Proceedings Series on Physical & Formal Sciences, Volume 3
Proceedings of Digital Literacy in Education and Science
ISBN: 978-623-5729-30-5, ISSN: 2808-7046

Development and Evaluation of a Nature of Science-Based Online Course in Tenth-Grade Evolution

Kenneth Ian Talosig Batac[1], Voltaire Mallari Mistades[2]
[1,2]Department of Science Education, Br. Andrew Gonzalez FSC College of Education, De La Salle University

ARTICLE INFO

Article history:

DOI:
10.30595/pspfs.v3i.266

Submited:
January 20, 2022

Accepted:
February 14, 2022

Published:
March 9, 2022

Keywords:

Nature Of Science, Evolution, Natural Selection, Online Learning, Classroom Climate, COVID-19

ABSTRACT

Worldwide, misconceptions and non-scientific notions about evolution are prevalent within academic circles. As online learning gains popularity because of the COVID-19 pandemic, it is crucial to identify practices that support learning in these contexts. Using the ADDIE instructional model, this study developed and evaluated a nature of science-based online course in evolution for tenth-grade junior high school students. Results revealed that the biology teachers considered the quality of pedagogies, resources, and delivery strategies in the online course excellent. Correspondingly, the students deemed the classroom climate in the online course exceptional in terms of instructor behaviors, course structure, course clarity, and student connectedness. The online course also helped them understand how evolution works through the videos and informative content and accept evolution by considering that several pieces of evidence and information support it and science and religion are not contradictory. Although the online course is good the way it is for most students, some of them provided recommendations for improvement. Overall, the students regarded the online course as recommendable because it is educational and manageable.

Corresponding Author:
Kenneth Ian Talosig Batac
Department of Science Education
Br. Andrew Gonzalez FSC College of Education, De La Salle University
2401 Taft Avenue, Manila, Philippines
Email: kenneth_batac@dlsu.edu.ph

1. INTRODUCTION

Online learning is envisaged to be mainstream worldwide by the year 2025 [1]. Thus, its preparation for the future is of paramount importance [2]. However, the COVID-19 pandemic can hasten this timeline as it has produced the most significant education disturbance in history, impacting billions of students worldwide [3]. Halting face-to-face instruction is the most effective way to contain the transmission of COVID-19 [4]. Several learning institutions worldwide have shifted to online delivery of lessons to ensure learning continuity [3]. Online learning offers flexibility for the students in the place and time they learn [5]. It improves their retention of information and allows them to work through the material quickly, which means that the changes caused by COVID-19 might persist [6]. Resources to support online learning are indispensable at this time, and they will remain to be essential even after the COVID-19 pandemic is over [7]. As online learning gains popularity nowadays, it is crucial to identify practices that highly support learning in these contexts. Furthermore, it is imperative to align online learning with the Philippine K to 12 science curriculum.

The Philippines' Department of Education [8] envisions a K to 12 science curriculum that is geared towards the "development of scientifically, technologically, and environmentally literate and productive members of society who are critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed

decision-makers, and effective communicators." Moreover, the Philippine K to 12 science curriculum intertwines both science content and processes. In the absence of content, the students will struggle in using science processes, which are best learned contextually. Situating the curriculum around problems that stimulate students' curiosity facilitates them in learning and appreciating the relevance and usefulness of science. Instead of relying on textbooks, teachers must use different hands-on, minds-on, and hearts-on activities to hone students' interests and develop them into active learners [8]. Implementing the Philippine K to 12 science curriculum in the new normal and beyond requires significant adjustments in the teaching practices, particularly in the online delivery of lessons. Furthermore, this study focused on evolution since the breadth and depth of understanding needed to grasp this science content area is under the Philippine K to 12 science curriculum.

Evolution has been considered the core theme of biology since it provides a powerful elucidation for the unity and diversity of life on Earth [9]. Theodosius Dobzhansky [10], one of the founders of modern evolutionary theory, remarkably declared that "Nothing in biology makes sense except in the light of evolution." In the Philippines, students are first introduced to evolution at the junior high school level (tenth grade) [11], although some underlying concepts are taught beforehand. For most students, evolution is hard to grasp [12]. Several of them hold a multitude of misunderstandings about this science content area (e.g., evolution is goal-directed and improves organisms) [13]. Moreover, students deem evolution to contradict the sacred scriptures since it considers the equality between humans and animals [14]. These misconceptions and non-scientific notions often result in misunderstanding and rejecting evolution. Educational efforts must be made to inculcate the significance of evolution to modern biology, how the scientific community understands and accepts this theory, and how it typifies well-grounded scientific practices yet remains tentative scientific knowledge.

To tackle these pertinent issues in evolution education, particularly in the Philippines, Partosa [15] called for integrating the nature of science (NOS hereafter) in the science curricula. NOS describes how scientists do what they do, how science answers questions, and how scientific knowledge is generated [16]. It includes several aspects such as tentativeness, observation and inference, social and cultural embeddedness, creativity and imagination, theories and laws, and scientific methods [17]. For the students to learn about the NOS, they must discuss and reflect on the characteristics of scientific knowledge [18], [19]. Local and foreign empirical investigations have shown that explicit instruction about the NOS can improve the students' understanding of science and enhance their understanding and acceptance of evolution [20]–[22]. Given the essential role of evolution in the Philippine K to 12 science curriculum, it is a suitable science content area for improving instructional practices.

To improve the teaching of evolution in online contexts during the new normal and beyond, we developed and evaluated a NOS-based online course in tenth-grade evolution. In this study, we sought to answer the following questions: (1) What are the biology teachers' ratings of the online course quality in terms of pedagogies, resources, and delivery strategies? (2) What are the students' ratings of the classroom climate in the online course in terms of instructor behaviors, course structure, course clarity, and student connectedness? (3) What are the students' perceptions of how the online course supports their learning of evolution?

2. METHODOLOGY

This study is an action research that used the Plan-Do-Study-Act (PDSA) Cycle as a research design to improve online instructional practices in tenth-grade evolution. The participants include twenty-one tenth-grade junior high school students from the Science, Technology, and Engineering Program (STEP) of a public high school at Calapan City, Oriental Mindoro, Philippines, and ten biology teachers with remarkable experience and qualifications.

In developing and evaluating the NOS-based online course in tenth-grade evolution, this study used the ADDIE instructional model, which consists of the following major parts: Analysis, Design, Development, Implementation, and Evaluation. The Most Essential Learning Competencies (MELCs) released by the Department of Education [11] for tenth-grade science were examined in the analysis phase. The design phase is concerned with the assessment tools, online activities, content, subject matter analysis, lesson planning, and media selection. In the development phase, the lessons in evolution were created on Canvas® based on the design phase. After the lessons were developed, the online course was implemented to the tenth-grade students during the fifth and sixth week of the third quarter of School Year 2020-2021 for two two-hour online class sessions. One lesson was taught per week. For each week, the first hour of the two-hour session was intended for the synchronous online class session, whereas the remaining one hour was intended for the asynchronous online class session. Lastly, in the evaluation phase, the biology teachers evaluated the quality of the online course after the development phase using the Quality Guidelines for Online Courses (QGOC) adapted from Herrington et al. [23]. The results from this instrument were then analyzed, and the online course was revised based on their suggestions. The students also evaluated the classroom climate in the online course using the Online Learning Climate Scale (OLCS) adopted from Kaufmann et al. [24]. In determining the mean level of agreement for each item in the QGOC and OLCS, the following categories were used: strongly agree (4.20-5.00), agree (3.40-4.19), neutral

(2.60-3.39), disagree (1.80-2.59), and strongly disagree (1.00-1.79). Furthermore, four open-ended questions were used to encourage the students to express how the online course facilitated their learning of evolution. The data collected from their responses to these questions were subjected to thematic content analysis, following the steps of Mills and Gay [25].

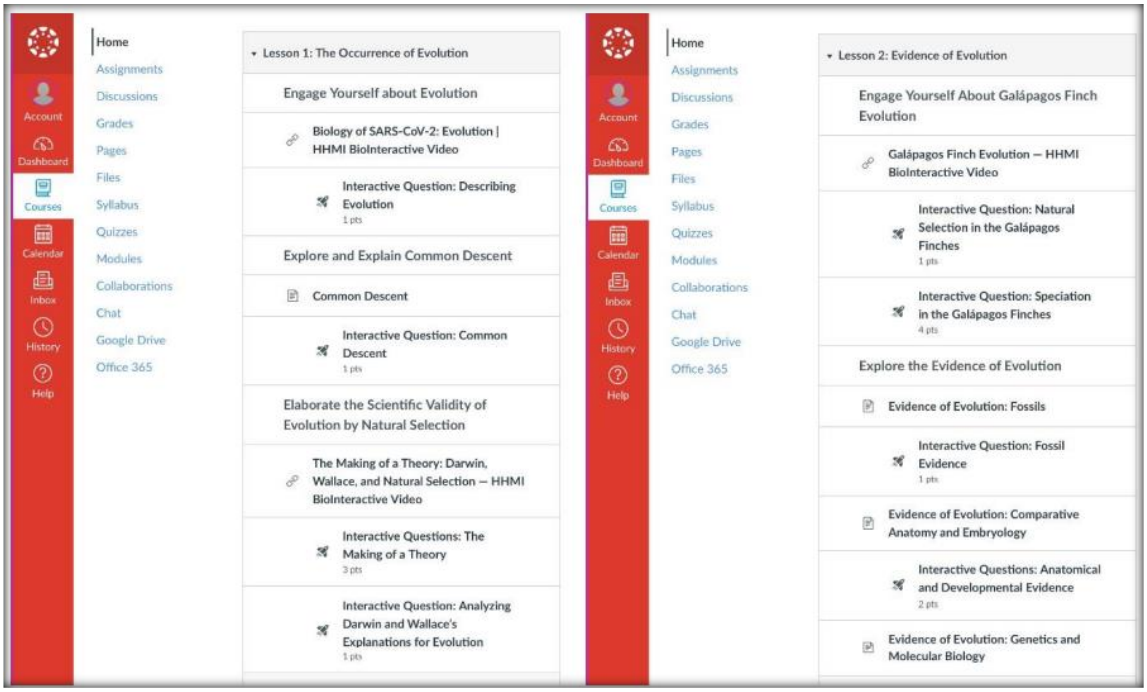

Figure 1. Screenshots of the Lessons in the Online Course

Informed by the MELCs, the NOS-based online course in tenth-grade evolution has two lessons that focus on how evolution occurs by natural selection and the pieces of evidence (i.e., paleontological, anatomical, embryological, and genetic and molecular evidence) that support it (Fig. 1). Moreover, these lessons introduce and reinforce aspects of the NOS such as tentativeness, observation and inference, social and cultural embeddedness, creativity, scientific laws and theories, and scientific methods. In terms of pedagogies, the teacher serves as coach and facilitator of the online course, and the students are linked through buddy systems. Students' metacognitive skills are supported and developed through multiple answers and free-response questions with unlimited attempts that provide tolerance for errors and opportunities to test out, get feedback, and refine their NOS ideas iteratively. Engaging problems and activities that highlight the accurate representation of evolution were also provided in the online course to facilitate the students in constructing more scientifically accurate evolutionary conceptions. In addition, intuitive and clear organizational strategies were employed in arranging various resources (i.e., illustrative materials, videos, and texts) for the students to see how the key ideas are related. The resources used are current and relevant and provide a scientific perspective about the evolutionary theory. Specifically, the videos provide a genuine depiction of how the development of evolutionary thought has been done, how biologists have designed experiments to investigate the occurrence of natural selection in the wild, and how science and religion are compatible. Besides, the concept cartoons and scientific diagrams provide a scientifically correct explanation for the occurrence and evidence of evolution. Concerning delivery strategies, the site where the online course was developed can be accessed reliably on several electronic devices, its navigation and orientation are seamless, and the materials can be viewed and downloaded within a reasonable time. Students can also find the information on the website about the online course, and the instructions are placed in each online activity. Furthermore, the site has an appropriate communication channel available to students and teachers.

3. RESULTS AND DISCUSSION

a. Biology Teachers' Ratings of the Online Course Quality

Presented in Table 1 are the biology teachers' average ratings of pedagogies. Each element was highly acceptable to them. All in all, pedagogies had an average rating of 4.40, which is verbally interpreted as "strongly agree."

Table 1. Biology Teachers' Average Ratings of Pedagogies

Main Area	Elements	Mean	SD	Verbal Interpretation
Pedagogies	*Authentic tasks.* The learning activities involve tasks and contexts that reflect the way in which the knowledge will be used in real-life settings.	4.50	0.53	Strongly Agree
	Opportunities for collaboration. The environment encourages and requires students to collaborate to create products that could not be produced individually.	4.40	0.84	Strongly Agree
	Learner-centered environments. There is a focus on activities that provide degrees of freedom, decision-making, reflection, and self-regulation.	4.50	0.53	Strongly Agree
	Engaging. The learning environment challenges learners and provides some form of encouragement and motivation to support the engagement.	4.20	0.79	Strongly Agree
	Meaningful assessments. Authentic and integrated assessment is used to evaluate students' achievement.	4.40	0.70	Strongly Agree
	Overall	**4.40**	**0.68**	**Strongly Agree**

Biology teachers' average ratings of resources are shown in Table 2. Each element for resources was highly acceptable to them. Generally, this area had an average rating of 4.53, which is verbally interpreted as "strongly agree."

Table 2. Biology Teachers' Average Ratings of Resources

Main Area	Elements	Mean	SD	Verbal Interpretation
Resources	*Accessibility.* The resources are organized in ways that make them easily accessed and located.	4.70	0.48	Strongly Agree
	Currency. The age of resources is appropriate to the subject matter.	4.50	0.53	Strongly Agree
	Richness. The resources reflect a rich variety of perspectives.	4.30	0.67	Strongly Agree
	Strong use of media. The materials use the various media in appropriate ways.	4.60	0.52	Strongly Agree
	Overall	**4.53**	**0.55**	**Strongly Agree**

Table 3 shows the biology teachers' average ratings of delivery strategies. Most of the elements for delivery strategies were highly acceptable to them. In general, this area had an average rating of 4.34, which is verbally interpreted as "strongly agree."

Table 3. Biology Teachers' Average Ratings of Delivery Strategies

Main Area	Elements	Mean	SD	Verbal Interpretation
Delivery Strategies	*Reliable and robust interface.* The materials are accurate and error-free in their operation.	4.60	0.52	Strongly Agree
	Clear goals, directions, and learning plans. The course information and expectation of student roles are clear.	4.20	0.79	Strongly Agree
	Communication. The course provides opportunities and encourages dialogue between students and between teachers and students.	4.40	0.70	Strongly Agree
	Appropriate bandwidth demands. The materials are accessible without lengthy delays.	4.10	0.74	Agree
	Equity and accessibility. The course materials and activities are accessible and available to all students.	4.40	0.84	Strongly Agree
	Overall	**4.34**	**0.72**	**Strongly Agree**

b. Students' Ratings of the Classroom Climate in the Online Course

Students' average ratings of the instructor behaviors are presented in Table 4. Generally, instructor behaviors had an average rating of 4.95, which is verbally interpreted as "strongly agree."

Table 4. Students' Average Ratings of the Instructor Behaviors

Factor	Items	Mean	SD	Verbal Interpretation
Instructor Behaviors	*Based on my online class interactions with the instructor, I perceived my instructor:*			
	As understanding.	4.95	0.22	Strongly Agree
	As respectful toward me.	5.00	0.00	Strongly Agree
	As supportive.	4.90	0.30	Strongly Agree
	As responsive (e.g., provides feedback on assignments).	4.95	0.22	Strongly Agree
	As engaged in the course.	4.95	0.22	Strongly Agree
	As approachable (e.g., someone I would email or visit in virtual office hours).	4.95	0.22	Strongly Agree
	Overall	**4.95**	**0.55**	**Strongly Agree**

Shown in Table 5 are the students' average ratings of the course structure. Overall, the course structure factor had an average rating of 4.65, which is verbally interpreted as "strongly agree."

Table 5. Students' Average Ratings of the Course Structure

Factor	Items	Mean	SD	Verbal Interpretation
Course Structure	*Based on my experiences with and perceptions of this online course:*			
	The design of this course encouraged student interactions with students.	4.48	0.68	Strongly Agree
	The technology used in this course fostered collaboration among students.	4.71	0.46	Strongly Agree
	This online course provided ample opportunities for communication among students.	4.76	0.54	Strongly Agree
	Overall	**4.65**	**0.56**	**Strongly Agree**

Table 6 shows the students' average ratings of the course clarity. In general, the course clarity factor had an average rating of 4.83, which is verbally interpreted as "strongly agree."

Table 6. Students' Average Ratings of the Course Clarity

Factor	Items	Mean	SD	Verbal Interpretation
Course Clarity	*Based on my experiences with and perceptions of this online course:*			
	The organization of the course was clear.	4.81	0.40	Strongly Agree
	The instruction for use of technology was clear.	4.81	0.40	Strongly Agree
	The instruction for assignments were clear.	4.86	0.36	Strongly Agree
	Overall	**4.83**	**0.39**	**Strongly Agree**

Presented in Table 7 are the students' average ratings of student connectedness. All in all, the student connectedness factor had an average rating of 4.75, which is verbally interpreted as "strongly agree."

Table 7. Students' Average Ratings of Student Connectedness

Factor	Items	Mean	SD	Verbal Interpretation
Student Connectedness	*Based on my experiences with and perceptions of this online course:*			
	Students as respectful of one another.	4.76	0.54	Strongly Agree
	Students as cooperative of one another.	4.67	0.66	Strongly Agree
	Students as comfortable with one another.	4.81	0.40	Strongly Agree
	Overall	**4.75**	**0.53**	**Strongly Agree**

c. Students' Perceptions of the Online Course

The first open-ended question, *Did the online course help you understand the occurrence of evolution? If so, how? Why? If not, why not?* elicited agreement among all students. Two major themes emerged from the analysis of answers to this question. They were:

(1) The videos in the online course facilitated me in understanding the occurrence of evolution.

(2) The online course provided me with important information about the occurrence of evolution.

The second open-ended question, *Did the online course help you accept evolution? If so, how? Why? If not, why not?* also brought about agreement among all students. Two major themes emerged from the analysis of answers to this question. They were:

(1) Numerous pieces of evolutionary evidence and information.

(2) Notion of compatibility between science and religion.

Regarding the third question, *What can be done to the online course to make it better?*, most students found that the online course is fine as it is currently. On the other hand, some students recommended more discussion time. Other students suggested more learning materials, more engaging activities, and more information to improve the online course.

Lastly, the fourth open-ended question, *Would you recommend this online course who want to learn evolution? Why?* elicited agreement among all students. Two major themes emerged from the analysis of answers to this question. They were:

(1) The online course is educational.

(2) The online course is manageable.

4. CONCLUSIONS AND RECOMMENDATIONS

The NOS-based online course in tenth-grade evolution has excellent pedagogies, resources, and delivery strategies. Primarily, it can foster the mental involvement and reflection of students on NOS and has various resources such as illustrative materials, videos, and texts. Also, the site where the online course was developed can be accessed reliably regardless of electronic devices, and its navigation and orientation are smooth and efficient. Teachers teaching evolution can use this online course to improve their online instructional practices in evolution as this educational intervention is suitable and ready for online instruction. What is more, the online course produced a positive classroom climate among students. It shows that the online course instructor created opportunities to be deemed by the students as understanding, available, obliging, present, and compassionate. Likewise, it indicates that the instructor provided ways for the students to interact with, connect, and work with their peers. It also suggests that the online course presented explicit instructions, expectations, and proficiency in using technology to support students' learning.

Besides, the students highly valued the videos and informative content in the online course to help them understand how evolution occurs. Incorporating these ways of engaging with the content is necessary to provide the students an accurate representation of evolution, highlight its scientific validity, and point out the relatedness among the living and extinct organisms on Earth. Moreover, the online course helped the students accept evolution by considering that various evidence and information support it, and science and religion are not in conflict. It is critical to provide students with shreds of proof and facts as evidentiary lines that they can use to justify their acceptance of the evolutionary theory. In addition, religious beliefs have a crucial role in developing worldviews, and teachers should not regard them as wrong or mistaken ideas. The primary purpose of teaching evolution is to facilitate the students to understand and accept evolution and not change their religious beliefs.

On top of that, while most students considered the online course good the way it is, some recommended additional time for online discussion for its improvement. Other students suggested more learning materials, more engaging activities, and more information. In this study, the most significant challenge we faced was the limited time allotted in teaching science (2 hours/week). To maximize online discussion time, we suggest providing pre-lecture videos to the students and utilizing synchronous online class discussions to address their questions or concerns about the lesson. Overall, the students regarded the online course as recommendable because it is educational and manageable. This confirms the online course's effectiveness and efficiency in teaching tenth-grade evolution.

As online courses keep on gaining popularity to prevent the transmission of COVID-19 and educational disturbances, teachers must foster the best instructional and learning practices in online learning contexts, especially in improving the teaching of evolution. This study showed that using explicit instruction about the NOS is beneficial in teaching evolution in an online learning environment since this instructional approach facilitated the students to accept evolution. Future studies must investigate the use of explicit instruction about the NOS in teaching evolution using other learning delivery modalities, such as modular distance learning, television/radio-based instruction, blended distance learning, and homeschooling.

REFERENCES

[1] S. Palvia *et al.*, "Online Education: Worldwide Status, Challenges, Trends, and Implications," *Journal of Global Information Technology Management*, vol. 21, no. 4, pp. 233–241, Oct. 2018, doi: 10.1080/1097198X.2018.1542262.

[2] D. Zancanella and M. F. Rice, Eds., "Framing Policies and Procedures to Include Digital Literacies for Online Learning During and Beyond Crises," *J. Adolesc. Adult Liter.*, vol. 65, no. 2, pp. 183–188, Sep. 2021, doi: 10.1002/jaal.1194.

[3] United Nations, "Policy Brief: Education during COVID-19 and beyond," 2020. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/08/sg_policy_brief_covid-19_and_education_august_2020.pdf

[4] K. I. T. Batac, J. A. Baquiran, and C. B. Agaton, "Qualitative Content Analysis of Teachers' Perceptions and Experiences in Using Blended Learning during the COVID-19 Pandemic," *IJLTER*, vol. 20, no. 6, pp. 225–243, Jun. 2021, doi: 10.26803/ijlter.20.6.12.

[5] T. Joosten and R. Cusatis, "Online Learning Readiness," *American Journal of Distance Education*, vol. 34, no. 3, pp. 180–193, Jul. 2020, doi: 10.1080/08923647.2020.1726167.

[6] P. Churi, K. Mistry, M. M. Asad, G. Dhiman, M. Soni, and U. Kose, "Online learning in COVID-19 pandemic: an empirical study of Indian and Turkish higher education institutions," *WJE*, vol. ahead-of-print, no. ahead-of-print, Jul. 2021, doi: 10.1108/WJE-12-2020-0631.

[7] A. L. Adams, "Online Teaching Resources," *Public Services Quarterly*, vol. 16, no. 3, pp. 172–178, Jul. 2020, doi: 10.1080/15228959.2020.1778598.

[8] Department of Education, "K to 12 Science Curriculum Guide," 2016. https://www.deped.gov.ph/wp-content/uploads/2019/01/Science-CG_with-tagged-sci-equipment_revised.pdf

[9] L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, and R. B. Orr, *Campbell Biology*, 12th ed. New York, NY: Pearson, 2021.

[10] T. Dobzhansky, "Nothing in Biology Makes Sense except in the Light of Evolution," *The American Biology Teacher*, vol. 35, no. 3, pp. 125–129, Mar. 1973, doi: 10.2307/4444260.

[11] Department of Education, "K to 12 Most Essential Learning Competencies With Corresponding CG Codes," 2020. https://commons.deped.gov.ph/K-to-12-MELCS-with-CG-Codes.pdf

[12] M. C. K. Ma and J. Y. H. Au, *Misconceptions in Biology*, 1st ed. Wan Chai, Hong Kong: Red Publish, 2017.

[13] T. R. Gregory, "Understanding Natural Selection: Essential Concepts and Common Misconceptions," *Evo Edu Outreach*, vol. 2, no. 2, pp. 156–175, Jun. 2009, doi: 10.1007/s12052-009-0128-1.

[14] H. Deniz and L. A. Borgerding, "Evolutionary Theory as a Controversial Topic in Science Curriculum Around the Globe," in *Evolution Education Around the Globe*, H. Deniz and L. A. Borgerding, Eds. Cham: Springer International Publishing, 2018, pp. 3–11. Accessed: Aug. 14, 2020. [Online]. Available: http://link.springer.com/10.1007/978-3-319-90939-4_1

[15] J. D. Partosa, "Evolution Education in the Philippines: A Preliminary Investigation," in *Evolution Education Around the Globe*, H. Deniz and L. A. Borgerding, Eds. Cham: Springer International Publishing, 2018, pp. 391–405. Accessed: Aug. 14, 2020. [Online]. Available: http://link.springer.com/10.1007/978-3-319-90939-4_21

[16] W. F. McComas and M. P. Clough, "Nature of Science in Science Instruction: Meaning, Advocacy, Rationales, and Recommendations," in *Nature of Science in Science Instruction*, W. F. McComas, Ed. Cham: Springer International Publishing, 2020, pp. 3–22. Accessed: Aug. 14, 2020. [Online]. Available: http://link.springer.com/10.1007/978-3-030-57239-6_1

[17] W. F. McComas and K. Kampourakis, "Using Anecdotes from the History of Biology, Chemistry, Geology, and Physics to Illustrate General Aspects of Nature of Science," in *Nature of Science in Science Instruction*, W. F. McComas, Ed. Cham: Springer International Publishing, 2020, pp. 551–576. Accessed: Aug. 14, 2020. [Online]. Available: http://link.springer.com/10.1007/978-3-030-57239-6_30

[18] J. Angle, "Strengthening Future Science Teachers' Understanding of Nature of Science: The Role of an Embedded Research Experience in Teacher Preparation," in *Nature of Science in Science Instruction*, W. F. McComas, Ed. Cham: Springer International Publishing, 2020, pp. 675–695. Accessed: Aug. 14, 2020. [Online]. Available: http://link.springer.com/10.1007/978-3-030-57239-6_37

[19] L. C. Scharmann, M. U. Smith, M. C. James, and M. Jensen, "Explicit Reflective Nature of Science Instruction: Evolution, Intelligent Design, and Umbrellaology," *Journal of Science Teacher Education*, vol. 16, no. 1, pp. 27–41, Mar. 2005, doi: 10.1007/s10972-005-6990-y.

[20] M. A. Clores, "Changing students' beliefs and concepts about the evolutionary theory using pedagogy based on History and Philosophy of Science (HPS)," Dissertation, De La Salle University, Manila, 2004. [Online]. Available: https://animorepository.dlsu.edu.ph/etd_doctoral/60/

[21] H. Cofré, P. Núñez, D. Santibáñez, J. Pavez, and C. Vergara, "Theory, Evidence, and Examples of Teaching the Nature of Science and Biology Using the History of Science: A Chilean Experience," in *Teaching Science with Context*, M. E. de B. Prestes and C. C. Silva, Eds. Cham: Springer International Publishing, 2018, pp. 65–84. Accessed: Aug. 14, 2020. [Online]. Available: http://link.springer.com/10.1007/978-3-319-74036-2_5

[22] H. Cofré *et al.*, "The effect of teaching the nature of science on students' acceptance and understanding of evolution: myth or reality?," *Journal of Biological Education*, vol. 52, no. 3, pp. 248–261, Jul. 2018, doi: 10.1080/00219266.2017.1326968.

[23] A. Herrington, J. Herrington, R. Oliver, S. Stoney, and J. Wills, "Quality guidelines for online courses: the development of an instrument to audit online units," 2001. https://ro.ecu.edu.au/ecuworks/4815/

[24] R. Kaufmann, D. D. Sellnow, and B. N. Frisby, "The development and validation of the online learning climate scale (OLCS)," *Communication Education*, vol. 65, no. 3, pp. 307–321, Jul. 2016, doi: 10.1080/03634523.2015.1101778.

[25] G. E. Mills and L. R. Gay, *Educational Research: Competencies for Analysis and Applications*, 11th ed. Essex, England: Pearson, 2016.