Measuring the Level of Achievement of Standards-Based Basic Education STEM Research and its Effect on Students' Quality of Research: A Predictive Modelling as Basis for Improvement

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Abstract- The introduction of the Enhanced Basic Education Act of 2013 has paved the way for the introduction of formal study of research in basic education across senior high school catering schools in the Philippines. Thus, it is imperative to assess how standards related to research in both learning, teaching, and leading standards are achieved by Science, Technology, Engineering, and Mathematics (STEM) providing schools and how these standards affect the quality of research papers produced by the students, and how to improve curricular structure and instruction based on the findings of the study. A total of 123 students, 16 teachers who took and taught research subjects last 2021-2022, and five school heads of two public schools participated in the study. Using four researcher-made instruments with good to excellent reliability results, in which teachers assessed learning standards, student and school heads measured teaching standards and teachers assessed leading standards.

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Strictly as per the compliance and regulations of:

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Abstract of the Study- The introduction of the Enhanced Basic Education Act of 2013 has paved the way for the introduction of formal study of research in basic education across senior high school catering schools in the Philippines. Thus, it is imperative to assess how standards related to research in both learning, teaching, and leading standards are achieved by Science, Technology, Engineering, and Mathematics (STEM) providing schools and how these standards affect the quality of research papers produced by the students, and how to improve curricular structure and instruction based on the findings of the study. A total of 123 students, 16 teachers who took and taught research subjects last 2021-2022, and five school heads of two public schools participated in the study. Using four researcher-made instruments with good to excellent reliability results, in which teachers assessed learning standards, student and school heads measured teaching standards and teachers assessed leading standards. Results showed that the research assessed were found to need improvement in terms of quality, learning standards were achieved at an average beginner level, and teaching and leading standards were found to be on the proficient level. Predictive modeling showed that the quality of the research paper is directly influenced by learning standards, teaching standards domains one, two, and seven, and overall leading standards. In conclusion, schools must improve student, teacher, and school heads' skills and capacity to do research and achieve the standards related to research to increase the quality of research papers produced by the students through the revision of curricular structure, instruction, and development programs for concerned stakeholders.

Keywords: learning standards, teaching standards, leading standards, quality of research, science education.

I. Introduction

a) Context of Research in Basic Education

Only after the legislative foundation for the addition of two more years to extend high school education to prepare for the university level was approved was research in basic education introduced. The aims for college, vocational, and technical job opportunities are expanded by Republic Act No. 10533, also known as the Enhanced Basic Education Act of 2013. Following this law, the Department of Education (DepEd) published Department Order (DO) number 43

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(2013), which implements the rules and regulations of the Republic Act No. 10533 and DO No. 21 s. 2019 Policy Guidelines for the K–12 Basic Education Program enable K–12 implementation standardization. These changes to the basic education curriculum correspond with Sustainable Development Goal 4, which aims to deliver quality education. Its guiding concept of offering a curriculum that is inclusive, progressive, appropriate, and pertinent supports SDG 4's objectives (Quick Guide to SDG 4 and its Indicators, 2018). Students are formally introduced to research courses in Senior High School (SHS). In the SHS core curriculum, two particular core courses aim to provide skills that lead to systematic research in the applied course of the SHS tracks, three courses are dedicated to research: Practical Research 1, dealing with qualitative research; Practical Research 2 which trains the student for quantitative research and Inquires, Investigations, and Immersion, on the practical application of research and integrative, scientific and creative academic manner. In the Science Technology, Engineering, and Mathematics (STEM) Strand, the students also have their final research commonly termed a Research capstone. The Enhanced Basic Education Program and curriculum's target skills were established as the learning outcomes for this course, and the DepEd set these applied courses to require students to produce well-written research reports as their product. Accordingly, in translation research productivity, quantity, and quality are the most appropriate measures of basic education institutions if these outcomes are achieved. However, as things stand, there is a dearth of studies and research on basic education research quality, which is followed by standards-based evaluation of the attainment of standards, particularly student-led research (Kuzhabekova & Lee, 2018; Atieno et al., 2021).

b) Learning Standards of Research Courses in Basic Education

Standards can be understood as definitions of what someone should know and be able to do to be considered competent in a (professional or educational) domain. Standards can be used to describe and communicate what is most worthy or desirable to achieve, what counts as quality learning, or as good practice. Standards can also be used as measures or benchmarks, and, thus, as a tool for decision-making, indicating the distance between actual performance and

the minimum level of performance required to be considered competent. In other words, standards can be understood as defining the dimensions of performance or the domains of learning that are valued and that are worthy of being promoted, but they can also be used to assess if what is valued is being achieved or not. Thus, standards can be used in the sense of a banner or flag and as a yardstick or a measuring rod (Centre of Study for Policies and Practices in Education, 2013). In the Philippine context, the spiral progressive curricular framework of the K to 12 programs is explicitly articulated in its learning standards and learning competencies that are iterated to be research-based (Policy Guidelines on the K to 12 Basic Education Program, 2019, pg. 9). Standards and principles of the curriculum mandates for a learner-centered, inclusive, developmental program that is relevant, responsive, and research-based (Implementing Rules and Regulation of the Republic Act 10533, 2013, pg. 3, Rule II, Section 10.2). Under section VII, Monitoring and Evaluation, the key immediate evaluation of Intermediate outcomes is the attainment of learning standards (Policy Guidelines on the K to 12 Basic Education Program, 2019, pg. 13). Learning standards were divided into two major reiterations, content standards and performance standards, which are detailed in the learning competencies provision of the curriculum. These standards were set as guidance for instruction and ultimately the education goal for each course to attain the ultimate holistic development ready students for higher education (Policy Guidelines on the K to 12 Basic Education Program, 2019, pg. 13). Each plotted course in every strand has a corresponding learning standard. In the STEM curriculum, research subjects were generally plotted with standards that aim for students to develop scientific research knowledge and skills necessary for them to create a scientific report or paper, especially in Research Capstone (Policy Guidelines on the K to 12 Basic Education Program, 2019, Annex 2, pg. 65-66; Clarifications and Additional Information to DepEd Order No. 30, 2018, Enclosure No. 3). The research of White (2021) stipulated that the shift to standards-based grading and assessment should be strengthened in such a way that all teacher's means of verification should be anchored to the intended learning, teaching, and leading standards prescribed by the authorities. Another crucial and contentious component of a genuine standards-based system is behavior grading. To understand how teachers determined students' final marks on report cards, Tierney et al. (2011) conducted a study and stated that they deducted points for unfinished work and concurred that a student's grade was determined by how well they ranked among their peers. Grading standards change depending on teacher experience and school contexts, according to Gershenson's (2020) study of how teacher evaluations affect content

knowledge. Students must be taught the skill that is being scored to have correct grading systems; otherwise, grades are fundamentally faulty and no longer a reliable indicator of student competency (Schimmer, 2016). Parents need to know that the marks they see for their students are an accurate depiction of their learning at that time because grades should indicate proficiency rather than reward actions (Schimmer, 2016). Thus, pieces of evidence of learning must be aligned with standards. Further, this implies revisitation of the means of verification guidelines of the department of education in which verifications still include ICT integration/utilizing technology resources in planning, designing, and delivery of the lesson, materials to be used are specified in the LP, and all parts are present. Several research has examined whether standards-based systems' skills link to greater test scores and achievement and have shown the correlation between test scores and standards-based grading systems (Lehman et al., 2018; U.S. Department of Education, 2017).

However, few have been reported to have investigated the actual accomplishment of these learning standards, thus, this study was delved into finding out the attainment of these learning standards by closely examining the students and their research outputs against these prescribed standards.

c) Teaching Standards Related to Research for Basic Education

Teaching standards were described as the demands placed on teachers' professional engagement, practice, and knowledge levels that also give teachers the freedom to apply their developing knowledge in a variety of more sophisticated teaching and learning scenarios (National Adoption and Implementation of Professional Standards for Teachers, 2017, pg. 4).

The DepEd Order (DO) number 43, Implementing Rules and Regulation of the Republic Act 10533 (2013, pg. 3), under rule II, curriculum, explicitly stated that one of the principles of the K to 12 curricula is capable teachers' availability in implementing the guidelines. This means that all learning standards, both content and performance, of the curriculum shall be masterfully possessed by teachers implementing the respective courses, in this case, teachers teaching research courses should be capable of all the knowledge and skills of research, its process, and the writing of the report, to be able to completely implement the curriculum and produce the intended outcomes. Moreover, it has also been stipulated that the implementation of the curricula should be research-based (Policy Guidelines on the K to 12 Basic Education Program, 2019, pg. 4), implying that teachers who implement the respective learning standards prescribed by the national education governing body shall possess the necessary research skills needed. Moreover, it has

also put a premium on pedagogical approaches that hone students' ability to question, investigate, prove, probe, explain, predict, and establish connections among information such as inquiry-based learning, reflective learning, and collaborative learning (Policy Guidelines on the K to 12 Basic Education Program, 2019, pg. 5). All which are covered entirely by the basic education research courses, starting from observation to questioning, to formulating a hypothesis, testing the hypothesis, concluding down to the actual writing of the report and the collaborative nature of how the courses groups student. In support, the DepEd provided a framework that entails training and developing teachers who are qualified to teach the curriculum (National Adoption and Implementation of Professional Standards for Teachers, 2017). It has been stated that through quality teachers the Philippines be able to produce holistic students with 21st-century learning skills that will help the aid development and progress of the Philippines (National Adoption and Implementation of Professional Standards for Teachers, 2017, pg. 3). Implications that teachers must possess the necessary skills to teach the subject aiming for the accomplishment of the learning standards, in context research teachers should have a masterful understanding of the knowledge, increasing student achievement, propelling quality of learning through the quality of teaching.

The Philippine Professional Standards for Teachers (PPST) provides seven distinct domains described according to four career stages, from beginner teacher to distinguished teacher, across the domains there are specific sections that are highly related to the possession of research skills (National Adoption and Implementation of Professional Standards for Teachers, 2017, pg. 4-8). First, Content Knowledge and Pedagogy, in which teachers are trained and expected to use masterful teaching of content knowledge in congruence with skills in applying the set content knowledge to principles of teaching theories and the teaching-learning process. Strand 1.1 of the domain, states that teachers must be able to expertly use content knowledge across the target learning standards and around curricular relations of the entire program, in the context of the research subject teachers must be able to demonstrate excellent usage of content knowledge in the teaching of quantitative and qualitative research and guidance to the student during the writing of the report. Strand 1.2, explicitly includes the research-based knowledge and principles of teaching and learning to be applied by the teachers, implying that any K to 12 teachers must possess the ability to research information and use the research process in the teaching and learning of their respective course, thus, in the context of teachers implementing basic education research courses, must possess masterful skills in researching. Under the domain, strand 1.4, teachers

must use strategies that promote literacy and numeracy, across the three main research courses, literacy is developed through qualitative research and numeracy through quantitative research and cumulatively by research capstone, thus, teachers are expected to have the skills in reading, writing, computing, and inferencing, a skill that is fundamentally needed by researchers. Additionally, all the same strands 1.3, use of information and communications technology (ICT), 1.5 state, teachers are expected exemplary skills in using strategies that develop higher-order thinking skills, critical and creative thinking of students, and 1.6 and 1.7 state teacher ability to communicate effectively in the classroom (National Adoption and Implementation of Professional Standards for Teachers, 2017, pg. 10-11). Whether a learner learns anything or not is greatly influenced by the teacher and the following factors. One well-known factor is the teacher's instructional approach and performance effectiveness, which also includes teaching time management, content index, teacher instructional quality, variety of classroom setup, content and cognitive mastery of concepts and skills to be taught, among other important components of successful learning (Yustina et al., 2018; Abu Siri et al., 2020). Knight and Cooper (2019) proved that standards-based grading increases the focus, effectiveness, and enjoyment of teaching and learning, and teachers believe it to be a workable reform.

Consequently, the National Adoption and Implementation of Professional Standards for Teachers (2017) included Domain standard 2, learning environment, which that states to encourage student responsibility and achievement, it is the job of instructors to provide learning environments that are secure, fair, and supportive. This domain focuses on developing learning environments where teachers can effectively control students' conduct both in real-world settings and online. It emphasizes the necessity for educators to use various tools and offers mentally engaging and demanding activities to foster positive classroom interactions directed toward achieving high standards of learning. In the context of basic education research subjects, teachers are demanded to provide learning environments that support the mastery of research and all needed skills and competencies by the students through real-world settings, activities, classroom interaction, and support. According to Ibrahim Abbas (2017), teachers play a significant role in online classrooms as they may create a learning atmosphere and supply instructional materials for students in blended courses. The learning environment is the canvas of teachers' instructional approaches, methods, activities, and theories (Sadera et al., 2014). Fisher (2005) provided several physical measures of an effective learning environment that include the learner and teacher's physical space, availability of learning resources, classroom physical arrangement, and

characteristics, and classroom compatibility to teaching and learning activities, strategies, and methods. Balog (2018) added teaching materials, technical tools, curriculum, training, and instruction.

The inclusion of this requirement in the teaching standards under Domain 3 on learner diversity emphasizes the critical role that teachers play in developing inclusive learning environments. It encourages students to value diversity in the classroom and stresses the importance of using a variety of teaching techniques to prepare all students to be productive members of a local and global community that is always changing. It highlights how important it is for teachers to consider and show respect for their pupils' diverse characteristics and experiences when arranging and developing learning opportunities. The following five requirements must be met for standards to be effective: they must be flexible and developmental (Udvari-Solner, 1996), not one-size-fits-all (Bay, 1997); they must evaluate a range of competencies using guides for creating public policy and engaging learning environments for all students. They allow equitable access to meaningful content (Strong, Silver, & Perini, 1999); they involve the entire school and community in implementing standards (Cook & Friend, 1995); and they allow for a variety of assessment measures rather than high-stakes tests. This implies teaching standards must also cater to the diverse challenges of the students. In the context of teaching research, this includes the ability of teachers to instruct and guide different learning abilities of students to accomplish the necessary learning standards for the research subject. The guidelines also include curriculum and planning under Domain 4 which focuses on the understanding and application of the local and national curricular standards by teachers. This domain covers their capacity to convert curriculum material into engaging learning activities that are founded on the fundamentals of successful teaching and learning. To plan and develop well-structured and sequential classes, either on their own or in conjunction with others, it is expected instructors to use their professional knowledge. These lesson plans and related materials encourage student engagement, knowledge, and achievement, learning programs should be contextually appropriate, responsive to learners' needs, and provide a variety of ways to communicate learning goals. This domain includes standards of planning and management of the teaching and learning process, implying a masterful formulation of teaching, and learning practices for the accomplishment of the intended learning standards and includes alignment of learning outcomes with learning competencies, in the context of research subjects This includes systematic creation of teaching and learning strategies, activities and assessment to accomplish the learning standards.

Additionally, enhanced support for teacher quality training and equipping, with its connective process on Department of Education Order No. 42, series of 2017, the basic education sector adopted the Philippine That allows well-defined domains, strands, and indicators that measure learning, competent practice, and engagement, founded on philosophies of learner-centeredness, lifelong learning, and inclusiveness, thus requiring the teacher to acquire knowledge and skills to effectively deliver quality education. This facet of the guidelines is specific in targeting SDG 4 Quality education, indicator c.1 on teacher training and capacity building (UNESCO Quick Guide to SDG 4 and its indicators, 2018). Factors revealed by research to affect student output and outcomes (Prihantoro et al., 2019; Abu Siri et al., 2020).

The quality of education depends on the quality of teachers; thus, the selection, recruitment, and development of teachers must follow standards to ensure quality teachers that were implemented in the curriculum and help students attain the necessary learning standards (Organization for Economic Cooperation and Development, 2018, p. 20). Results from multilevel modeling demonstrated that fostering conceptual knowledge has a considerable positive impact on students' achievement and situational interest can be characterized by five key factors, according to qualitative analysis. In light of this, integrating Fostering Conceptual Knowledge into biology training appears promising (Förtsch et al., 2020).

d) Leading Standards Related to Research for Basic Education

The quality of education can be explicitly affected by the rules, regulations, and guidelines that govern the school and its human resources, thus, the implementors of these guidelines, the school heads, shall possess the necessary qualifications to shape school environment (Organization for Economic Cooperation and Development, 2018, p. 20). The Philippine educational system has adopted this particular professional standard for school heads, defined as a set of quality measures that are K–12-aligned, globally comparable, and attentive to school principals' career objectives.

The National Adoption and Implementation of the Philippine Professional Standards for School Heads (PPSSH) (2020), stipulates standards for school heads that include, department heads and school principals or any positions similar. The guidelines recognize the role of school heads in the actual implementation of the intended curriculum and subsequent learning standards and the impact of the attainment of school heads leading standards to the holistic development of teachers and learners. This is in congruence with the Implementation of the Philippine Professional Standards for Supervisors (2019). This particular guideline provided

a framework for the expectations for professional development, effective support for teaching and learning, and leadership skills and proficiency that lead to an efficient and high level of accomplishment of the intended curriculum and standards. PPSSH framework emphasizes that school heads and their leading styles should be learner-centered, build a network of stakeholders for school and people effectiveness, be able to understand and pinpoint problems and issues at the school and address them, formulate high-quality instruction, develop a strong school culture, and work-embedded professional development programs for school personnel presents values and concepts in promoting school success, highlights the function of accountability and transparency, and embeds the principles of inclusivity (National Adoption and Implementation of the Philippine Professional Standards for School Heads, 2020, pg. 4-5). PPSSH framework defines five (5) leading standards or domains, which are (1) Leading Strategically, (2) Managing School Operations and Resources, (3) Focusing on Teaching and Learning, (4) Developing Self and Others, and (5) Building Connections.

School leadership standards in the Philippines were defined in five (5) additional themes; (1) sets the direction of the school, they uses various information and establish patterns for decision-making, this includes the ability to use conduct school wide research and use existing research in formulating plan of action for the whole school; (2) Manages the systems and processes of the school, they ensures the complete implementation of laws, policies, guidelines and regulations relating to all resources of the school contextually this include the managing of the attainment of learning standards for research courses; (3) School leaders promote quality teaching and learning, that encompasses the promotion of necessary 21st century skills that includes the essential characteristics of researchers, this also include the building of learner-centred environment and competence improvement of teachers; (4) Nurture themselves and other through explicit professional development programs and activities this includes attending to seminars and workshop and contextually on research and related-topics; (5) lastly, school leaders engages stakeholders in all school improvement activities this includes building and production of knowledge through research (Philippine Professional Standards for School Heads, 2020). Moreover, the DepEd provided policy guidelines on research management for school heads that insinuates evidence-based decision-making from various education reforms or initiatives shall strengthen the culture of research in the Department headed by school heads in school-based research activities (Research Management Guidelines, 2017). In addition, it improves the fund-sourcing mechanisms and reinforces the link of research to education processes through research dissemination, utilization, and advocacy (Research Management Guidelines, 2017).

Congruently, the Implementing Rules and Regulation of the Republic Act 10533 (2013, pg. 4-6), under Teacher Education and Training, stipulates the principles of Training School Leadership. Superintendents, principals, subject area coordinators, and other instructional school leaders shall likewise undergo workshops and training to enhance their skills in their roles as academic, administrative, and community leaders. DepEd teachers who implement the enhanced basic education curriculum but have not undergone pre-service education aligned with the enhanced basic education curriculum shall be trained to meet the content and performance standards.

e) *Standards and Student Outputs*

Standards have been defined with the following purposes, for fostering commitments to equity (Barber and Mourshed, 2007), providing common criteria against which to assess students' progress (ACARA 2011, as cited in Organization for Economic Cooperation and Development, 2018, p. 18-19), facilitating communication between the various groups interested in education and its quality, emphasizing the end goal of the school system, and focusing on learning outcomes for students are all ways to make learning expectations for students in schools clear and explicit (Sadler, 1987). Most often standards are created for all areas of learning, going beyond academic achievement and, in some cases, taking social and personal development competencies or the use of technologies into consideration. These standards describe the learning progress along a continuum from beginner to expert for the entire school cycle and in the end the entire education level. Standards have been profoundly stated to direct developmentally appropriate expectations and learning standards, as well as inform instruction that accurately reflects children's ability levels throughout the educational years, to be truly effective in promoting children's development as evidenced by their academic outcomes (Litkowski, 2020), describing general learning paths for particular skills (Clements & Sarama, 2017), concentrates on fundamental concepts that kids have previously understood and promote student academic advancement (Engel et al., 2016) and emphasize aligned of standards across educational years (Stipek et al., 2017). Thus, it provides direct guidance among students, teachers, and school heads on the target learning outcomes and student evidence of learning increasing the quality of outputs.

A study by Leithwood (2008) on school leadership concerning important teacher variables and student performance investigated how much different sources of this leadership contributed on average and whether variations in collective leadership styles were associated with variations in student accomplishment.

the degree to which student achievement varies between schools. All students and other stakeholders received more leadership influence from higher-achieving schools than from lower-achieving schools. The leadership exhibited by school teams, parents, and students was where these distinctions were most noticeable. At all achievement levels, principals received the highest ratings for influence in the classroom implicating that power seems to be a limitless resource. An investigation into how instructional strategies and principals' leadership behaviors in lower secondary schools affect students' achievement and outcomes revealed that teachers have a mediating role in the indirect positive effects that principals' leadership behaviors have on students' math achievement (Özdemir, 2019). To improve the quality of instruction and student accomplishment, principals should acknowledge and support teachers' shared accountability and deprived practices across all educational systems and courses among different student educational levels including basic education. Although standards-based reform is sometimes an underappreciated aspect of instructional leadership (Guskey & Link, 2019), school leaders who are courageous enough to encourage their faculty in this direction are urged to consider several leadership lessons from the literature. This is crucial since principals frequently concur with the principles of altering grading practices but disproportionately report using these principles in their buildings (Carter, 2016). Starting the discussion on grading in schools should follow realistic suggestions. While crucial to teachers and parents, determining the meaning of grades should come after a leadership team has decided on its objectives. To put it another way, schools should carefully analyze the grading reform concepts before tackling policies and procedures (Reeves, 2011).

With all this presented evidence, it is imperative that a thorough investigation into how these standards and the level of achievement of students, teachers, and school heads affect the quality of research papers of STEM students as a measure of culminated research skills.

f) Research Questions

1. What is the level of quality of research capstone of STEM students in their Research Capstone Subject?
2. What is the level of achievement of standards-based research education, in terms of:
   i. Learning Standards as assessed by teachers,
   ii. Teaching Standards as assessed by students and school heads,
   iii. Leading Standards as assessed by teachers?
3. Can the level of standards-based education predict the quality of STEM student research papers?

II. METHODOLOGY

a) Research Design

The study employs a descriptive regression design, aiming to create a validated and evaluated instructional material for employing a quantitative predictive modeling design to gather complementary data on the above-mentioned facets of standards-based basic education research to the quality of student research papers (Creswell, Plano Clark, et al., 2003).

b) Sampling, Participants, and Research Locale

The study used purposive stratified random sampling. Selected National Public High Schools of Nueva Ecija catering to the STEM-SHS program was the locale of the study. Participants included Grades 11 & 12 STEM SHS students (n=103) and teachers (n=16) across academic years (AY) 2021-2022 who took and taught practical research 1 & 2 and Research Capstone. Teachers were asked to assess the level of achievement of learning standards and leading standards. The school principals and assistant principals (n=5) were also asked to participate in the evaluation of teaching standards.

c) Data Collection Procedures

The experiment must follow ethical guidelines, and authorization from the administration and school principal must first be obtained. Only students with a parental agreement were involved in the trial. Consent forms from the parents were also secured and incorporated into the computerized forms. A letter to the school heads with all the relevant information was used to get institutional authorization. Following the institution's policy, the steps to retrieve student work from the library shall be followed. For the qualitative portion of the study, a semi-structured interview was created based on the learning-teaching-leading standards set by the DepEd. Google Forms and a shared spreadsheet were used to implement and keep track of surveys, reviews, and evaluations. A review meeting was also done virtually, and it included a discussion of how to implement the evaluation instruments that were used. This study uses various methods to evaluate research productivity. Document and output resources include student research papers, teaching aids, and institutional policies, involving detailed archive examination, organized item lists, and data accuracy checks (Brownson et al., 2009; MacDonald et al., 2001). Direct measurement assesses the quantity and quality of outputs and the research abilities of students and instructors, using a survey to collect qualitative data through essays for statistical analysis and generalizable interpretation. Additionally, semi-structured interviews with key informants gather data on factors affecting study productivity through online recorded sessions.

d) Instrumentation

i. Instrument 1: Quality of Research Rubric (QRR)

This study used rubric tools, to measure the independent and dependent variables of the study. The quality of the research paper created in the research capstone of the students was assessed using the rubric used by Santiago and Soliven (2022) among STEM research papers, computed with a reliability of 0.868 alpha score (Hedden, 1997). It is composed of 24 elements that make up the instrument and assesses everything from the feasibility of the study to the conclusion and recommendations. They cover everything from completing key research components through statistics and data analysis to results, interpretation, and debate. It rates the four categories on a Likert scale from Questionable (1) to Excellent to evaluate the article and the researchers' abilities (4). All papers were categorized using a verbal interpretation bracket scheme into four categories: questionable (grades of 1 to 1.49), needs improvement (1.50 to 2.49), competent (2.50 to 3.49), and excellent (grades of 3.5 to 4.0) (Dancey & Reidy, 2002).

ii. Instrument 2: Research Learning Standards Tool

To assess the achievement of learning standards the researchers created a questionnaire based on the learning standards of Practical Research 1 & 2 Curriculum Guide (2013) & Research Project/ Capstone Curriculum Guide (2016). It rates the achievement of learning standards using the Likert scale from Not Observed at all (1) to Excellent to evaluate the article and the researchers' abilities (4). It is composed of eleven (11) items. Achievement of learning standards was categorized using a verbal interpretation bracket scheme into four categories: Needs improvement (grades of 1 to 1.49), beginner (1.50 to 2.49), proficient (2.50 to 3.49), and highly proficient (grades of 3.50 to 4.0) (Dancey & Reidy, 2002). This was employed by both the students and teachers to ensure unbiased data from both raters.

iii. Instrument 3: Research Teaching Standards Tool

For the measurement of achievement of teaching standards concerning research, the researcher created a rubric based on the Philippine Professional Standards for Teachers (2017), it used the indicators in the guidelines, and it is composed of 37 items placed under seven distinct domains. It was also measured using Not observed at all (1) to Excellent (4) and was interpreted using the verbal interpretation bracket scheme into four categories: beginner (1 to 1.49), proficient (1.50 to 2.49), highly proficient (2.50 to 3.49), and distinguished (3.50 to 4.0) the same career stage description of the PPST. This was given to the principal, assistant principal, and school heads who assessed the research teachers. Cronbach alpha test revealed an internal consistency score of 0.871 which means the test has an excellent consistency that is adequate for individual measurement and diagnosis.

iv. Instrument 4: Research Leading Standards Tool

Leading standards were measured using the rubrics created based on the Philippine Professional Standards for School Heads, (2020), it is composed of 35 items based on the indicators of the PPSSH across five distinct domains (Appendix D). It was also measured using Not observed at all (1) to Excellent (4) and was interpreted using the verbal interpretation bracket scheme into four categories: beginner (1 to 1.49), proficient (1.50 to 2.49), highly proficient (2.50 to 3.49), and distinguished (3.50 to 4.0) (Dancey & Reidy, 2002). the same career stage description of the PPSSH. This was given to the research teachers who were assessed by their school heads.

e) Data Treatment

Descriptive statistics was employed to describe the frequency, percentage, standard deviation, and mean of the qualitative and quantitative data. The number and quality of research, the scientific literacy of students and teachers, and performance evaluation were described using these descriptive data. By offering predictive models of the leading, teaching, and learning standards as independent factors to the dependent variable quality of the study paper, all of which were evaluated using SPSS 26.0, stepwise multivariate linear regression analysis was used.

III. RESULTS AND DISCUSSION

a) Level of quality of research capstone of STEM students in their Research Capstone Subject

A total of 17 completed papers were recorded and stored in the school's library, the average production of completed papers was 17 papers with composed of an average with six student authors per paper, formed from the usual strategy of grouping students from either student-led formation or teacher-assigned strategy (Wang et al., 2021). Using the quality rubric tool assessed by three research experts revealed a quality score that corresponds to the need improvement description (M=2.79, SD= .366). In this regard, there is a low quality of STEM research papers even with quite a several individuals per group. Amenable with related studies, this result shows student decreased learning and academic productivity during and after the pandemic, proving as well negative impact and room for improvement in the online educational system, which further suggests a widening gap in the educational system and significant challenges for both teachers and learners (Feng et al., 2021; Wang et al., 2021). This is also congruent with the research of Santiago and Soliven (2022) wherein private school STEM Research was scored low in quality by experts, implying an agreement 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 the research, and notable that published papers are mostly created by teachers 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).

This 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 and DO 16 s. 2017, Research Management Guidelines. 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 basic education schools. These concerns with instructional practices should be in line with the precise learning objectives specified in the curriculum, and curricular innovations should be implemented with integrity (MacDonald, et al., 2016; Phillips, et al., 2017). Implementing the curriculum includes many various elements, such as delivering the material via tools and teaching techniques. Instructional techniques must be in line with the curriculum and support each student's unique requirements to implement curricula with fidelity (Causarano, 2015). Additionally, teachers must be ready to implement the curriculum (McNeill et al., 2016).

This also implies that standards related to research are not yet fully achieved, allowing equity commitments resulting in a more robust student output in this case research paper (Barber & Mourshed, 2007). This also evidences that the uniform criteria for evaluating students' progress needs further improvement in achievement, it has been stated that standards have been profoundly stated to direct developmentally appropriate expectations and learning standards, as well as inform instruction that accurately reflects children's ability levels throughout the educational years (Litkowski, 2020), describing general learning paths for particular skills (Clements & Sarama, 2017), and focuses on fundamental concepts that learners need to understand.

b) *Level of Achievement of Standards-Based Research Education*

i. *Learning Standards as Assessed by Teachers*

On average, the 123 assessed students by 16 teachers, were found to be beginners (M=2.37, SD= 3.92) across the basic education research learning standards based on the curriculum guide provided by the Department of Education (Clarifications and Additional Information to DepEd Order No. 30, 2018, Enclosure No. 3) (Table 1).

Table 1: Descriptive Statistics of Learning Standards of Two Public Schools for Grade 11 And Grade 12 STEM Students As Assessed By Teachers.

Domains of Learning Standards	Mean	SD	Verbal Description
Domain 1 (Identifying Scientific Problem)	2.65	0.548	Proficient
Domain 2 (Differentiating Research Problem)	1.96	0.615	Beginner
Domain 3 (Selecting Relevant and Related Studies)	2.57	0.605	Proficient
Domain 4 (Reviewing, Digesting, and Concisely Stating the Studies Cited)	2.61	0.588	Proficient
Domain 5 (Hypothesizing)	2.57	0.548	Proficient
Domain 6 (Planning the Experimentation)	2.61	0.588	Proficient
Domain 7 (Selecting Data Collection Procedure)	2.12	0.808	Beginner
Domain 8 (Analyzing Data Obtained)	2.12	0.826	Beginner
Domain 9 (Interpreting and Discussing the Results)	2.16	0.791	Beginner
Domain 10 (Drawing Conclusion)	2.51	0.579	Proficient
Domain 11 (Making Recommendations)	2.22	0.754	Beginner
Total Average	2.37	0.392	Beginner

Legends: Needs improvement (grades of 1 to 1.49), Beginner (1.50 to 2.49), Proficient (2.50 to 3.49), and Highly proficient (grades of 3.50 to 4.0)

This means that students were at least able to get the basics of the 11 learning standards for quantitative and qualitative research, including processes, concepts, and skills. Six out of 11 domains of learning standards were found to be proficient.

Students were most proficient at domain one, deciding on the suitable research in a specified area of interest, (M=2.65, SD= 0.548), this makes sense as this domain is taught at the very first lesson and is particularly given the effort by teachers while least scored in domain

seven, gathering and analyzing data with appropriate techniques, (M=2.12, SD=0.808) and eight, concluding, (M=2.12, SD=0.826) (Table 1). This least mastered domain is taught at the very end of the lessons, moreover, teachers who do not specialize in data analysis procedures and treatment have a hard time teaching the domain. This includes skills to utilize appropriate tools to gather data, present and interpret data in tabular and graphical forms, analyze data using statistical methods, with the examination of differences and associations being limited to bivariate analysis, and make conclusions from research findings.

ii. *Teaching Standards as Assessed by Students and School Heads*

In general, the 16 teachers assessed by 123 students, were proficient (M=2.32, SD 0.392) across the research-related teacher standards based on the PPST provided by the Department of Education (National Adoption and Implementation of Professional Standards for Teachers, 2017, pg. 4-8) (Table 2).

Table 2: Descriptive Statistics of Teaching Standards of Two Public Schools for Research Teachers as Assessed by Students and School Heads.

Domains of Teaching Standards	Mean	SD	Verbal Description
Domain 1 (Content Knowledge and Pedagogy)	2.51	0.402	Highly Proficient
Domain 2 (Learning Environment)	2.26	0.486	Proficient
Domain 3 (Diversity of Learners)	2.41	0.462	Proficient
Domain 4 (Curriculum and Planning)	2.23	0.375	Proficient
Domain 5 (Assessment and Reporting)	2.23	0.379	Proficient
Domain 6 (Community Linkages and Professional Engagement)	2.31	0.457	Proficient
Domain 7 (Personal Growth and Professional Development)	2.27	0.539	Proficient
Total Average	2.32	0.392	Proficient

Legend: Beginner (1 to 1.49), Proficient (1.50 to 2.49), Highly Proficient (2.50 to 3.49), and Distinguished (3.50 to 4.0).

This means that teachers were at least masterful in teaching standards related to quantitative and qualitative research. 6 out of 7 domains of teaching standards were found to be proficient and only one is rated highly proficient. Teachers scored highest at domain one, content and pedagogy, (M=2.51, SD= 0.402) while least scored in domain four, curriculum and planning, (M=2.23, SD=0.375) and five, assessment and reporting, (M=2.23, SD=0.379) (Table 2). This means teaching standards related to research were perceived by the students and the school heads to have been at least proficiently achieved by the teachers. The wide array of intended standards such as content knowledge of principles and concepts of research and its implementation, evaluation, and reporting is highly achieved by the teachers, this also includes research-based knowledge practice for teaching and learning, usage of ICT tools in teaching research, promotion of literacy of research writing and numeracy for data analysis and classroom communication strategies. This provides proof of adequate achievement of teaching standards across all the applied and specialized basic education research.

The findings of this study are supported by Kelcey et al. (2019) on the role of instructional quality as a mediating factor for students' learning gains, which includes student-acquired skills and cognitive competency. This implies that the quality of instruction offered by the instructor, which in turn is influenced by the teacher's capacity to produce, manage, and process scientific knowledge, mediates students' ability to develop, manage, and process scientific information necessary for excellent research papers.

iii. *Leading Standards as Assessed by Teachers*

In general, the six school heads assessed by 16 teachers, were proficient (M=2.33, SD 0.386) across the research-related leading standards based on the PPSSH provided by the Department of Education (National Adoption and Implementation of the Philippine Professional Standards for School Heads, 2020) (Table 3).

Table 3: Descriptive Statistics of Leading Standards of Two Public Schools for School Head Assessed by Teachers.

Domains of Leading Standards	Mean	SD	Verbal Description
Domain 1 (Leading Strategically)	2.46	0.374	Proficient
Domain 2 (Managing School Operations and Resources)	2.31	0.366	Proficient
Domain 3 (Focusing on Teaching and Learning)	2.38	0.499	Proficient
Domain 4 (Developing Self and Others)	2.20	0.380	Proficient
Domain 5 (Building Connections)	2.32	0.480	Proficient
Total Average	2.33	0.386	Proficient

Legend: Beginner (1 to 1.49), Proficient (1.50 to 2.49), Highly Proficient (2.50 To 3.49), and Distinguished (3.50 to 4.0).

This means that teachers were at least masterful in teaching standards related to quantitative and qualitative research. All the five domains of leading standards were found to be proficient; school heads scored highest at domain one, leading strategically, (M=2.374, SD= 0.374), this implies while least scored in domain four, developing self and others (M=2.20, SD=0.380) and two, Managing school operations and resources (M=2.31, SD=0.366) (Table 3). School heads' capacity to manage the school strategically in terms of its operations, material, and human resources, development programs, and connections are necessary to run a school and achieve its goal of developing holistic and globally competitive learners through the basic education program. Thus, the Department of Education must monitor and evaluate the achievement of leading standards among schools and the existing school heads.

c) *Predictive Modeling using the Level of Standards-Based Education to the Quality of STEM Student Research*

To determine the predictive pattern of the standards-based domain to the quality of the research paper multiple linear stepwise regression analysis was done. Results reported five models, with model five, being with the highest predictive capacity at 94.7% (Table 4), a value predictive power above the standard set at 60% (Moksony, 1999), and significant ANOVA due to regression result, $F_{(1,96)}=346.07$, $p<.0001$. The model includes the following predictive factors, the overall achievement of leading standards, learning standards, and teaching standards in domains one, two, and seven (Table 5). All variables can be seen in positive correlation with the quality of the research paper, implying that the more learners, teachers, and school heads increase their achievement of standards related to research the more the quality of paper of STEM student research increases in quality, this implies that as students increase in their capacity to perform the content and performance standards of research such as deciding on a suitable design, formulating clear research questions, selecting and synthesizing related pieces of literature and studies, creating a conceptual framework, selecting and creating appropriate methods and resources, able to collect, process and analyze data and coming up with conclusions, the quality of their paper output increase, thus further implying that the quality of research paper is a reflection of overall students learning. Moreover, this established predictive relationship between these variables correlates with the impact of teaching based on set learning standards allowing the expression of students' high learning achievement. It has been described that factors such as skills and academic characteristics a predictive factors for research productivity, as an individual increases with scientific skills the research productivity elevates (Sulo

et al., 2012; Atieno et al., 2021). This claim is also supported by the result of Santiago and Soliven (2021) that the quality of research papers is significantly predicted by student research skills, which are aimed to be developed by the learning standards. This suggests that it is imperative to train students in scientific research skills as it affects student research productivity, much more in the context of basic education, when it has only been formally introduced in the year 2013 (Enhance Basic Education Curriculum, 2013). This also provides inputs for augmenting instruction and curriculum for more qualified and quantified research outputs as student skill reflection.

Agreeable to this result is the predictive relationship of teaching standards domains one, two, and seven to the quality of the research paper. Domain one includes teachers' content knowledge and performance ability for research, congruent with the overall learning standards, it also includes teachers' research-based knowledge and teaching and learning teaching and subsequent factors have a huge impact on learning that includes content and cognitive mastery of skills, such as the scientific method and research skills, for successful learning (Prihantoro et al., 2019; Abu Siri et al., 2020). It also implies that teachers' overall skills in using ICT, such as using computer software in organizing data collected and using research statistical software in analyzing data affect positively student research papers, moreover, this also implies that as teachers' skills in promoting literacy, numeracy and higher order thinking skills their research paper increases in quality, teachers ability to train students in writing the research report based on standards of formal research writing while training them in analyzing data and interpreting it are part of this literacy, numeracy and higher order thinking skills promotion (Edelson et al., 2021). Lastly, this domain includes teachers' skills in a communication strategy that includes the ability of the teacher to provide effective feedback for student knowledge construction, and the ability to provide constructive comments to increase the quality of the paper. teacher's role in changing classroom practices should be revisited to change subsequent outcomes (Edelson et al., 2021).

It may not come as a surprise the overall achievement of learning standards set by education authorities significantly predicts the quality of student research outputs. However, it is enlightening that not just teaching and learning standards related to research affect the quality of student research output but also leading standards. As seen leading standards include strategic leadership skills related to research such as formulation, implementation of the school's vision, mission, and core values related to research, planning, and implementation that includes policy review, notably it explicitly mandates strategic leading through research and innovation that includes monitoring and evaluation

of process and tools, this means that school head's ability to lead that utilizes concepts and principles of research affects the quality of student works. This can be further observed with the school head's ability to design and implement research programs for both students and teachers. Moreover, the total leading standards include managing school operations and resources, such as records management that is essential for data gathering for research, moreover, management of school facilities and equipment is also included such as libraries that store student research works for future reference technological devices that students and teacher can use for research. This also includes openness to opportunities and challenges that can be addressed to make research easier and more manageable.

Table 4: Stepwise Regression Modelling of the Standards-Based Domains to Quality of STEM Student Research.

Model Summary								
Model	R	R^2	Adjusted R Square	Std. Error	df1	df2	Sig.	Durbin-Watson
5	.973	0.947	0.945	0.08877	1	96	0.039	0.687

Predictors: (Constant), Learning Standards, Teaching Standards 1, 2, 7 and Total Leading Standards.
Dependent Variable: Quality of Research Paper

Additionally, leading standards include school leaders' skills in reviewing school-based contextual-lization and implementation of learning standards that include basic education research subjects while utilizing the achievement of teaching standards and pedagogies associated with it augmented with teacher and learner's feedback to school teaching and learning system. This also includes management of learning assessment and evaluation processes and results, innovation in the learning environment, and discipline. All of these are directly evidenced to affect student learning and performance, as such it is safe to conclude based on the result of the study that as the school head achieves proficiency to these leading standards student research also increases in quality. However, it is notable that the last domains include developing a leader's self and others and building connections is also included in this total leading standard. This implies that school leader's personal and professional development related to research affects how leaders manage learners and teachers in terms of the engagement and development for research, this also includes rewards and recognition systems for the school leaders, teachers, and learners. Additionally, it also provides conclusive evidence that school heads' relations and management of internal and external organizations and partners affect student quality of research. With external and internal personal and professional development for research, school heads increase their capacity in planning, implementing, and evaluating research endeavors, and in turn affects teachers' and learner's skills in research through careful planning of programs for the development of research skills.

Table 5: Stepwise Regression Coefficient Table

Variables	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	0.526	0.085		6.152	0
Total Leading Standards	0.221	0.083	0.226	2.666	0.009
Total Learning Standards	0.255	0.086	0.215	2.98	0.004
Teaching Standards Domain 1	0.255	0.066	0.272	3.889	0
Teaching Standards Domain 2	0.128	0.058	0.165	2.204	0.03
Teaching Standards Domain 7	0.092	0.044	0.131	2.096	0.039

Table 5, provides a modeling formula:

$$y = .526 + .221 \cdot X^1 + .255 \cdot X^2 + .255 \cdot X^3 + .128 \cdot X^4 + 0.092 \cdot X^5$$

Whereas y is the quality of STEM student research, X^1 is the score of overall learning standards, X^2 is the score of the overall achievement of learning standards, X^3 is the score of teaching standards under domain 1, while X^4 is domain 2 and X^5 is Domain 7.

IV. Conclusions

Schools must have adequate if not high, research productivity. After all, it is one of the best indicators of a student's knowledge and skills because it captures all of their thinking abilities according to Bloom's taxonomy. Additionally, it shows how well the school has done in comparison to other institutions of higher learning. With the findings, the study concludes that STEM senior high schools have relatively poor research about beginner achievement levels on learning standards for research, teachers were found to achieve the teaching standards for research at a proficient level together with a proficient achievement level of leading standards. The predictive model concludes a direct relationship between student quality of research output with learning standards, overall leading standards, and teaching standards domains one, two, and seven.

V. Recommendations

The result of that directly implies the relationship between the level of learning standards, leading standards, and teaching standards in domains one, two, and seven, it is recommended that schools offering STEM courses achieve a high level of accomplishment of these standards. Provide students with learning opportunities that are anchored firmly to the learning standards in both content and performance standards. Schools and government authorities should also focus on the achievement of the high level of leading standards among school heads, provision of professional development opportunities across areas of strategic leading, management of school operations and resources, and skills in the management, measurement, and innovation of teaching and learning, developing self and others, and building connections about research can increase the quality of research paper produced by students. Lastly, achieving a high level of teaching standards in areas of content and pedagogy of teachers for research needs to be further developed, and provision of training for teachers in the area of research and the different teaching strategies and learning activities for teaching research should be firmly implemented and consistently done, moreover, provision of the conducive learning environment in the teaching and learning of research should also be a focus, such as the provision of access to national and international research papers, classroom structures that allow easy access to research instruments that allow a higher percentage of student participation, and lastly, schools must also focus in providing teachers in furthering themselves for personal and professional growth that impacts their philosophy, increased professional links and improvement of practice for better teaching of research subject in the basic education sector.

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