ALIGNMENT OF THE SCIENCE COMPETENCIES WITH THE 21ST - CENTURY SKILLS

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ABSTRACT: *The study aimed to determine the alignment of the science competencies with the 21st Century Skills measured in the National Achievement Test (NAT). The competencies per quarter for each grade level considered in this study were mapped using the researcher-made competency alignment analysis matrix to articulate 21st-century skills such as information literacy, problem-solving, and critical thinking skills. The competencies in science for Grades 3 and 10 have a high representation of developing information literacy skills and moderate representation in critical thinking and problem-solving skills. The Grade 6 science competencies have a high representation of developing information literacy skills than the other skills. In contrast, the senior high school science competencies have a high representation of developing information literacy and critical thinking skills. The study showed that the science curriculum addressed the development of some 21st-century skills but needed to fully address the development of problem-solving skills. Thus, the science written curriculum may need to be reviewed to revise some competencies and include more competencies on problem-solving skills development.*

Keywords: basic education**,** science curriculum, K-12 curriculum, information literacy skills, critical thinking skills

I. INTRODUCTION

Technological and economic changes profoundly affect the nature and demand of the workplace, and the modern workplace requires workers to learn new skills and ways of thinking. Education has become the main mechanism providing individuals with the knowledge, skills, and competencies needed [1]. In response to these societal demands, every aspect of our education system—standards, assessments, professional development, curriculum and instruction, and learning environments—must be aligned to prepare the students with the 21st-century skills needed to be successful in work and life [2]. These 21st-century skills have been elaborated that include being able to use the information to solve complex problems, to think critically about tasks, to effectively communicate and work in collaboration with people from a variety of different cultures and use a variety of other techniques, to adapt, to be creative and innovate to the rapidly changing environments and demands and circumstances, to gain global awareness, and to have mastery of rigorous academic content [3–5].

In consequence, the Philippine basic education also revisited its curriculum to comply with the needed competencies for the 21st century with an intention to integrate 21st-century skills such as information, media, and technology skills, learning and innovative skills, communication skills, and life and career skills into the K-12 curriculum to prepare young people the skills needed to keep the nation competitive to the global economy [6], [7]. The Department of Education defines 21st-century skills as the knowledge, skills, attitudes, and competencies that learners need to develop to prepare and succeed in work and life in the 21st century[6].

Curricular reforms have mainly reflected a desire to move away from a relatively narrow set of cognitive skills and subject areas, responding formally to the desire to develop competencies that value the transformation and application of learning[1]. Hence, a curriculum is about what should be taught and combines thought, action, and purpose [8]. The written curriculum usually refers to the content, objectives, and learning organization produced by educational authorities. In the case of the Philippines, the K to 12 science curriculum followed the spiral progression approach. A spiral curriculum is not simply the repetition of a topic taught; it also requires deepening, with each successive encounter building on the previous[9], [10]. The competency has different degrees of difficulty and performance levels [6] along with the concepts in Life Sciences, Physics, Chemistry, and Earth Sciences are presented with increasing levels of complexity from one grade level to another in a spiral progression to have a deeper understanding of core concepts[11].

Competency is the ability to perform activities according to expected standards by drawing from knowledge, skill, and attitudes[6]. Using competencies in the curriculum increases the possibility of transforming learning experiences into performance-based organizational outcomes[12]. The learners must demonstrate their learned capabilities in science after they have acquired a necessary combination of knowledge, skills, and abilities in a certain grade level.

Correspondingly, the national assessment of students' learning is an integral part of the department of education framework as it primarily aims to monitor the country's educational system. Assessment measures learners' progress in attaining learning standards and 21st-century skills[13]. In the country's National Achievement Test, 21CS are again identified for administration at the end of Grades 6, 10, and 12, which covers core 21st-century skills and the core learning areas, of which science is one of them.

The enhanced basic education program is also a response to improving students' performance in the National Achievement Test (NAT) across subjects. Thus, the alignment or agreement or a match between two categories, the curriculum to state standards and assessment specifications [14], is important to examine. Yet, there is still limited study specifically looking into the alignment of the science competencies of the enhanced basic education with the 21st-century skills assessed in the national achievement test. Thus, this study aimed to analyze the alignment of the Philippine K-12 Science curriculum with 21st-century skills such as information literacy, problem-

solving, and critical thinking skills as assessed in the national achievement test.

II.RESEARCH METHODOLOGY

Document analysis is employed in this study to examine the alignment of the K to 12 enhanced basic education science curriculum regarding the set learning competencies with 21st-century skills. The analysis is focused on the curriculum guide issued by the Department of Education for grades 3, 6, 10, and senior high school (Earth and Life Science and Physical Science). The competencies per quarter for each grade level considered in this study were mapped using the researcher-made competency alignment analysis matrix to articulate 21st-century skills such as information literacy, problem-solving, and critical thinking skills. Bloom's taxonomy was used to determine its congruence and alignment with 21st-century skills. The study underwent a full review by the University Research Ethics Committee (REC). The study used frequency and percentage to quantify the number and degree of representations for each of the 21st-century skills against the enumerated competencies in the K to 12 science curriculum for Grade 3, Grade 6, Grade 10, and Grade 11/12 curriculum (non-STEM). The number of times the 21st-century skills were manifested in the competencies was tabulated and counted. The frequency was converted to percentage using the total number of competencies as the divisor with the number of occurrences as the dividend. The analysis was then interpreted using the table below.

Table 1. Percentage and Qualitative Interpretation of the Data

Range	Qualitative Description
0%	No Representation
1-33%	Low Representation
34-66%	Moderate Representation
67-100%	High Representation

III.RESULTS AND DISCUSSIONS

Table 2. Alignment of the Enhanced Basic Education on Its Written Curriculum in Science based on the 21st Century Skills

21st Century Skills	Grade Level											
	3			6			10			SHS		
	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD
Problem Solving	16	48.48	MR	0	0	NR	14	48.28	MR	48	34	MR
Information Literacy	32	96.97	HR	17	85	HR	29	100.00	HR	142	99	HR
Critical Thinking	18	54.55	MR	3	15	LR	18	62.07	MR	143	100	HR

Table 2 shows the alignment of the K to 12 competencies in science with 21st-century skills, namely problem-solving, information literacy, and critical thinking, across the key stages of Grade 3, Grade 6, Grade 10, and Grade 12. High representation is evident for information literacy across the different grade levels. The high representation of information literacy competencies is consistent with the policy guidelines on the k to 12 basic education program, which mentioned that information and communication technology competencies had been integrated into the curriculum to equip learners with skills that will enable them to cope with the technological demands of our time[6]. This is noteworthy as information literacy supports science literacy[15]. But it has also been observed that problem-solving skills in Grade 6 Science are not represented and are moderately represented in the other grade levels. Noting that the ability to solve complex scientific problems is one of the key competencies in science education[16], and problem-solving skills are one of the main competencies needed for Industry 4.0[17]. On the other hand, critical thinking skills can be accounted for low and moderate in different levels but high representation in senior high school. As gleaned in table 3, problem-solving skills are least represented in the science written curriculum across the grade level under study. Most of the competencies evaluated are stated in remembering and understanding based on the revised Bloom's taxonomy, describe, explain discuss, among others. This result somehow supports the study of Scoular [18] on the audit of the English and Science curricula at Grades 4, 6, 8, and 10, which revealed that there is greater prominence within the Philippines national curriculum on critical thinking subskills as opposed to collaboration and problem solving, in both subject areas. But then again, according to Dossey et. al.[19], problem-solving skills require learners to identify variables or relationships, critically evaluate information, justify/prove solutions, generalize or predict applicability, and communicate solutions. In the Science Curriculum guide considered as represented in the learning competency column of Grade 6, these were not observed and moderately represented in the other grade level. Still, it is more on the subskill - analyzing outcomes. Nevertheless, the capacity to solve problems is one of the generic skills now being promoted at the tertiary level[20]. Problem-solving is one of the most important skills children can develop because it prepares them to face increasingly complex academic and interpersonal issues as they mature[21]. Thus, schools and teachers need to ensure that all competencies are emphasized in the teaching and learning process at the basic education level.

Information literacy, on the other hand, was found to be highly represented in the Science curriculum across all grade levels. Given the overwhelming amount of information in the 21st century, information literacy skills are the essential tools that help individuals successfully navigate the present and future landscape of information[22]. The term information literacy can refer to the set of skills required to identify information sources, access information, evaluate it, and use it effectively, efficiently, and ethically[23]. Incorporating it into the curriculum will ensure that students learn these skills. Students surely need these skills to process information about science concepts found on the Internet. Interestingly, most of the competencies in the grade levels are accounted for the ability to manage information and less representation in identifying types of information and the ability to

Table 3. Alignment of the Enhanced Basic Education on Its Written Curriculum in Science based on Problem-Solving Skills, Information Literacy Skills, and Critical Thinking Skills

	Grade Level											
	3			6			10			SHS		
21st Century Skills on Problem Solving												
	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD
Analyzing Outcomes	16	48.49	MR	0	0	NR	13	44.83	MR	48	34	MR
Executing Strategies/Methods	0	0.00	NR	0	0	NR	1	3.45	LR	0	0	NR
Understanding the Problem	0	0.00	NR	0	0	NR	0	0.00	NR	0	0	NR
21st Century Skills on Information Literacy												
	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD
Ability to Manage Information	31	93.94	HR	0	0	NR	24	82.76	MR	141	99	HR
Identifying Types of Information	1	3.03	MR	12	60	MR	4	13.79	LR	2	1	LR
Ability to Communicate Information	0	0.00	NR	5	25	LR	1	3.45	LR	0	0	NR
21st Century Skills on Critical Thinking												
	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD	Total	Percentage	QD
Analyzing Relevance	17	51.52	MR	2	10	LR	14	48.28	MR	138	97	HR
Evaluating Sources	0	0.00	NR	0	0	NR	0	0.00	NR	0	0	NR
Using Evidence to Formulate an Argument	1	3.03	LR	1	5	LR	4	13.79	LR	5	4	LR

communicate information. These skills are also essential to be developed for students to avoid challenges like using, synthesizing, and evaluating information[24].

Table 3 shows the representation or articulation of critical thinking skills broken into sub-categories of analyzing relevance, evaluating sources, and using evidence to formulate an argument. Among the grade levels, it was only in Grade 12 that analyzing relevance was highly represented in the learning competencies. This was somehow attributed to the fact that critical thinking subskills (particularly analyzing, synthesizing, and applying logic to information) are also generally intrinsic to learning; thus, said skills appear so strongly in the curriculum[18]. It was also stressed that SHS subjects need to infuse critical thinking skills because they need to think critically or understand the problem before they can solve or make a decision[25]. When critical thinking skills are developed, students can use inductive or deductive approaches to identify facts and phenomena and systemic thinking[26]. It is also needed to develop these skills to other grade levels to avoid difficulty in classifying, coding, categorizing, reviewing ideas, assessing arguments, analyzing arguments, assessing questions and assessing arguments, asking for evidence, alternative allegations, drawing conclusions, stating outcomes, justifying procedures, presenting arguments and self-examinations, corrections self [27].

However, it is alarming to note that critical thinking has low or no representation in Grades 3, 6, and 10 levels. This is also observed in a study conducted that critical thinking had very few presence in Science Education. The subskill - use of evidence to formulate an argument, needed to be better catered across the different key stages. Also, evaluating

sources needed to be represented or articulated in the learning competencies in science in the different grade levels. The ability to evaluate sources is needed in today's wide use of social media and Internet resources. Allowing the students to practice validating the credibility of sources would lead to the opportunity to make sound decisions and informed practice to avoid the spread of fake news and unsubstantiated information, which is essential in the study of science. Evidently, problems were also found in the implementation of critical thinking in the classrooms, and applying critical thinking strategies helps improve critical thinking[28]. Noting that developing students' critical thinking skills depends on the frequency of guided activities and exercises coupled with inquiry-based learning can greatly help enhance students' critical thinking[27][29]. Also, putting more emphasis on the process and application of science rather than just scientific facts will help improve critical thinking and scientific literacy[30]. Positively, when students develop these skills, they can navigate how to think critically about science in their own context.

IV. CONCLUSION

It was evident that the K to 12 written science curriculum for Grade 3, Grade 6, Grade 10, and senior high school, when evaluated using the taxonomies, were able to address the development of some 21st-century skills, particularly in information literacy and critical thinking skills but was not able to address fully well the development of problem-solving

skills. Thus, the written curriculum may need to be reviewed to include problem-solving skills development.

V. RECOMMENDATIONS

The findings of this study are limited to the learning competencies in Grades 3, 6, 10, and SHS. Thus, a thorough analysis can also be conducted on other grade levels to examine the alignment of the competencies with 21st-century skills, as we know that the science curriculum follows a spiral progression approach. Modification can be done to some competencies to develop other vital skills is recommended. Aligning the components of the science education system—namely, curriculum, assessment, and pedagogy is also a must. Science teachers' understanding of 21st-century skills, the skills in designing authentic tasks, and pedagogical knowledge played an important role in attaining these science competencies. Hence, more training and development to capacitate teachers is also recommended. Other core subjects can also look into the alignment of their competencies with 21st-century skills as it is embedded into the whole k to 12 curriculum.

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REFERENCES

[1] E. Care, H. Kim, A. Vista, and K. Anderson, "Education system alignment for 21st century skills: Focus on assessment," *Cent. Univers. Educ. Brookings Institution.*, pp. 1–40, 2018, [Online]. Available: https://onlinelibrary.wiley.com/doi/10.1111/cdev.13673.

[2] K. Kay and V. Greenhill, "Bringing Schools into the 21st Century," *Bringing Sch. into 21st Century*, pp. 41–65, 2011, DOI: 10.1007/978-94-007-0268-4.

[3] J. A. Koenig, *Assessing 21st Century Skills*. 2011.

[4] E. Duran, D. Yaussy, and L. Yaussy, "Race to the Future: Integrating 21st Century Skills into Science Instruction," *Sci. Act. Classr. Proj. Curric. Ideas*, vol. 48, no. 3, pp. 98–106, 2011, DOI: 10.1080/00368121.2010.535222.

[5] and M. R. Marilyn Binkley , Ola Erstad , Joan Herman , Senta Raizen , Martin Ripley , May Miller-Ricci, "Assessment and teaching of 21st century skills," in *Assessment and teaching of 21st century skills*, vol. 9789400723, E. Griffin, Patrick; McGaw, Barry; Care, Ed. Springer, 2012, pp. 17–66.

[6] Department of Education, "Policy Guidelines on the K to 12 Basic Education Program," 2019. [Online]. Available: https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf.

[7] SEAMEO INNOTECH, *K to 12 Toolkit*, no. November 2011. 2016.

[8] W. Null, *Curriculum from Theory to Practice*. United Kingdom: ROWMAN & LITTLEFIELD PUBLISHERS, INC., 2011.

[9] R. M. Harden and N. Stamper, "What is a spiral curriculum?," *Med. Teach.*, vol. 21, no. 2, pp. 141–143, 1999, DOI: 10.1080/01421599979752.

[10] E. C. Valin and S. S. Janer, "Spiral Progression Approach in Teaching Science," *Int. J. Eng. Sci. Comput.*, vol. 9, no. 3, pp. 19976–19984, 2019.

[11] DepEd, "K to 12 Curriculum guide - Science," no. July, p. 247, 2016, [Online]. Available: http://www.deped.gov.ph/sites/default/files/page/2017/English CG!.pdf.

[12] S. Y. Chyung, D. Stepich, and D. Cox, "Building a Competency-Based Curriculum Architecture to Educate 21st-Century Business Practitioners," *J. Educ. Bus.*, vol. 81, no. 6, pp. 307–314, 2006, DOI: 10.3200/joeb.81.6.307-314.

[13] Deparment of Education, "POLICY GUIDELINES ON THE NATIONAL ASSESSMENT OF STUDENT LEARNING FOR THE K TO 12 BASIC EDUCATION PROGRAM," 2016, [Online]. Available: https://www.deped.gov.ph/wp-content/uploads/2016/06/DO_s2016_55-3.pdf.

[14] D. Squires, "Curriculum Alignment Research Suggests That Alignment Can Improve Student Achievement," *Clear. House A J. Educ. Strateg. Issues Ideas*, vol. 85, no. 4, pp. 129–135, 2012, DOI: 10.1080/00098655.2012.657723.

[15] K. Klucevsek, "The intersection of information and science literacy," *Commun. Inf. Lit.*, vol. 11, no. 2, pp. 354–365, 2017, doi: 10.15760/comminfolit.2017.11.2.7.

[16] R. Scherer and R. Tiemann, "Factors of problem-solving competency in a virtual chemistry environment: The role of metacognitive knowledge about strategies," *Comput. Educ.*, vol. 59, no. 4, pp. 1199–1214, 2012, doi: 10.1016/j.compedu.2012.05.020.

[17] L. M. Kipper *et al.*, "Scientific mapping to identify competencies required by industry 4.0," *Technol. Soc.*, vol. 64, no. October 2020, 2021, DOI: 10.1016/j.techsoc.2020.101454.

[18] C. Scoular, *Analysis of 21st century skills integration as applied in the Philippines K to 12 program. Final report*, no. March. 2020.

[19] J. A. Dossey, S. McCrone, and Y. Christine, "Problem Solving in the PISA and TIMSS 2003 Assessments Technical Report," *Yeskisti.Net*, 2006, [Online]. Available: http://www.yeskisti.net/yesKISTI/InfoSearch/ReadD

B02.jsp?CNO=TRFO200700046241%5Cnpapers3://publication/uuid/65C76465-C287-4396-B83F-DFFCC8B4AFA6.

[20] R. W. Hollingworth and C. McLoughlin, "Developing science students' metacognitive problem solving skills online," *Australas. J. Educ. Technol.*, vol. 17, no. 1, pp. 50–63, 2001, doi: 10.14742/ajet.1772.

[21] Marlborough, "Why is Problem Solving Important in Child Development? | Marlborough News," 2020. https://www.marlborough.org/news/~board/health-and-wellness/post/why-is-problem-solving-important-in-child-development (accessed Nov. 13, 2022).

[22] M. B. Eisenberg, "Information Literacy: Essential Skills for the Information Age," *DESIDOC J. Libr. Inf. Technol.*, vol. 28, no. 2, pp. 39–47, 2008, DOI: 10.14429/djlit.28.2.166.

[23] H. Julien and S. Barker, "How high-school students find and evaluate scientific information: A basis for information literacy skills development," *Libr. Inf. Sci. Res.*, vol. 31, no. 1, pp. 12–17, 2009, doi: 10.1016/j.lisr.2008.10.008.

[24] C. Dipetso and K. H. Moahi, "Information Literacy Skills of High School Students in Botswana," *Sch. Libr. Worldw.*, vol. 25, no. 1, pp. 105–121, 2021, DOI: 10.29173/slw8237.

[25] J.-J. R. Ramos and Maed, "Critical Thinking Skills Among Senior High School Students and Its Effect in Their Academic Performance," *Int. J. Soc. Sci. Humanit.*, vol. 3, no. 1, pp. 60–72, 2018, [Online]. Available: http://ijssh.ielas.org/index.php/ijssh/article/view/69/pdf.

[26] T. Wrahatnolo and Munoto, "21-st Centuries Skill Implication on Educational System," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 296, no. 1, 2018, DOI: 10.1088/1757-899X/296/1/012036.

[27] E. Elisanti, S. Sajidan, and B. A. Prayitno, "The Profile of Critical Thinking Skill Students in XI Grade of Senior High School," vol. 218, no. ICoMSE 2017, pp. 205–209, 2018, DOI: 10.2991/icomse-17.2018.36.

[28] L. F. Santos, "The Role of Critical Thinking in Science Education," *J. Educ. Pract.*, vol. 8, no. 20, pp. 159–173, 2017.

[29] M. Duran and I. Dökme, "The effect of the inquiry-based learning approach on student's critical-thinking skills," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 12, no. 12, pp. 2887–2908, 2016, doi: 10.12973/eurasia.2016.02311a.

[30] M. P. Rowe, B. Marcus Gillespie, K. R. Harris, S. D. Koether, L. J. Y. Shannon, and L. A. Rose, "Redesigning a general education science course to promote critical thinking," *CBE Life Sci. Educ.*, vol. 14, no. 3, pp. 1–12, 2015, DOI: 10.1187/cbe.15-02-0032.