Investigating STEM Senior High School Scientific Research Productivity and Selected Affecting Factors: A Mixed Triangulation Study

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Abstract: Only recently, primary education institutions in the Philippines started to embrace research, resulting in few investigations into research productivity and affecting factors. This mixed method triangulation study measures senior high school scientific research productivity and influencing factors. A total of 130 students, 68 papers, nine faculty, and ten evaluators were the participants in the study. Results showed low research productivity in the quantity and quality of papers. Results also revealed a significant relationship between student and teacher scientific research skills (SRS) and research policy to the quality of research. In conclusion, there is a need for improvement in primary education research productivity by increasing student and teacher SRS and holistically formulating a research policy.

Keywords: Basic Education, Science Education, Scientific Research Skills, Research Policy, Quality Education

1. Introduction

Research Productivity has been defined by varied literature widely as the quantity and quality of research produced by an individual and the institution, with various indicators such as several published research papers in quality-indexed and highly refereed journals (Atieno et al., 2021; Hassan Al et al., 2020; Kuzhabekova & Lee, 2018; Malsch & Tessier, 2015). Most of the primary education institutions in the Philippines are starting to embrace the culture of research. Based on the bibliometrics for Scopus, published journals indicated an annual growth rate of 19.19%, ranking the country 5th among the seven (7) Asian countries it was compared with, and was found only to have few citations and was only recently that HEIs, in specificity, increased pressure in research creation and publication among faculty and students that has been driven due to its requirement for getting degree and promotion but not for academic productivity (Guido & Orleans, 2020). Department of Education (DepEd) Order 39 (2016), Adoption of Basic Research Agenda for Primary and secondary education, Junior High School (JHS) & Senior High School (SHS), was created to augment efforts to increase research productivity for the primary education concern. Moreover, the curriculum for the Science, Technology, Engineering, and Mathematics (STEM) strand has also been augmented with structuring of courses that provide fundamental skills for scientific

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research (e.g., Practical Research 1; Practical Research 2, Inquiry, Investigation & Immersion & Research Project). One of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Sustainable Development Goals (SDG) participated by the Philippines is Quality Education (So et al., 2012), which is composed of ten (10) targets that encompass a wide range of education concerning, that aims to progress the educational system and its product in consideration of attaining sustainability in all its aspect. One of the targets is 4.1, seeking 2030 to ensure quality secondary education that results in relevant and effective learning outcomes. This goal shouts drive to lessons that students can use in life, such as the ability to research and use the scientific method (Mirnezami et al., 2016; Robnett et al., 2018). Moreover, target 4.6, aiming by 2030 that all youth in each gender achieve literacy and numeracy, another target that screams fundamentals in using the scientific method and creating research, literacy when constructing and crafting the paper, reading, understanding, and organizing of scientific information and skills in numeracy for data analysis and proper interpretation (Guide & Orleans, 2020; Hassan Al et al., 2020).

The low production of quality research by students as a reflection of low content and cognitive achievement of students can pose a problem for their next educational level. This connection is fully represented in the Philippine National Qualification Framework, composed of various academic and monitoring organizations such as DepEd, in which all national qualifications a student can attain as a foundation from its primary education indicated by completion of Grade 12 Senior High School and has provided minimum proficiency, students must achieve in the eight levels of qualification (Pajić, 2015). Commonly students, upon completion of primary education, proceed to higher education level and are expected to possess functional knowledge in scientific, critical, and creative thinking and use of technologies and be able to apply sound reasoning, informed decision-making, and the judicious use of resources, all are reflected with their research output. Moreover, a baccalaureate degree requires students to apply and create research in a specialized field of discipline and further study, which requires mastery of the basic education qualifications (Pajić, 2015). Bridging the results of large-scale assessments of primary education to the demand for higher education qualifications, strengthening research skills and capacity of students, teachers, and educational institutions in senior high school through increasing research productivity in quantity and quality is one way of managing the decreasing scientific trend of the Philippines.

1.1 Context of Research in Basic Education SHS Curriculum

Research in primary education was only introduced during the approval of the legal basis for adding two more years to expand high school education in preparation for the tertiary level. The Republic Act No. 10533, known as the Enhanced Basic Education Act of 2013, broadens the goals for college, vocational, and technical career opportunities. Under this law, the Department of Education (DepEd) released its Department Order (DO) no. 21 s. (2015), Policy Guidelines on K to 12 Basic Education Program, that support standardization of the K to12 implementation. This amendment to the basic education program aligns with promoting research among primary education students for quality education.

Another principle in its pursuit is a responsive and research-based curriculum, which clearly indicates the effort toward research-cultured learners ultimately aiming to produce new knowledge under a productive research-based academic community (Huenneke et al., 2017). Under the same article (Department Order no. 21 s. 2015), the policy stipulated that it aimed to produce holistically developed graduates with skills for lifelong learning and other facets supporting research in primary education. Skills definition under this section stipulates desired skills for primary education, and one particular stipulation is Learning and innovation skills; the guidelines have described these as the skills on creativity, curiosity, critical thinking, problem-solving, adaptability, managing complexity, self-direct, and sound reasoning skills, all which are needed for research, moreover, these aimed skills are the precise foundation of research skills, its interaction produces student ability to observe, ask, plan, experiment, collect data, interpret data and arrive in a conclusion (Gauch et al., 2003; Kalinowski & Willoughby, 2019). However, these skills do not include dissemination skills. However, the policy provided another set of aimed skills, the policy guideline, and the communication skills necessary for writing, publishing, and disseminating completed papers. Moreover, life and career skills were also included in the skills targeted by the program, another facet that needs research skills among the students, as research has been one of the rising academic skills required by the industry (Huenneke, 2017). However, more studies and research on primary education research productivity, specifically student-led analysis, are needed (Atieno et al., 2021; Kuzhabekova & Lee, 2018).

1.2 Student Scientific Research Skills and Research Productivity

Knowingly, all the above-mentioned cognitive skills measured by the TIMSS 2019 (Mullis et al., 2019) are components students need in crafting research; therefore, low science achievement reflects the quality and quantity of research produced in the later years of their education. For a STEM student to be able to do quality scientific research follows a framework, commonly using the scientific method (Gauch et al., 2003; Kalinowski & Willoughby, 2019). In this framework, the student must be able to (1) critically observe, (2) ask questions, and one can only critically observe and ask a question if they have become knowledgeable of various concepts and principles in science, (3) students then construct a hypothesis in which they can only achieve with at least an essential skills in reasoning, assessing and evaluating information and data at hand, (4) Test hypothesis, that requires the ability to design experiment, solve complex problems that involve multiple steps, and navigate through unfamiliar situations and information, (5) after this students must analyze the data and draw a conclusion which also in need of the higher order thinking skills that international assessment measures and lastly (6) share results, in this case, students ability to craft and create a cohesive paper presenting the process of hypothesizing, to designing the experiment to result in the collection, analysis, and conclusion.

Premise claims consensual agreement that undergraduate students need scientific thinking skills to understand science concepts and their daily application (Commission on Higher Education, 2018). Skills required for the scientific method can collectively be termed Science Process Skills equated with Science Research Skills (Hassan Al et al., 2020; Okstad & Dahlk, 2021). Literature shows that a researcher's qualification, such as skills and academic characteristics, is a predictive factor for research productivity; as an individual increases their qualification, research productivity elevates (Atieno et al., 2021; Siri et al., 2020). Regardless, little to no investigation has focused on student scientific research skills and how it affects student research productivity, much more in the context of primary education, especially since research has only been formally introduced in the year 2013 (Enhance Basic Education Curriculum, 2013), a vital concern that can provide inputs for augmenting instruction and curriculum for more qualified and quantified research outputs as student skill reflection. Thus, this paper investigates student research skills and their relation to research productivity.

1.3 Effects of Teacher-Related Factors on Student Research Productivity

Teaching is only present when there is learning, a common principle among educators. Teaching and subsequent factors significantly impact whether a student will learn or not. One known factor is the teaching strategy of the teacher and the congruent performance effectiveness, which includes teaching time allocation, index of a range of content, quality of teacher's instructional activities, variedness of class setup, content, and cognitive mastery of concept and skills to be taught and many more, are a vital component of successful learning (Polic Guidelines on K to 12 Basic Education Program, Philippines, 2019; Sandström et al., 2020, Westerlund, & Barrett, 2021). The Enhanced Basic Education Curriculum (2013), with its principle that the curriculum shall be relevant, responsive, and research-based, relatively stipulating guidance for the qualification of teachers of STEM strand in teaching specialized courses has come to the limelight. It has been widely known in congruence with the National Higher Education Research Agenda (NHERA) collaborating teaching to develop research and innovation for global competitiveness, which recognizes that teaching is an indispensable factor in increasing the quantity and quality of research (Commission on Higher Education, 2009).

Another prevailing factor that heavily affects student achievement, in general, is the effectiveness and skill in mentoring and advising teachers. In postgraduate studies, appropriate mentoring is one of the substantial factors perceived by students to be vital. Investigations revealed that students could show an increase in outcomes such as quality of work, presentations, publication, the scientific identity of students, and the structure and strategy of mentoring, making advisor-student mentoring a heart of postgraduate education (Lunsford, 2012; Prihantoro et al., 2019). The effects of mentoring on student outcomes, performance, and productivity have been regressed with the type of mentoring (e.g., psychosocial or career) and discipline of both parties (Chemers et al., 2011; Lunsford, 2012; Prihantoro et al., 2019). However, studies also revealed the opposite effect when mentoring could be classified as bad or unproductive. The strategy also includes relational factors, such as how teachers build their relationships with mentees and the type of relationship they are building (Lofthouse, 2009). However, most of the kinds of literature are investigated in either higher education or postgraduate education context, and little has been published in both quantitative and qualitative design regarding primary education, much more with senior high school, especially in the Philippines (Lunsford, 2012; Prihantoro et al., 2019). Thus, this must be investigated if directly related to the quality of the research paper.

1.4 Research Policy and Research Productivity

Fostering research and culture in middle size to the smaller institution was found to include sufficient infrastructure, human resources, such as an established research office and committee, grants & awards, the exclusion of research productivity in criteria for tenure and promotion, and the absence of graduate assistants and postdoctoral researchers to enhance output, faculty also stipulate the lack of training and exposure as a hurdle for high research productivity and lastly, pedagogical capacity to teach research and advise student was another barrier to research productivity (Atieno et al., 2021; Gillespie & Robertson, 2010; Heunneke et al., 2017; Okstad & Dahlk, 2021; Siri et al., 2020).

Westerlund & Barett (2021) illustrated that changes in the policy based on evidence could address subsequent challenges in research productivity and impact. A high attestation to this by Okstad & Dahlk (2021) stated that a policy that provides an appropriate system and approach could indeed increase research culture and productivity. As a form of commitment by the leaders, the policy also factored in research-based practices that provide student modeling. On top of that, the policy ensures commitment to support resources from the institution, including personnel, facilities, and information technology. Moreover, in the same paper, Okstad & Dahlk (2021) argued that cross-discipline stakeholder engagement, establishing research frameworks and agenda, with the addition of a provision to student engagement opportunity, that consequently play a crucial role in student success is imperative to the mentoring system with teacher-led research project bring forth advents curiosity and practical academic skills (Institutional Research, Planning & Accreditation, 2020; Lopatto, 2009). Howbeit, all of which are in the context of higher education institutions and qualifications, it has yet to be investigated if establishing research policy on primary education institutions can increase research productivity. Additionally, in the local context, as stipulated above, DepEd Basic Research Agenda has been around since 2016. However, few have been published to measure the direct relationship between establishing guidelines and systems to research productivity, especially at the senior high school level.

Thus, this research aims to measure the trend in STEM students' scientific research productivity in a private school in student-related, teacher-related, and policy-based factors.

2. Methodology

2.1 Research Design

The study employed a mixed method triangulation design that aimed to gather complementary data on the facets mentioned above of research productivity and subsequent affecting factors (Creswell et al.l, 2003)

2.2 Research Sample, Sampling Procedure & Environment

Participants include Grades 11 & 12 STEM SHS students across AY 2017-2018 (n=50), 2018-2019 (n=60), and 2021-2020 (20), sampled using stratified random sampling, Faculty Member (n=9) who taught practical research, ten (10) teacher evaluators of research papers private school higher education institution (PHEI) in Nueva Ecija that the Commission accredits on Higher Education (CHEd) and Department of Education (DepEd) to deliver Senior High School (SHS) education including the permit for STEM strand. All research output of the institution was retrieved from the senior high school library. The academic director, principal, and students evaluated the teaching strategy of the faculty using the institutional faculty performance evaluation. Lastly, the research coordinator, quality assurance office representatives, academic director, program chairs, and principal reviewed the research policy of the institution.

2.3 Instruments

All instruments utilized in the study were carefully adapted from the institution and relevant studies, ensuring their validity had been thoroughly assessed by experts within the institution. These experts, including but not limited to the Chief Executive Officer, Academic Director, Quality Assurance Officer, Research Coordinator, and Principal, have reviewed and approved the instruments.

2.3.1 Instrument 1: Rubrics for Assessing Quality Student Research Paper

The measuring tool employed in this study has been adapted from the institution's research policy. This comprehensive tool consists of 24 items designed to assess the thoroughness of essential research components, ranging from statistical and data analysis to results, interpretation, discussion, conclusion, and recommendation. It measures the paper and research skills into four Likert-scale measures from Questionable (1) to Excellent (4). Additionally, the interpretation bracket scheme was used to categorize all papers into Questionable (Q)=1-1.49), Needs Improvement (NI)=1.50-2.49, Adequate (A)=2.50-3.49, Excellent (E)=3.50-4.00 (Dancey & Reidy, 2002). 25 of the 26 total completed papers for 2017-2018 were evaluated 30 of 32 for 2018-2019, and all ten completed papers for 2020-2021 for 68 papers. Two different teachers evaluated each paper; all were randomly assigned. The instrument's Cronbach alpha score (α=.868) shows excellent reliability and is adequate for individual testing (Hedden, 1997).

2.3.2 Instrument 2: Scientific Research Skills Questionnaire

The study used a research skills questionnaire adapted from Cobos-Alvarado et al. (2016), with modifications and additional items. It fully divides student research skills into three categories. First, measuring student ability to develop scientific information, these items measure conduct related to new understandings and new working skills, composed of seven (7) items. Second, the student's ability to process scientific information and data, which measures the student's ability to skills factored with organizing, collecting, and analyzing scientific information, is composed of ten (10) question items. The last category measures student management of scientific information, and these items evaluate skills of the management, organizing, and search of scientific information, composed of nine (9) items. It used the Likert scale with a scaling of1-strongly agree up to 5- strongly agree and was described using the following category Questionable (Q) (1-1.49), Needs Improvement (NI) (1.50-2.49), Good (2.50-3.49), Competent (C) (3.50-4.49), Excellent (E) (4.50-5.0) (Dancey & Reidy, 2002). Cronbach alpha score (α=.956) shows excellent reliability and is adequate for individual testing (Hedden, 1997).

2.3.4 Instrument 3: Researcher-made Policy Evaluation Rubrics

The researcher-developed rubrics assess various aspects of policy, including Policy Purpose, Agenda & Goals. It also covers funding, grants, and awards, as well as systems and frameworks for resource support, infrastructure, capacity building, mentoring, and exposure to research and related activities. The tool is composed of twenty-two items using four scales which are as follows: 4- Excellent, 3- Adequate, 2-Needs Improvement, 1-Not in the policy. Results categorized the measurement of the policy into Questionable (Q)=1-1.49), Needs Improvement (NI)=1.50-2.49, Adequate (A)=2.50-3.49), Excellent (E)=3.50-4.00 (Dancey & Reidy, 2002).

2.4 Data Gathering Procedure

2.4.1 Preparation

Permission to experiment was obtained from the school administration and principal. Consent forms, integrated into electronic forms, were utilized for both parents and students with parental approval.

Institutional permission was obtained by sending a letter to the academic director, following the procedures outlined in the institution's policy for accessing student outputs from the library.

2.4.2 Implementation

Reviews and evaluations were recorded using the electronic form the institution uses. Moreover, a review meeting was held via Google, including a discussion on accomplishing the evaluation tools used. Additionally, MS forms were used to administer the scientific research skills questionnaire (SRSQ) to the students, given the restrictions imposed during the pandemic. The SRSQ was adapted from the tool developed by Cobos-Alvarado et al. (2016), and subsequent revisions and addition of items using principles of test and scale construction adhered. The following are the data collection methods used by the study: 1) Document & Output Resources, which employed information from documents such as the completed research papers of students and institutional policy. The research methodology involved meticulous examination of archives, employing a structured checklist to assess information reliability (So et al., 2012; MacDonald et al., 2001). Direct measurement, encompassing quantitative and qualitative evaluations of output levels, as well as the research skills of students and teachers, was deemed the most appropriate approach. To ensure generalizability, a survey was administered to gather statistical data on students' and teachers' research skills. Additionally, the survey included an essay section to collect qualitative data. Furthermore, a Rubric-based evaluation procedure was employed to assess the quality of completed research papers, learning materials, and institutional research policy. To explore the various factors influencing research productivity, semi-structured interviews were conducted with selected participants and recorded online.

2.5 Data Analysis Procedure

Descriptive statistics were used to describe the qualitative and quantitative data in frequency, percentage, standard deviation, and mean. These descriptive statistics were used in the description of the quantity & quality of research, scientific literacy levels of students and teachers, and performance evaluation. The SRS questionnaire was tested for internal consistency to ensure data reliability. Descriptive statistics describe the quantity and quality of research outputs and institutional research productivity. Descriptive statistics were also employed to describe the teaching strategy. Pearson R Moment correlation was used to determine the relation of research skills, teacher-related factors, and research policy to student research productivity. A qualitative analysis approach was used to substantiate the study's findings in each of the identified factors. Data were treated by organizing the data finding, organizing ideas and concepts, creating overarching themes, and finding possible and plausible explanations for findings; step guidelines adhered O'Connor et al., 2008: 2017).

3. Results & Discussion

3.1 Quality of Completed Paper

The study using the library repository data files has determined the following research produced by the senior high school from AY 2017 to 2021. However, data shows no completed papers during 2019-2020, when school activities were suddenly stopped due to the CoVid-19 Pandemic Lockdown in the Philippines starting in March.

However, research productivity cannot solely be described via completing a research paper. Another productivity metric is the quality of research completed throughout students' education. In this regard, the study also measured the quality of papers across the three years in which some students completed research papers during practical research. Table 1 shows that the general quality scores based on expert rubric-based evaluation can be categorized as needing improvement (M=2.37, SD=0.246). Across the academic years, 2018-2019 has the highest quality (M=2.64, SD=.249) described as competent, and the other two academic years are described as needing improvement. Across all evaluated parts of the research, all were categorized as needing improvement. The highest quality score can be observed in the relevance & feasibility (M=2.44, SD=0.273) but still described as needing improvement, which is the section that proves the importance of the study in general, the time & logistics projection needed to accomplish the study. On the other hand, the category with the lowest quality score is the methods (M=2.31, SD=.412) still needs improvement, and it is composed of evaluation of the quality of data gathering procedures used by the paper, data organization & statistical analysis implemented sampling procedure, and instrumentation.

Table 1: Quality of research per year

AY	S	BL	RF	M	AI	C	QS	D
2017-2018	M	2.24	2.20	2.10	2.18	2.72	2.29	NI
	SD	.319	.247	.553	.385	.486	.279	
2018-2019	M	2.48	2.74	2.76	2.86	2.44	2.64	E
	SD	.192	.251	.431	.516	.597	.249	
2020-2021	M	2.24	2.38	2.06	2.19	1.95	2.19	NI
	SD	.226	.319	.253	.358	.224	.315	
Total Mean		2.32	2.44	2.31	2.41	2.37	2.37	NI
Average SD		0.246	0.272	0.412	0.420	0.436	0.246	
Description		NI	NI	NI	NI	NI	NI	

Legend: AY, Academic Year; S, Statistics; BL, Background & Literature; RF, relevance & feasibility; M, methods; AI, Analysis & Interpretation; C, conclusion; QS, Quality Score; Description

Description Interpretation: Questionable (Q)=1-1.49), Needs Improvement (NI)=1.50-2.49, Adequate (A)=2.50-3.49), Excellent (E)=3.50-4.00.

In this regard, augmented with quantitative research productivity, the quality of papers also needs improvement, suggesting relatively low research productivity. This result agrees with the rank of the Philippines in the study conducted among Asian countries based on the bibliometrics for Scopus-published journals. The few citations received by the published research are also indicative of the probable low quality of research, and notable that teachers mostly create published papers since it was only recently that HEIs pushed the effort for research and publication among faculty and students (Guido & Orleans, 2020; Atieno et al., 2021). The level of research productivity also evidences the need for improvement in the system and implementation of the DO 39 s. 2016, adoption of basic research agenda for primary and secondary education of the DepEd. Moreover, this result provides implications in revisiting the curriculum structure, its contents, and implementation among the STEM strand students and suggesting an imperative mandate among policymakers and implementors in elevating the efforts in furthering the culture of research among primary education schools. Moreover, this research of low-quality research production reflects low content and cognitive achievement of students as research requires all levels of thinking skills; this poses potential problems for their next educational level since grade 12 is the foundation of the PHL NQF before their tertiary level that has been posited to expect the student to possess functional knowledge in scientific, critical, creative thinking applying sufficient reasoning, and decision-making ability reflective of their output in research (Philippine Qualification Framework NCC, 2014).

3.2 Factors Affecting Research Productivity

Several kinds of literature, as pointed at the introduction, have determined several factors that affect research productivity. This study has been divided into three categories: Student-related, Teacher-related factors, and Research Policy.

3.2.1 Students' Scientific Research Skills

Several studies have found Scientific Research Skills (SRS) to predict research productivity among undergraduate and postgraduate students; however, this has not been thoroughly investigated with primary education students, much less with senior high school (Atieno et al., 2021, Sulo et al., 2012). Results of the descriptive analysis indicated that students across the academic years are described as needing improvement (M=2.14, SD= .594). In the three years, the highest student SRS was observed in AY 2017-2018 (M=2.36, SD= .468) and observed lowest in 2020-2021 (M=1.82, SD= .718) all of which are described as needing improvement (Table 2).

Table 2. Summary of student research skills per academic year

AY	S	DSI	PSI	MSI	Overall SSR	Description
2017-2018	M SD	2.32 .645	2.31 .714	2.47 .618	2.36 .468	NI
2018-2019	M SD	2.19 .654	2.22 .739	2.27 .580	2.23 .597	NI
2020-2021	M SD	1.65 .730	1.99 .889	1.82 .805	1.82 .718	NI
Total Mean		2.05	2.17	2.19	2.14	NI
Average SD		0.676	0.781	0.668	0.594	
Description		NI	NI	NI	NI	

Legend: AY, Academic Year; S, statistics; DSI, Developing Scientific Information; PSI, Processing Scientific Information; MSI, Managing Scientific Information; SSR, Student Research Skills.

Description Interpretation: Questionable (Q) (1-1.49), Needs Improvement (NI) (1.50-2.49), Good (2.50-3.49), Competent (C) (3.50-4.49), Excellent (E) (4.50-5.0)

Observing the three dimensions of how SRS was measured as perceived by the students. The highest perceived skill was managing scientific information (M=2.19, SD=.668); this evidenced that student, though still described as needing improvement, is most confident with their skills in managing and searching scientific information, including the ability of students to draw theme from scientific papers and databases, organize information from literature reviews, identifying reputable sources, and using the scientific rule in managing scientific information. Among all the items, students perceived themselves as good at intelligently recognizing scientific papers and sources from reputable resources (M=2.66), evidencing their skills in searching for reliable and valid scientific information across a wide range of modalities while assessed themselves as lowest at creating a sound and organize literature review (M=2.39) this means the student needs improvement in organizing information into a concise literature review. Students rated themselves in the scientific processing information second to the highest, Table 6, though still generally needs improvement (M=2.17, SD= .668); this is comprised of students' ability to collect, organize, analyze, interpret, critically review, and structure information at hand although this still in the needs improvement description. Among the item in the category, the highest rating is the ability of the student to critically review research article articles (M=2.63) described as good, providing evidence of the student's ability to criticize and analyze research articles for academic literature review. On the contrary, students perceived that their skills in organizing information using scientific techniques still need improvement (M=2.34), evidencing a need to increase student's ability to fully utilize scientific techniques, technological and logical ability to organize information from data at hand, or related studies.

The lowest of the three is the developing scientific information (M=2.05, SD=.676); this shows that students' skills need improvement in creating their information with the available data and crafting the necessary parts of research. The highest rated item in this skill category is the skills of the student to craft keywords for a scientific topic (M=2.77), notably since this can be easy among all tasks in a research project. Alarmingly the lowest perceived skills are the student's ability to bring their ideas in developing scientific information and their scientific inquiry or question based on data available at hand that are scientifically correct (M= 2.39). Proof of evidence that student needs improvement in their ability to develop and provide scientific research questions that stem from their keen ability to observe problems and situation that needs improvement; this is also congruent with their perceived skill in developing new topic interest. This evidence shows that students' higher-order skills are highly needed in crafting research, from developing to processing to managing information.

Descriptively, this shows that students do poorly in the knowledge, application, and general thinking that are ultimately required for creating research, according to the findings of the large-scale assessment TIMSS 2019 (Mullis et al., 2020). Additionally, the general designation of student SRS as "needs improvement" indicates that students generally are lacking in the ability to use skills necessary for the scientific method, such as critically observing scientific phenomena for investigation (Kalinowski & Willoughby, 2019, pp. 1270-1271) This is consistent with the findings that students are least likely to develop scientific data that includes observing, and the findings also demonstrate that students are least likely to ask questions., consistent with the result of students being lowest in formulating their scientific inquiry. Data also suggest students are low in the scientific method of testing hypotheses, which is also under the measurement of developing scientific information, and lastly, students in need of improvement in analyzing data and drawing conclusions, both in conformance with the low student score in processing and developing scientific information.

According to qualitative research based on student interviews and essay transcriptions, the main reason why students believe their SRS could use improvement is that they do not practice the following skills enough: One, writing research papers themselves; most students find the rules of scientific writing to be challenging, unfamiliar, and requiring a lot of high-order thinking skills, making the process challenging than with the inadequate amount of time as they perceived in practice, they find their current level to be need of improvement. Second, the insufficient practice in designing an experiment; students posited that their skills needed to be fully honed because most of the activities were concerned with the actual writing and scientific rules, that little practice was given to designing and trying to implement varied experimental setups. Lastly, there needs to be more role model implementation in the research process. The students stipulated that the teacher primarily provided examples of the research process through an informative lecture and that there is little time for the student to be provided that actual example of the process of research, and that only through the critiquing process that most are of limited time due to the amount of research paper a teacher needs to critique resulting to limited exposure to examples of the implementation and writing of the research process.

Another primary reason found within focus group discussions and essays is the need for more exposure to research. Evidently, in the DepEd curriculum from kinder to grade twelve, it is only in the senior high school years that a formal research course is introduced. Thus, the student claims to be exposed to research only during these academic years, and the student perceives this as the limited duration for total exposure that would elevate their SRS skills. Moreover, students stated that exposure to research reviews, conferences, and activities that would further require the student to research reading increases their exposure. According to the institution's records, it is only once every academic year that students can attend research conferences and related activities. With the physical setup during 2017-2019, limited students were selected to attend, and only in 2020-2021 that all grade levels of senior high school could attend in total attendance during the first research colloquium of the institution catering to the basics of research and its process.

These claims are in line with the assertions that undergraduate students need scientific thinking skills to comprehend science concepts and their everyday applications (National Research Council, 2012; Ozgelen, 2012), and those researcher qualifications, such as skills and academic characteristics, are a predictor of research productivity; as an individual's level of scientific proficiency rises, so does research productivity (Sulo et al., 2012; Atieno et al., 2021). This shows that it is crucial to develop students' scientific research skills since it impacts their research productivity, particularly in the primary education setting, given that it was just formally introduced in 2013 (Enhance Basic Education Curriculum, 2013). Additionally, this offers inputs for enhancing curriculum and instruction for a better qualified and measurable research output to represent student skill.

3.2.2 Teacher Scientific Research Skills

Teacher competence has always been a driving force of student outputs, and this study's immediate investigation of how teacher SRS affects student SRS. Descriptive analysis showed in Table 3 that generally, teachers' SRS is averagely good (M=2.96, SD=.446). Data reveals that teachers also perceived themselves highest in managing scientific information (M=3.09, SD=.482), they perceived themselves as adequately communicating, oral or written, the results of a review of scientific literature (M=3.60) and creating and understanding literature review (M=3.53) and identify reputable and reliable scientific journals and sources (M=3.47) while assessed SRS lowest in masterfully manage scientific data (M=2.93).

Table 3: Summary of teacher research skills per academic year

AY	S	DSI	PSI	MSI	Overall TRS	Description
2017-2018	M SD	3.15 .500	3.0 .411	3.06 .300	3.07 .369	G
2018-2019	M SD	2.72 .359	3.08 .596	3.27 .588	3.03 .394	G
2020-2021	M SD	2.20 .722	2.71 .804	2.93 .557	2.61 .540	G
Total Mean		2.69	2.93	3.09	2.96	G
Average SD		0.527	0.604	0.482	0.446	
Description		G	G	G	G	

Legend: AY, Academic Year; S, statistics; DSI, Developing Scientific Information; PSI, Processing Scientific Information; MSI, Managing Scientific Information; TRS, Teacher Research Skills.

Description Interpretation: Questionable (Q) (1-1.49), Needs Improvement (NI) (1.50-2.49), Good (2.50-3.49), Competent (C) (3.50-4.49), Excellent (E)(4.50-5.0)

Teachers processing scientific information was second to the highest, the same with the student's results (M=2.93) described as good; this means teachers can process scientific information adequately, such as analyzing the main ideas of a scientific article (M=2.73), using scientific techniques to organize information the same with the student, providing descriptive congruence in research skills (M=3.07) and ability discuss intelligently critical research article (M=3.13). Incidentally, teachers are also the lowest, the same as a student, in developing scientific information (M=2.69, SD=.527); although it is still described as good, teachers assessed themselves to have minimal adequacy in bringing ideas in developing a research topic (M=3.10). However, statistics have evidenced the lowest perceived skills in developing own scientific inquiry or question based on data available at hand that are scientifically correct (M=2.22) and creating a new research topic from literature review or scientific data available at hand (M=2.20). Descriptively, this provides evidence of the status of the individuals shaping students' knowledge and skills. In all three areas, teachers are generally in good standing and one level measurement ahead of their students. It has been stated that teachers' teaching and subsequent factors significantly impact learning, including content and cognitive mastery of skills, such as the scientific method and research skills, for successful learning. However, teachers who demonstrate low skills in developing scientific inquiry and question questions and creating new research topics from literature evidence an inadequacy in the skill of the scientific method (Yustina et al., 2018; Prihantoro et al., 2019; Abu Siri et al., 2020).

This also suggests that the Enhance Basic Education Curriculum (2013), which was created with the guiding principle that the curriculum must be current, responsive, and research-based, should be revisited in terms of its implementation and proposes further training and human development implementation and revisitation of strategy, in addition to revising the teacher's role in changing classroom practices (Edelson et al., 2021). These findings also align with the National Higher Education Research Agenda (NHERA), which affirms the importance of teaching in boosting both the amount and caliber of research (Commission on Higher Education, 2009). Included in this assertion is the DepEd's subsequent review of teacher training with a focus on SDG 4. b on the provision of competent teachers who incorporate functional literacy, such as research skills and its components (UNESCO, 2018), particularly in the least developed countries and small island developing areas.

Qualitative results based on teacher interviews and essay transcriptions stipulated the same with students that the primary reason for assessing themselves to be generally good in their SRS is due to the lack of exposure to research. Teachers themselves, even though they are teaching research, there are still plenty of areas under the process they have not fully mastered and misconceptions, especially with aligning the various parts of the research, such as anchoring the methodology with the research objectives, as well as research introduction, evidently with the assessed paper as presented above, even with the series of mentorship and critiquing, there are parts not anchored with the research objectives. Moreover, a considerable amount of research introductions assessed does not provide an academic gap, that pieces of evidence there is still improvement in teacher SRS, according to the records of the institution. Students only get to participate in research conferences and related events once every academic year. Due to the physical setup, only a few senior high school teachers could attend the institution's first research colloquium, which covered the fundamentals of research and its process and subsequent research methods, during the academic years 2017–2019—evidencing the lack of exposure among teachers themselves. Additionally, teachers perceived themselves to lack the opportunity to develop research skills due to factors such as lack of interest and lesser priority due to piling academic and administrative responsibilities.

3.2.3 Evaluation of Institutional Research Policy

The experts' analysis of institutional research policy has revealed that overall, the policy can be described as questionable (M=1.59, SD=.047), implying that most of the items in the tool need improvement in the evaluated research policy (Table 4).

Table 4: Summary of research policy evaluation per academic year

AY	S	AG	FGA	FS	Overall PS	Description
2017-2018	M SD	1.71 .186	1.83 .166	1.56 .034	1.59 .049	NI
2018-2019	M SD	1.70 .170	1.78 .156	1.55 .031	1.58 .047	NI
2020-2021	M SD	1.70 .101	1.77 .155	1.55 .033	1.59 .043	NI
Total Mean		1.70	1.79	1.55	1.59	NI
Average SD		0.152	0.159	0.033	0.047	
Description		NI	NI	NI	NI	

Legend: AY, Academic Year; S, Statistics; AG, Agenda & Goals; FGA, Funding, Grants & Awards; FS, Framework & System; PS, Policy Score.

Description Interpretation: Questionable (Q)=1-1.49), Needs Improvement (NI)=1.50-2.49, Adequate (A)=2.50-3.49), Excellent (E)=3.50-4.00.

Among the three factors of this variable, the framework and system were scored the lowest (M=1.55, SD=.033), which infers that framework for increasing student and faculty skill and engagement is not entirely in place and systems of increasing quality and quantity of research among faculty and students need improvement. Among the items of the framework and system, the factor is the system for quality assurance of student research graded as not in the policy (M=1.00), implying that the policy does not provide policy procedure on review and quality system that can be used by faculty as a standard template for evaluating students research ensuring quality of paper additionally no policy is in place for a system of publication of student & faculty research in a local and international context (M=1.00). Another sub-factor is the framework for increasing student research engagement (M=1.00) and no policy for the research mentoring and advising system for students (M=1.00).

The highest among the factors were the funding, grants & awards factor (M=1.79, SD=.159), but still, the description is questionable, implying that among the factors that the institution policy has put into liberty, the formulation of funding, grants, and awards to research specifically research publication. However, it can be observed that among the items of this variable, a section for an adequate system of support for data analysis software research (M=1.00) needs to be included together with an adequate statement for research grants for student-proposed projects (M=1.00). The qualitative investigation provided that the research policy lacks the following provisions found by related studies to be crucial in an adequate research policy (Gillespie & Robertson, 2010; Institutional Research, Planning, & Accreditation, 2020; O'Connor & Madge, 2017) policy and guidelines for quality assurance of student research in senior high school; publication of student research in a local and international context; provision of guidelines increase student and faculty engagement in research context which includes rewards system for research completion, as well as a system of the referral or research conferences and related events and as well as the procedure for internal and external research collaboration including the provision of procedure for application of research grants from an outside organization; research mentoring and advising system for students, including the straightforward process of mentor and mentee referral system; policy and guidelines for funding, awards, and assistance to student and faculty-proposed studies are also not included. Evidencing the inadequacy of the institution's research policy ultimately caters to research productivity.

A barrier to high research productivity, according to studies, is the lack of infrastructure, human resources, grants, and awards, the exclusion of research productivity from criteria for tenure and promotion, the presence of graduate assistants and postdoctoral researchers who increase output, training, and exposure, and finally, the pedagogical capacity to teach research and advise students to engage in research Gillespie & Robertson, 2010; Eder & Pierce, 2011; Sulo et al., 2012; Huenneke et al., 2017; Institutional Research, Planning, & Accreditation. 2020; Okstad & Dahlk, 2021); thus, the descriptive general "need improvement" evaluation of the research policy of the institution might have impacted the quantity and quality of the research paper.

3.3 Relationship Between the Affecting Factors and Scientific Research Productivity in Terms of Quality.

The descriptive statistics discussed above only describe the quantity and quality of research productivity in SHS students across the academic years and the measurement of the literature-based factors affecting research productivity. Pearson Moment Correlation was used to thoroughly investigate if these factors are related to the quality of research.

Data suggest that among the factors, student SRS [r (130) = .564, p=<.0001], teacher SRS [r (130) = .504, p=<.0001], Research Policy [r (130) = .480, p=<.0001] have a significantly positive correlation with the quality of student research papers (Table 7). The student SRS & quality relationship provides linear evidence that student SRS can affect the quality of research papers, implying that as student SRS increases, the quality of research paper papers also increases. Results also revealed that teacher SRS directly affects the quality of created research papers, implying that teachers should have high SRS to increase the quality of research papers. Additionally, this also reveals that teacher SRS directly affects student SRS, that as teacher SRS increases, the student SRS also increases [r (130) = .766, p=<.0001]. The relationship between the Research Policy and the quality of the paper insinuates that as the institutional research policy becomes more comprehensive the more the quality of research produced increases. It is also observable in the table that research policy is linearly associated with teacher SRS [r (130) = .469, p=<.0001], suggesting that the more comprehensive the research policy is, the more teacher research skills can be elevated that in, turn provides an enhancement for research policy.

Results provide evidence that these factors have a positive relationship with the quality of papers, suggesting that a subsequent decline in the quality of papers is expected whenever each factor decreases. Student skills in managing scientific information from their experiment and related studies and literature, and their processing scientific information ability in organized, appropriate, and correct scientific-based guidelines such as skills to analyze data, discuss scientific findings, analyze information from own experiment and literature and various data sources and lastly, student ability to developing their scientific inquiry and hypothesis, to formulate scientific information from literature and own experiment to devising research plans and its implementation, are vital factors in the quality of research paper being completed, thus, training students in this particular regards is imperative.

Table 5: Pearson moment correlation of affecting factors and scientific research quality

Variable	S	QP	SRS	TRS	FP
Quality of Paper	r *p*	-	-	-	-
Student Research Skills	r *p*	564** .000	-	-	-
Teacher Research Skills	r *p*	.504** .000	.766** .000	-	-
Research Policy	r *p*	*.480*** *.000*	0.645** .000	.469** .000	0.014 .870

Legend: S, statistics; QP, Quality of Paper; SRS, Student Research Skills; TRS, Teacher Research Skills; FP, Faculty Performance

**Significant at 0.01 level (2-tailed)

Additionally, the connection result promotes the appropriate integration and application of research-based or research skills-developing methodologies in teaching, creating learning activities, and organizing the curriculum at the basic senior high school level (Balagtas et al., 2019). When conducting research, students must effectively use their functional knowledge and literacy, be able to observe phenomena that might be of interest to them, and then ask scientific questions based on those observations. They must also be able to formulate hypotheses, conduct experiments, draw conclusions, and share their findings, all of which require expertise in various domains of the learning taxonomy. Although this also requires students' ability to recall scientific information and understand phenomena. Application skills needed in planning, implementing, and crafting the experiments it is cumbersome in the higher order thinking skills such as analysis, used during the analysis of experimental data and pieces of literature up to the evaluation of the reliability of experimental implementation and data sources to the subsequent creation of findings, conclusion, among others (Atieno et al., 2021; Kalinowski & Willoughby, 2019; National Research Council, 2012; Ozgelen, 2012; Sulo et al., 2012). In this regard, increasing the quality of research papers via elevating student SRS could be a way to increase the Philippines at large-scale large scale assessment like TIMSS that requires the scientific ability to know, apply, and reason (Mullis et al., 2020) as well as a strategy in targeting SDG 4 and its indicator on the quality of education for equitable and quality primary and secondary education leading to relevant and effective learning outcomes (UNESCO, 2018)

This is the same with the implication of the positive relationship between the quality of research paper and teacher scientific research skills and subsequently teacher SRS and student SRS. The degree of learning is the criterion by which teaching effectiveness is determined. The teaching process is influenced by extrinsic and intrinsic factors, most frequently the teacher's innate abilities, which students display at various stages of instruction. It has been discovered in several studies that teachers' abilities serve as a model for how students should adapt academically while learning (Blo¨meke et al., 2017; Abu Siri et al., 2020). Studies also have claimed that the competence of teachers brought elevates student motivation for higher academic productivity.

The study has provided empirical evidence that suggests a direct link between teacher SRS and the quality of research being produced, as it, is the teacher's critique guides detailed student research and the broad spectrum of cognitive skills needed to provide correction and suggestions are given by the teachers and at some point in instruction are being modeled by the teacher on how to properly execute the various sections and stage of the research process, implementation, and its writing, implying that teachers knowledge and skills affect student progress and ultimately the quality of research paper they produce (Blo¨meke et al., 2017; Hill & Chin, 2018). Moreover, teachers' skills and knowledge ensure the quality of instructions; that can also be said with teaching research, the scientific process of research planning, implementation, and writing is guided by a broad spectrum of scientific rules, especially with STEM-related studies that need accurate experimental designs, and teacher needs to provide the correct and appropriate ways to the student when doing research, which presents the importance of quality of instruction that has directly been found to be connected with their skills (Bruckmeier et al., 2016; Hill et al., 2007; Kelcey et al., 2019). The chain effect relationship between teacher competence, instructional quality, and instructional quality to student academic progress and outputs provides empirical support to the result of the study (Bruckmeier et al., 2016; Blo¨meke et al., 2017; Hill et al., 2007; Kelcey et al., 2019).

Additionally, results also reveal a direct positive relationship between teacher SRS and student SRS. Zhu et al. (2019) investigated the impact of instructional quality as a mediating factor for students' learning gains, including student-gained skills and cognitive competence, providing support to the result of this study. This insinuates that the ability of students to develop, manage and process scientific information necessary for a quality research paper is mediated by the instructional quality being provided by the teacher and, in a chain effect, being affected by the teacher's competence to develop, manage, and process scientific information. The positive relationship found between institutional research policy and the quality of paper suggests a direct relationship of systems and guidelines on the research of the institution with the quality of student paper, implying that the evaluated non-inclusion of a system for quality assurance of student research contributed to student low-quality research paper, the non-standardized mechanism in reviewing and critiquing including the presence of institutional review tool impacted the quality of research paper. To boot, the absence of a framework to increase student engagement in a research context might also have contributed based on the positive relationship result of the study, contextualizing that provision of engagement and development framework specific to senior high school affect the quality of paper, fostering research and culture at middle size to the smaller institution is hurdle institutions for high research productivity providing support on the relationship found in the study (Eder & Pierce, 2011; Gillespie & Robertson, 2010).

Furthermore, the absence of a system for the publication of student research in the local and international contexts could have also affected the quality of the paper, as student research needs to be reviewed accordingly. A suitable support system for research resources is also essential (Huenneke et al., 2017; Institutional Research, Planning, & Accreditation. 2020). Above all this, a framework to research mentoring and advising systems for students is also absent from the research policy, system, and guidelines that give a standardized procedure for assigning mentors (Atieno et al., 2021; Institutional Research, Planning, & Accreditation, 2020; Huenneke et al., 2017; Sulo et al., 2012).

The mentor's responsibility to the student and institutionalized process of research critiquing and panel reviewing among mentors. Studies have claimed that the pedagogical capacity to teach research and advise students was another obstacle to research productivity (Okstad & Dahlk, 2021; Westerlund & Barett, 2022).

Any policy that offers a suitable system and approach can increase research culture and productivity. Policy as a form of commitment by the leaders also factored in research-based practices that provide modeling for students. On top of that, the policy ensures commitment to support resources from the institution, including personnel, facilities, and funds (Brazeau, 2013). Additionally, Okstad & Dahlk (2021) argued in the same paper that the mentoring system, along with teacher-led research projects, bring forth advents of curiosity and pragmatic academic ability (Lopatto, 2009; Institutional Research, Planning & Accreditation, 2020) and that cross-discipline stakeholder engagement, establishing research frameworks and agenda, with the addition of a provision to student engagement opportunity, play an essential role in student success. Howbeit, all of which are in the context of higher education institutions and qualifications, this establishing research policy on primary education institutions can indeed be probable in increasing research productivity, additionally, complete adaptation and implementation of the DepEd Basic Research Agenda as an establishment of guidelines and system to research productivity, especially in senior high school level.

Moreover, an increase in the scientific research literacy of students provides the foundation for molding the future scientific community of the country. Subsequently, it increases human capital effect affecting the economic state of the country through research and development, the primary goal of the Department of Science and Technology through their human capacitating programs, such as the Capacity Building Program in Science and Mathematics Education (CBPSME) that aims to improve the quality of science education in the country and accelerate the development of a critical mass of experts in science and mathematics education (Department of Science and Technology-Science Education Institute, 2021, March 08). The researchers also observed in the participating school that there needs to be more research for students and faculty in the institution. Moreover, since its opening in 2016, there has been zero publication in any local or international journal. Additionally, the research policy is centered only on maritime courses but not across all the departments, especially for its senior high school, another opportunity in which research policy is about research productivity can be improved.

4. Conclusions

Research productivity can be viewed as one of the ultimate measures of knowledge and skills of students, as it reflects the entirety of students thinking skills based on blooms taxonomy, and the overall research productivity, both quantity, and quality, also reflect the quality of education provided by an educational institution. With the results provided above, the study concludes relatively low research productivity in both quantity and quality of private senior high schools differently from claimed results of various studies (Atieno et al., 2021; Feng et al., 2021; Kuzhavekova & Lee, 2018; Pajic, 2015; Wang et al., 2021). Affecting factors such as student SRS were found to be of need improvement. At the same time, teachers' SRS is generally good, indicative of below excellent skills in developing, processing, and managing scientific information needed for research development. Research policy is also conclusively proven to be questionable as most of the criteria needed for an adequate research policy were not included in the actual policy (Okstad & Dahlk, 2021; Westerlund & Barett, 2022). Additionally, the study concluded, based on the result of Pearson r, that student SRS, teacher SRS, and research policy have a significant positive effect on the quality of student research, conclusively proving evidence that this factor elevates the quality of paper goes along with it increasing in level.

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