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Investigating the Factors Affecting the Teaching Efficacy of Filipino Science Teachers: A Correlational Study

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Abstract: Objective: This study investigated the factors influencing the science teaching efficacy of Filipino science teachers. **Methods:** A correlational research design was employed to collect the data from 261 Filipino science teachers using adapted and validated research instrument, encoded and administered via web-based program. **Findings:** The results uncovered that student technology use, 21st century learning attitudes, and teacher leadership attitudes are not significant predictors of science teaching efficacy. The teaching outcome expectancy beliefs, STEM instruction, and STEM career awareness, however, can significantly explain the variation in the science teaching efficacy of the respondents. This indicates that teacher actions in science classroom, their pedagogical practices, and their awareness to STEM-fields should be considered in crafting capacity building program for science teachers. **Conclusions:** These factors are crucial in enhancing of teacher quality of science educators, thereby, uplifting the quality of science education in the country.

Keywords: science teaching efficacy, STEM career awareness, STEM instruction, teaching outcome expectancy beliefs.

Abstrak: ***Tujuan:*** *Penelitian ini menyelidiki faktor-faktor yang mempengaruhi kemanjuran mengajar IPA guru IPA Filipina.* ***Metode:*** *Desain penelitian korelasional digunakan untuk mengumpulkan data dari 261 guru sains Filipina menggunakan instrumen penelitian yang diadaptasi dan divalidasi, dikodekan dan dikelola melalui program berbasis web.* ***Temuan:*** *Hasil penelitian mengungkapkan bahwa penggunaan teknologi siswa, sikap belajar abad ke-21, dan sikap kepemimpinan guru bukan merupakan prediktor yang signifikan terhadap kemanjuran pengajaran sains. Keyakinan harapan hasil pengajaran, instruksi STEM, dan kesadaran karir STEM, bagaimanapun, dapat secara signifikan menjelaskan variasi dalam kemanjuran pengajaran sains dari responden. Hal ini menunjukkan bahwa tindakan guru di kelas sains, praktik pedagogis mereka, dan kesadaran mereka terhadap bidang STEM harus dipertimbangkan dalam menyusun program pengembangan kapasitas untuk guru sains.* ***Kesimpulan:*** *Faktor-faktor ini sangat penting dalam meningkatkan kualitas guru pendidik sains, sehingga meningkatkan kualitas pendidikan sains di negara ini.*

Kata kunci: *kemanjuran pengajaran sains, kesadaran karier STEM, instruksi STEM, keyakinan harapan hasil pengajaran.*

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INTRODUCTION

Quality STEM education higlights the readiness of the future workforce equipped with STEM-related skills and other applicabe skills corresponds with the new skills demanded by new era (Ejiwale, 2013). STEM-skilled workforce is critical to meet economic challenges and sustainability in the 21st Century. The increasing demand for this type of labor force prompted global efforts for improvement in STEM education across nations (Partnership for 21st Century Skills, 2017). The Philippine educational system has realized the vital role of science, technology, engineering, and mathematics (STEM) education as vehicle towards innovation and economic mobility (Oxfords Business Group, 2021; Padolina 2014). In fact, the Philippine archipelago has adapted an enhanced basic education program which includes creation of a specialized track for students who aim to pursue STEM-related field in the future. The STEM track in senior high school is intended for the development of learners' skills from simple to complex associated to science, engineering, technology, and mathematics. It paves the way for broader opportunities in basic education to explore the practice of science and mathematics, which can prepare learners for global education and employment, as well as entrepreneurship. (Department of Education, 2016).

According to the data of World Economic Forum, the Philippines registered as one of the low performing countries in terms of the quality of mathematics and science education resulting to low numbers of STEM graduates. In the recent report of Trends in International Mathematics and Science Study (TIMSS) 2019, it revealed that the country placed significantly lower than any other country that participated in math and science assessment. The Philippines scored 249 in science which is considered as disadvantaged rank among the 58 participating nations. Based from the Program for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development (OECD) in 2019, a similar scenario is observed (DepEd, 2019). In its report, Philippines ranked second-lowest in mathematics and science among the 79 participating countries. The results detailed that Filipino students scored 353 in mathematics, compared to the OECD average of 489, and science resulted to 357, compared to the OECD average of 483 (Balagtas et al., 2020). The National Achievement Test also revealed that Filipino students lagged behind proficiency level placing in low performance especially in Mathematics, Science, and English. These undesirable findings have alarmed the Department of Education to significantly take steps in determining and explaining its sources such as the significant factors that influence such occurrence.

This poor performance of basic education science curriculum is attributed to the inadequate science curriculum and insufficient preparation of teachers (Bernardo, 2004). The study of Tupas & Matsuura (2019) further contended that teachers' qualifications and their passion for teaching is a strong point to become an implementing model STEM education. In response to this national concern, the Department of Education initiated a program dubbed as Sulong EduKalidad as a primary tool to uplift the quality of basic education in the country. This initiative encapsulates four cluster of intervention program known as KITE. where K is for the K to 12 Curriculum Review and Update, I is for the Improvement of the Learning Environment, T is for Teacher Upskilling and Re-skilling, and E is for the Engagement of Stakeholders (Balagtas & Montealegre, 2020; DepEd, 2019). This encouraged various education institutions to set effort in investing to capacity building program for teachers. For instance, the Department of Science and Technology expanded the

scholarship grant to qualified Filipino STEM educators to pursue graduate studies in Mathematics and Science education in any reputable universities in the country. This program aims to increase the pool of experts in the country which will eventually translate improved country's level of quality mathematics and science education. Current efforts to enhance STEM education are primarily centered on establishing more partnerships with local and international industries (Oxfords Business Group, 2021).

Teachers' self-efficacy has significant implications for teaching effectiveness, instructional practices, and for students' academic achievement (Klassen & Tze, 2014). It is grounded on Bandura's (1977) Social Cognitive theory which asserts that that behavior is explained by some cognitive and affective factors. Self-efficacy is a focal figure within several theories and was found in studies to be the strongest determinant of motivation and behavior. Teaching efficacy also provides a solid framework to increase the quality of science education, enhance critical and creative thinking of the learners, and encourage the students to partake in science classes (Tastan et al., 2018). Kurt et al. (2014) contended that having the necessary self-efficacy perception and high responsibility perception is vital to become qualified teachers. Science teaching efficacy is the confidence associated with the teaching of science subject (Friday Institute for Educational Innovation, 2012). It is closely associated to the science teacher identity since it draws its sources from the prior experiences of the teachers (Menon, 2020). Yang and Wang (2019) confirmed that science teachers' self-efficacy varies as to gender, years of experience, and educational attainment. This indicates that teacher qualification is an influencing factor that directly affect the self-efficacy of science teachers. Similarly, Senler (2016) uncovered that a positive association exists between attitudes towards science and science teachers' science teaching self-efficacy. This suggests that positive attitude toward science should be emphasized in order to display higher self-efficacy among science teachers.

It is well-established in the literature that teacher qualification significantly explains the quality of teaching beliefs and education provided to the students (Kabadayi, 2010). This has also significant implications to instructional practices such as collaboration with other professionals, teaching strategies, and classroom supplies and resources (Dean & Negassa, 2019). The job performance of teachers is built from the teachers' characteristics. Demographic factors such as gender, age bracket, educational level, pay and length of service of teachers have established significant influence on the level of job satisfaction (Alyaha & Mbogo, 2017). In the study conducted by Zhang (2008), it revealed that teacher's advanced studies and professional experience emerged to have significant effect to the science achievement of the students. Similar findings were shown in the study of Antony & Elangkumaran (2020), the result indicated that teaching experience, educational qualification and subject major were strong significant positive predictors of student performance in science. It can be noted from the study that these factors can explain 58% variance in the students' performance in science. Bamidele & Adekola, (2017) further revealed that significant difference arose in the achievement of students in basic science when taught according to teacher educational qualification, professional experience, and professional development. In view of this, educational agencies were encouraged to put emphasis in building the qualification of the teachers to obtain desirable learning outcomes.

Beliefs, attitudes, and self-efficacy are considered as affective factors (McLeod, 1992). It is widely accepted that the general attitude of

an individual regarding their profession has an impact on their job performance. Attitude toward teaching is further connected to the self-efficacy of the teachers. Teachers' attitudes towards teaching science are central as they enhnace their teaching which eventually affects student achievement and interest in science (Walma, van der Molen, & Asma, 2012). In fact, teachers who demonstrate higher level of self-efficacy can manage to display positive attitude of becoming a teacher (Uyanik, 2016). Hence, this study aimed to explore the teacher qualification, beliefs and attitudes relevant to science teaching, and teaching efficacy of Filipino science teachers. Specifically, it aimed to describe their teacher qualifications, personal teaching efficacy and beliefs, teaching outcome expectancy beliefs, student technology use, STEM instruction, 21st century learning attitudes, teacher leadership attitudes, and STEM career awareness. This study also aimed to determine the relationship among these variables and explain the underlying reasons to these links. The results from this study would provide baseline information that would serve as inputs for policy making and program development towards equipping science teachers to become effective implementer of STEM education in the country

METHODS

This study employed correlational research design to address the research problem. This research design intended to examine the statistical relationships among study variables without manipulating either one of them. The independent variables include teacher qualification such as teaching experience beliefs and attitudes such as teaching Outcome Expectancy Beliefs, students technology use, STEM instructions, 21st century Learning attitudes, Teacher Leadership Attitudes, and STEM career awareness. The dependent variable is the personal teaching efficacy in science. There are 261 Filipino science teachers who voluntary participated in the study. These respondents were selected via convenience sampling technique. The summary of teacher-respondents demographics is presented in Table 1.

It can be seen from Table 1 that majority of the respondents are employed in public school comprising the 74.3% of the respondents, while the remaining 25.7% are employed in a private institution. The respondents are composed of 60% female, 29.9% male, while 1.1% chose not to disclose their sexual identity. Further, the age of the teacher-respondents ranges from 21 to 67. The mean age is 31.67 years where majority of the teacher-respondents belong to the age bracket of of 26 to 30 year (33.0%). Majority of the teacher-respondents gained 4 to 7 years (34.1%) of teaching experience which indicates of adequate experience in teaching profession. In terms of highest educational attainment, majority of them are academic unit-earner in master's level (43.7%). The bachelor's degree holder comprised the 34.1%, the master's degree and doctorate degree holder represents the 38% and 3% of the total respondents, while the unit-earner in doctorate level is only 6.5%. The table further shows that the study is dominated by Biology (47.1%) and Physics (63%) major teacher-respondents

The Teacher Efficacy and Attitudes Toward Science Survey (Friday Institute for Educational Innovation, 2012) was used to probe the constructs under study. The instrument was tested in terms of its validity and reliability. Table 2 presents the details of subscales of the instrument. Data collection was conducted through online survey encoded on web-based program. The online survey was distributed via private and group messages with the assistance of the Faculty of College of Teacher Education. The data were treated using descriptive and inferential statistics.

Table 1. Teacher's professional experience. educational attainment, and course specialization of the teacher-respondents

Teacher Demographics		**Frequency**	**Percentage (%)**
School	Private	67	25.7
	Public	194	74.3
	Total	261	100
Sex	Female	180	60.0
	Male	78	29.9
	Prefer not to say	3	1.1
	Total	261	100
Age	21 to 25 years old	65	25.0
	26 to 30 years old	86	33.0
	31 to 35 years old	45	17.0
	36 to 40 years old	22	9.0
	41 to 45 years old	16	6.0
	45 to 50 years old	10	4.0
	50 years old and above	15	6.0
	Total	261	100
Teaching Experience	3 year and below	75	28.7
	4 to 7 years	89	34.1
	8 to 11 years	48	18.4
	12 to 15 years	25	9.6
	16 to 20 years	4	1.5
	20 to 24 years	13	5.0
	25 years and above	7	2.7
	Total	261	100
Educational Attainment	Bachelor's Degree Holder	89	34.1
	Master's Degree Units Earner	114	43.7
	Master's Degree Holder	38	14.6
	Doctoral Degree Units Earner	17	6.5
	Doctoral Degree Holder	3	1.1
	Total	261	100
Course Specialization	Biology	123	47.1
	Chemistry	11	4.2
	Earth Science	3	1.1
	General Science	49	18.8
	Physics	63	24.1
	Physical Science	12	4.6
	Total	261	100

Measures of frequency, mean, and standard deviation were used to describe the teacher qualification, beliefs and attitudes, and teacher efficacy. The researcher employed Pearson product-moment of correlation coefficient (Pearson r) to assess the association among the study variables. Thereafter, multiple regression analysis was employed to determine whether teacher efficacy can be predicted by teacher qualifications and their beliefs and attitudes.

Table 2. Instrument subscales, number of items, and measurement application

Subscale	No. of Items	Measurement Application
Science Teaching Efficacy (STE)	11	self-efficacy and confidence related to teaching the specific science subject
Teaching Outcome Expectancy Beliefs (TOEB)	9	degree to which the respondent believes, in general, student-learning in the specific science subject can be impacted by actions of teachers
Student Technology Use (STU)	8	how often students use technology in the respondent's classes
STEM Instruction (STEM-I)	14	how often the respondent uses certain STEM instructional practices
21st Century Learning Attitudes (21CLA)	11	attitudes toward 21st century learning
Teacher Leadership Attitudes (TLA)	6	attitudes toward teacher leadership activities
STEM Career Awareness (STEM-CA)	4	awareness of STEM careers and where to find resources for further information

■ RESULT AND DISCUSSIONS

This study aims to investigate the predicting role of STOEB, STU, STEM-I, 21CLA, TLA, and STEM- CA of Filipino science teachers to their STE. The present study reported the mean and standard deviation of the aforementioned variable used in the study. It further presents the correlation and regression analysis to determine the predicting role of the identified antecedents to the outcome variable considered.

Table 3. Correlation analysis, mean, standard deviation, and cronbach's alpha among study variables

Study variables	1	2	3	4	5	6	7
1. Science Teaching Efficacy (STE)							
2. Teaching Outcome Expectancy Beliefs (TOEB)	.561**						
3. Student Technology Use (STU)	.357**	.300**					
4. STEM Instruction (STEM-I)	.473**	.322**	.688**				
5. 21st Century Learning Attitudes (21CLA)	.243**	.239**	.229**	.329**			
6. Teacher Leadership Attitudes (TLA)	.371**	.382**	.248**	.391**	.593**		
7. STEM Career Awareness (STEM-CA)	.526**	.373**	.386**	.444**	.310**	.396**	
Mean	4.25	3.98	3.92	3.98	4.60	4.59	4.16
Standard Deviation	.43	.53	.74	.63	.48	.45	.64
Cronbach' Alpha	.850	.842	.956	.948	.950	.862	.927

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

Table 3 revealed that the TLA (M=4.59, SD=.45) registered the highest mean indicating that the respondents have positive assessment about their attitude towards teacher leadership activities. The STEM-CA (M=4.16, SD=.64) of the teachers also obtained a favorably high mean suggesting that the respondents are knowledgeable about STEM careers and where to find relevant resources about it. The table further showed that the STE of the respondents are commendable as revealed by the mean value (M=4.25, SD=.43). This implies that the respondents have beliefs and confidence in teaching and learning science subject. The instrument subscales obtained Cronbach's alpha ranging from .842 to .956. This is a good indicator that the instrument has an excellent internal consistency.

Table 3 further presented that all study variables established moderate and positive association among one another as revealed by their respective r-values which emerged to be statistically different from zero based from 95% confidence interval. This indicates that as the determinants go higher the STE also increases. It can also be noted on in Table 3 that TOEB registered to be positively correlated to STE which gained relatively higher r-value (r=.561) compared to other determinants. This suggests that the high level of teachers' belief about their actions affecting the teaching and learning in science is statistically related to high level of self-efficacy in teaching science. This is consistent with findings revealed by Bergman and Morphew (2015) on their study that pre-service teachers that have high personal science teaching efficacy also demonstrate moderate to high science teaching outcome expectancy. Wiebe et al. (2018) further contended that "expectancy-value theory helps frame both self-efficacy in terms of expectancies of success in a particular academic domain and outcome expectancy in terms of the value of this academic subject area to future goals" (p. 2). Similar scenario can be observed with STEM-CA and STEM-I to STE beliefs with r-values of .526 and .473 respectively, signifying positive correlation. It implies that the STEM-relevant pedagogical practices employed by the teachers and their awareness to STEM-related fields of work are linked with their confidence to teach science courses. Salonen et al. (2018) argued that STEM career-related teaching enables students' interests in STEM learning and facilitates them be involved in their learning activities. This in turns helps science teachers strengthen their belief about their science instruction.

Table 4 presents the effect of the determinants to outcome variable – STE. Regression analysis revealed that TOEB (â=.303, p=.000), STEM-I (â=.163, p=.000), and STEM-CA (â=.190, p=.000) positively influence the STE of the respondents as revealed by their â coefficients and p-values. at a 95% confidence interval. On the other hand, STU (â=-.016, p=.654), 21CLA (â=-.032, p=.524), and TLA (â=.048, p=.410) do not significantly explain the variation in the STE. This indicates that one-unit change in TOEB, STEM-I, and STEM-CA can predict the .303, .163, and .190 unit change respectively to STE of the respondents. The prediction assumes in all cases that all other predictors are held constant. The table further indicate that the significant predictors can largely explain an estimated 47.2% variation on the science teaching efficacy as revealed by the R2 value.

TOEB significantly explains the STE of Filipino science teachers. This result is supported by the study of Han et al. (2021) indicates that self-efficacy and expectancy-beliefs are critical for both teachers and students in learning in integrated STEM education. Teacher's self-efficacy beliefs can be enhanced over time,

Table 4. Regression analysis of science teaching efficacy as outcome variable

	Unstandardized Coefficient		Standardized Coefficient		
	B	***Std. Error***	***B***	***t***	***Sig.***
constant	1.593	.233		6.850	.000
Teaching Outcome Expectancy Belief (TOEB)	.303	.042	.377	7.279	.000
Student Technology Use (STU)	-.016	.036	-.028	-.449	.654
STEM Instruction (STEM-I)	.163	.045	.237	3.595	.000
21st Century Learning Attitudes (21CLA)	-.032	.051	-.037	-.638	.524
Teacher Leadership Attitudes (TLA)	.048	.059	.051	.825	.410
STEM Career Awareness (STEM-CA)	.190	.037	.282	5.180	.000

building a robust foundation for a strong expectancy outcome. It follows that both STE and TOEB are critical in improving science teaching capability and value in science courses (Ward et al., 2020). This suggests that strong TOEB is crucial to ensure STE that does not decline over time. However, Flores (2015) showed that increase in Science Teaching Outcome Expectancy Belief may not necessarily equate to increase Science Teaching Efficacy. This is confirmed in her study which found out that the increase of field-based science teaching significantly improved the STE of the pre-service science teachers, while their STOEB was improved in a lesser degree. A similar finding was obtained in the study of Mulholland et al (2004), which revealed that the completion of two science teaching subjects within the pre-service teacher program had a significant influence to science teaching efficacy, but not to STOEB.

The STEM-I used by the Filipino science teachers in their classroom determines their STE. The teaching efficacy of science teachers are influenced by professional development and lesson implementation using integrated STEM-I (Kelley et al., 2020). This means that science teachers largely furthered from learning within a community of practice, engaging ins science practices, and applying scientific knowledge to solve real-life problems. There are various studies who dealt with the effect of STEM instruction in attitudes towards science. For instance, Toma & Greca (2018) implemented an inquiry-based STEM education approach to improve scientific attitude. Findings revealed that the scientific attitude was greatly enhanced in the students exposed on such STEM-I compared to those who were exposed to conventional learning. Similarly, Hodges et al. (2016) investigated the teacher self-efficacy during the implementation of a problem-based science curriculum. Their study revealed that science teacher reported high confidence level throughout the study. It implies that teachers are confident in their capabilities to deliver such curriculum mode, an indicative of positive self-efficcay in teaching science. Khanshan & Yousefi (2020) contended that self-efficacy of soft and hard science teachers was strongly correlated to their teaching practices. This suggests that teachers need to build and differentiate their instructional practices based on the needs of the learners and their objectives.

The study revealed that STEM-I is a significant predictor of Filipino science teachers' STE. This finding is supported by the study of Blotnicky et al. (2018) which reported that students with more confidence and comfort in mathematics tend to be more aware about

mathematics and science requirements for STEM careers. This further uncovered that mathematics self-efficacy is a statistically significant predictor of the likelihood of the students to pursue STEM careers. Halim and others (2018) also confirmed significant correlation between STEM self-efficacy and their interest towards STEM careers. It further revealed that self-efficacy in a specific discipline display strongest correlation with its related career path as compared to other discipline. The science self-efficacy, for instance, exhibited strong association with interest in science. Kwon et al. (2019) confirmed that self-efficacy is highly correlated to interest in pursuing STEM careers. This is also supported by other previous studies that students with higher self-efficacy has a higher likelihood of pursuing STEM career.

■ CONCLUSIONS

The present study investigated the factors influencing the science teaching efficacy of Filipino science teachers. It examines the beliefs and attitudes of the target respondents as determinants of teacher's self-confidence in teaching science courses. The beliefs and attitudes were defined as to teaching outcome expectancy beliefs, student technology use, STEM instruction, 21st century learning attitudes, teacher leadership attitudes, and STEM career awareness. The goal of raising the quality of STEM education in the Philippines is fueled by the dismal performance of the country to various international and national assessments. The lack of qualified teachers is identified as the root cause of this poor performance of Filipino students. Based on the research problem and salient findings of this study, the following conclusions were drawn: Majority of the respondents rated themselves as fairly high in terms of their teaching efficacy, beliefs and attitudes towards science. The study also reports moderate and positive association among study variable indicating that changes in teacher self-efficacy can be attributed on their related beliefs and attitudes towards science. The study further reveals that student technology use, 21st century learning attitudes, and teacher leadership attitudes are not significant predictors of science teaching efficacy. The teaching outcome expectancy beliefs, STEM instruction, and STEM career awareness, however, can significantly explain the variation in the science teaching efficacy of the respondents.

The results of the study disclose that variables such as science teaching outcome expectancy beliefs, STEM instruction, and their STEM careers awareness are classified as highly affiliated construct to science teaching. It indicates that teacher's efficacy in science teaching can be strengthened via enhancing their beliefs that their actions can influence their students, capacitating their ability to employ integrated STEM pedagogical approaches, and raising their awareness about allied STEM field and where to get resources about this. The educational institutions must allocate funding in teacher training programs emphasizing the vital elements that determines their efficacy to teach science. For the teachers, they should be engaged in a community practicing the process of scientific inquiry, which will help them employed STEM approach in their respective classrooms. Likewise, since science education aim to produce productive STEM workforce, the teachers and administration should establish linkages to different industries to boost their awareness about future careers in STEM track.

The study was cross-sectional in nature which means that the data were obtained in a single time. The data collection also used self-report instrument which can be affected by the emotional well-being of the respondents during responding the survey. Likewise, a relatively low numbers of respondents participated in the survey, increasing the number of the participants would merit the results of the study. Future lines of research may focus on monitor the

development of the science teaching efficacy of the respondents since efficacy as a construct may change over time. Examining the impact of the use of actual STEM instructional strategies on the development of science teaching efficacy is also recommended. This would provide empirical evidence about the influence of instructional practices to self-efficacy development. Qualitative methodological approach may also be employed to document the development of self-efficacy of the Filipino science teachers as affected by various factors such as those identified in this present research.

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