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Future Skills of Science Graduate Teachers in Teaching Industry: Curriculum Implications in STEM Education

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Abstract

Assessing how could an educator catch up with the evolving world necessitates the need to assess the skills he or she possess for such a future. This study sought to assess the level of competence of graduate science teachers in the Pangasinan State University across 17 future skills. Also, it aimed at correlating the level of competence of science graduate teachers across gender, age, and academic levels. The study was carried out using a cross-sectional descriptive survey under the quantitative research design. The quantitative data garnered were analyzed using descriptive statistics via SPSS version 25.0. The results of the study show very high competence in four future skills (communication competence, reflective competence, Initiative and Performance Competence, and cooperation competence) and high competence in the remaining thirteen future skills. Also, based on the computed p-values there was no significant relationship observed in all of the 17 future skills in relation to gender and academic levels of respondents. All future skills remained the same across age levels except Doctoral-level graduate teachers who had higher levels of self-competence than master-level graduate teachers. The results of the study suggest that future skills may be consciously integrated across the postgraduate curriculum of Higher Education Institutions to help develop industry-driven graduates who are prepared for the world of work.

Keywords: Future skills, Science education, Industry-based graduates, Higher education, Philippines

INTRODUCTION

The employability of graduates is a top priority of any higher education institutional policy (Schomburg & Teichler, 2011). This underscores the need for higher education institutions to focus primarily on helping graduates acquire future skills. Universities must prioritize the development of future skills that would make students employable to ensure their economic welfare and heighten the competitive advantage of their countries (Brown et al., 2003). This calls for customizing and/or relating the university teaching curriculum to the graduate or future skill preferences of employers (Suleman, 2016). Higher education institutions must consciously plan, develop, and mount employability programs coupled with life-long education programs aimed at enhancing individual skills and knowledge that are in tandem with industrial requirements (Bridgstock, 2009). Higher education institutions must continuously update the employability programs they teach their students to meet the ever-changing demands of the business environment (Tanyel et al., 1999). This can be made possible if university and industry linkages are developed

and continually maintained (Sart & Çalışkan, 2019). The foundational skills required of graduates by employers noted in the literature include strong written and oral communication skills, problem-solving skills, critical analytical skills, flexibility, and adaptive capacity skills, learning with autonomy skills, ideation, and innovation skills, team working skills, Information Technology skills, interpersonal skills, stress and pressure coping skills, technical and domain-specific skills (Bennett, 2002; Tymon, 2013; Olivier et al., 2014). These future skills are often known in the employability literature as 21st-century skills because they are to fully bake future-ready citizens for the world of work (Almazroa & Alotaibi, 2023).

In a systematic review of various empirical studies on the 21st Century skills, Beers (2011) intimated that the common 21st Century skills were creativity and innovation, critical thinking and problem-solving, communication, collaboration, information management, effective use of technology, career and life skills, and cultural awareness (Beers, 2011; Esman et al., 2023). They are skills in thinking processes and behaviors. In fact, among these future skills, those of high priority to employers are the applied skills that could be used in the real life of work and not just the basic or knowledge skills (Conference Board, 2006). Ehlerss (2020: 53) defines Future Skills as "[…] competencies that allow individuals to solve complex problems in highly emergent contexts of action in a self-organized way and enable them to act (successfully). They are based on cognitive, motivational, volitional and social resources, are value-based and can be acquired in a learning process". Ehlerss (2020) identifies 17 future skills (Figure 1). Each of the Future Skills profiles belongs to one of three clusters which are *individual development-related* (e.g., reflection competence, learning competence), *individual-object-related* (e.g., digital competence), and *individual-organization-related* (e.g., future and design competence), While all of the future skills are relevant to the world of work and development of societies, creativity and innovation skills as well as problem-solving skills are of top priority among employers because they claim it help graduates to function effectively at the workplace (Almazroa & Alotaibi, 2023).

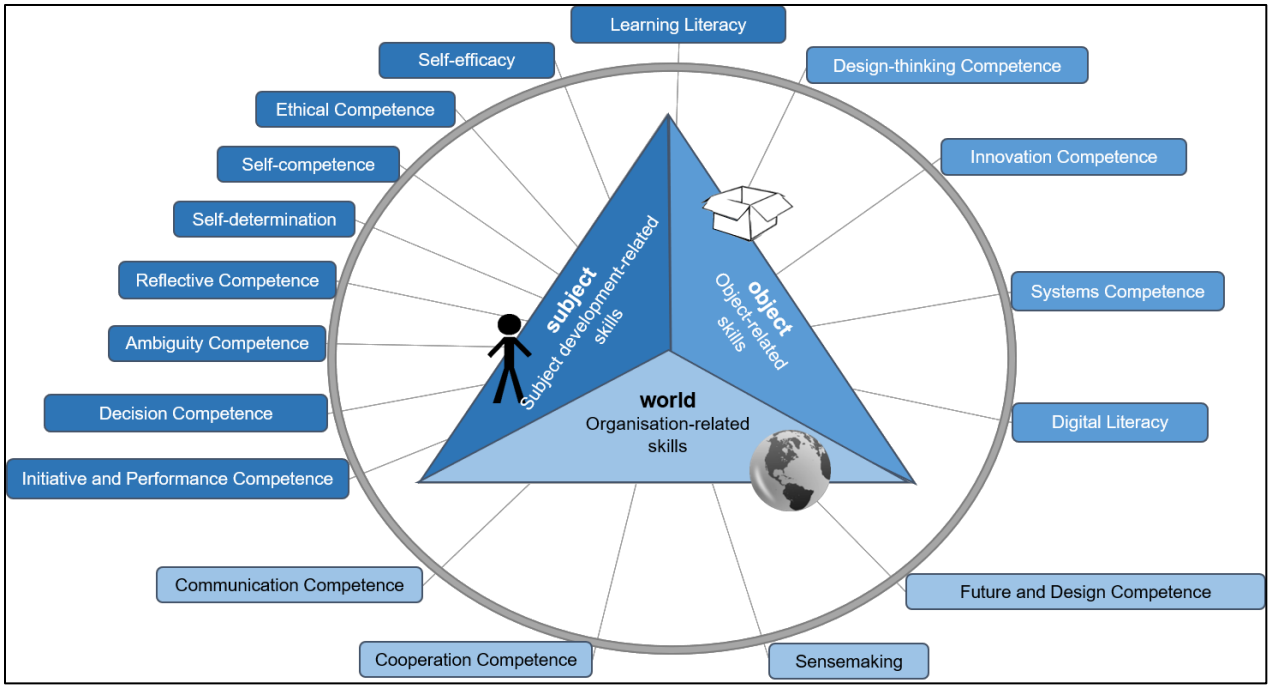

Figure 1. Future Skills overview – allocation to three dimensions (Ehlerss, 2020).

Several studies have been conducted on future or 21st-century skills in the Philippines. For instance, Mugot & Sumbalan (2019) investigated the 21st-century learning skills and teaching practices of pre-service teachers, emphasizing communication, collaboration, problem-solving, citizenship, and digital fluency skills. The pre-service teachers intimated that communication, collaboration, and critical thinking skills were applied most in delivering their teaching and learning activities. However, they rarely used technology skills. This may indicate the deficiency or lack of emphasis on their graduate training in digital fluency skills. Their study suggested strengthening the 21st-century skills among pre-service teachers, especially in digital literacy skills, to deliver to learners efficiently. Scoular (2020) analyzed the integration of 21st-century skills into teaching, learning, and assessment in the Philippines. Her study focused on problem-solving skills, critical thinking skills, and collaboration skills in English and Science subjects in grades 4, 6, 8, and 10 among the pronounced skill sets of information, media, and technology skills, learning and innovation skills, communication skills and life and career skills. The study found that integration of 21st-century skills has not been fully achieved because they have not been aligned with assessment, curriculum, and pedagogy. Daga (2021) investigated the perspectives of future teachers in the Philippines on their readiness to embark on their teaching profession in the spirit of future skills. He discovered that future teachers must be multi-skilled, possessing 21st-century

skills such as utilizing teaching strategies, leadership, knowledge, innovation, content, faith in God, talent, and understanding skills. Esman et al. (2023) conducted a quantitative descriptive-comparative and correlational study on the 21st-century skills and job satisfaction of public Senior High School teachers in Central Philippines. They found out that the highest-rated 21st-century skill was collaboration, with the lowest-rated skill being making global connections. It highlighted the need for teacher education institutions to continuously improve and update the 21st-century skills for trainee teachers to help them function effectively in their future places of work.

While these studies have explored various dimensions of 21st-century skills or, more appropriately, future skills, there is still the need to provide baseline data on the status or level of competence of graduate Science teachers in the seventeen (17) future skills by Ehlerss (2020) to inform curriculum development of the Science graduate program in the Pangasinan State University, Philippines. Specifically, the study sought to (1) Assess the level of competence in future skills of graduate Science teachers in the Pangasinan State University, Philippines, and (2) Correlate the level of competence in future skills of graduate Science teachers across demographics such as gender, age, and academic level.

The results from the study would inform the enhancement of the existing curriculum for the graduate Science program to holistically train students in all 17 future skills for them to function efficiently in the world of work. After all, Higher Education Institutions (HEIs) are tasked with the responsibility of empowering students to develop these future skills independently (Ehlerss, 2020). This study would help ensure that students trained to teach Science are endowed with the employability potentials dictated by the 17 future skills needed in the 21st Century to transform teaching and learning activities for better citizens globally.

METHOD

Research Design

The study was driven by the quantitative research design to compare the 17 future skills by Ehlers (2020) with the competence of the graduate science teachers at a state university in pangasinan, Philippines and correlate the competence in the 17 future skills by Ehlers (2020) across gender, age and academic level following Ehlers's (2022) that Future Skills can be analyzed and described using a profile set that categorizes the 17 skills. The profile set included three socio-academic factors:

Gender: This factor was measured by asking the study participants whether they were men or women.

Age: This factor was measured by asking study participants to state their age regarding the number of years.

Academic level: This factor required study participants to state their academic year. For instance, Master of Philosophy or Doctor of Philosophy students.

Research Method

The study employed a cross-sectional descriptive survey that used descriptive comparative and correlational design methods to describe and analyze the level of competence of Science graduate teachers across the 17 Future skills. This aided in offering a snapshot of the acquisition and rating of the 17 future skills among the Science graduate teachers (Mathers et al., 2007).

Data Collection Procedure and Tools

The data were collected via a questionnaire from Ehlerss (2020). Each of the Future Skills profiles belongs to one of three clusters, which are *individual development-related* (e.g., reflection competence, learning competence), *individual-object-related* (e.g., digital competence), and *individual-organization-related* (e.g., future and design competence. The Future Skills questionnaire was first validated and used in the Next Skills studies by the author, where it was used to assess their importance for future higher education. Variables were collected via a 5-step Likert scale ranging from 5=Very important to 1=Not important to assess the ability of the higher education institution to promote these future skills. The results showed high values for each of the 17 future skills, vouching for validity. High values were recorded for Self-determination Competence (*M*= 4.53, *SD*= 0.62), Reflection Competence (*M* = 4.50, *SD* = 0.67), Learning Competence (*M* = 4.48, *SD* = 0.69), Decision Competence (*M* = 4.46, *SD* = 0.72), Initiative and Performance Competence (*M* = 4.13, *SD* = 0.89), System Competence (*M* = 2.53, *SD* = 0.87), Innovation Competence (*M* = 2.52, *SD* = 0.85), Cooperation Competence (*M*=4.59 (*SD* = 0.67) and Communication Competence (*M* =4.67, *SD* = 0.67). The questionnaire was administered digitally during the study period from May 2023 to September 2023. The online survey was adopted for the study because of its user-friendliness, flexibility, swiftness, and accuracy in generating rich data (Nayak & Narayan, 2019). To ameliorate the often-noted ignorance of compliance laws in surveys, ethical protocols where participants signed an informed consent form were duly followed (Research Lifeline, 2012).

Sampling Technique and Sample Size

Total population sampling was adopted for selecting all the Science graduate teachers in science education (n=41) in Regions I and III, Philippines who were presently studying in a graduate school of a highly performing state university in Pangasinan, Philippines, with 9 satellite campuses. This sampling technique was adopted for the study because the population size was relatively small (Laerd Dissertation, 2020). All the population elements were selected to ensure a high participation level and high response rate required for a relatively small sample size of this nature for cross-sectional surveys (Ficham & Draugalis, 2013).

Ethical Considerations

Ethical considerations were carried out by sending the Google form link to official group chats containing a call for participation and a mandatory filling and signing of an informed consent form in the survey. It is worth mentioning that the graduate school was preparing to revise its curricula during this data-collection period.

Data Analysis Plan

The descriptive statistics of the quantitative data generated were processed via SPSS version 25.0. The relationship between the scale variables was established by calculating Pearson's correlation among categorical variables.

RESULTS AND DISCUSSION

Assessment of the Level of Competence in Future Skills of Industry-based Graduate Teachers

Table 1. Weighted Mean and Descriptive Equivalents of Future Skills of Graduate Teachers as Ranked

R	Skills	Competence	WM	SD	DE
1	Communication Competence	I could communicate successfully and strategically through language skills, discourses, and dialogues in the respective situation and context.	4.33	0.6	VHC
2.5	Reflective Competence	During reflection, I could ask myself about my behavior, thoughts, and values to develop my competence constructively and make decisions holistically.	4.26	0.65	VHC
2.5	Initiative and Performance Competence	I could motivate myself and contribute something to my achievement despite failures.	4.26	0.68	VHC
4	Cooperation Competence	I could collaborate in (intercultural) teams in face-to-face or digitally-supported interactions within or between organizations to transform differences into commonalities.	4.23	0.74	VHC

R	Skills	Competence	WM	SD	DE
5.5	Decision Competence	I could take the opportunity to decide on important matters, evaluate different alternatives against each other, make a final decision, and take responsibility for my own decision.	4.17	0.74	HC
5.5	Digital Literacy	I could use digital media and develop them productively and creatively to critically reflect on their usage and the impact media have on society and work, both for private and personal contexts, as well as the understanding of the potential and limits of digital media and its effects.	4.17	0.64	HC
7	Sensemaking	I could construct meaning and understanding from the rapidly changing structures of meaning within future work and life contexts to further develop existing structures of meaning or promote the creation of new ones where they have been lost.	4.15	0.6	HC
8.5	Self-determination	I could act productively even under pressure from external and internal factors for me to self-develop and be autonomous or independent.	4.13	0.68	HC
8.5	Ethical Competence	I could perceive a situation as ethically relevant, including its conceptual, empirical, and contextual considerations.	4.13	0.62	HC
10	Future and Design Competence	I could master the current situation with courage for the new mode of thinking and develop situations into other new and previously unknown visions of the future by approaching these creatively.	4.11	0.57	HC
11	Ambiguity Competence	I could productively recognize, understand, and handle ambiguity, heterogeneity, and uncertainty and act in different roles.	4.09	0.59	HC
12	Systems Competence	I could recognize and understand complex personal-psychological, social, and technical (organizational) systems.	4.08	0.59	HC
13.5	Self-competence	I could develop my personal and professional capabilities largely independent of external factors.	4.07	0.83	HC
13.5	Learning Literacy	I could learn in a self-directed and self-initiated fashion	4.07	0.61	HC
15	Self-efficacy	I could master the tasks by relying on my abilities and taking responsibility for my decisions.	4.02	0.61	HC
16	Design-thinking Competence	I could use concrete methods to carry out open-ended creative development processes about given problems and topics and to involve stakeholders in a joint problem and solution design process.	3.96	0.59	HC
17	Innovation Competence	I could promote innovation as an integral part of any organizational object, topic, and process and	3.93	0.71	HC

R	Skills	Competence	WM	SD	DE
		contribute to the organization as an innovation system.			
		Average Weighted Mean	4.13	0.65	HC

Table 1 shows the level of competence in future skills of industry-based graduate teachers in a state university in pangasinan, Philippines, based on weighted mean and descriptive equivalents across the 17 future skills. The results show very high competence in four future skills (communication competence, reflective competence, Initiative and Performance Competence, and cooperation competence). Also, the industry-based graduate teachers demonstrated high competence in the remaining thirteen future skills. The development of all 17 future skills in a satisfactory manner may point to the fact that the Department of Education, which runs the Science Education program at a state university in pangasinan, Philippines, has put up measures in students' curriculum to promote the teaching and development of all the skills in a more integrated fashion as suggested by Wrahatnolo & Munoto (2018). They posit that the conscious integration of measures to foster the development of these skills that prepare students to face the real world of work in the 21st Century and beyond should be in every subject or course that is taught to students. When this is effectively done with equity, students could potentially develop all 17 future skills.

While all 17 future skills are essential for the holistic development of graduates for the world of work, some are viewed as indispensable in every higher education training. These include communication, cooperation, reflection, initiative, and performance skills promoting critical thinking and problem-solving abilities (Soule & Warrick, 2015). The high ratings of these competencies in the results of this study is a positive indicator that instructors in the Department of Education that runs the Science Education program at a state university in pangasinan, Philippines. However, they are determined to help students develop all 17 future skills and may consciously or unconsciously prioritize these four future skills because of their noticeable measurable impacts in the world of work in the 21st Century and beyond. Interestingly, these same future skills are a part of the eight critical characteristics that define high-quality learning that is seen to drive the Fourth Industrial Revolution (World Economic Forum, 2020). This potentially implies that the a state university in pangasinan, Philippines's science education curriculum structure and mode of instruction are commendable as they are tailored to produce high-quality graduates with the required competencies to drive the Fourth Industrial Revolution. However, to

heighten the development of these future skills, consistency and systematic methods must be put in place by the Department of Education that runs the Science Education program at a state university in pangasinan, Philippines to ensure that the graduates from the university at any period are endowed with the right future skills needed for the global labor market (International Labour Organization (2015).

Correlation of the level of competence in future skills of industry-based graduate teachers across demographics such as gender, age, and academic level

Table 2. P-values for correlates between competence and sex, age, and level

Code	Skills	Sex	Age	Level
A	Learning literacy	0.840	0.207	0.782
B	Self-efficacy	0.951	0.202	0.756
C	Self-determination	0.712	0.916	0.542
D	Self-competence	0.963	0.023[S]	0.180
E	Reflective competence	0.412	0.559	0.145
F	Decision competence	0.464	0.485	0.642
G	Initiative and performance competence	0.882	0.425	0.333
H	Ambiguity competence	0.848	0.767	0.438
I	Ethical competence	0.626	0.448	0.884
J	Design-thinking competence	0.951	0.859	0.920
K	Innovation competence	0.637	0.228	0.452
L	Systems competence	0.509	0.716	0.748
M	Digital literacy	0.597	0.191	0.534
N	Sensemaking	0.779	0.753	0.417
O	Future and design competence	0.843	0.645	0.669
P	Cooperation competence	0.702	0.676	0.991
Q	Communication competence	0.394	0.586	0.473

Table 2 reports on the p-values on the correlates between competence and the profile variables, including sex, age, and level (i.e. Master's or doctoral level). Based on the computed p-values, no significant relationship was observed in all 17 future skills about the respondents' sex, which means that both the males and females have the same perception of their competence along the 17 future skills. However, in the study of Segbenya et al. (2023) in Ghana, they observed significant differences across various future skills among males and females. They noted that male graduates were more inclined towards digital competence, while females were reported to be more inclined towards communication competence. This study was for undergraduate students and might have accounted for some of the competence differences. Yet, in postgraduate level students,

both males and females are more mature and determined to hone their competence in various skills, even bracketing their personal choices to function better in the world of work.

Further, the respondents in the various age groups similarly perceive themselves with one another on their level of competence of the 17 future skills, except for self-competence, where a significant relationship was statistically observed through chi-square ($p<0.05$). It was noted that the higher the age level, the higher the self-competence level. Thus, doctoral students who are more advanced in age exhibited higher levels of self-competence than master-level students. Since advanced age comes with age-based experience, self-competence levels are also increased, as noted by (Priyadharsana & Saravanabawanb, 2021).

Further, the graduate teachers at the Master's level perceive themselves in the same way the doctoral students perceive themselves regarding their level of competence along the 17 future skills. This result is different from what other previous researchers have found. For instance, Dondi et al. (2021) realized in their survey of 18.000 people in 15 countries that in all the skill sets or competence required for the world of work, graduates with higher degree education were seen as better prepared and more competent than those with lesser degree education. Our results did not show any significance across the 17 future skills under review because various courses studied in Science Education are similar across Master's level students and doctoral level students. Likewise, seminars and workshops organized at a state university in pangasinan, Philippines are always for postgraduate students in general. Thus, it is not surprising that postgraduate students, though at different academic levels (i.e. Master's and Doctoral) exhibited similar levels of competence across the 17 future skills.

CONCLUSION

This study was undertaken to assess the level of competence of 41 graduate Science teachers at a state university in pangasinan, Philippines across 17 future skills. Moreover, it correlated the level of competence of science graduate teachers across gender, age, and academic levels. The study's key results are that the Science graduate teachers possess very high competence in four future skills (communication competence, reflective competence, Initiative and Performance Competence, and cooperation competence) as well as high competence in the remaining thirteen future skills. This implies that the science graduate program curriculum at a state university in pangasinan, Philippines has satisfactorily incorporated all the future skills, empowering its graduates to perform well in the teaching industry. Also, no significant relationship was observed

in all the 17 future skills about the respondents' sex, which means that both the males and females have the same perception of their competence along the 17 future skills. This suggests that instructors of the Science program ensure gender parity in their teaching and learning activities and offer inclusive education for all their students.

Moreover, all the study participants, irrespective of the variance in their ages and academic levels, demonstrated similar levels of competence in the 17 future skills, except for self-competence, where a significant relationship was statistically observed with Doctoral students possessing higher self-competence than the Master's students. This suggests two things. First, postgraduate programs, workshops, and seminars for the Science graduate program at a state university in pangasinan, Philippines are tailored for both Masters and Doctoral students, helping the former to keep pace and learn from the latter, which is good for the professional development of all the postgraduate students. Second, the higher form of self-confidence noticed among the Doctoral students is a step in the right direction, clearly showing the advanced form of training offered to them as expected from all HEIs worldwide. The results of the study have various international implications for science education. First, to achieve a holistic development of future skills among graduate students to function effectively in the teaching industry, curriculum planners must consciously incorporate each of the future skills in the curriculum for each course students offer. Learning objectives, expected learning outcomes, and teaching and learning activities for each course must show specific attempts to incorporate all 17 future skills fairly.

Despite the interesting results of this study, there were some limitations. This quantitative study relied on statistical data to arrive at the conclusions. Also, the study relied on the internalized future skills of graduate teachers across their demographic profile and did not correlate the skills to their work output. Future studies could use qualitative or mixed methods design to assess the level of competence of the graduate Science teachers in all 17 future skills to shed some qualitative views on the distinctive driving factors that must have influenced their acquisition of each of the future skills. Also, future studies must assess the work outputs of science graduate teachers against each of the future skills to assess how the nurtured future skills are translated into the actual world of work.

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