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Lessons Learned in Pursuit of Lifelong Learning in Science, Technology, and Society

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ABSTRACT

This case study aims to assess whether the course, Science, Technology, and Society, as part of the recent science education reforms in Philippine higher education, can foster science literacy and bring about lifelong learning in science, technology, and society. Five students, who were enrolled in Science, Technology, and Society during the first semester of the academic year 2018 to 2019 in an institution of Jesuit higher education in the Philippines, participated in a focus group discussion about their class experiences. Thematic analysis of verbatim transcript revealed that students were not confident in considering themselves literate about science after a semester of classes because of several concerns in the content and delivery of the course. Specifically, topics covered were not interdisciplinary as they should be, lacked depth, and were not relatable to students. Some teachers were inclined towards knowledge transmission and required more support for teaching that espouses student-centered learning. Teachers' lack of motivation to teach the course was also noticeable among students and might have left a negative impression about the course. These findings can provide valuable insights into how efforts in reforming science education towards lifelong learning in science, technology, and society can be made better and effective using a constructive alignment of intended learning outcomes, teaching-learning activities, and assessment tasks.

Keywords: curricular reforms, higher education, science education, science literacy, constructive alignment

1. INTRODUCTION

The world today is beset by wicked problems of hunger, pollution, climate change, disease, and poverty, among others. The practical and timely solutions to these wicked problems do not lie in science or economics or politics alone. Good and sustainable solutions to these wicked problems lie instead in a multi-disciplinary and interdisciplinary approach. This need for such an approach has been the driving force for bridging science, technology, and society. This is the very reason why there is now a growing demand for public understanding of science and acquisition of science literacy [1].

Reforms in science education have been underway in many parts of the world to respond to the challenge of teaching for lifelong learning in science, technology, and society [2]. In the Philippines, these series of curricular reforms, according to its Commission of Higher Education (CHED) [3], aim to "expose undergraduate students to various domains of knowledge and ways of comprehending social and natural realities" so as to develop the "intellectual competencies and civic capacities" that are necessary to cope with issues prevalent in the 21st century. Specifically, such reforms in science education aspire for the science literacy of the public by "[engaging] students to confront the realities brought about by science and technology in society" [4].

These reforms in science education at the level of higher education in the Philippines are, however, relatively recent. Little is known whether these current curricular reforms in Philippine higher education have been effective in instilling lifelong learning in science, technology, and society. Thus, this study intends to assess whether these reforms in science education can foster lifelong learning in science, technology, and society among undergraduate students in an institution of Jesuit higher education in the Philippines. Particularly, we seek to explore the development of science literacy among students taking the CHED-mandated course in Science, Technology, and Society. Using Brigg's theory of constructive alignment as a lens, we aim to examine which aspects of the course do students attribute their sense of science literacy so that we can come up with a set of recommendations, which other institutions of higher education in the Philippines and elsewhere can take on as part of their efforts in reforming science education towards lifelong learning in science, technology, and society.

2. LITERATURE REVIEW

To provide a brief background to this study, this literature review examines some definitions of science literacy and discusses how science literacy is viewed in the Philippines based on the curriculum for Science, Technology, and Society. It then explores Bigg's theory of constructive alignment as a lens to understand the teaching-learning process that takes place in science education, among others.

Definitions of Science Literacy

Science literacy was first used in 1958 when Paul Hurd coined it at a time when individuals, as described by Laugksch [5], "became concerned whether their children were receiving the kind of education that would enable them to cope with a society of increasing scientific and technological sophistication." Since then, it refers to the goals of science education and how science should be contextualized in society [6]. It pertains to "what the general public ought to know about science" [7] and this involves "an appreciation of the nature, aims, general limitations of science, coupled with some understanding of the more important scientific ideas" [8]. In many ways, science literacy, as Holbrook and Rannikmae [9] point out, "sums up, at the school level, the intentions of science education."

However, science literacy remains an ill-defined concept, carrying different meanings and interpretations [5]. Miller [10], for example, describes science literacy not only as "the ability of the individual to read about, comprehend, and express an opinion on scientific matters," but it also entails an "awareness of the impact of science and technology on society and the policy choices that must inevitably emerge." This includes an understanding of basic scientific constructs, scientific approach, and science policy issues.

Despite these proposed definitions that commonly emphasize knowledge on science and abilities in applying science to society [11], no universally accepted definition of science literacy has been reached [2]. This is probably because it has stood for what should be the goals of science education reform [6]. In short, it is innately relative to the society in which it is employed [12]. Nonetheless, science literacy, as argued by Gormally et al. [13], seems to "emphasize students' abilities to make use of scientific knowledge in real-world situations."

Views of Science Literacy in the Philippines

In the Philippines, reforms were recently made in basic and higher education to respond to the dynamic needs and challenges of a rapidly changing world. Among these include reforms in the science education curricula. Science, Technology, and Society is now a required course in the general education curriculum of higher education. Based on its desired learning outcomes, it generally aims to engage students in examining scientific and technological developments within the "context of society with all its sociopolitical, cultural, economic, and philosophical underpinnings at play" [4].

Science, Technology, and Society as a course is not new though in the institution of Jesuit higher education that we studied here. Previously known as Science and Society, it was first introduced as part of the general education curriculum of this institution in 1999 to reinforce the science education of undergraduate students taking non-science-related degrees. Since then, this course has undergone curriculum review and revisions in consultation with students, alumni, faculty, administrators, and industry partners to make itself more responsive and relevant to contemporary times. To foster science literacy among students in non-science and science-related degrees, Science, Technology, and Society has been redesigned in 2018 as an interdisciplinary course that will provide not only a holistic understanding of the nature of science and technology but also a firm grasp of its impact on culture and society.

To provide meaningful and relevant opportunities for lifelong learning in science, technology, and society, topics covered during the semester for Science, Technology, and Society were arranged into four modules: Nature and Practice of Science and Technology; Science, Technology, and Lifestyle; Environment and Sustainable Development; and Origins of Life and the Universe. Four weeks of classroom discussion were allotted to cover the topics per module. By the end of the course, students are expected that they can discuss general ideas about the practice of science, provide solutions to issues utilizing the learned concepts in science, demonstrate knowledge in contemporary issues in the realm of science and technology, and advocate personal and social values, particularly those intrinsic and imbued in the study of scientific practices.

Teachers from the different disciplines of Science and Engineering teach the classes for Science, Technology, and Society. They undergo regular training so that they can be adept at the interdisciplinary nature of the course. The same instructional materials are used as references across the different sections of the course. There are also plenary lectures delivered by common guest lecturers to synthesize the topics covered in each module. However, teachers have the academic freedom on what style of teaching to adopt, what class activities to give, and how students will be assessed.

Bigg's Theory of Constructive Alignment

To achieve science literacy as a goal of science education in a higher education setting, there should be "a web of consistency" among the intended learning outcomes, teaching-learning activities, and assessment tasks [14]. This constructive alignment allows less motivated students to actively take part in their learning as much as the motivated students by being engaged in teaching-learning activities that can most likely bring about the intended learning outcomes and being given assessment tasks that can most likely measure and evaluate how well the intended learning outcomes are achieved [14-16]. "Constructive alignment," as Wang et al. [17] describe, "reflects the shift of paradigm from a teacher-centered teaching to a student-centered one, which emphasizes encouraging and supporting students' construction of their own knowledge inside and outside the classroom instead of teacher's transmission of the knowledge in class." There is a shift in paradigm because the "principles of constructive alignment," as Hailkari et al. [18] point out, "emerge from a constructivist approach to teaching and learning, which means that the knowledge is created through the activities of the learner." The focus therefore during the teaching-learning process is not on what the student is and what the teacher does but on what the student does [14]. "The key," as Briggs [15] elaborates, "is to define what students are supposed to do with the content that they have learned, apart from reporting back in their own words what they had been taught."

The use of constructive alignment in designing courses can enhance the quality of teaching and learning [17] as it can promote a deep approach to learning among students particularly when teaching exhibits deliberate efforts to engage students in teaching-learning activities that are most appropriate to the verbs used for the intended learning outcomes [15, 18]. As opposed to rote memorization of facts that characterizes the surface approach to learning, a deep approach to learning entails students to understand the information deeply by showing a willingness to grasp the overarching purpose of an academic task [16, 18]. Attention is now focused on the "hows" of teaching instead of the "whats" [19]. Hailkari et al. [18] and Wang et al. [17], for instance, demonstrated in their studies how carefully selected teaching-learning activities vis-à-vis the intended learning outcomes can bring about a deep approach to learning among students.

Choosing the appropriate teaching-learning activities is reliant though on the experience and judgment of the teacher [20]. Teachers whose approach to teaching is towards conceptual change, whose chosen teaching-learning activities are student-centered to a greater extent, and whose assessment tasks form an integral part of teaching are more likely to facilitate a deep approach to learning among students. On the other hand, teachers whose approach to teaching is predicated on knowledge transmission with the use of teacher-centered strategies are more likely to lecture course content and assess students' learning in terms of illogical parts rather than a coherent whole. They tend to espouse a surface approach to learning wherein the primary aim among the students is to simply pass the course [19].

Notably, there is a growing literature on science literacy as an outcome of science education. However, studies examining the acquisition of science literacy in terms of Bigg's theory of constructive alignment are limited. Evidence is likewise scarce on how the principles of constructive alignment can account for students' learning based on their points of view [18].

3. METHODOLOGY

This study used a qualitative research design to evaluate whether the curricular reforms in science education in the Philippines can foster lifelong learning in science, technology, and society among selected students from an institution of Jesuit higher education. Specifically, a case study was conducted to "draw attention to what can be learned" and to illustrate the "uniqueness, complexity, and contextual embeddedness" [21] of teaching science education. It offered a deeper understanding of naturally occurring phenomena within its real-life context, such as the teaching and learning that take place in science education [22].

Setting and Participants

This case study was set in an institution of Jesuit higher education in the Philippines, which aims to form students into "lifelong learners, who can discover and fulfill their distinctive calling and mission" as well as "transformative] leaders, who are globally attuned but also deeply rooted in local needs and aspirations, especially of the poor and marginalized" [23]. They are envisioned to be individuals, who can "integrate the values of science and technology with human and Christian values," among others [24]. This institution of Jesuit higher education recently underwent curricular reforms in science education as a response to the directive of CHED [3] for a new general education curriculum that can "deliver all the objectives of higher education."

Undergraduate students enrolled in Science, Technology, and Society from this institution of higher education during the first semester of the academic year 2018 to 2019 were eligible as participants in this study. Four to twelve students, as suggested by Slaughter et al. [25] for focus group discussion, were needed for this study. Simple random sampling using a random number generator was done in selecting students for this study. Those students, who did not give their informed consent and who withdrew from the study, were not included in data gathering and analysis. Recruited students were informed that their participation or non-involvement in the study had no bearing on their final grade for the course. They were reassured of anonymity and data confidentiality through encryption of gathered data and the use of pseudonyms in reporting the findings.

Data Gathering and Analysis

Before gathering data, ethics clearance was secured from an accredited institutional review board. A set of questions was outlined to guide the discussion for the focus group. These questions were directed on the coverage and delivery of Science, Technology, and Society as well as on students' sense of science literacy. Peer review and pre-testing of these guide questions were carried out for their validity and reliability so that prompts, which seemed problematic, were revised accordingly.

A focus group discussion with audio-recording was conducted on student participants at the end of the semester. The verbatim transcript of this focus group discussion was then shown to the study participants for member checking. To identify emerging themes on students' sense of science literacy, a thematic analysis was carried out with the three researchers serving as multiple coders. It included writing down notes along the margins of the transcript, identifying codes, reducing codes to salient themes by looking for patterns, organizing codes into categories, and aggregating the categories into larger units of themes. This process of coding and re-coding was done until all the researchers reached an intercoder agreement and no new meanings were derived from the gathered data [26]. In reporting the findings, excerpts from the student participants were de-identified.

4. FINDINGS

21 out of 593 undergraduate students were randomly selected for this study's focus group discussion. They were notified through their email accounts and mobile phones about the purpose and pertinent details of the focus group discussion. Five students agreed to be included in the focus group discussion, while two withdrew their participation, nine declined the invitation, and five did not respond to the notifications.

Aaron and Ben were both males belonging to the class taught by a teacher from Environmental Science, while Charles was a male from the class handled by a teacher from Biology. Dan was a male enrolled in the class of two Biology teachers, whereas Erin was a female registered in the class of a Physics teacher. In contrast to Aaron, Ben, Charles, and Dan, who came from classes that had about 24 pupils, Erin originated from a class that comprised of 78 pupils. All of them were sophomores taking up management-related degrees at the time the study was conducted. When asked if they considered themselves literate about science after taking Science, Technology, and Society for a semester, all were not confident to say so because there were certain aspects related to the content and delivery of the course that seemed least helpful in their learning and sense of science literacy (Table 1).

Content

Despite the intention of the course to be interdisciplinary in content, topics covered in the class were mainly focused on their teachers' specific disciplines. Erin, for instance, found her classes leaning towards Physics as "what was taught in class and the tasks assigned to [them] were mostly related to [her teacher's field of] specialization." Classes for Charles were "inclined to Biology" as he "had to know biological terms, which were most likely to appear in the test." Ben also observed that he learned more about the "environment and society as a whole" because he came from a class taught by a teacher from Environmental Science.

Additionally, Erin felt confused about what she was supposed to learn as the instructional materials handed out for them to read were not followed by her teacher. This made the topics discussed in class seemed "random" and "a mess." For her, "[it] did not make sense" that "out of nowhere" she and her classmates had to estimate the height of a specific building in centimeters for one of their quizzes in the Nature and Practice of Science and Technology. She ended up feeling at a loss as it seemed no explanation was given for them to understand the purpose of such an assessment.

The topics under Science, Technology, and Society, as Aaron and Charles noticed, were "too general" compared to how "specific and exact" they must learn their choice of natural sciences (e.g. Biology, Chemistry, Environmental Science, and Physics) during their freshmen year. Charles even remarked that "the course seemed like a high school subject" as most of the topics discussed in his class were "redundant" from what he learned for integrated science under an international baccalaureate program. Meanwhile, Dan identified some of the plenary lectures, which were meant to enrich the lessons in class through common guest lecturers, as "repetitive" since he observed there were some topics that tended to overlap among the plenary lectures.

But Charles did not mind if the topics for Science, Technology, and Society looked so general if "there can be more depth to it." The five of them also agreed that it would be useful in their learning if the topics taken in class are relatable to them. As Erin suggested, topics, such as "how corporations should function to be sustainable towards the environment," are something that students taking management-related degrees will appreciate discussing in class. Charles further recommended that it would be much better if they have an opinion on what topics can be taken in class and if they have options as to which plenary lectures they can attend based on their interests.

Delivery

In terms of delivery of the course, all of them believed that the style of teaching matters. This became apparent particularly for Dan, who was taught by two teachers having opposite approaches. He had “most fun” in the class when the first teacher allowed them to apply their learning through class activities and group discussions during the early part of the semester, while he “really disliked” the remaining half of the semester when the second teacher barely let them have a clearer grasp of the concepts as she simply “discussed the points in rapid speech” and “just went on” with her lectures. The first teacher guided them in relating science to society, whereas the second teacher made them “too busy copying notes to actually appreciate or understand the topic” and left them, most of the time, memorizing for the test. Even the type and design of their tests, as Dan observed, were different.

Aaron, Ben, and Charles considered it most useful in their learning whenever there were occasions that their respective teachers showed efforts “to make sure [they] understood” how “science applies to society.” The teacher of Charles, for example, gave them activities throughout the semester to make the class “lively” and “not [turn it out to be] too technical.” In fact, Charles found it specifically “enlightening” on how “[they] were helping or not helping the environment” because “[they] had to measure [their] own carbon dioxide emission” in one of their class activities. Instances like this gave him the impression that the course was “more of society than science.”

Erin, however, felt differently about the method of teaching in her class. She was bombarded with scientific terms, which she “did not see as to how [these] connect to society.” Similar to the sentiments of Aaron, Ben, and Charles, it was also not helpful for her that the plenary lectures came across “as required” since their teachers would later give a quiz on the content. Belonging to a big class size was not difficult though for Erin given that it would “depend on [her] teacher whether he can teach or not [a large class].”

Surprisingly, students could sense if their teachers were demotivated to teach this course. As pointed out by Charles, “some teachers seemed to teach [the course] in a way that gives the vibe of being required to do so.” It also became evident to them if the teacher is not invested in Science, Technology, and Society as exemplified in Erin’s statement, “Like the [teacher] was not there too [in class].”

The course, nevertheless, can be “made enjoyable” and less “monotonous” if, as Dan suggested, they can be “[brought] outside the typical classroom setting” and be allowed to “explore by themselves.” This includes, according to Ben, “doing things” in contrast to merely “knowing [concepts] just from someone else.” It could also be helpful if, as shown in the class of Charles, there can be more interactive opportunities during class and the discussions in plenary lectures can be followed through by their respective teachers. Furthermore, the style of teaching in class, as proposed by Charles and Dan, should be able to actively involve them in applying their learning “to their chosen career, to their daily life, and the Philippine society.”

Table 1. Emerging Themes on the Content and Delivery of the Course that Might Affect Students’ Science Literacy

Content
Topics were not interdisciplinary as they should be
Topics were too general and redundant
Topics should be relatable to the students
Given instructional materials were not followed
Students’ voice should be considered in choosing the topics
Delivery
Class activities should allow students to apply their learning
Class activities should be interactive and relevant
Assessments should not focus on rote memorization
Teachers need to be motivated to teach the course

5. DISCUSSION

Science literacy as a goal of science education has become more relevant nowadays as we need to adapt to a rapidly changing world and respond to the challenges of the 21st century. It is not only essential to understanding the role of science in social issues, but it is also integral to forming individuals into socially responsible and competent citizens [27].

As a mandatory course in higher education, Science, Technology, and Society represents the recent reforms in science education in the Philippines towards science literacy and lifelong learning in science, technology, and society. The findings of this study, however, suggest Science, Technology, and Society offered in an institution of Jesuit higher education fell short of these aims.

Possible reasons include concerns about topics covered in class were not as interdisciplinary as they should be, topics were lacking in depth when discussed by teachers, and several topics were not as relevant and meaningful to the students. There were likewise some instances wherein the instructional materials designed particularly for the course were not used during class. All these concerns tend to reflect how teachers of Science, Technology, and Society were not confident to teach the interdisciplinary aspect of the course even though they underwent a series of training to get familiarized with the variety of topics and to learn from each other’s best practices. Similar to the study of Pitot [28] on science teachers in Colorado, what was expected of these teachers to teach for science literacy seemed not aligned to what they knew. Hence, teachers of this course, as Sarkar and Corrigan [29] also mentioned in their research about science teachers in Bangladesh, were more likely to “[promote] a culture of [discipline-based] academic science that resulted in students’ difficulty in finding connections between the science they study in school and their everyday lives.”

Another probable reason was the inclination of some teachers of Science, Technology, and Society towards knowledge transmission instead of knowledge construction. Referred by Freire [30] as “banking education,” such teachers tend to “make deposits [of content knowledge], which the students patiently receive, memorize, and repeat.” Unfortunately, “[meaningful] learning,” as Cakir [31] emphasizes, “does not occur by throwing more science facts and principles at the students.” This style of teaching most often espouses rote memorization among students rather than engaging them for a critical discussion of issues in science, technology, and society [32]. Students, in turn, only develop “limited short-term retention of information” as opposed to “meaningful long-term knowledge acquisition” [33]. A surface approach to learning about science, technology, and society ensues instead of a deep approach to learning as the teaching-learning activities and assessment tasks are not aligned to the intended learning outcomes of the course.

One more reason could be related to the lack of motivation to teach among some of the teachers of Science, Technology, and Society. This is a crucial finding as teacher motivation has implications on teaching practice, classroom effectiveness, student motivation, and educational reforms, among others [34]. For example, the study of Thoonen et al. [35] demonstrated that committed teachers are more likely to enact goals of curricular reforms into classroom practice, while the study of Patrick et al. [36] revealed that teachers, who primarily taught enthusiastically, can motivate students to learn. In fact, “their own attitudes and professional comportment,” as Mifsud [37] points out, “may detract from the levels of enthusiasm and motivation of their students” in as much as “students’ lack of motivation may adversely affect their teaching.”

Our findings reiterate the importance of a student-centered approach to learning as students particularly appreciated the course more when they had interactive teaching-learning activities and group discussion during class where they were given meaningful and relevant opportunities for practical application. As shown in the study of Swarat et al. [38] and as stressed in the literature review of Cakir [31] on science pedagogy, students are more interested and engaged to learn about science, technology, and society if there are teaching-learning activities in class, which are "hands on" and "minds on." This is likely because students assume an active stance on their learning by taking responsibility and accountability for their learning [39].

Recognizing that teachers are central to fostering science literacy and instilling lifelong learning in science, technology, and society among students, institutional support should be provided to the teachers so that they gain mastery of the interdisciplinary content of Science, Technology, and Society, be more aware of socio-scientific issues, be prepared to a style of teaching that promotes student-centered learning, and be more mindful of constructive alignment during the teaching-learning process. Teacher capacity should be built towards creating educational experiences, which are challenging and enriching for the students [40]. Many factors must be considered then for teaching training and development: these include factors affecting teacher motivation, such as teachers' autonomy, competence, and sense of relatedness [41]. To do so, school leaders need to exemplify transformational leadership, which can inspire teachers to take on institutional goals as personal goals, assure them of institutional support, and challenge them to become better in teaching [35].

Also salient to student-centered learning is respect for student agency because "[implicit] within this [student-centered] approach," as Lea et al. [39] explain, "is the principle that students should be consulted about the learning and teaching process." In science education, institutions of higher education should therefore set up mechanisms, which can incorporate students' voice in school planning, designing curricula, and deciding policies, among others, since studies have demonstrated that students are "most likely to be engaged in learning when they are active and given some choice and control over the learning process" [42].

To strengthen the society aspect of Science, Technology, and Society and similar courses, teachers should carry out their teaching-learning activities around a compelling socio-scientific issue by presenting the issue at the start of instruction, providing scaffolding for reasoning, argumentation, and decision-making, and offering a culminating experience wherein students can integrate what they have learned with prior knowledge and relate this new learning to real-world situations [43]. This may warrant customizing the design of the course to the discipline of students not only to make their science education more meaningful and relevant to their chosen career and everyday life but to also render it responsive to the needs of society.

6. LIMITATIONS AND RECOMMENDATIONS

The contribution of this study to reforms in science education should be considered though in view of several limitations. First, the five students, who participated in the focus group discussion, were from management-related degrees and may not represent those students from other degrees. Additional studies are needed to consider the perspectives of students from other disciplines. Second, this study could have gotten a better understanding of science literacy through triangulation of data. Further studies can benefit from reviewing the syllabi, gathering data from student evaluation, and conducting classroom observations, among others. Lastly, one semester of Science, Technology, and Society may not be enough to instill lifelong learning in science, technology, and society. A longitudinal follow up should be carried out to assess the impact of the course in relation to other aspects of the curriculum on the students.

7. CONCLUSION

Science literacy has become vital nowadays as our rapidly changing world is fraught with wicked problems. An understanding of socio-scientific issues is imperative if solutions to these wicked problems are sought. Recent reforms in science education in the Philippines and elsewhere have aimed to respond to the need to educate for lifelong learning in science, technology, and society. Lessons can be learned from the experiences of educational institutions in their pursuit of fostering science literacy and instilling lifelong learning in science, technology, and society among their students. Insights from this study on an institution of Jesuit higher education in the Philippines, for example, showed the importance of aligning classroom practices of teachers to the goals of curricular reforms in science education. Conscious efforts to support teacher development are therefore crucial if science literacy and lifelong learning in science, technology, and society are desired from students.

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9. REFERENCES

[1] P. Agre & A.I. Leshner, "Bridging Science and Society", **Science**, Vol. 327, No. 5968, 2010, p. 921.

[2] X. Liu, "Beyond Science Literacy: Science and the Public", **International Journal of Environment and Science Education**, Vol. 4, No. 3, 2009, pp. 301–311.

[3] Commission on Higher Education. 2013. General Education Curriculum: Holistic Understandings, Intellectual and Civic Competencies. Retrieved from https://ched.gov.ph/cmo-20-s-2013/, pp.1-2.

[4] Commission on Higher Education. 2017. Science, Technology, and Society. Retrieved from https://ched.gov.ph/wp-content/uploads/2017/10/Science-Technology-and-Society.pdf, p. 1.

[5] R.C. Laugksch, "Scientific Literacy: A Conceptual Overview", **Science Education**, Vol. 84, No.1, 2000, p. 72.

[6] G.E. DeBoer, "Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship To Science Educational Reforms", **Journal of Research in Science Teaching**, Vol. 37, No 6., 2000, pp. 582–601.

[7] J.R. Durant, "What is Scientific Literacy?", **Science and Culture in Europe**, Science Museum, 1993. J. R. Durant & J. Gregory, eds, p. 129.

[8] E.W. Jenkins, "Scientific Literacy", **The International Encyclopedia of Education**, Pergamon Press, 1994. T. Husen & T. N. Postlethwaite, eds., p. 5345.

[9] J. Holbrook & M. Rannikmae, "The Meaning of Scientific Literacy", **International Journal of Environment and Science Education**, Vol. 4, No. 3, 2009, p. 275.

[10] J.D. Miller, "Scientific Literacy: A Conceptual and Empirical Review", **Daedalus**, Vol. 112, No. 2, 1983, pp. 30-31.

[11] B.A. Brown, J.M. Reveles, & G.J. Kelley, "Scientific Literacy and Discursive Identity: A Theoretical Framework for Understanding Science Learning", **Science Education**, Vol. 89, No. 5, 2005, pp. 779–802.

[12] J.D. Miller, (1989, February). Scientific Literacy. Paper presented at the annual meeting of the American Association for the Advancement of Science, San Francisco, CA.

[13] C. Gormally, P. Brickman, & M. Lutz, "Developing a Test of Scientific Literacy Skills (TOSLS): Measuring Undergraduates' Evaluation of Scientific Information and Arguments", **CBE-Life Sciences Education**, Vol. 11, No. 4, 2012, p. 364.

[14] J. Biggs & C. Tang, **Teaching for Quality Learning at University**, Open University Press, 2011, p. 99.

[15] J. Biggs, "Constructive Alignment in University Teaching", **HERDSA Review of Higher Education**, Vol. 1, No. 1, 2014, pp. 5-22.

[16] O. Fransson& T. Friberg, "Constructive Alignment: from Professional Teaching Technique to Governance of Profession", **European Journal of Higher Education**, Vol. 5, No. 2, 2015, pp. 141-156.

[17] X. Wang, Y. Su, S. Cheung, E. Wong, & T. Kwong, "An Exploration of Biggs' Constructive Alignment in Course Design and Its Impact on Students' Learning Approaches", **Assessment & Evaluation in Higher Education**, Vo. 38, No. 4, 2013, p. 478.

[18] T. Hailkari, V. Virtanen, M. Vesalainen, & L. Postareff, "Student Perspectives on How Different Elements of Constructive Alignment Support Active Learning", **Active Learning in Higher Education**. Advance online publication, 2021, p. 2.

[19] K. Trigwell & M. Prosser, "Qualitative Variation in Constructive Alignment in Curriculum Design", **Higher Education**, Vol. 67, No. 2, 2014, pp. 141-154.

[20] J. Biggs, "Enhancing Teaching through Constructive Alignment", **Higher Education**, Vo. 32, No. 3, 1996, pp. 347-364.

[21] T.H. Schram, **Conceptualizing and Proposing Qualitative Research**, Pearson Education, Inc, 2006, p. 107.

[22] W.A. Edmonds& T.D. Kennedy, **An Applied Guide to Research Designs: Quantitative, Qualitative, and Mixed Methods**, SAGE Publications, Inc., 2017.

[23] B.G.T.J. Tolosa, The Educational Philosophy and Curricular Frameworks of the Loyola Schools [PowerPoint presentation], 2020, p. 20

[24] Ateneo de Manila University. 2009. The Ideal ADMU Graduate. Retrieved from https://aifis.ateneo.edu/AIFIS/system/application/assets/files/The_Ideal_ADMU_Graduate.pdf, p. 1.

[25] P. Slaughter et al., 1999. Focus Groups in Health Services Research at the Institute for Clinical Evaluative Sciences. Retrieved from https://www.ices.on.ca/flip-publication/focus-group-in-health-servicesatICES/files/assets/common/downloads/ICES%20.pdf

[26] J. W. Creswell, **Qualitative Inquiry and Research Design: Choosing among Five Approaches**, SAGE Publications, Inc., 2013.

[27] J. Van Aalsvoort, "Logical Positivism as a Tool to Analyse the Problem of Chemistry's Lack of Relevance in Secondary School Chemical Education", **International Journal of Science Education**, Vol. 26 No. 9, 2004, pp. 1151-1168.

[28] L.N. Pitot. 2014. Determining the Alignment Between What Teachers are Expected to Teach, What They Know, And How They Assess Scientific Literacy. PhD Dissertation. Colorado State University.

[29] M. Sarkar & D. Corrigan, "Promotion of Scientific Literacy: Bangladeshi Teachers' Perspectives and Practices", **Research in Science & Technological Education**, Vol. 32, No. 2, 2014, p. 162.

[30] P. Freire, **Pedagogy of the Oppressed**, The Seabury Press, 1970, p. 58.

[31] M. Cakir, "Constructivist Approaches to Learning in Science and their Implications for Science Pedagogy: A Literature Review", **International Journal of Environmental and Science Education**, Vol. 3, No. 4, 2008, p. 202.

[32] W.L.P. Dos Santos, "Scientific Literacy: A Freirean Perspective as a Radical View of Humanistic Science Education", **Science Education**, Vol. 93, No. 2, pp. 361-382.

[33] C.E. Weinstein,D.S. Ridley, T. Dahl, & E.S. Weber, "Helping Students Develop Strategies for Effective Learning", **Educational Leadership**, Vol. 46, No. 4, 1989, p. 17.

[34] J. Han, & H. Yin, "Teacher Motivation: Definition, Research Development and Implications for Teachers", **Cogent Education**, Vol. 3 No. 1, 2016, pp. 1-18.

[35] E.E. Thoonen, P.J. Sleegers, F.J. Oort, T.T. Peetsma, &bF.P. Geijsel, "How to Improve Teaching Practices: The Role of Teacher Motivation, Organizational Factors, and Leadership Practices", **Educational Administration Quarterly**, Vol. 47, No. 3, 2011, pp. 496–536.

[36] B.C. Patrick, J. Hisley, & T. Kempler, "What's Everybody So Excited About?: The Effects of Teacher Enthusiasm on Student Intrinsic Motivation And Vitality", **The Journal of Experimental Education**, Vol. 68, No. 3, 2000, pp. 217-236.

[37] M. Mifsud, "How Much Does Teacher Enthusiasm Affect Student Learning", **Perspectives on Educational Practice Around the World**, Bloomsbury Publishing Plc, 2019. S. Hammond & M. Sangster, eds., p. 68.

[38] S. Swarat, A. Ortony, & W. Revelle, "Activity Matters: Understanding Student Interest in School Science", **Journal of Research in Science Teaching**, Vol. 49, No. 4, 2012, pp. 515–537.

[39] S.J. Lea, D. Stephenson, & J. Troy, "Higher Education Students' Attitudes to Student-Centred Learning: Beyond 'Educational Bulimia'?", **Studies in Higher Education**, Vol. 28 No. 3, 2003, p. 322.

[40] N. Zepke, & L. Leach, "Improving Student Engagement: Ten Proposals for Action", **Active Learning in Higher Education**, Vol. 11, No. 3, 2010, pp.167-177.

[41] D. Stirling. 2016. Teacher Motivation. Retrieved from https://www.researchgate.net/profile/Diana_Stirling /publication/309481949_Teacher_Motivation/links/5812a79008aea2cf64e26949/Teacher-Motivation.pdf

[42] T. Murphey, J. Falout, J. Elwood, & M. Hood, "Inviting Student Voice. Accepting Alternative Voices," **Accepting Alternative Voices**, Asian EFL Journal Press, R. Nunn & J. Adamson, eds., pp. 202.

[43] M.L. Presley, A.J. Sickel, N. Muslu, D. Merle-Johnson, S.B. Witzig, K. Izci, & T.D. Sadler, "A Framework for Socio-Scientific Issues Based Education.", **Science Educator**, Vol 22, No. 1, 2013, pp. 26-32.