Journal of Systemics, Cybernetics and Informatics (2022) 20(4), 8-14
https://doi.org/10.54808/JSCI.20.04.8

Exploring Students' Attitudes toward Science and Course Engagement as Predictors of Science Literacy

Genejane ADARLO
Health Sciences Program, Ateneo de Manila University
Quezon City, Metro Manila, Philippines 1108

Marlene DE LEON
Department of Information Systems and Computer Science, Ateneo de Manila University
Quezon City, Metro Manila, Philippines 1108

Abigail Marie FAVIS
Department of Environmental Science, Ateneo de Manila University
Quezon City, Metro Manila, Philippines 1108

ABSTRACT[1]

Studies that investigate the relationship of students' attitudes toward science and their engagement in the teaching-learning process to science literacy in a higher education setting and within the context of a pandemic are limited. This cross-sectional, correlational study sought to determine whether 1) students' attitudes toward science and student course engagement are significantly related to science literacy; and if 2) students' attitudes toward science and their course engagement are significant predictors of science literacy. The survey included 67 undergraduate students taking the mandated Science, Technology, and Society course during the second semester of the academic year 2020 to 2021 in an institution of Jesuit higher education in the Philippines. Results revealed 1) a positive moderate relationship between students' attitudes toward science and science literacy ($p < 0.001$); 2) a positive strong relationship between student course engagement and science literacy ($p < 0.001$); and 3) both students' attitudes toward science ($p = 0.02$) and their course engagement ($p < 0.001$) are significant predictors of science literacy. Such results can be helpful in (re)designing science education in a higher education setting and within the context of a pandemic.

Keywords: Science Education, Science Literacy, Higher Education, Remote Learning, Students' Attitudes toward Science, Student Course Engagement, COVID-19 Pandemic

1. INTRODUCTION

One of the central aims of science education is to facilitate a public understanding of science and its impact on society [1-2]. Such literacy about science among the public not only involves a critical apprehension of socio-scientific issues but also warrants the astute use of scientific inquiry to foster social change [2]. In this sense, science literacy is not only about acquiring scientific knowledge. It includes applying scientific inquiry to address real-world situations and appreciating science as a social enterprise or as a social practice of the community [3].

To be effective in its aim for science literacy, science education should go beyond being conceptual and cognitive in its approach. It must also pay attention to the social and affective aspects of the teaching-learning process of science [3]. Among these aspects of science education that call for careful consideration are students' attitudes toward science and their engagement in the teaching-learning process [4-6]. Several science educators believe that disaffection with science among students can adversely affect their achievement in science, whereas being part of an interesting and engaging class can motivate students to learn more about science [3-4].

Recently, the COVID-19 pandemic adds another layer of complexity to the already challenging landscape of science education. To avoid disruption of learning during this global crisis, schools and universities in countries under COVID-19 restrictions and lockdowns have turned to online delivery of classes using a diverse range of e-learning tools, platforms, and approaches. Although this global crisis is relatively new, there has been a growing interest among scholars to investigate the different aspects of remote learning in adverse situations, such as pandemics [7]. Available literature, for example, reports that access to technology for remote learning and previous experience in using online education tools were found to be determinants of student satisfaction with the shift from in-person classes to e-learning during this pandemic [8]. Other studies reveal this shift in the teaching-learning

[1] The authors acknowledge the valuable contribution of Brian Karlo Zuñiga for peer-editing this article.

process resulted in improved student achievement and increased technology proficiency among students and teachers alike [9]. Some research, on the other hand, documents how the COVID-19 pandemic unsettled familiar ways of teaching and learning science, among others [7].

However, studies that investigate the relationship of students' attitudes toward science and their engagement in the teaching-learning process to science literacy in a higher education setting and within the context of a pandemic are rather few. The extant literature has been mostly focused on a K-12 setting and situated in less stressful conditions. This present study is therefore relevant as the unprecedented shift from in-person classes to remote learning during the COVID-19 pandemic may have a bearing on the development of science literacy among students for several reasons. First, the social and affective aspects of the class in an online mode tend to differ from face-to-face instruction. Second, the dynamics of student-teacher interaction and student-student interaction in class have remarkably changed as remote learning has become the new normal. Third, both students and teachers are accustomed to in-person classes and are therefore challenged to adapt to a new mode of teaching and learning during this pandemic [7].

Hence, this study is framed in a pandemic context and aims to determine if 1) students' attitudes toward science are significantly related to science literacy; 2) student course engagement is significantly related to science literacy; and 3) students' attitudes toward science and their course engagement are significant predictors of science literacy. Students referred to in this study are those in a higher education setting. Students' attitudes toward science and student course engagement are the independent variables, while science literacy is the dependent variable in this study.

2. THEORETICAL FRAMEWORK

Science literacy carries a wide variety of meanings throughout history [10]. But what is clear from these definitions is that they reflect the changes in aspirations and needs of the society [3]. In a globalized society that characterizes the twenty-first century, science education is increasingly viewed to foster science literacy among students by preparing them "to lead fulfilled responsible lives as global citizens," who seek "for the larger good" [11].

Taking into consideration the various aspirations and needs of a globalized society, a science literacy framework most suited to responding to the demands and challenges of the twenty-first century has been re-conceptualized and proposed [12]. This framework consists of five dimensions: 1) content knowledge, 2) habits of mind, 3) character and values, 4) science as a human endeavor, and 5) metacognition and self-direction. Content knowledge is about the use of big ideas of science to understand socio-scientific issues, while habits of mind refer to the application of effective communication and collaboration skills, systematic thinking, and information management in solving complex problems in society. Character and values include belief systems and preferences, which are necessary for acting responsibly as global citizens. Ecological worldview, compassion, and socio-scientific accountability are among the belief systems and preferences that are found crucial to science literacy. Science as a human endeavor, on the other hand, is about recognizing that scientific knowledge is a human construct, understanding that science and society are interrelated, and employing the spirit of science (e.g., curiosity, creativity, intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas) in arriving at a better grasp of socio-scientific issues. Lastly, metacognition and self-direction involve the cognitive processes of planning, monitoring, and evaluating in making decisions and actions on socio-scientific issues [11-12].

Students can better appreciate the role of science in their daily lives and come up with informed decisions and actions about socio-scientific issues if they are motivated to do so by interest [4]. Their attitudes toward science are thereby seen as valuable to science literacy. However, assessing students' attitudes toward science tends to be difficult as several dimensions must be considered [5, 13]. The My Attitudes toward Science (MATS) framework aims to account for the multidimensional nature of students' attitudes toward science by reviewing the related literature. This framework has identified four dimensions, which emerged most frequently in past research. These dimensions include 1) attitude toward science as an academic subject, 2) interest in a science-related career, 3) perception of scientists, and 4) value of science to society [5].

Students' engagement in class reflects their cognitive, emotional, and behavioral investment in the teaching-learning process [14]. Such investment is viewed by science educators as essential not only in examining the effectiveness of their instruction but also in bringing about science literacy among students. The Student Course Engagement Questionnaire (SCEQ) framework seeks to measure course engagement among students of higher education by asking selected students and teachers to describe their perceptions of what engaged students do, feel, and think in class [15]. Four dimensions have been identified using exploratory factor analysis: 1) skills engagement, 2) participation/interaction engagement, 3) emotional engagement, and 4) performance engagement [15]. However, the SCEQ framework is most suited for traditional face-to-face instruction. It has therefore undergone minor revisions to make it more relevant to measure course engagement among students in an online setting. The Modified Student Course Engagement

Questionnaire (SCEQ-M) framework features four dimensions of student engagement in remote learning: 1) applied engagement, 2) goal-oriented engagement, 3) self-disciplined engagement, and 4) interactive engagement. Applied engagement refers to the emotional involvement of students in class and to the perceived relevance of class material in their lives. Goal-oriented engagement pertains to behaviors that are deemed necessary to achieve learning outcomes and goals, whereas self-disciplined engagement involves behaviors that are consistent with self-regulated learning. Lastly, interactive engagement is concerned with the level of student-teacher interaction and student-student interaction that take place during remote learning [16].

3. METHODOLOGY

To determine if there is a significant relationship between the independent and dependent variables in this study, and whether the independent variables are significant predictors of the dependent variable, a cross-sectional, correlational study design was used as a form of quantitative research. This research design was most appropriate for this study as data were collected at one point in time only [17]. It can offer a snapshot of a given population at a certain time by determining the relationships that exist between independent and dependent variables, among others [18]. It can also be useful for researchers in predicting outcomes, such as science literacy, through statistical analysis [17].

Setting and Participants

This study was conducted at the Loyola Schools (LS), the higher education unit of Ateneo de Manila University, which is a Jesuit educational institution located in the capital of the Philippines. Since 1999, a course subject called Science and Society has been part of the general education curriculum of LS, mostly for undergraduate students of non-science degrees. This course subject has then evolved to meet the demands of a globalized society and respond to the challenges that confront science education in the twenty-first century. By 2018, it has become a required course subject for all undergraduate students as mandated by the Commission of Higher Education of the Philippines. It has been renamed Science, Technology, and Society (STS 10) and has been designed as an interdisciplinary course subject meant to provide students with a holistic understanding of the nature of science and technology (S&T), engage them in socio-scientific issues, and offer opportunities to transform social habits and cultural mindsets. To foster science literacy among students, learning outcomes of STS 10 include the following:

1) Students should be able to evaluate the capabilities as well as limitations of S&T through distinguishing what questions and methods are valid in the realm of science based on its nature and practice.
2) Students should be able to contextualize issues using perspectives from and beyond S&T to dissect the interplay of various factors in analyzing the complexity of the human experience.
3) Students should be able to synthesize insights from various disciplines to propose solutions to contemporary issues with a view toward sustainable development and improving quality of life.
4) Students should demonstrate how individuals and an entire generation - guided by Ignatian Values - can participate in and contribute to the practice of S&T, driving the transformation of society through their various professions and leadership.

LS transitioned to remote learning in the middle of the second semester of the academic year 2019 to 2020 after COVID-19 restrictions and lockdowns were declared by the Philippine government on 12 March 2020. Since then, classes, such as STS 10, have been delivered fully online through the Canvas Learning Management System.

After obtaining ethics approval from an accredited institutional review board, students enrolled in STS 10 during the second semester of the academic year 2020 to 2021 were recruited by volunteer sampling to participate in this study. A minimum of 60 students were needed as a sample population in this study given that an estimate of 30 students is required per independent variable [18]. Remote learning that took place a year into the imposed COVID-19 restrictions and lockdowns was the chosen period for this study so that both students and teachers have become familiarized with e-learning by then.

Data Gathering

A URL link to the survey was sent via email to the cohort of STS 10 students upon completion of the course subject. This survey included demographic questions and items from existing instruments, such as MATS, SCEQ-M, and Global Scientific Literacy Questionnaire (GSLQ).

The 5-point Lickert-type scale items in MATS demonstrated at least an inter-rater agreement of 80% and a Cronbach's alpha of 0.70 for three out of its four dimensions [5]. 14 items from the subscale on students' attitude toward school science and 12 items from the subscale on the value of science to society were included in the survey. These items were specifically chosen in this study to consider how STS 10 students become consumers of scientific knowledge.

The 5-point Likert-type scale items in SCEQ-M showed validity using confirmatory and exploratory factor analysis. They also exhibited at least a Cronbach's alpha of 0.70 for all four dimensions [16]. The entire 19 items of SCEQ-M were added to the survey.

The 5-point Likert-type scale items in GSLQ were deemed valid based on confirmatory and exploratory factor

analysis. A Cronbach's alpha of 0.80 and above were observed for the scale's four dimensions, namely habits of mind, character and values, science as a human endeavor, and metacognition and self-direction [11]. All 48 items of GSLQ were included in the survey.

Data Analysis

Descriptive statistics were used for demographic information, such as age and gender. To determine if the independent variables are significantly related to the dependent variable in this study, Pearson correlation at a 0.05 level of significance was done. To determine if the two independent variables in this study are significant predictors of the dependent variable, a multiple linear regression at a 0.05 level of significance was performed.

4. RESULTS

A total of 67 STS 10 students participated in the survey. They were 19.54 $\pm$ 0.93 years of age. 62.69% (42 students) were females, while 37.31% (25 students) were males. Almost all of them were in their second year of undergraduate studies.

The survey participants obtained a MATS score (i.e., students' attitudes toward science) of 108.12 $\pm$ 8.95 out of 130 and a SCEQ-M score (i.e., student course engagement) of 71.31 $\pm$ 11.80 out of 115. Their GSLQ score (i.e., science literacy) is measured at 208.54 $\pm$ 20.76 out of 240.

Students' Attitudes toward Science and Science Literacy

Table 1 shows there is a positive moderate relationship between MATS and GSLQ scores ($p < 0.001$). 28% of the GSLQ score could be accounted for by the survey participants' responses to the MATS items.

Table 1. Relationship between MATS and GSLQ

Variable	r	r^2	p value
Attitude	0.41	0.17	< 0.001
Value	0.36	0.13	< 0.001
MATS	0.53	0.28	< 0.001

The positive relationship between scores for the subscale on attitude toward school science and scores for GSLQ was moderate ($p < 0.001$), while the positive relationship between scores for the subscale on value of science to society and scores for GSLQ was rather weak ($p < 0.001$). 17% and 13% of the variances in GSLQ score could be attributed to the scores garnered for the subscale on attitude toward school science and for the subscale on the value of science to society, respectively.

Student Course Engagement and Science Literacy

Table 2 demonstrates a positive strong relationship between SCEQ-M and GSLQ scores ($p < 0.001$). Based on the coefficient of determination (r^2), 49% of the GSLQ score could be explained by item responses to SCEQ-M.

Table 2. Relationship between SCEQ-M and GSLQ

Variable	r	r^2	p value
AE	0.70	0.49	< 0.001
GE	0.60	0.36	< 0.001
SE	0.58	0.33	< 0.001
IE	0.56	0.32	< 0.001
SCEQ-M	0.70	0.49	< 0.001

Looking at the subscales of SCEQ-M, a positive strong relationship existed between applied engagement (AE) and GSLQ scores ($p < 0.001$). Goal-directed engagement (GE), self-disciplined engagement (SE), and interactive engagement (IE) scores, on the other hand, displayed a positive moderate relationship with GSLQ scores ($p < 0.001$). At least 30% of the variations in GSLQ scores could be due to variations in AE, GE, SE, and IE scores.

Predictors of Science Literacy

Table 3 reveals MATS and SCEQ-M were significant predictors of GSLQ scores ($p < 0.05$). Both MATS and SCEQ-M could explain 51% of the variances in GSLQ scores.

Table 3. MATS and SCEQ-M as Predictors of GSLQ

Variable	Regression Coefficient	Standard Error	p value
Intercept	76.28	21.60	< 0.001
MATS	0.56	0.23	0.02
SCEQ-M	1.01	0.18	< 0.001

Adjusted $R^2 = 0.51$

Focusing on the two dimensions measured by MATS, table 4 shows attitude toward school science and value of science to society were significant predictors of GSLQ scores ($p < 0.05$).

Table 4. MATS Dimensions as Predictors of GSLQ

Variable	Regression Coefficient	Standard Error	p value
Intercept	64.46	29.78	0.03
Attitude	1.11	0.29	< 0.001
Value	1.53	0.46	0.002

Adjusted $R^2 = 0.27$

However, only 27% of the GSLQ scores could be caused by attitude toward school science and value of science to society.

Paying attention to the different dimensions of SECQ-M, table 5 shows only applied engagement (AE) as a significant predictor of GSLQ scores ($p < 0.001$).

Table 5. SECQ-M Dimensions as Predictors of GSLQ

Variable	Regression Coefficient	Standard Error	p value
Intercept	116.42	9.46	< 0.001
AE	4.01	0.92	< 0.001
GE	1.68	0.87	0.06
SE	0.01	0.70	0.99
IE	0.59	0.68	0.39

Adjusted $R^2 = 0.53$

Nonetheless, 53% of the GSLQ scores could be attributed to the four dimensions of SECQ-M.

5. DISCUSSION

The Philippines faces daunting challenges in science education as the 2018 Programme for International Student Assessment (PISA) results showed that the country ranks second-lowest among 79 countries in terms of science literacy [19]. These dismal results underscore the need to assess how students are learning science and how teachers are teaching them so that necessary educational reforms can be instituted. In the Philippine higher education, one of the educational reforms aimed at promoting science literacy among students is to integrate Science, Technology, and Society as a required course subject in the general education curriculum beginning in 2018.

These reforms in Philippine higher education, however, are relatively recent. Moreover, the COVID-19 pandemic may have hindered the progress of these educational reforms, as the American Educational Research Association revealed that "[students] are struggling to learn science during the pandemic, even as they find it increasingly interesting and relevant to their lives" [20]. As such, further studies are warranted to gain insights into the different aspects of science education, including the likely factors that are related to the development of science literacy in a higher education setting and within the context of a pandemic. The likely factors investigated in this study are students' attitudes toward science and their course engagement.

This study showed that an increase in students' attitudes toward science had a corresponding modest increase in science literacy as evidenced by the positive moderate relationship between them using Pearson correlation. Furthermore, the dimension, attitude toward school science, of MATS was more related to science literacy compared to the dimension, value of science to society. Students' attitudes toward science and its two dimensions were observed to be significant predictors of science literacy. These results suggest that a heightened interest in science as a course subject can better facilitate learning and appreciation of science among students [21]. Letting students understand the practical application of science in society and recognize the relevance of science in their daily lives can be helpful as well in promoting science literacy among them. In remote learning set in highly stressful conditions, such as pandemics, science educators must therefore incorporate class activities that pique a genuine interest among their students about science, as studies revealed that constructing a conducive learning environment that is "hands-on" is more preferred by students over knowledge transmission of scientific content [22].

Additionally, this study illustrated that an increase in student course engagement had an almost similar increase in science literacy based on the positive strong relationship between these variables using Pearson correlation. The dimension, applied engagement, of SCEQ-M was substantially related to science literacy as opposed to goal-directed engagement, self-disciplined engagement, and interactive engagement. Moreover, student course engagement and its dimension, applied engagement, were found to be significant predictors of science literacy. These results imply that applied engagement largely contributes to the relationship between student course engagement and science literacy. Given that applied engagement refers to the emotional investment of students in class and the perceived relevance of course-related materials in their daily lives, these results seem to corroborate observations on the importance of attitude toward school science and the value of science to society in facilitating science literacy. Studies also demonstrated that eliciting cognitive and emotional interest among students can more likely engage them in class. To foster science literacy among undergraduate students during pandemics and similar scenarios, science educators must be creative in devising

virtual classroom experiences that can guide their students to apply course content in real-world situations [21].

6. LIMITATIONS AND RECOMMENDATIONS

The implications of this study on teaching and learning science in a higher education setting and within the context of a pandemic and similar adverse situations should consider the limitations encountered.

First, the survey participants may not be representative of other undergraduate students within and outside the studied institution since they volunteered to take part in the research. Future studies can address this issue of representativeness by employing probability sampling and carrying out the research in multiple institutions.

Second, the number of samples in the study may not be large enough despite fulfilling the minimum sample size requirement. Other studies should incorporate strategies that can allow them to recruit more participants by probability sampling so that generalizability is ensured.

Third, more females participated in this study than males. This skewed distribution introduces gender bias. Subsequent research may include gender as a covariate in statistical analysis. Gender was not included in the regression model in this study because of constraints in sample size.

Fourth, the survey participants came from STS 10 classes handled by different teachers. Their experiences of remote learning during this pandemic may therefore vary from each other. Aside from enforcing probability sampling to guarantee equal chances of being selected in the study, later studies may incorporate differences in teachers as a covariate in statistical analysis. This variable was not added to the regression model in this study as information was not readily available.

Fifth, other variables can account for science literacy in this study as shown by figures gathered from computing r^2 and R^2. Succeeding studies may need to include other variables related to science literacy based on an exhaustive literature review.

Sixth, statistical tests employed in this study were limited to Pearson correlation and multiple linear regression as the sample size was not large enough for sophisticated analysis, such as structural equation modeling. Larger-scale research is therefore highly recommended in the future.

Lastly, this study can only show the correlation between independent and dependent variables because the chosen statistical tests cannot prove causality. The constructs used for the variables are also confined to the theoretical frameworks adopted in this current research. Hence, this study is more exploratory rather than confirmatory. Further research with a more sophisticated statistical analysis is needed to support the results of this study. Additional studies may also benefit from employing other theoretical frameworks.

7. CONCLUSION

Science literacy deals with socio-scientific issues. As such, science education should not be confined to knowledge transmission of scientific concepts and be isolated from the concerns of society. It entails attending to the social and affective aspects of the teaching-learning process of science, such as students' attitudes toward science and their course engagement. The results of this study, although exploratory, highlight the importance of providing meaningful and relevant opportunities to undergraduate students for them to connect science to society, particularly at this time of the pandemic where remote learning has become the status quo. Doing so can help bring about science literacy, which is the endmost aim of science education in the twenty-first century.

8. DECLARATION OF FUNDING AND COMPETING INTEREST

This research study was made possible through a grant from the Ateneo Research Institute of Science and Engineering (ARISE). The authors have no conflict of interest to declare.

9. REFERENCES

[1] G. Adarlo, A.M. Favis, C.K. Gotangco-Gonzales, & A.V. Guidote Jr. "Lessons Learned in Pursuit of Lifelong Learning in Science, Technology, and Society," in **The 15th International Multi-Conference on Society, Cybernetics, and Informatics**, N. Callaos, J. Horne, B. Sanchez, & M. Savoie, Eds. Jul. 2021, pp. 88-93.

[2] M.J. Reisse, "What Should be the Aim(s) of School Science Education," in **The Re-Emergence of Values in Science Education**, D. Corrigan, J. Dillon, & R. Gunstone, Eds., Rotterdam, NL: Sense, 2007, pp. 13-28.

[3] J. Osborne, "Science Education for the Twenty-First Century," **Eurasia Journal of Mathematics, Science and Technology Education**, Vol. 3, No. 3, 2007, pp. 173-184.

[4] H.S. Lin, Z.R. Hong, & T.C. Huang, "The Role of Emotional Factors in Building Public Scientific Literacy and Engagement with Science," **International Journal of Science Education**, Vol. 34, No. 1, 2012, pp. 25-42.

[5] S.J. Hillman, S.I. Zeeman, C.E. Tilburg, & H.E. List, "My Attitudes Toward Science, (MATS): The

Development of a Multidimensional Instrument Measuring Students' Science Attitudes," **Learning Environments Research**, Vol. 19, No. 2, 2016, pp. 203-219.

[6] A. Words-McConney, M.C. Oliver, A. McConney, R. Schibeci, & D. Maor, "Science Engagement and Literacy: A Retrospective Analysis for Students in Canada and Australia," **International Journal of Science Education**, Vol. 36, No. 10, 2014, pp. 1588-1608.

[7] G. Adarlo, M. De Leon, & A.M. Favis, "Unsettling Familiar Ways of Teaching and Learning: Challenges in Science Education during a Pandemic," unpublished.

[8] J. Qazi, K. Naseer, A. Qazi, H. AlSalman, U. Naseem, S. Yang, G. Hardaker, & A. Gumaei. "Evolution to Online Education around the Globe during a SARS-CoV-2 Coronavirus (COVID-19) Pandemic: Do Develop and Underdeveloped Cope Alike," **Children and Youth Services Review**, Vol. 119, 2020, pp. 105582.

[9] A. Elzainy, A. El Sadik, & W. Al Abdulmonem. "Experience of e-Learning and Online Assessment during the COVID-19 Pandemic at the College of Medicine, Qassim University," **Journal of Taibah University Medical Sciences**, Vol. 15, No. 6, 2020, pp 456-462.

[10] G.E. De Boer, "Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform," **Journal of Research in Science Teaching**, Vol. 37, No. 6, 2000, pp. 582-601.

[11] K. Mun, N. Shin, H. Lee, S.W. Kim, K. Choi, C.Y. Choi, & J.S. Krajcik, "Korean Secondary Students' Perception of Scientific Literacy as Global Citizens: Using Global Scientific Literacy Questionnaire," **International Journal of Science Education**, Vol. 37, No. 11, 2015, pp. 1739-1766.

[12] K. Choi, H. Lee, N. Shin, S.W. Kim, & J. Krajcik, "Reconceptualization of Scientific Literacy in South Korea for the 21st Century," **Journal of Research in Science Teaching**, Vol. 48, No. 6, 2011, pp. 670-697.

[13] C.L. Blalock, M.J. Lichtenstein, S. Owen, L. Pruski, C. Marshall, & M. Toepperwein, "In Pursuit of Validity: A Comprehensive Review of Science Attitude Instruments 1935-2005," **International Journal of Science Education**, Vol. 30, No. 7, 2008, pp. 961-977.

[14] Y. Ta, M. Subasi, & S. Yerdelen, "The Role of Motivation between Perceived Teacher Support and Student Engagement in Science Class," **Educational Studies**, Vol. 345, No. 5, 2019, pp. 582-592.

[15] M.M. Handelsman, W.L. Briggs, N. Sullivan, & A. Towler, "A Measure of College Student Course Engagement," **The Journal of Educational Research**, Vol. 98, No. 3, 2005, pp. 184-191.

[16] M.A.M. Nasir, T. Janikowski, W. Guyker, & C.C. Wang, "Modifying the Student Course Engagement Questionnaire for Use with Online Courses," **Journal of Educators Online**, Vol. 17, No. 1, 2020, p. n1.

[17] J.W. Creswell, **Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research**, Boston, MA: Pearson Education, Inc., 2012.

[18] L. Cohen, L. Manion, & K. Morrison, **Research Methods in Education**, New York, NY: Routledge, 2007.

[19] Organisation for Economic Co-operation and Development, "Programme for International Student Assessment (PISA) Results from 2018: Country Notes," 2019. [Online]. Available: https://www.oecd.org/pisa/publications/PISA2018_CN_PHL.pdf

[20] Education Week, "Science Teaching and Learning Found to Fall Off in Pandemic," 2021. [Online]. Available: https://www.edweek.org/teaching-learning/science-teaching-and-learning-found-to-fall-off-in-pandemic/2021/04

[21] J.P. Mazer, "Validity of the Student Interest and Engagement Scales: Associations with Student Learning Outcomes," **Communication Studies**, Vol. 64, No. 2, 2013, pp. 125-140.

[22] 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.