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Gender and tenure predict Filipino science teachers' instrumentation skills

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Abstract: Instrumentation skills coupled with appropriate pedagogical skills are important in the science classroom. This study examined the instrumentation skills of science teachers from public urban schools representing the three major island groups in the Philippines. Using post-positivist descriptive-correlational survey research, a total of 200 science teachers served as the respondents of this study. A valid (CVI=0.83) and reliable (α=0.98) researcher-made instrument was used to gather data. Stepwise multiple linear regression was used to analyze the data. The results suggest that gender and tenure are significant predictors of instrumentation skills among secondary science teachers. Workshops emphasizing practical hands-on experiences, focusing on female teachers who have stayed longer in the service, are recommended.
Keywords: *Instrumentation, Philippines, Science education, Science laboratories, Stepwise multiple linear regression.*

1. Introduction

Science education is important for improving problem-solving skills, critical thinking, and deeper understanding of the natural world [1]. For Science instruction to be effective, there is a need for skillful utilization of the laboratories including equipment and instruments. Teachers play an essential role in this so that students can gain practical experience to enhance their learning.

Laboratory activities are essential in science learning as they give opportunities for students to do experiments, gather data, and improve their scientific reasoning skills [2]. Nevertheless, the effective execution of laboratory activities relies on the teachers' expertise in operating and resolving issues with different instruments [3]. Science teachers with strong instrumentation skills are adept at guiding students in conducting experiments, ensuring the safe and accurate use of equipment while fostering enriching learning experiences [4]. A lack of proficiency in essential scientific instruments among science teachers can significantly hinder student learning in various ways. Teachers may face challenges in effectively demonstrating procedures and protocols, which can lead to inaccurate results and flawed data [5]. Additionally, a lack of understanding of the instruments can pose safety risks and impede the development of students' practical skills.

Science education in the Philippines faces several challenges, including a lack of resources, particularly laboratory equipment, and a shortage of qualified science teachers. Many educational institutions struggle with limited financial resources, which hinders their ability to provide essential laboratory materials and instruments. Consequently, this results in the utilization of obsolete or inadequate equipment, thereby impeding the ability to provide practical learning opportunities. This situation calls for a collaborative effort among policymakers, schools, and stakeholders to address these challenges by increasing funding for science education, implementing comprehensive teacher training programs, and nurturing a culture that values science and scientific inquiry [6]. In response to this issue, the Philippine Department of Education (DepEd) has provided educational resources to adequately support public schools, particularly those offering Science, Technology, Engineering, and Mathematics (STEM) programs. However, the lack of sufficient training and professional development opportunities for science teachers has become a significant concern, as many educators struggle to

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effectively utilize the technology available to them and deliver high-caliber teaching-learning process. This situation was aggravated when classes shifted to modular and online modalities during the pandemic [7-10]. Science activities developed for learners were inclined towards using what is available at home or geared towards maximum utilization of computer programs, videos and the like [11-14]. At present, these learning activity sheets are still used in science classes rendering the available materials and equipment unutilized. As a faculty in a receiving teacher education institution of graduates from public schools, the researcher has observed that entrant learners have minimal instrumentation skills which may be influenced by their teachers' instrumentation skills. This is also observed by other faculty members handling the same set of students.

To tackle these issues, it is important to prioritize the creation of development programs that efficiently train science teachers on using laboratory instruments in science instruction. These trainings should surpass basic instrument operation and include a thorough comprehension of principles, calibration methodologies, troubleshooting solutions, and safety protocols. It is hoped that with the execution of thorough instrumentation training, schools may equip science teachers with the necessary skills needed to deliver attractive and significant laboratory experiences to their students.

1.1. Research Problem

This study measured the instrumentation skills of science teachers from public urban schools representing the three major island groups in the Philippines. Specifically, it sought answer to the following questions:

1. Do science teachers' instrumentation skills significantly differ by their gender, age, tenure, major, and highest educational attainment?
2. Which of the science teachers' personal variables predict their instrumentation skills?

2. Research Methodology

2.1. General Background

This study used the post-positivist descriptive-correlational survey research using stepwise multiple linear regression. This design was used to determine the predictors of a science teachers' instrumentation skills. In addition, it also sought if teachers' instrumentation skills significantly vary by some of their personal demographics. Data collection was done using online forms from October to November 2024.

2.2. Respondents of the Study

Two hundred (200) Science teachers determined a priori using G*Power served as the respondents of this study. Table 1 presents the demographic profile of the respondents, categorized by various variables highlighting key trends, like gender predominance, age distribution, educational qualifications, and fields of study. These respondents were chosen randomly from among secondary science teachers from urban areas representing the three major islands in the Philippines. Majority of the respondents were female (f=151, 75.5%), younger (f=105, 52.5%), graduates of a pre-service education degree (f=156, 78.0%), Science, General Science or Natural Science majors (f=77, 38.5%), and held a bachelor's degree (f=108, 54.0%). In terms of tenure, an equal number of respondents (f=100) were categorized as having either a shorter or a longer duration of teaching.

Table 1.
Demographic profiles of study participants.

Variable	f	%
Gender		
Male	49	24.5
Female	151	75.5
Age		
Younger 38 years old and below)	105	52.5
Older (39 years old and above)	95	47.5
Tenure		
Shorter (10 years and below)	100	50.0
Longer (11 years and above)	100	50.0
Major		
Biology	69	34.5
Physical Science	42	21.0
Science/General Science/Natural Science	77	38.5
Others	12	6.0
Highest Educational Attainment		
Bachelors	108	54.0
Graduate	92	46.0
Total	200	100.0

More females in the sample show that there seems to be a gender imbalance in the survey populated. As for the age distribution, the sample used in this case has a relatively younger profile. The service length category showed that there is an equal proportion of both shorter and longer tenures, indicating that experience among the respondents was balanced. The substantial majority of the respondents holding degrees in pre-service teacher education indicate a strong educational background relevant to teaching. The context of the new teacher education curriculum as well as the pre-service science education landscape in the locale where the study was conducted dictated the majority of the respondents of the study. Moreover, the data show that just over half of the respondents have attained a bachelor's degree, while nearly half have pursued graduate education, indicating an overall well-educated sample.

2.3. Instrument and Procedures

A 21-item researcher made instrument was used to gather data for this investigation. Reading and scanning of science publications that deal with instrumentation as well as Science laboratory skills, government issuances and statutes and other related references, were done in framing the questionnaire. These were accompanied by informal consultations with secondary and university level science teachers and experts in the field. The instrument was subjected to content validity (CVI=0.83) and reliability testing (α=0.98) conducted at a non-respondent set of schools.

After satisfying ethical protocols, data were gathered using an online survey form. Science Education Supervisors from the identified areas assisted in the distribution of the survey form. To ensure the study's ethical soundness, the researcher focused on the ethical principles of fairness, beneficence, and respect for others.

2.4. Data Analysis

To answer descriptive questions, mean and standard deviation were utilized. To determine the normality of the variables for comparison, Shapiro-Wilk test was used with results showing issues, hence non-parametric statistics were used. To assess instrumentation skills according to teachers'

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personal variables, Mann-Whitney U test and Kruskal Wallis test were used. Stepwise Multiple linear regression was used to determine the predictors of instrumentation skills.

3. Research Results

The table below presents data on the level of instrumentation skills among different demographic and educational groups indicating overall proficiency in instrumentation skills. The mean ranges from 2.47 to 2.99, all interpreted as "High" except for one group, which is rated as "Low."

Table 2.
Level of Instrumentation Skills of Science Teachers when Taken as a Whole and when Grouped According to Gender, Age, Tenure, Bachelor's Degree, and Major, and Highest Educational Attainment.

Variable	M	SD	Interpretation
Gender			
Male	2.99	0.70	High
Female	2.57	0.57	High
Age			
Younger	2.74	0.68	High
Older	2.61	0.56	High
Tenure			
Shorter	2.81	0.65	High
Longer	2.54	0.57	High
Major			
Biology	2.67	0.67	High
Physical Science	2.82	0.73	High
Science/General Science/Natural Science	2.60	0.52	High
Others	2.72	0.60	High
Highest Educational Attainment			
Bachelor	2.73	0.64	High
Graduate	2.61	0.60	High
Whole	2.68	0.63	High

Male teachers had a higher mean score of 2.99 (SD = 0.70) compared to female teachers who scored 2.57 (SD = 0.57). This shows there is a gap within the proficiency in using instruments based from the participants' gender. The younger group of teachers is perceived to have better instrumentation skills than the older group (M=2.81, SD = 0.65). The data also a suggests that age determines the level of skill. More experienced teachers (M = 2.54, SD 0.57) seem to have performed worse when comparing them to less experienced teachers (M = 2.81, SD = 0.65). This gap in performance might indicate that novice teachers have more recent emphasis on 'sills or training'. Teachers with education degrees have a mean of 2.65 (SD = 0.62), while those with non-education degrees have a higher mean of 2.76 (SD = 0.63). For the major category, Physical Science had the highest mean score at 2.82 (SD = 0.73) while those who majored in Science/General Science/Natural Science have the lowest mean at 2.60 (SD = 0.52). This could reflect the varying demands of different subjects regarding instrumentation skills. Bachelor's degree holders scored slightly higher (M = 2.73, SD = 0.64) than graduate degree holders (M = 2.61, SD = 0.60).

Table 3.
Difference in the Instrumentation Skills according to Gender, Age, Tenure, Bachelor's degree, and Highest Educational Attainment.

Variable	U	z	p
Gender	2359.500*	-3.809	0.000
Age	4263.500	-1.772	0.076
Tenure	3659.500*	-3.278	0.001
Bachelor's Degree	3127.000	-0.900	0.368
Highest Educational Attainment	4332.000	-1.560	0.119

Note: *the difference in the means is significant when p≤0.05.

There was no significant difference in instrumentation skills when they were grouped according to year level [U=3337.500, p=0.374], age [U=4263.500, p=0.076], bachelor's degree [U=3127.000, p=0.368], and highest educational attainment [U=4332.000, p=0.119]. There was a significant difference in instrumentation skills when they were grouped according to gender [U=2359.500, p=0.000] and tenure [U=3659.500, p=0.001].

Table 4.
Difference in the Instrumentation Skills according to Position and Major.

Variable	χ^2	df	*p*
Position	5.677	3	0.128
Major	3.306	3	0.347

Note: the difference in the means is significant when p≤0.05.

Although there are variations in the descriptive data presented in Table 2, there was no significant difference in the level of instrumentation skills of science teachers when they were grouped according to their position [$\chi^2(3)=5.677$, $p=0.128$] or major [$\chi^2(3)=3.306$, $p=0.347$].

Gender and tenure indicated a collective significant effect on instrumentation skills based on multiple linear regression results. The regression results indicated that the predictor explained 10.9% of the variance [F(2, 197)=12.019, p=0.000, R^2=0.109)]. Further examination of individual predictors indicated that gender [β=-0.371, t=-3.705, p=0.000] and tenure [β=-0.199, t=-2.313, p=0.022] significantly predicted instrumentation skills.

Table 5.
Predictors of Instrumentation Skills.

R	R^2	Adjusted R^2	F	df	*p*
0.330	0.109	0.100	12.019	2. 197	0.000
Variables	Beta			t	*p*
(Constant)	3.626			18.271	0.000
Gender	-0.371			-3.705	0.000
Age	-0.496			-8.105	0.000
Tenure	-0.199			-2.313	0.022

Thus, the equation for the regression line is:

$$\hat{y} = 3.626 - 0.371*\text{gender} - 0.199*\text{tenure}$$

Therefore, using this equation, given the "gender," and "tenure," you can come up with a prediction for the "instrumentation skill" variable.

4. Discussion

In terms of science instrumentation technical skills, it had long been established that male teachers have greater confidence than their female counterparts El-Emadi, et al. [15]. Roper [16] also emphasized this gap which shows a negative view towards the place of women in science. Evidence

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suggests that less seasoned teachers tend to be more skillful on some dimensions than their older, more seasoned colleagues [17-21].

As to type of bachelor's degree obtained, results indicate that those with non-education backgrounds may contribute positively to instrumentation skills. In the Philippine context, science teachers who do not have teacher education degrees are graduates of bachelor of science (BS) degrees such as BS Biology, BS Chemistry, BS Natural Science, BS Physics or in some instance, BS Nursing. Moreover, a good number of science teachers are engineering degree holders such as BS Chemical Engineering, BS Civil Engineering, and BS Mechanical engineering. When one dissects the prospectus of these BS degrees, one can surmise that these teachers who are non-education graduates have more exposure to laboratory subjects, thus, likely to be exposed to opportunities to enhance their laboratory skills and efficiency.

With regards to highest educational attainment, it could be implied that practical training during undergraduate studies maybe more effective than theoretical knowledge gained in graduate studies. Investigations in science teachers' efficacy and laboratory skills present varied results. As one work discovered that teachers with bachelor's degrees had higher total efficacy than those with master's degrees [22] another found out that most science teachers held master's degrees but fall short on in-service training opportunities which might impact their effectiveness in using laboratory resources [23]. In Türkiye, pre-service science teachers with increased laboratory hours had significantly greater self-efficacy in laboratory usage [24]. Undergraduate science education teachers show moderate laboratory self-efficacy and low science process skills, with a significant association between the two [25]. These researches show the multi-layered relationship between one's educational history, laboratory efficiency, and teaching efficacy. These propose that other variables aside from the degree obtained, such as trainings and laboratory work, are equally important for effective training of science teachers.

The effectiveness of practical training during undergraduate programs has been emphasized in recent studies, suggesting that hands-on experience is crucial for developing competencies in technical fields. This result put forward the importance of practical, hands-on training in developing instrumentation skills and general competence in science education. This suggests that different concentrations in science may influence teachers' proficiency in technical aspects of science instruction.

Looking into differences in the instrumentation skills according to certain variables, findings suggest that while factors such as year level taught, age, bachelor's degree, and highest educational attainment do not significantly influence instrumentation skills, an individual's gender and tenure do have a notable impact.

Significant differences in the instrumentation skills when teachers are grouped according to gender show possible disparities in training, opportunities, or innate skills between the two genders. This may require targeted interventions or provisions to ensure equal skill development across genders.

The significant impact of tenure on instrumentation skills leaning towards those with shorter experience spells that practical experience does not play a crucial role in skill development. With this, one may question the significance of on-the-job training and continuing professional development programs. Neophyte teachers may have more up-to-date science laboratory skills potentially outdoing those with longer experience. Secondary school teachers' effectiveness significantly improved in their first four years with new teachers exhibiting sharper development Henry, et al. [26]. Silverstein [27] indicated that learners taught by educators with recent laboratory skills training achieved performance levels 44% higher than those instructed by teachers lacking such training. Wong, et al. [28] noticed an increase in engagement in inquiry-based laboratories among newly-hired science teachers as they participate in science-targeted induction programs. In addition, Huang [29] discovered that new teachers show better learning development in inquiry-based laboratory courses than their more tenured peers. Finally, Yildirim, et al. [30] concluded that the length of service do not significantly impact the teachers' scientific process skills. These discoveries show the importance of continuing professional development and up-to-date workshops, seminars and trainings for science teachers to sustain and improve their efficacy in the classroom.

Research on relationship between teaching experience and quality presents mixed findings. While some studies suggest experienced teachers are more effective [31, 32] others find no significant differences across experience levels Gore, et al. [18]. Graham, et al. [19] did not find evidence of lower teaching quality for beginning teachers, but noted a potential decline for those with longer experience. Factors contributing to experienced teachers' effectiveness may include on-the-job skill development, professional development opportunities, and retention of more effective educators OECD [31]. Gore, et al. [18] forward that tenure being associated with proficiency, which is a common supposition, cannot be warranted. This highlights that novice teachers may do better than what is expected of them. Thus, it is a must to come up with targeted and evidence-based professional learning for all teachers irrespective of their length of service [18, 19].

Formal education alone may not suffice for developing strong instrumentation skills of science teachers. This is glaring in the results showing no significant differences based on bachelor's degree and highest educational attainment. Tomas [33] reinforce this observation when she found out no substantial variations in the science process skills of teachers coming from different educational attainment levels. This necessitates a call for a more hands-on, practical training in the undergraduate and graduate level education curricula. In addition, no significant differences were found based on age showing that instrumentation skills can be developed and sustained throughout one's teaching career. This supports the idea of lifelong learning and skill development in this field.

Recent studies have explored the scientific process skills and professionalism of science teachers across various career stages and major. There is no significant difference between in-service and pre-service science teachers' scientific process skill [30]. Likewise, no considerable variations were detected in the science process skills at different career stages [33]. On the other hand, in the work of Hebert and Cotner [34] no meaningful variations in science competency were found between biology and non-biology majors.

Gender and tenure are significant predictors of instrumentation skills among secondary science teachers in the Philippines as suggested by the multiple linear regression results. There is a 10.9% variance in the instrumentation skills as explained by the model. This simply means that while these variables are significant, other factors not considered in the model may also play vital roles in determining skill levels. There may be disproportions in instrumentation skills between male and female teachers, with males showing better skills than females. This is based on the negative coefficient for gender (-0.371). Longer service may correlate with diminishing instrumentation abilities as manifested in the negative correlation for duration of service (-0.199). This suggests a continuing professional development with neophyte teachers leading as they can be more proficient with the latest trends in instrumentation procedures. The results can also be an advantage for human resource planning for data-based decision making for training requirements based on teachers' gender and tenure.

5. Conclusions and Implications

The results drawn out from the study can guide the design of more successful training courses emphasizing on gender-based disparities and capitalizing on the advantages of longer tenure rather than only stressing formal education or age-based issues.

A comprehensive training program may be developed for science teachers focusing on several key areas since the results emphasize the importance of custom-made workshops that address gender-based differences and ensure that professionals maintain and improve their skills throughout their careers. The program should emphasize for constant skill development as long as the teachers are in the service, irrespective of age and length of experience. Recent trends incorporating latest technologies and methodologies must be included in the workshops to make the teachers abreast with the current practices.

The program should include focused interventions to help female teachers in strengthening their instrumentation abilities since male and female teachers have very different levels of expertise in this regard. Confidence-building activities, practical seminars, and mentoring programs could all fit here.

The developed workshops should emphasize practical hands-on experiences. This could include laboratory sessions, simulations, and real-world problem-solving exercises. This is because based on the results, formal education alone does not seem to significantly impact instrumentation skills.

More exhaustive research delving in to the causal circumstances, primarily on gender differences and the certain effects of in which tenure hinders development of instrumentation skills must be done based on the glaring disparities found in the study. As suggested by the modest R^2 value, other factors that may influence instrumentation skills may be looked into for a more thorough appreciation of instrumentation skills development.

Transparency:

The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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