Scientific Literacy Questionnaire (GSLQ), and the Test of Scientific Literacy Skills (TOSLS), the scientific literacy levels of the STEM student-respondents were assessed. The results of data analyses are shown in Table 6, 7 and 8 as follows.

Scientific Literacy Level Using GSLQ.

Table 6: Table 6 STEM Student-Respondents Scientific Literacy Levels Using GSLQ

GSLQ Dimensions	Mean	Interpretation
Habits of Mind	3.994	Often
Character and Values	4.059	Often
Science as a Human Endeavor	4.352	Often
Metacognition and Self-direction	4.226	Often
Grand Mean	4.167	Often

Table 6 show, using the Global Scientific Literacy Questionnaire majority of the STEM students-respondents got a high mean score in the three dimensions of GSLQ: habits in the mind (4.059), metacognition and self-direction (4.226), and science as a human endeavor (4.352), respectively, while a mean of 3.994 in habits of mind.

Generally, the overall scientific literacy level of the STEM students-respondents using GSLQ is 4.147 mean score, interpreted as "often" which implies that often/frequently the practice the scientific literacy skills indicated in the different dimensions of the GSLQ.

These results confirm the findings of Mun et al (2015) that most of the middle school students from Australian, Chinese, and Korean showed high scores for "Science as human endeavor" but contradicts on the "Meta-cognition and self-direction" dimension as the scores are low. Further, as cited by Georgiou and Kyza (2023), students should develop "global scientific literacy" with an integrated understanding of the core ideas of science (habits of mind), realizing the nature of science (as a human endeavor) including attitudes, morals (character and values), and worldviews that can lead people to make appropriate choices and decisions to ensure a sustainable planet (metacognition and self-direction).

Table 7: Table 7, STEM Student-Respondents SL Levels Using TOSLS Dimension 1

TOSLS Dimension 1	Criteria	SL Score out of 14 Skills (Dimension 1)	Frequency	Percentage
Understand methods of inquiry that lead to scientific knowledge	Very Good	12 or ≤	0	0
	Good	10-11	2	0.58
	Enough	8-9	21	6.07
	Low	5-7	138	39.88
	Very Low	3-4	139	40.17
	Extremely Low	2 or ≤	46	13.29
	Total		346	100.0

Table 7, using the Test of Scientific Literacy Skills (Dimension 1: Understand methods of inquiry that lead to scientific knowledge), it is revealed that majority of the STEM students-respondents scored within a range score of 7-2≤ out of 14 multiple choice questions, which is described as very low (139 or 40.17%), low (138 or 39.88%), and extremely low (46 or 13.29%) respectively.

Table 8: Table 8, STEM Student-Respondents SL Levels Using TOSLS Dimension 2

TOSLS Dimension 2	Criteria	SL Score out of 14 Skills (Dimension 1)	Frequency	Percentage
Organize, analyze, and interpret quantitative data and scientific information	Very Good	12 or ≥	0	0
	Good	10-11	2	0.58
	Enough	8-9	9	2.60
	Low	5-7	106	30.64
	Very Low	3-4	163	47.11
	Extremely Low	2 or ≤	66	19.08
	Total		346	100.0

Table 8 shows Dimension 2, organize, analyze, and interpret quantitative data, and scientific information. It shows majority of the STEM students-respondents scored within a range score of 7-2≤ out of 14 multiple choice questions, which is also described as very low (163 or 47.11%), low (106 or 30.64%), and extremely low (66 or 19.08%) correspondingly.

These results imply that the STEM students-respondents have low scientific literacy levels using TOSLS, which are similar to the findings of various researchers who assessed the scientific literacy levels of secondary school students in different countries. For example, Wahab et al. (2023), found that 62 out of 102 students had deficiencies in scientific literacy. A study in South Sulawesi Junior High School by Adnan et al. (2021) revealed that poor scientific literacy skills is displayed among biology students. Other studies conducted elsewhere supported similar findings, such that of Shahzadi and Nasreen (2020) who had a survey of public schools in Lahore and found that there is a very low level of scientific literacy, and in the study of Baltikian, et al (2023) in Lebanon secondary school which revealed that methods of inquiry, data organization, data analysis, and interpretation are severely lacking among students, therefore concluding that scientific literacy is low.

Difference in Scientific Literacy Levels Between Grades 11 and 12; Male and Female Based on the TOSLS Analysis Result

Table 9: Scientific Literacy Mean Difference According to Grade Level and Gender

Grade Level	Gender	No. of Respondents	Mean SL level/28	Standard Deviation
Grade 11	Male	58	11.00	2.54
	Female	107	9.00	2.69
	Total	165	10.00	2.67
Grade 12	Male	71	7.00	2.47
	Female	128	8.00	2.45
	Total	181	7.00	2.46

Table 9 depicts the difference in scientific literacy levels between Grades 11 and 12; male and female. Based on the analysis result, it is indicated that the mean score of the grade 11 students' scientific literacy level is 10.0 out of 28, which is considered "very low" while grade 12 is 7 out of 28 and described as "extremely low".

For gender, the mean score of male students' scientific literacy level of 9 out of 28 interpreted as "very low", whereas female students' mean score scientific literacy level is 8 out of 28, interpreted as "very low". Arikunto's (2013) TOSLS score interpretation were used in interpreting the aforementioned results.

These results confirm the finding of Shahzadi and Nasreen (2020) that scientific literacy of government school students is very low. They cannot describe the ideas in their own words, relate the different concepts and use science procedures in daily life activities. They can use science vocabulary, define a concept properly, and recognize scientific terminologies but have little conception regarding these and less comprehension of the concepts. Additionally, they cannot expand the scientific and technological viewpoints in life.

Table 10: Table 10, Difference in Scientific Literacy Levels Between Grades 11 and 12; Male and Female

Independent Variable	Dependent Variable	p-value	Interpretation
Grade Level	Scientific Literacy	0.000	Significant
Gender		0.041	Significant

Table 10 reflects that there is significant difference of scientific literacy levels between grades 11 and 12 with a p-value of 0.000. Similarly, with a p-value of 0.041 significant difference also exists between male and female scientific literacy levels. These findings corroborate that of Baltikian et al (2024) who found statistically significant differences in scientific literacy levels between grade 10 and grade 11, and between grade 10 and grade 12. But opposes the result since no differences were observed in terms of gender.

DISCUSSION

The study examined gender-based differences in scientific literacy levels among STEM students in the Division of Eastern Samar, serving as the foundation for crafting innovative teaching-learning strategies. The research specifically focused on evaluating the scientific literacy competencies of male and female senior high school STEM students, with the aim of addressing disparities through targeted interventions. Quantitative analysis of the gathered data effectively addressed the research questions, and the findings are summarized as follows:The majority of STEM student-respondents are female (216 or 62.4%), while male students make up 130 or 37.6% of the total. This trend reflects increasing interest among female students in STEM-related courses, contrary to traditional gender norms and findings by Wang et al. (2023) and Meinck & Brese (2019), which emphasized male dominance in STEM fields.There are more students enrolled in Grade 12 STEM (181 or 52.3%) than in Grade 11 STEM (165 or 47.7%). The declining enrollment from Grade 11 to Grade 12 may be attributed to factors such as personal goals, career aspirations, and socioeconomic influences, aligning with the findings of Nazareno et al. (2021) and Madriaga et al. (2022).High mean scores were observed across the four dimensions of the Global Scientific Literacy Questionnaire (GSLQ) Habits of Mind = 4.059 (interpreted as "often"), Character and Values = 3.994 (interpreted as "often"), Science as a Human Endeavor = 4.352 (interpreted as "often"), Metacognition and Self-Direction = 4.226 (interpreted as "often"). The overall scientific literacy level, with a mean score of 4.147, indicates that students often practice scientific literacy skills.As to the Categories of Scientific Literacy Using TOSLS, in Dimension 1 (Understand Methods of Inquiry), most students scored in the "very low" (40.17%) or "low" (39.88%) categories. In Dimension 2 (Organize, Analyze, and Interpret Quantitative Data) similarly, the majority scored in the "very low" (47.11%) or "low" (30.64%) categories. These findings highlight a significant deficiency in scientific literacy, consistent with studies by Wahab et al. (2023), Adnan et al. (2021), and Shahzadi & Nasreen (2020).The differences in Scientific Literacy Levels are also observable. Grade 11 students had a mean score of 10 out of 28, categorized as "very low," while Grade 12 students had a mean score of 7 out of 28, categorized as "extremely low." The difference in scientific literacy levels between Grades 11 and 12 was statistically significant (p-value = 0.000). Male students scored an average of 9 out of 28 ("very low"), while female students scored 8 out of 28 ("very low"). A significant difference was observed in scientific literacy levels between genders, with a p-value of 0.041. This result confirms disparities in scientific literacy but contrasts with findings by Baltikian et al. (2024), who reported no significant gender-based differences.The high GSLQ scores suggest frequent application of scientific literacy dimensions; however, low TOSLS scores indicate challenges in scientific inquiry and data interpretation. Grade-level and gender differences highlight potential inequalities in STEM education, necessitating targeted interventions to improve scientific literacy. These findings align with global research indicating that contextual and structural factors (e.g., socioeconomic status, access to resources, and pedagogical preparation) significantly influence scientific literacy.

CONCLUSIONS

In view of results and findings of this study, the following conclusions were made:

Female students dominate STEM enrollment, indicating a shift in traditional gender norms regarding STEM participation. This reflects increasing interest among females in STEM-related courses.

The decline in STEM enrollment from Grade 11 to Grade 12 suggests challenges related to personal goals, career preferences, and socioeconomic barriers, which influence students' continuity in the STEM strand.

STEM students frequently demonstrate scientific literacy in terms of habits of mind, character and values, science as a human endeavor, and metacognition and self-direction.
Despite frequent practice of scientific literacy dimensions, students struggle with applying scientific inquiry methods and interpreting data, as reflected by low scores in TOSLS assessments.
Scientific literacy significantly decreases from Grade 11 to Grade 12, with both groups exhibiting very low to extremely low levels. This indicates challenges in sustaining literacy skills over time.
Male and female students exhibit similar scientific literacy challenges, with males slightly outperforming females. Significant differences highlight gender-specific learning gaps.
The low scientific literacy levels in the categories of scientific inquiry and data interpretation (as reflected by TOSLS scores) indicate a need for more engaging and effective teaching-learning strategies that emphasize practical application and critical thinking.
The high performance in GSLQ dimensions suggests that students possess foundational scientific literacy skills but lack opportunities to apply these in dynamic, real-world contexts.
Disparities in scientific literacy between grade levels and genders point to the necessity of personalized, adaptive teaching approaches that cater to diverse learning needs.

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