The Asian Journal of Biology Education

ISSN 1447-0209

Volume 16: December 2024

Editorial Board

The Asian Journal of Biology Education (AJBE) is published electronically by the AJBE Editing and Publishing Office for the Asian Association for Biology Education (AABE). The Journal is on the AABE website: **http://www.aabe.sakura.ne.jp/Journal. htm**

The Asian Journal of Biology Education

Volume 16: December 2024

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_2

Practical Note

Effectiveness of *Ecosystemforkids.com* and *Quizizz.com* in Learning Human Organ Systems

Narendra D. DESHMUKH [1] and Vinita A. SHROUTY [2]

[1] *Homi Bhabha Centre for Science Education, TIFR,*
[2] *SNDT Women's University, INDIA*

(Received: 12 August 2022; Accepted for publication: 18 December 2023)

The use of ICT in education paved the way for online teaching. Though online teaching faces the challenge of engaging students, various strategies help to overcome it. The present study is a single group pre-test and post-test quasi-experiment that examines the effects of the interactive and gamified e-quizzes in teaching five human body systems, namely the digestive system, the excretory system, the respiratory system, and the male and female reproductive systems, in online science classes. In the study, thirty-two sixth-grade students participated in the classes and two gamification tools, *Ecosystemforkids.com* and *Quizizz.com*, were used. Both the tools helped to improve the performance of students. Interactive quizzes provided by *Ecosystemforkids.com* were found to be effective in remembering the names and understanding the functions of various organs, making it a valuable homework resource. *Quizizz.com* was found to be effective as a formative assessment tool as well as providing fun competition-based learning. Both tools had a positive impact on student performance.

Keywords*:* Ecosystemforkids.com*, formative assessment, gamified e-quizzes, human body systems, online education,* Quizizz.com

Author for correspondent: Narendra D. DESHMUKH, email: ndd@hbcse.tifr.res.in

INTRODUCTION

Background

The use of information and communication technology (ICT) can help teachers instruct students in an interesting way whereby students are not bound to limited resources or curriculum. It helps students to broaden the area of their knowledge. According to Flores (2015), today's learners process information in different ways, yet the educational system does not cater to their needs. Hence, by using ICT, "digital natives" will learn the way they want to learn which will prepare them to face the challenges of a fast-transforming information-driven society (NCERT, 2006). Various researches show the positive impact of using games in education. According to Sahin and Namli (2016), games increase enjoyment for students by providing rewards and feedback, which improves students' attitudes towards learning in traditionally challenging subjects like mathematics or science. In school science, learning several biological functions and phenomena are particularly difficult for students to grasp (Fokides and Mastrokoukou, 2018). Younger children often have naive ideas regarding the organs which make up the digestive and respiratory systems and they sometimes associate the stomach with respiration (García-Barros *et al*., 2011).

The present study was conducted during the COVID-19 Pandemic when online teaching became a challenge for engaging the students (Dhawan, 2020). One of the present authors, as a teacher, observed that students faced difficulties in

remembering the names and functions of organs related to various human body systems. Taking this into account, in the present study, we used two online tools, *Ecosystemforkids.com* and *Quizizz.com*, in online 6th-grade science classes. *Ecosystem-forkids.com* was used for homework as an out-of-class activity. *Quizizz.com* was used for administrating pre-tests and post-tests as a formative assessment gamification tool (Permana and Prematawati, 2020) since gamification tools are better for assessing the learning performance of the students specifically in terms of formative assessment (Areed *et al.*, 2021). We examined the effects of using interactive and gamified e-quizzes on students' achievement on the topics of five human body systems, namely the digestive system, the excretory system, the respiratory system, and the male and female reproductive systems.

The questions that the research is going to address, and the null hypothesis are as follows:

RQ1: What are the effects of using *Ecosystem-forkids.com* as a homework tool for learning about the five human body systems on student achievement?

RQ2: What are the effects of using *Quizizz.com* as a formative assessment tool?

Null Hypothesis (H_0): There is no significant difference in student achievement scores regarding the five human body systems before and after using *Ecosystemforkids.com* for homework.

METHODOLOGY

Methods

In the present study, a single-group pre-test and post-test quasi-experimental design (Cranmer, 2017) was adopted, in which all participants are given the same treatment and the effect of the treatment is determined by calculating the difference between pre-test and post-test scores. In this study, one e-quiz was developed on each of five human body systems and used for both pre-test and post-test. Each e-quiz composed of 10 multiple-choice questions with each correct answer awarding one mark. The content validity of the e-quizzes was checked by three biology teachers before the e-quizzes were utilized as formative assessments. Based on the comments and suggestions raised by them, several modifications were made to the questions. The test reliability was obtained by using the test-retest method. The reliability correlation coefficient was determined to be 0.82.

Sample

A purposive sampling technique which can be used for both qualitative and quantitative research (Tongco, 2007) was used. Participants in this study consisted of 32 students, 18 girls and 14 boys of 6th-grade from the age group 12-14 years from the same school. The students attended all the online sessions, completed the online homework on *Ecosystemforkids.com*, and answered pre-tests and post-tests.

Online class design

Seven online sessions of one hour each were conducted as an intervention programme via the Zoom platform. In the first session, the students were given hands-on practice in using *Quizizz.com* and *Ecosystemforkids.com*. From the second session onwards, online classes were conducted for teaching the five human body systems. A pre-test was conducted at the beginning of teaching each topic and after the completion of the homework related to the topic post-test was conducted.

Though *Quizizz.com* allows the student to make as many attempts as possible, only a single attempt was allowed in the present case. To facilitate communication with students for out-of-class activities, we used *WhatsApp* (https://www.whatsapp.com/?lang=en) as a communication tool.

Following the explanation of each topic, we shared a link to an interactive game quiz from

Ecosystemforkids.com in the group chat. Students solved the quiz by labeling the diagram. Their performances were automatically evaluated.

Figure 1 shows a game quiz on the diagram of the human respiratory system from *Ecosystem forkids.com*. Students were asked to label the organs by dragging and dropping. They could check whether their answers are correct by clicking on the check button below the diagram.

Figure 2 shows a screenshot of a question from *Quizziz.com*. Students were instructed to select an answer tab, and they received one mark for each correct response. The quiz additionally provided the correct answer in the case where a student had chosen an incorrect option.

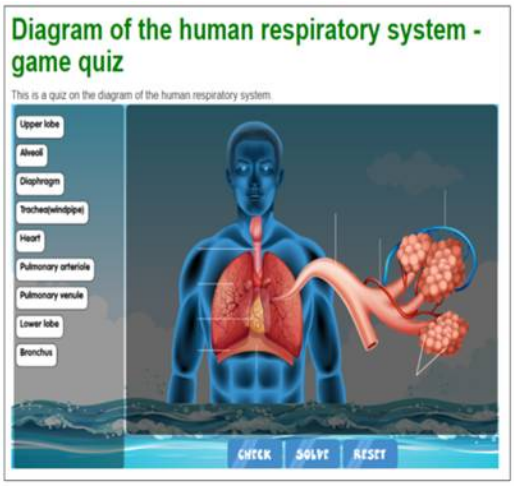


***Figure 1: Screenshot from* Ecosystemforkids.com**

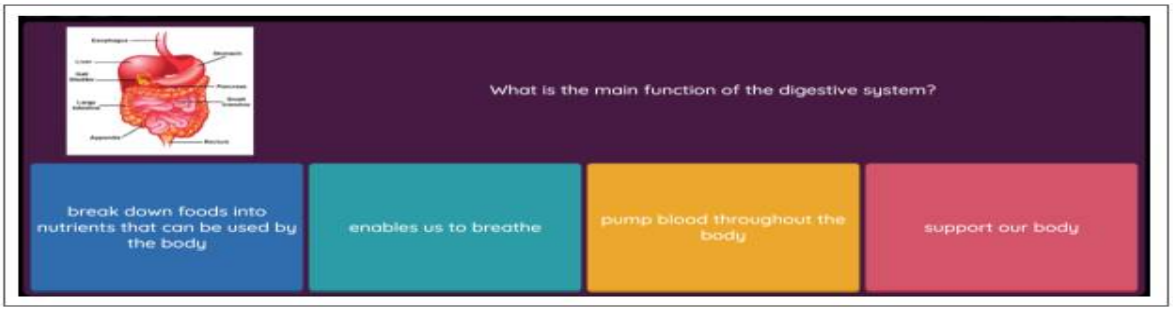


***Figure 2: Screenshot from* Quizziz.com**

RESULTS and DISCUSSION

The results of descriptive analysis of the study for the first research question, RQ1, are shown in Table 1 which gives the highest and lowest scores, mean and SD on each pre-test and post-test. The mean score of post-test on each e-quiz was higher compared to the respective average pre-test score.

Before verifying the null hypothesis, we first assessed the normality of pre-test and post-test data. The results of Shapiro-Wilk Test (Shapiro and Wilk, 1965) of normality are shown in Table 2. The significant (Sig.) value for each of the pre-tests and post-tests was less than 0.05. The results imply that the pre-test and post-test data for all five human body systems were not normally distributed.

As the normality of data was rejected, the non-parametric Wilcoxon Signed Rank Test (Sarty, 2022) was used to analyze the data. This test is used to verify the hypothesis of whether there is a difference in the mean score of students' achievement before and after a given treatment. For example, this test was used by Putri *et al.* (2018) in an experimental study to examine the difference between two data pairs in modified flipped classroom approach.

Table 1: Results of pre-test and post-test on each topic

Human Body System	Pre-test score				Post-test score			
	L*	H**	Mean	SD	L*	H**	Mean	SD
Digestive	1	7	3.5	1.35	5	10	6.8	1.39
Excretory	0	5	2.5	1.32	4	10	6.5	1.34
Respiratory	2	5	3.2	0.89	5	10	7.0	1.50
Male Reproductive	0	4	2.1	1.13	4	10	6.6	1.36
Female Reproductive	0	4	2.1	0.90	4	9	6.4	1.32

*: Lowest score; **: Highest score

Table 2: Shapiro-Wilk Tests of normality for pre-test and post-test

Human Body System	Pre-test			Post-test		
	Statistic	df	Sig.	Statistic	df	Sig.
Digestive	0.89	32	0.004	0.91	32	0.012
Excretory	0.91	32	0.011	0.93	32	0.035
Respiratory	0.87	32	0.001	0.91	32	0.013
Male Reproductive	0.88	32	0.003	0.93	32	0.034
Female Reproductive	0.89	32	0.005	0.88	32	0.002

Table 3 shows the results of the Wilcoxon Test for all the pre-test and post-test scores. There were significant differences at the $p = 0.05$ level between the pre-test and post-test scores for each topic.

Hence, the null hypothesis is rejected, and the alternative hypothesis, *i.e.*, there is a significant difference between the students' achievement before and after a given treatment, is accepted for all the e-quizzes. Therefore, it can be concluded that the use of *Ecosystemforkids.com* for homework improved each student's learning performance in the five human body systems.

While learning about the human body systems, students find it challenging to remember the organ names of each organ system and its related functions. This problem is compounded in an online classroom. Hence, the present study

Table 3: Result of Wilcoxon Signed Rank Test

Human Body System	Mean	SD	Z.	*P* Value
Digestive	264	53.48	-4.87	<.00001
Excretory	248	51.03	-4.86	<.00001
Respiratory	264	53.48	-4.94	<.00001
Male Reproductive	248	51.03	-4.86	<.00001
Female Reproductive	248	51.03	-4.86	<.00001

investigated the effects of interactive quizzes on students' achievement while learning five human body systems. The data from each formative assessment indicate a remarkable gain in students' knowledge after every session.

The possible reasons for this result are as follows:

1. *Ecosystemforkids.com* might be useful as a platform which facilitates interactive quizzes.
2. Interactive quizzes as homework might have engaged students. Hence, they might have become interested and actively involved in each topic.
3. Immediate automatic validation might have motivated students to reattempt the quiz even though the results of reattempt were not a part of the post-test scores. Thus, multiple attempts and timely feedback might have helped students to practice, relearn and perform better.
4. The "Ready Notes" available on *Ecosystem-forkids.com* might have helped students to consolidate the topic.

In the following paragraphs, the students' impressions of using the gamification tools are presented, and the benefits of using *Quizizz.com* as a formative assessment tool are discussed in detail.

Students' experiences of using the gamification tools

Below are some of the experiences shared by the students which support the findings of the study:

Student 1: I found it interesting to answer the test in a play-way mode; it allowed me to compete with my classmates.

Student 2: Ranking on the leaderboard motivated me to prepare for the topic.

Student 3: I enjoyed learning using online tools.

Student 4: Novelty in homework created interest; it helped me to identify and name the parts of five human body systems which I thought difficult to remember.

Student 5: It helped me to practice the in-class material at my own pace and place.

Student 6: Interactive quizzes gave me the opportunity to relearn and practice using multiple trials; it helped me perform better.

What are the effects of using Quizizz.com as a formative assessment tool?

Improvement in achievement can also be attributed to the gamification tool *Quizizz.com* which is used as a formative assessment tool in the study. The students actively participated in solving the e-quizzes.

They found it interesting to attempt the e-quizzes in play-way mode by competing with their classmates. Leaderboard provided by *Quizizz.com* fostered a sense of competition in them and motivated them to prepare for the tests. In addition to the leaderboard, badges and points which are also provided by *Quizizz.com* might have interested students and encouraged them to prepare for the test of each topic and to strive for a higher position on the leaderboard by putting forth their best efforts (Zainuddin *et al*., 2020). Immediate feedback helped them quickly identify and correct any misunderstandings they might have. Automated grading saves the teacher's time.

The present study showed an increase in students' achievement. However, it was conducted on a small sample. Therefore, it is vital to examine the effects on a larger sample, incorporating more quantitative data for the generalization of the findings.

ACKNOWLEDGEMENTS

Dr Narendra D. Deshmukh acknowledges the support of the Government of India, Department of Atomic Energy, under Project

Identification No. RTI4001. The authors would like to acknowledge all three reviewers and Ms Meena Kharatmal for their valuable comments that have helped us improve the manuscripts. The authors would like to recognize the support of the students and teachers at Shree Maa Gayatri English School, Akot, Akola, Maharashtra, India.

REFERENCES

Areed, M. F., Amasha, M. A., Abougalala, R. A., Alkhalaf, S. and Khairy, D. (2021) Developing gamification e-quizzes based on an android app: the impact of asynchronous form. *Education and Information Technologies* **26**: 4857-4878. https://link.springer.com/article/10.1007/s10639-021-10469-4

Cranmer, G. A. (2017) One-group pretest–posttest design. *In*: Allen, M. (ed.) *The SAGE Encyclopedia of Communication Research Methods*, pp. 1124-1126. SAGE Publications, Inc., CA. https://dx.doi.org/10.4135/9781483381411.n388

Dhawan S. (2020) Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems* **49**(1): 5–22. https://doi.org/10.1177/0047239520934018

Flores, J. F. F. (2015) Using gamification to enhance second language learning. *Digital Education Review*: 32-54. https://files.eric.ed.gov/fulltext/EJ1065005.pdf

Fokides, E. and Mastrokoukou, A. (2018). Results from a study for teaching human body systems to primary school students using tablets. *Contemporary Educational Technology* **9**(2): 154-170. https://doi.org/10.30935/cet.414808

Garcia-Barros, S., Martínez-Losada, C. and Garrido, M. (2011) What do children aged four to seven know about the digestive system and the respiratory system of the human being and of other animals? *International Journal of Science Education* **33** (15): 2095–2122. https://doi.org/10.1080/09500693.2010.541528

National Council of Educational Research & Training, NCERT (2006) *Position Paper: National Focus Group on Teaching of Science*. https://ncert.nic.in/pdf/focus-group/science.pdf

Permana, P. and Prematawati, I. (2020) Using Quizizz as a formative assessment tool in German classrooms. *Proceedings of the 3rd International Conference on Language, Literature, Culture, and Education (ICOLLITE 2019)*, pp. 155-159. Atlantis Press SARL. https://doi.org/10.2991/assehr.k.200325.073

Putri, M. D., Rusdiana D. and Rochintaniawati, D. (2018) Students' conceptual understanding in modified flipped classroom approach: An experimental study in junior high school science learning. *Journal of Physics: Conference Series* **1157**(2): 022046. https://iopscience.iop.org/article/10.1088/1742-6596/1157/2/022046/meta

Şahin, M. C. and Namli, N. A. (2016) Gamification and effects on students' science lesson achievement. *International Journal on New Trends in Education and Their Implications* **7**: 41-47. http://www.ijonte.org/FileUpload/ks63207/File/04.mehmet_can_sahin_.pdf

Sarty, G. E. (2022) 16.5 Paired Wilcoxon signed rank test. *Introduction to Applied Statistics for Psychology Students*. University of Saskatchewan, Canada. https://openpress.usask.ca/introtoappliedstatsforpsych/chapter/16-5-paired-wilcoxon-signed-rank-test/

Shapiro, S. S. and Wilk, M. B. (1965) An analysis of variance test for normality (complete

samples). *Biometrika* **52**(3-4): 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Tongco M. D. C. (2007) Purposive sampling as a tool for informant selection. *Ethnobotany Research & Applications* **5**:147-158. https://scholarspace.manoa.hawaii.edu/bitstream/10125/227/4/I1547-3465-05-147.pdf

Zainuddin, Z., Shujahat, M., Haruna, H. and Chu, S. K. W. (2020) The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system. *Computers & Education* **145**(C): 103729. https://www.academia.edu/40802741/The_role_of_gamified_e_quizzes_on_student_learning_and_engagement_An_interactive_gamification_solution_for_a_formative_assessment_system

APPENDIXIES

Ecosystemforkids.com

Ecosystemforkids (https://www.ecosystemforkids.com/) is a free website with interactive materials for kids and educators. It is systematically structured according to science topics and science branches.

Each topic is covered with a variety of resources like games, quizzes, worksheets, flash cards, etc. Some topics covered here include, ecosystems, classification of plants and animals, scientific names, electricity and magnetism, heat flow and waves, force and energy, the earth and the solar system, etc. These interactive science activities and enjoyable e-learning games on multiple topics help science teachers to make the class interesting and fun. It provides teachers with worksheets and tests in the form of multiple-choice questions for the assessment.

Quizizz.com

Quizizz (https://quizizz.com/) is a user-friendly interface, a gamified student engagement platform. It is used in classes for group assignments, pre-test review and formative assessments. It offers multiple features to make a classroom fun, interactive and engaging.

It is also a formative test tool that is suitable for getting information about the overall class condition in understanding the content of the topic being taught. It helps to assess the performance of the students (Permana and Permatawati, 2020). Teachers have access to the students' performance reports and can see the overall class performance on a particular quiz, or progress of the individual student. Students can attempt each quiz repeatedly; it helps them to practice and improve their scores.

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_9

Research Note

A Preliminary Study on Effect of Providing Linking Words in Concept Mapping for Representing Cell Biology Knowledge

Meena KHARATMAL* and Gadiraju NAGARJUNA
Homi Bhabha Centre for Science Education,
Tata Institute of Fundamental Research, INDIA

(Received: 23 August 2023; Accepted for publication: 21 January 2024)

Concept mapping is an established method to create a network of knowledge. Concept map is made of interconnected propositions in which each proposition comprises of two concepts connected with linking words. The article is to study effect of providing linking words in concept mapping for representing cell biology concepts, comparing with traditional concept mapping among college biology students. A criterion concept map was used to evaluate concepts, linking words and valid propositions. The students' concept maps were scored for structural complexity and propositional validity. The students' propositions where they used the provided linking words showed a higher proximity percentage with criterion concept map as compared to concept maps without the provided linking words. We discuss the pedagogical implications of our study for understating or forming biological concepts with linking words in concept mapping.

Keywords*: biological concepts, cell biology, concept mapping, language of science, linking words*

***Author for correspondence:** Meena KHARATMAL, email: meena@hbcse.tifr.res.in

INTRODUCTION

Concept mapping method is a two-dimensional graphical representation of concepts connected with linking words organized in hierarchical levels with branches and cross-linkages (Novak and Gowin, 1984; Mintzes *et al.*, 2000; Novak, 2010; Canas *et al.*, 2015). It is based on the Ausubel's classroom learning theory of subsumption. The branches indicate progressive differentiation, and the cross-links indicate integrative reconciliation (Ausubel, 1978). It incorporates higher-order cognitive skills (Briggs *et al.*, 2016; Canas *et al.*, 2017) because students assimilate new knowledge into their existing framework of knowledge, in contrast to memorizing facts that require low-level cognitive skill (Momsen *et al.*, 2010). It has been successfully used in classroom learning for: mapping knowledge (Pearsall *et al.*, 1997; Hay *et al.*, 2008); assessing student understanding in biological science (Briggs *et al.*, 2016); in classroom and laboratory (Kaiser, 2010), and in novice-expert studies (Kinchin, 2001; Chi, 2006; Mintzes and Quinn, 2007; Briggs *et al.*, 2016; Price *et al.*, 2021; Lee *et al.*, 2022), and has established reliability and validity (Ruiz-Primo *et al.*, 2001).

The rationale of providing linking words in concept mapping is to facilitate expert-like thinking. Experts not only use appropriate linking words, but also use a diversity of linking words, while novices use linking words that often are inappropriate, using similar linking words for variety of meaning resulting in ambiguity (Kinchin, 2000). As one of the characteristics of an expertise is focusing on links, we adopt concept mapping with specific set of linking words facilitating students in expert-like think-

ing, serving as scaffolding in classroom learning (O'Donnell *et al.*, 2002). Studies indicated that providing linking words along with concepts during concept mapping helps to depict much greater number of valid propositions, facilitating disambiguity, consistency in representing knowledge (Kharatmal and Nagarjuna, 2016). Considering the significance of focusing on linking words, we investigated the effect of providing linking words in concept mapping for representing cell biology concepts.

METHODOLOGY

Participants

A voluntary participation of nine college biology students (18-20 years, with informed consent) were part of the study. The instructional program of teaching concept map began with the instructor introducing the tool with its features. A familiarization task on creating concept maps for introducing the elements of concepts, propositions, branches, hierarchy, cross links, scoring rubric was conducted to the students before the study. Students also worked out certain trial or practice concept maps on topics of 'food', 'transport system', from which it was ensured that students have learned the concept mapping tool. Further, a textbook (NCERT, 2007) passage on plastids was used to create concept map with the traditional method without providing linking words. This was followed by creating concept maps by providing linking words: includes/kind of, contains, known as; has function/has role; has shape; has size; has color.

Analysis of concept maps

The criterion concept was created in collaboration with teachers and researchers in consensus. The main concept is at the top and the concepts are linked with linking words to another concepts. A concept can be branched further into two to more concepts depicting progressive differentiation of the concepts. The concept map begins with a general concept and differentiates into more specific concepts by subsumption creating hierarchical levels. Some concepts from one domain are linked to another domain depicting integrative reconciliation and therefore cross links are scored highest. These conventions were part of the concept mapping familiarization task and creating criterion maps.

Both types of students' concept maps were compared with a criterion map. These maps were evaluated and scored for structural complexity (the total number of propositions used) and propositional validity (number of valid propositions/total number of propositions) based on the established scoring rubric (Novak & Gowin, 1984; Novak, 2010).

The scoring rubric follows as: 1 point for each non-redundant concept; 1 point for each proposition, 5 points for hierarchy, 10 points for cross links. Some research studies have also scored each branching for 3 points. However, for the current studies, the concept maps were scored and analysed for number of propositions only. Figure 1 shows the criterion concept map; Figure 2 shows a representative student's concept map on plastids without provided linking words. Figure 3 shows a representative student's concept map on plastids with provided linking words. A score of 1 point was assigned for each proposition, for example, "plastids contain chlorophyll pigment", "plastids are part of plant cells".

RESULTS

From the list of 20 propositions of criterion concept maps were used to compare the valid propositions of each student's concept maps from both the methods of without providing and with providing linking words. The percentage of valid and matching propositions was calculated for each student's concept maps to indicate a proximity percentage. The score for propositional validity was used to determine a proximity percentage to criterion

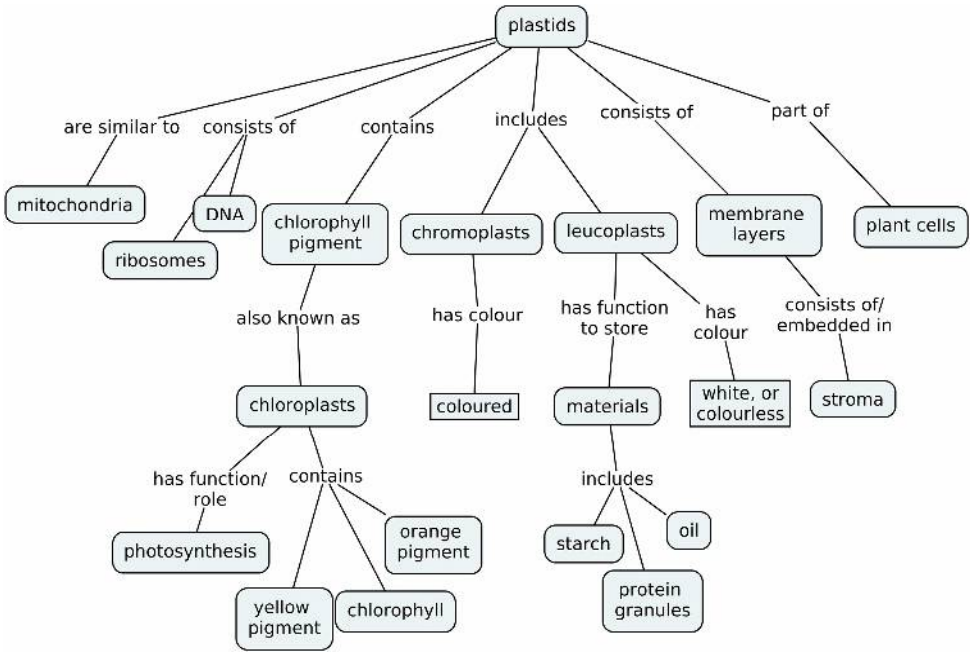


Figure 1: An expert's concept map on Plastids created by group of teachers in consensus from the textbook

Concepts are in boxes – plastids, ribosomes, DNA, mitochondria, etc. Linking words are used for connecting two or more concepts – consists of, contains, includes, part of, etc. A proposition is comprised of concepts and linking words - Plastids contains chlorophyll pigment.

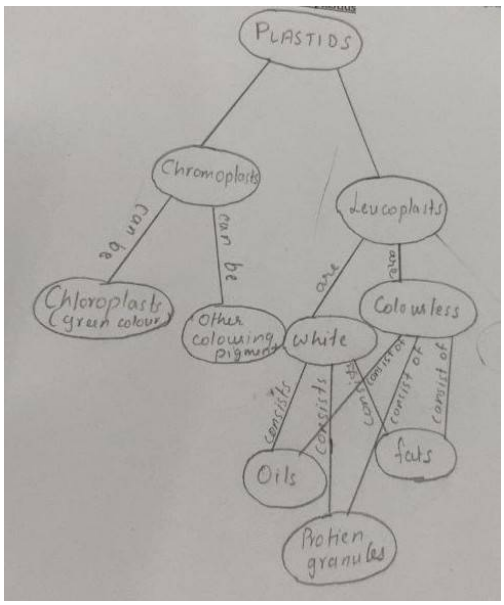


Figure 2: A student's concept map on Plastids created with no linking words provided

concept map. This was achieved by counting the percentage from total number of valid propositions that were matching with the criterion concept map (20 number of propositions). For example, if a student has a total proposition of 13 and from these there are nine invalid and four valid propositions (as in criterion concept map), then the proximity percentage was calculated as 31%.

The score of propositional validity of each student was quite high and showed a greater proximity percentage (Figure 3) due to the usage of the provided linking words that enables to create more valid, unambiguous propositions. The findings from this study indicated concept mapping with provided linking words facilitated towards students' higher proximity to expert's representations.

DISCUSSION & IMPLICATIONS

We used the established concept mapping method with a suggested addition to the method of providing linking words. Traditionally in the con-

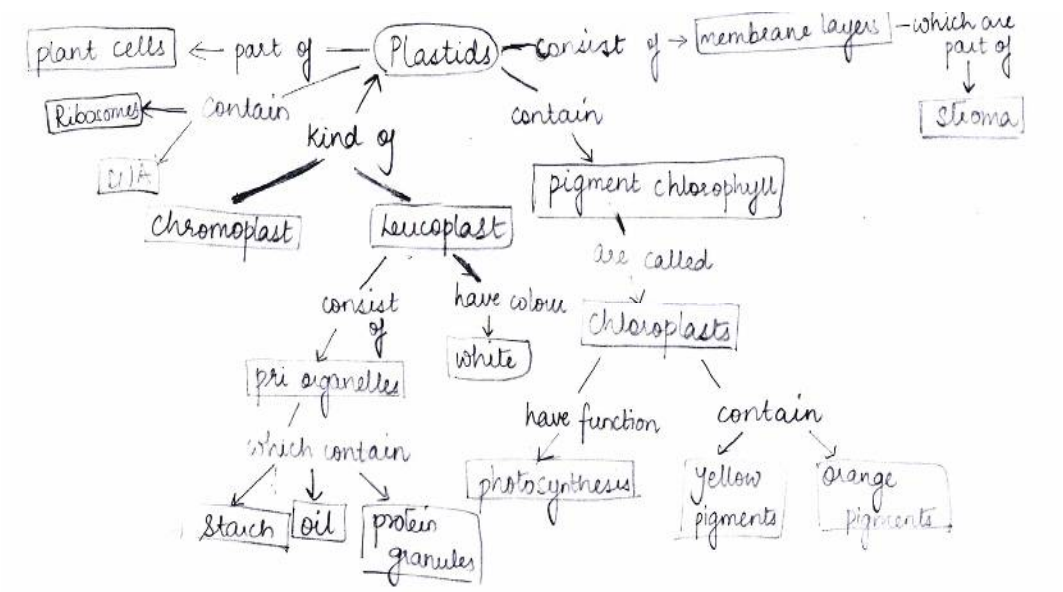


Figure 3: A student's concept map on Plastids created using the provided linking words

cept mapping method there is freedom in choice of linking words, whereas in our method we have provided the linking words. This was due to the focus on disambiguation and consistent use of the linking words that are meaning providers in the concept map.

It can be noted that without provided linking words, students used ambiguous and vague linking words such as has, can be, etc. However, in contrast, the provided linking words – part of, includes, etc. not only serves as scaffolding but also facilitate in expert-like representation of valid propositions. The same set of linking words would be sufficient even for representing a wider domain of knowledge. Further studies that can be based on a larger classroom for finding the statistical significance. The objective of the current study has been to find the effect of providing linking words and it is observed that it facilitates and is not a constraint in representing biology knowledge.

Concept mapping has been effectively used in conceptual learning, misconceptions research in biological sciences. These studies were focusing on the concepts while our study focuses on both concepts and linking words as we believe that the nature of linking words convey the scientific validity in a proposition. In our study, when we introduced the linking words to map a topic, these facilitated for students in organization of knowledge. We suggest that this also can help to facilitate in learning the jargonified biology terms by mapping knowledge. The educational implications of focusing on linking words not only helps to weed out ambiguities but also helps in consistency for mapping biology knowledge and scientific knowledge in general. As pedagogical implication, this method can facilitate teachers in creating teaching-learning material.

ACKNOWLEDGEMENTS

We thank all students for volunteering for study. We have no conflicts of interest. We acknowledge the support of the Department of Atomic Energy, Government of India, to TIFR under Project Identification No. RTI4001.

REFERENCES

Ausubel, D., Novak, J. and Hanesian, H. (1978) *Educational Psychology: A Cognitive View.*

Holt, Rinehart and Winston, New York.

Bloom, B. S. (1956) *Taxonomy of Educational Objectives, Handbook 1: Cognitive Domain*. Longman, New York. https://cir.nii.ac.jp/crid/1573105975722025344

Briggs, A. G., Morgan, S. K., Sanderson, S. K., Briggs, A. G., Morgan, S. K., Sanderson, S. K., Schulting, M. C. and Wieseman, L. J. (2016) Tracking the Resolution of Student Misconceptions about the Central Dogma of Molecular Biology. *Journal of Microbiology & Biology Education* **17**(3): 339–350. https://doi.org/10.1128/jmbe.v17i3.1165

Canas, A. J., Novak, J. D. and Reiska, P. (2015) How good is my concept map? Am I a good Cmapper? *Knowledge Management & E-Learning* **7**(1): 6. https://doi.org/10.34105/j.kmel.2015.07.002

Canas, A. J., Reiska, P. and Möllits, A. (2017) Developing higher-order thinking skills with concept mapping: A case of pedagogic frailty. *Knowledge Management & E-Learning* **9**(3): 348. https://doi.org/10.34105/j.kmel.2017.09.021

Hay, D., Kinchin, I. and Lygo-Baker, S. (2008) Making learning visible: The role of concept mapping in higher education. *Studies in Higher Education* **33**(3): 295–311. https://doi.org/10.1080/03075070802049251

Kaiser, G. E. (2010) Using concept maps in teaching microbiology. *Journal of Microbiology & Biology Education* **11**(1): 58–59. https://doi.org/10.1128/jmbe.v1.i2.142

Kharatmal, M. and Nagarjuna, G. (2016) Using semantic reference set of linking words for concept mapping in biology. *In:* Alberto Cañas, A., Reiska, P. and Novak, J. (eds.) *Innovating with Concept Mapping. CMC 2016. Communications in Computer and Information Science.* Vol. 635, pp. 315–329. Springer, Cham. http://link.springer.com/chapter/10.1007/978-3-319-45501-3_25

Kinchin, I. M. (2001) Can a novice be viewed as an expert upside-down? *School Science Review* **83**(303): 91–95. https://kclpure.kcl.ac.uk/portal/en/publications/can-a-novice-be-viewed-as-an-expert-upside-down

Kinchin, I. M. (2000) concept-mapping activities to help students understand photosynthesis and teachers understand students. *School Science Review* **82**(299): 11-14. https://kclpure.kcl.ac.uk/portal/en/publications/concept-mapping-activities-to-help-students-understand-photosynth

Lee, S., Zhong, M., Foster, C., Segura-Totten, M. and McCartney, M. (2022) From novice to expert: an assessment to measure strategies students implement while learning to read primary scientific literature. *Journal of Microbiology & Biology Education* **23**(3): e00126-22. https://doi.org/10.1128/jmbe.00126-22

Mintzes, J., Wandersee, J. H. and Novak, J. D. (eds.) (2000) *Assessing Science Understanding: A Human Constructivist View*. Academic Press. https://www.sciencedirect.com/book/9780124983656/assessing-science-understanding

Momsen, J. L., Long, T. M., Wyse, S. A. and Ebert-May, D. (2010) Just the facts? Introductory Undergraduate Biology Courses focus on low-level cognitive skills. *CBE - Life Sciences Education* **9**(4): 435–440. https://doi.org/10.1187/cbe.10-01-0001

NCERT. (2007) *Biology (Class XI Textbook)*. NCERT, New Delhi. https://ncert.nic.in/textbook.php

Novak, J. D. (2010) *Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations* (2nd ed.).

Routledge. https://www.routledge.com/Learning-Creating-and-Using-Knowledge-Concept-Maps-as-Facilitative-Tools/Novak/p/book/9780415991858

Novak, J. and Gowin, B. (1984) *Learning How to Learn*. Cambridge University Press. https://www.cambridge.org/core/books/learning-how-to-learn/D4E082D454735D8CC7FEDADFA25A3B99

O'Donnell, A., Dansereau, D. and Hall, R. (2002) Knowledge maps as scaffolds for cognitive processing. *Educational Psychology Review* **14**: 71–86. https://doi.org/10.1023/A:1013132527007

Price, A. M., Kim, C. J., Burkholder, E. W., Fritz, A. V. and Wieman, C. E. (2021) A detailed characterization of the expert problem- solving process in science and engineering: guidance for teaching and assessment. *CBE - Life Sciences Education* **20**(3): ar43. https://doi.org/10.1187/cbe.20-12-0276

Ruiz-Primo, M. A., Schultz, S. E., Li, M. and Shavelson, R. J. (2001) Comparison of the reliability and validity of scores from two concept-mapping techniques. *Journal of Research in Science Teaching* **38**(2): 260–278. https://doi.org/10.1002/1098-2736(200102)38:2<260::AID-TEA1005>3.0.CO;2-F

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_15

Practical Note

Plant Identification Mobile Apps: Users' Difficulties and Impressions

Paulina A. BAWINGAN [1, 2)]*, Emmanuel M. MONTEVIRGEN Jr. [1, 3)], Peter Paul L. CANUTO [1, 4)], Lorna E. LUCAS [1)], Julius C. PUMARAS [1, 5)]

[1)] Saint Louis University, [2)] University of Santo Tomas,
[3)] Lipay National High School, [4)] Ifugao State University,
[5)] Mariano Marcos State University, Philippines

(Received: 8 August 2022, Accepted for publication: 7 March 2024)

In this study, four plant identification mobile apps, namely *LeafSnap*, *PictureThis*, *Pl@ntNet*, and *PlantSnap*, were tried by volunteer participants who are students, teachers, and plant enthusiasts. The participants were asked to take images of at least four plants and upload them to these apps for their identification. The participants were then asked about their impressions of and difficulties with the use of these mobile apps by a questionnaire. Their responses reveal that they found the use of mobile apps interesting, enjoyable, and very useful. It could add to their knowledge of plants, help them connect with nature and the world, and provide data for research purposes. There were, however, difficulties that they encountered with the use of the mobile apps, such as the slow Internet connection, some inconsistencies in identification, and the need to purchase the apps after the trial period. Despite these difficulties, the satisfaction of the users supports the need to explore the idea of using mobile apps in teaching taxonomy or systematic biology among students or even as citizen's science tools.

Keywords: LeafSnap*, mobile apps,* PictureThis, Pl@ntNet, PlantSnap, *plant taxonomy*

***Author for correspondence:** Email address: pbawingan@gmail.com

INTRODUCTION

Plants play significant roles in the ecosystems and human lives. Unfortunately, some individuals show a lack of interest and appreciation of plants regardless of their ecological and economic relevance (Weigelt *et al*., 2021). Wandersee and Schussler (1999) considered this "plant blindness," referring to the lack of recognition among people of the plant's presence in the environment, its significance to the biosphere, and its aesthetic and biological features. Also, Balas and Momsen (2014) showed that most students prefer studying animal species compared to plants. Many people find plant identification much more complex than animal identification (Wang, 2017). Identifying plants through conventional methodologies is demanding, laborious, time-consuming, and requires botanical expertise, making it frustrating for beginners (Goëau *et al*., 2012; Yanikoglu *et al*., 2014; Wäldchen *et al*., 2018; Perera and Arudchelvam, 2021).

The utilization of automated plant identification systems, image recognition technology, apps, and curation of digital plant images have become functionally significant (Yanikoglu *et*

al., 2014; Zhu *et al*., 2016; Boho *et al*., 2020; Jones, 2020). In Serbia, Iskrenovic-Momcilovic (2020) compared the use of mobile identification apps with multimedia teaching using digital herbarium in botanical fieldwork. The results showed that the contribution to the quality and durability of students' learning at cognitive levels of analysis, evaluation, and synthesis is higher in using the mobile application than in multimedia teaching. In China, Wang (2017) also found that plant identification mobile apps in outdoor learning can significantly make the dimension of natural science learning interest and attitude higher than that of non-use of the apps. Several factors, however, affect the efficiency of automated plant identification systems. One is the basis for plant identification by the plant leaf, the most often used plant part and considered the most reliable (Sachar and Kumar, 2021). The leaf is the easiest part of the plant to collect during field studies, and it can provide plenty of data (Perera and Arudchelvam, 2021). The identification of the plant by its leaf depends on shape, color, texture, and venation (Sachar and Kumar, 2021). However, using the leaf as the basis for identification is not always functional due to its diversity and differences in features (Zhang *et al*., 2018). Flowers and fruits may also be used but they have a short span of production (Perera and Arudchelvam, 2021); hence, one has to wait during the flowering season. Whatever plant organ to use, problems in plant identification by mobile apps may be caused by the lack of data presentation and depiction of the organs of the plant (Boho *et al*., 2020), and the quality of the images to be uploaded, and the rareness of some species (Jones, 2020).

Filtered searches in Google Scholar revealed that in the Philippines articles on mobile plant identification apps are mostly related to app development and less focused on its implication for science education. No study has been done on the use of existing plant identification mobile apps in the classroom. Consequently, this study was conducted to test the use of four plant identification mobile apps: *LeafSnap*, *PictureThis*, *Pl@ntNet*, and *PlantSnap*. These mobile apps are readily available online and free to use (at least within a trial period for some of the apps). This study intended to explore the possibility of their use to facilitate classroom learning, particularly on plant taxonomy, by identifying difficulties encountered by the participants with their use of the plant identification mobile apps, their impressions of the use of the apps, their most preferred app, and the reason for their choice. In addition, to determine the potential of plant identification mobile apps as basic taxonomy teaching tools for citizen, plant enthusiasts who are not professional botanists were invited to participate in the study.

MATERIALS AND METHODS

Research Respondents

The participants in this study were 235 senior high school students and undergraduate college students 18 years old and above, and 50 biology teachers and plant enthusiasts. They signified their voluntary participation through an informed consent form after being explained the nature and objectives of the survey.

Research Procedures and the Questionnaire

The participants were instructed to download and install four mobile apps, *LeafSnap 2.21*, *PictureThis 3.9, Pl@ntNet 3.8.1*, and *PlantSnap 5.00.6*, on their smartphones or tablet computers. Next, they were asked to choose at least four plants they would like to know their scientific names and take their clear photos, giving special attention to the details of their leaves and flow-

ers if present. Then, they uploaded the plant photos individually to each plant identification mobile app and waited for the identification result provided by the app. They were requested to take screenshots of the results of plant identification for recording purposes. After using the apps, they were asked to answer a questionnaire on Google Forms.

The following data were gathered from the participants through the questionnaire: (1) their profile which included gender and category (whether they are students, teachers, or plant enthusiasts), (2) the difficulties they encountered when using the mobile apps, (3) their impressions of the use of the mobile apps, and (4) the mobile app they preferred the most and why. Six choices were given for the difficulties (Table 1) and eight items for the impressions. Choices were open-ended to allow the participants to add other difficulties encountered and impressions. For the difficulties, the participants were asked to choose all those that they encountered. For the impressions, the participants evaluated each item using a 5-point Likert scale: 1 = strongly disagree; 2 = disagree; 3= neutral; 4 = agree; and 5 = strongly agree.

The responses of the first fifty participants were subjected to Cronbach's alpha to determine the internal validity and reliability of the questionnaire. The result ($\alpha = 0.93$) showed excellent internal consistency of the questionnaire

Data Analysis

Frequency counts (f) and percentages were computed for the responses on the difficulties encountered and preferred mobile apps, and the median was used to determine the central tendency of participants' impressions.

Ethics Statement

All participants declared their voluntary participation in the study through a prior informed consent form. Participants, especially the students, were given sufficient time (two weeks) to do the activity at their most convenient time.

RESULTS AND DISCUSSION

Problems Encountered

As shown in Table 1, the students, teachers, and plant enthusiasts encountered similar problems or difficulties when they used the plant identification apps. The foremost encountered problem was the slow network connection, the second was the limited number of shots to be

Table 1: Difficulties encountered by the respondents in the use of the mobile apps

Difficulties encountered	Teachers and Plant Enthusiasts (n=50)	Students (n=235)		Total (n=285)	
	f*	**f***	**%**	**f***	**%**
1. Slow network connection affects the use of mobile apps.	34	150	63.8	184	64.6
2. The mobile apps have a limited number of shots per day.	19	105	44.7	124	43.5
3. We need to purchase the apps after a period of trial.	16	51	21.7	67	23.5
4. Plant identification varies among the mobile apps.	15	46	19.6	61	21.4
5. The mobile apps require a more sophisticated mobile operating system.	6	33	14.0	39	13.7
6. The mobile apps are too complicated to use.	5	15	6.4	20	7.0

*f: frequency counts

taken per day, the third was the need to purchase the apps, and the fourth was the inconsistency in the names of the plants provided by the apps. A small number of participants considered the mobile phone operating system as a problem or complicated to use.

The slow network connection that primarily affected the use of the plant identification apps among all the users (Table 1, item No. 1) reflected the poor Internet connection in the country (Natividad, 2021 Feb. 22). The poor and declining performance of Internet services is an unfortunate reality due to the country's weak telecommunications infrastructure, a lack of good information and communications technology (ICT) tools, low engagement of the citizens, insufficient capacity and training, the country's archipelagic and geographic environment (Salac and Kim, 2016), and the high cost of Internet services and subscriptions (Albert *et al*., 2016; Natividad, 2021 Feb 22). The limited number of shots per day (No. 2) and the need to purchase mobile apps (No. 3) are dependent on each of the app's features. Varied plant identification among the apps (No.4) could be due to the clarity of the photos taken, the rareness of the plant species, and whether the plant is included in the app's database. A few participants may have used phone models that lack the more sophisticated operating system required by the plant identification apps (No. 5) indicating that the app may not work efficiently on some phone models, especially the older models. However, similar to app operation complexity (No. 6), system sophistication requirements could be due to a lack of understanding of the instructions for the use of the apps.

Impressions on the Use of the Plant Identification Mobile Apps

Despite these difficulties, the participants gave favorable impressions of their use of the plant identification mobile apps (Table 2). Eight items were presented to the participants (No. 1 - 8), but two items (No. 9 - 10) were added by the participants. The median response for almost all items was 5 (strongly agree). The only response that was not given a median score of 5 by both the teachers and plant enthusiasts, and students was item No. 6, and those by teachers and plant enthusiasts were item No. 1 and No. 5.

Table 2: Impressions of the Participants on their Use of the Mobile Apps

Respondents' reactions	Median of Reactions*	
	Teachers and Plant Enthusiasts	Students
1. I find the mobile apps interesting and enjoyable.	4.5	5
2. It is user-friendly.	5	5
3. The mobile apps are content-rich, and I learned a lot about the plants.	5	5
4. I find the mobile apps useful in plant identification.	5	5
5. The mobile apps are easily accessible.	4.5	5
6. The plant identification is consistent in all four mobile apps.	4.5	4
7. The mobile apps are collaborative citizen science tools.	5	5
8. The mobile apps help me connect with nature and the world.	5	5
9. The mobile apps can be good sources of research data.	5	5
10. I will recommend its use to friends/colleagues/classmates.	5	5

*5-point Likert scale: 1 = lowest score (strongly disagree) and 5 = highest score (strongly agree).

Not only did the students find the mobile apps interesting and enjoyable but they also learned a lot about the plants. They may even have gained information not usually presented in their textbooks. The students' and teachers' impressions regarding the use of the plant identification mobile apps indicate that the teachers can adopt the use of these plant mobile apps in their teaching. The plant enthusiasts also found enjoyment in the activity while acquiring knowledge about the plants.

With the evolution of technology and the Internet, mobile learning has become a new field in educational applications (Fu and Li, 2010 as cited by Wang, 2017). The results of this study showed the great potential of the use of the four mobile apps *LeafSnap*, *PictureThis*, *Pl@ntNet*, and *PlantSnap* as a classroom teaching tool in plant taxonomy and even as a citizen's science teaching material. The use of plant recognition and learning mobile apps based on an expert system can allow students to flexibly and fully understand different plant genera and species and enable them to learn about these plants more actively and excitingly outdoors. Automated plant identification systems provide potential users with powerful tools to record, collect, and share images of plant species (Boho *et al.*, 2020). The use of these mobile apps is e-learning that not only allows the students to widen their knowledge, skills, and experiences but also provides opportunities for interactive learning and collaboration. Most of all, learning can be enjoyable. All these advantages that mobile apps provide may contribute to diminishing the so-called "plant blindness" that many manifest; instead, a greater appreciation for plants would develop.

Preferred Plant Identification Mobile Apps

Based on their learning and user satisfaction, the participants preferred one or two plant identification mobile apps. For the students, the most preferred app was *LeafSnap* (37.4%), next was PictureThis (31.3%), *Pl@ntNet* came next (19.8%), and last was *PlantSnap* (11.5%). The teachers and plant enthusiasts had the same order of preference: *LeafSnap* (36%), *PictureThis* (28%), *Pl@ntNet* (20%), and *PlantSnap* (16%).

According to the respondents *LeafSnap* was the most user-friendly because it has no limit on the photos to upload per day, provides the fastest identification and most accurate plant identification, and describes other interesting features about the plant. The most stated reason for the choice of *PictureThis* was the richness of information about the plant. It includes the plant's name story, its exciting facts, and its symbolism. In addition, it also gives users tips and simple instructions on how to take care of the plant. Most importantly, compared to the other apps, *PictureThis* blocks unnecessary ads. Some respondents liked *PlantSnap* because it is user-friendly and very informative. Others chose *Pl@ntNet* because of its high accurate identification rate and the inclusion of the author's information in the species name. A few participants chose all apps because they believe all are important in plant identification and are easy to use.

The fact that many participants prefer apps that provide more information about the plants suggests that existing apps should consider this when they upgrade or develop other versions. In addition, enrichment of the database of these apps, especially adding the profiles and IDs of wild and rare plants is essential. Contributions among the users are, therefore, necessary for the structured observations of species, which enhance the future improvement of these automatic plant identification systems (Rzanny *et al.*, 2019).

Despite some limitations, exploring plant identification mobile apps to enhance the learning of plants and plant taxonomy is advisable, timely, and relevant. Almost every student has a smartphone or a tablet and can be connected to the Internet at any time. Since the apps used in the present study were shown to be interesting and enjoyable to use besides being informative, their use can supplement traditional methods in teaching plant taxonomy.

ACKNOWLEDGMENT

Our heartfelt gratitude goes to all the participants who made this research possible.

REFERENCES

Balas, B. and Momsen, J. L. (2014) Attention "blinks" differently for plants and animals. *CBE-Life Sciences Education* **13**(3): 437–443. https://doi.org/10.1187/cbe.14-05-0080

Boho, D., Rzanny, M., Wäldchen, J., Nitsche, F., Deggelmann, A., Wittich, H. C., Seeland, M. and Mäder, P. (2020) Flora Capture: a citizen science application for collecting structured plant observations *BMC Bioinformatics* 21: 576. https://doi.org/10.1186/s12859-020-03920-9 https://doi.org/10.15173/ijsap.v3i2.3671

Goëau, H., Bonnet. P., Barbe, J., Bakic, V., Joly, A. and Molino, J-F. (2012) Multi-organ plant identification. *MAED '12: Proceedings of the 1st ACM International Workshop on Multimedia Analysis for Ecological Data - November 2012*. pp. 41-44. http://doi.org/10.1145/2390832.2390843

Iskrenovic-Momcilovic, O. (2020) Contribution of using mobile application on botanical fieldwork in primary school. *Interactive Learning Environments*: 1-13. https://doi.org/10.1080/10494820.2020.1826531

Jones, H. G. (2020) What plant is that? Tests of automated image recognition apps for plant identification on plants from the British flora. *AoB PLANTS* **12**(6): plaa052. https://doi.org/10.1093/aobpla/plaa052

Pärtel, J., Pärtel, M. and Wäldchen, J. (2021) Plant image identification application demonstrates high accuracy in Northern Europe. *AoB PLANTS* **13**(4): plab050. https://doi.org/10.1093/aobpla/plab050

Perera, P. S. T. and Arudchelvam, T. (2021) Leaf-based plant identification system for Sri Lankan medicinal plant. *In*: Arai, K. (ed.) *Advances in Information and Communication. Proceedings of the 2021 Future of Information and Communication Conference (FICC), Volume 2.* pp. 831–836. Springer Cham. https://doi.org/10.1007/978-3-030-73103-8_59

Rzanny, M., Mäder, P., Deggelmann, A., Chen, M. and Wäldchen, J. (2019) Flowers, leaves or both? How to obtain suitable images for automated plant identification. *Plant Methods* **15**: 77. https://doi.org/10.1186/s13007-019-0462-4

Sachar, S. and Kumar, A. (2021) Automatic plant identification using transfer learning. *IOP Conference Series: Materials Science and Engineering* **1022**: 012086. https://doi.org/10.1088/1757-899X/1022/1/012086

Salac, R. A. and Kim, Y. S. (2016) A study on the Internet connectivity in the Philippines. *Asia-Pacific Journal of Business Review* **1**(1): 67-88. http://dx.doi.org/10.20522/APJBR.2016.1.1.67

Wandersee, J. H. and Schussler, E. E. (1999) Preventing plant blindness. *The American Biology Teacher* 61(2): 82-86. http://online.ucpress.edu/abt/article-pdf/61/2/82/48775/4450624.pdf

Wang, C. (2017) The research on the application of plant identification and mobile learning APP based on expert system. *In*: Escudeiro, P., Costagliola, G., Zvacek, S., Uhomoibhi, J. and McLaren, B. M. (eds.) *Proceedings of the 9th International Conference on Computer Supported Education (CSEDU) - Volume 2*, pp. 332-339. SCITEPRESS. https://doi.org/10.5220/0006313103320339

Wäldchen, J., Rzanny, M., Seeland, M. and Mäder, P. (2018) Automated plant species identification-Trends and future directions. *PLoS Computational Biology* **14**(4): e1005993. https://doi.org/10.1371/journal.pcbi.1005993

Weigelt, P., Denelle, P., Brambach, F. and Kreft, H. (2021) BotanizeR: A flexible R package with Shiny app to practice plant identification for online teaching and beyond. *Plants, People, Planet* **4**(2): 122-127. https://doi.org/10.1002/ppp3.10226

Yanikoglu, B., Aptoula, E. and Tirkaz, C. (2014) Automatic plant identification from photographs. *Machine Vision and Applications* **25**: 1369-1383. http://doi.org/10.1007/s00138-014-0612-7

Zhang, S., Huang, W. and Wang, Z. (2018) Plant species identification based on modified local discriminant projection. *Neural Computing and Applications* **32**: 16329–16336. https://doi.org/10.1007/s00521-018-3746-0

Zhu, H., Huang, X., Zhang, S. and Yuen, P. C. (2016) Plant identification via multipath sparse coding. *Multimedia Tools and Applications* **76**: 4599–4615. https://doi.org/10.1007/s11042-016-3538-4

WEBSITES

Albert, J. R. G., Serafica, R. B. and Lumbera, B. T. (2016) Examining trends in ICT statistics: How does the Philippines fare in ICT? *PIDS Discussion Paper* Series No. 2016-16. Philippine Institute for Development Studies (PIDS), Quezon City. *ECONSTOR.* Retrieved: August 10, 2022, from https://www.econstor.eu/handle/10419/173537?locale=en

Natividad, N. (2021, February 22). Why Internet speeds in the Philippines are so slow. *Vice World News.* Retrieved: August 15, 2021, from https://www.vice.com/en/article/n7vy3m/why-internet-speeds-philippines-slow-laws

MOBILE APPS

LeafSnap: http://leafsnap.app/

PictureThis: http://www.picturethisai.com/

Pl@ntNet: https://pl@ntnet.or/en/

PlantSnap: https://www.plantsnap.com/

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_22

Obituary

The Legacy of CARMEN G. KANAPI, PhD

John Donnie A. RAMOS*
University of Santo Tomas, Philippines

(Received: 26 May 2024)

***Author for correspondence:** jaramos@ust.edu.ph

Carmen G. Kanapi is a distinguished Filipino zoologist, geneticist, and an esteemed administrator. Her influence reverberated throughout the academic community, particularly at the University of Santo Tomas (UST), Manila, Philippines, where she held pivotal leadership roles as the dean of the UST College of Science (1982-1996) and the dean of the UST Graduate School (1976-1982). In recognition of her exemplary and dedicated leadership, she was bestowed the title of Dean Emeritus by the University of Santo Tomas.

Kanapi's academic journey began with a Magna Cum Laude distinction in BS Zoology from UST in 1950. Her pursuit of knowledge continued as she honed her expertise through rigorous training abroad, obtaining an MS in Zoology from the University of Chicago, a

PhD in Zoology specializing in Genetics from the University of Texas at Austin, and engaging in pre-doctoral studies at the University of Hawaii and Johns Hopkins University. Her seminal contributions in Drosophila Genetics, including a groundbreaking PhD dissertation published in prestigious journals like the Proceedings of the National Academy of Sciences, underscored her prowess in the field. Moreover, her involvement in commemorating the centenary of Thomas H. Morgan, a renowned geneticist, exemplifies her commitment to advancing genetic research.

Beyond academia, Kanapi's legacy extends to her profound engagement in community service and advocacy. She served and devoted her leadership to various associations including being a member of the Executive Board of the Asian Association for Biology Education (AABE); president of the Biology Teachers Association of the Philippines (BIOTA-Phils); vice president of the Philippine Association for the Advancement of Science (PhilAAS), a founding in-corporator of the Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA) where she later became the treasurer and a commissioner.

She championed initiatives promoting scientific literacy and environmental stewardship. She organized the Eco Watch, Eco Act movement in UST whose awareness program resulted in the successful closing down of the incinerator on campus, and the banning of smoking within the UST College of Science which was later adopted by the whole university. She was the Project Leader of the UST Environmental Education Program Development Project or “EE for All at UST”.

As a trailblazing servant leader and a woman of science, Carmen G. Kanapi's legacy continues to inspire generations of scholars and administrators. Her dedication to excellence, coupled with her unwavering compassion, serves as a beacon for those striving to make meaningful contributions to academia and society at large. Carmen G. Kanapi was a founding and an honorary member of The Asian Association for Biology Education. She passed away on 16 December 2022. We at AABE celebrate her 97 years (1925-2022) of a well-fulfilled lifetime.

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_24

Country report

Teaching Sustainability in Australian Schools

Robert WALLIS*
Office of the Pro Vice-Chancellor (Research), Federation University Australia

(Received: 7 August 2024; Accepted for publication: 12 August 2024)

The Australian national curriculum has been adopted by Education Ministers in all Australian states and territories. There are eight key learning areas, including Science, in the Foundation to Level 10 program and three cross-curriculum priorities that include Sustainability. Thus, Sustainability is not taught as a separate discipline, but is integrated into the key learning areas wherever possible. There are three Organizing Areas relevant in the curriculum for teaching about Sustainability: Systems, World Views and Futures. Teachers have access to an array of resources to help in their teaching, including lesson plans, field work suggestions and work samples. In the senior secondary school curriculum (levels 11 and 12), Sustainability is again taught through established disciplines and subjects, including Biology, Geography and Earth & Environmental Science. The latter field may be taught under different titles – in New South Wales, for example, Earth & Environmental Science is a distinct Subject in levels 11 and 12, while in Victoria there are two so called Study Designs that cover the key learning area: Environmental Science and Outdoor and Environmental Studies.

Keywords: *Australian schools, cross-curriculum teaching, Sustainability education*

***Author for correspondence:** *r.wallis@federation.edu.au*

INTRODUCTION

On the first of January 1901, six colonies federated to form the Commonwealth of Australia. The colonies became the states of the single Australian nation and together with the more recently added territories (Australian Capital Territory and Northern Territory), maintain constitutional responsibility for education at all levels. Since 1963, however, the Commonwealth began funding schools and have sought closer national collaboration.

When the states and territories held this responsibility for education, there existed differences in curricula across Australia in key subject areas. This created problems – for example, when students moved between states and there were complaints from employers and universities about differences in learning backgrounds of school leavers. There has thus been a move for the development of a single national curriculum.

In December 2008 the Australian Curriculum Assessment and Reporting Authority (ACARA) was established as an independent statutory authority to have responsibility for the development of a national curriculum, a national assessment program, and a national data collection and reporting program. ACARA's work is overseen and approved by the education ministers in the Commonwealth, states and territories.

The first iteration of the national school curriculum was approved by ACARA's Board in 2012. There have been modifications made since. Schools have some flexibility in how and what they teach

within the framework which has been described more as a roadmap and guide, rather than a detailed description of precisely what is to be taught.

CURRICULUM LEVELS AND STRUCTURE

The F-10 curriculum framework essentially covers the first 11 years of schooling. The last two years of school are covered in the Senior Secondary curriculum. However, it is quite common for students in their year 10 to undertake some studies from the senior curriculum. Furthermore, schools or education groups can apply to ACARA for approval for alternative curriculum frameworks.

There are eight Key Learning Areas (or broad subjects) in the F-10 curriculum. These are English, Mathematics, Science, Humanities and Social Science, the Arts, Health and Physical Education, Languages and Technologies. As well, in Years 9 and 10 there is an optional area called Work Studies in which students prepare for employment. Importantly, there are three "Cross-disciplinary Priorities": Sustainability, Aboriginal and Torres Strait Islander History and Cultures and Asia and Australia's Engagement with Asia. These "priorities" should pervade all key leaning areas, although it is obvious it will be easier to cover priorities in some subjects more than others.

In the Senior Secondary Curriculum, there are five Key Learning Areas: English, Science, Mathematics, Humanities and Social Sciences. Science, for example, has the discrete subjects of Biology, Chemistry, Physics and Earth & Environmental Science.

Within the Key Learning Areas are subjects in the traditional sense and these may vary between the States.

WHAT IS EDUCATION FOR SUSTAINABILITY?

The Australian curriculum description of sustainability is widely accepted. For instance, "sustainability addresses the ongoing capacity of Earth to maintain all life. Sustainable patterns of living meet the needs of the present without compromising the ability of future generations to meet their needs. Sustainability education is futures-oriented, focusing on protecting environments and creating a more ecologically and socially just world through informed action. Actions that support more sustainable patterns of living require consideration of environmental, social, cultural and economic systems and their interdependence." (ACARA, undated).

The idea that sustainability can be taught across many disciplines is also widely accepted. McKeown and Hopkins (2003, p. 124) believe that every discipline can provide the "knowledge, skills, perspectives, and values: to create a holistic education for sustainability program". Wals and Blewitt (2010) have further argued against a rigid definition of sustainability as this would constrain a multi-disciplinary approach. They argue sustainability is contextual and subjective and can therefore be adaptable to any discipline.

Nonetheless, some disciplines seem more amenable than others to promoting education for sustainability. For example, Biology is frequently cited as a way of addressing many of the concepts and principles of sustainability (Cotton *et al.,* 2007; Kim and Diong, 2012; Christie et al., 2015).

F-10 SUSTAINABILITY CURRICULUM

There are three key concepts that underpin the F-10 Sustainability curriculum: Systems, World Views and Futures.

The Systems concept explores the interdependent and dynamic nature of systems that support all life on Earth and our collective wellbeing.

The second concept promotes the differences of world views on ecosystems, values and social justice.

The third concept is "aimed at building capacities for thinking and acting in ways that are necessary to create a more sustainable future. The concept seeks to promote reflective thinking processes in young people and empower them to design action that will lead to a more equitable and sustainable future." (ACARA, undated).

There are then nine key curriculum statements; these are listed in Table 1. Teachers would be expected to address these wherever possible in their student learning activities.

Table 1. The nine key "organising ideas" of Sustainability in the F-10 curriculum

Systems
• The biosphere is a dynamic system providing conditions that sustain life on Earth.
• All life forms, including human life, are connected through ecosystems on which they depend for their wellbeing and survival.
• Sustainable patterns of living rely on the interdependence of healthy social, economic and ecological systems.
World views
• World views that recognise the dependence of living things on healthy ecosystems, and value diversity and social justice are essential for achieving sustainability.
• World views are formed by experiences at personal, local, national and global levels, and are linked to individual and community actions for sustainability.
Futures
• The sustainability of ecological, social and economic systems is achieved through informed individual and community action that values local and global equality and fairness across generations into the future.
• Actions for a more sustainable future reflect values of care, respect and responsibility, and require us to explore and understand environments.
• Designing actions for sustainability requires an evaluation of past practices, the assessment of scientific and technological developments, and balanced judgements based on projected future economic, social and environmental impacts.
• Sustainable futures result from actions designed to preserve and/or restore the quality and uniqueness of environments.

Source: ACARA (undated).

Each of the Key Learning Areas (such as Science) has a set of learning statements relevant to Sustainability. For example, that for Science reads:

> "The Sustainability priority provides contexts for investigating and understanding chemical, biological, physical and Earth and space systems. Students explore a wide range of systems that operate at different time and spatial scales. By investigating the relationships between systems and system components and how systems respond to change, students develop an appreciation for the interconnectedness of Earth's biosphere, geosphere, hydrosphere and atmosphere. Relationships including cycles and cause and effect are explored, and students develop observation and analysis skills to examine these relationships in the world around them. In this learning area, students appreciate that science provides the basis for decision-making in many areas of society and that these decisions can impact on the Earth system. They understand the importance of using science to predict

possible effects of human and other activity and to develop management plans or alternative technologies that minimise these effects." (ACARA, undated).

STUDENT LEARNING RESOURCES FOR F-10 SUSTAINABILITY

There is a vast array of resources available to help teachers deliver on these learning outcomes. Many are found on the ACARA website, as well as in sites provided by education and for-profit agencies. These include Sustainability in Schools that includes 549 resources and case studies, the Australian Education for Sustainability Alliance, Environment Education Victoria, Green Choices, and various State Education Departments, for example, NSW Government Website-Education (see the website list for the URLs at the end of the text).

EDUCATION FOR SUSTAINABILITY AT THE SENIOR LEVEL

There is an expectation that sustainability can also be taught across disciplines at the secondary senior (11 and 12) years. In the Science key learning area, the subjects of Biology and Earth and Environmental Science especially have opportunities. Elsewhere (Wallis, 2023) I have described these opportunities in three subjects in the Victorian senior school curricula of Biology and Environmental Science in the Science key learning area. Outdoor and Environmental Education in the Humanities and Social Science area is especially relevant to education for sustainability. The two units at level 4 in this subject are Healthy Outdoor Environments and Sustainable Outdoor Environments; these topics deal with the biophysical, social, health and economic aspects of living outdoors.

CONCLUSIONS

Sustainability in the Australian national curriculum is not taught as a separate discipline, but instead is considered a priority study across all disciplines in the F-10 curriculum. At the senior levels, subjects in Science and the Humanities and Social Sciences have elements pertinent to education for sustainability.

REFERENCES

Christie, B. A., Miller, K. K., Cooke, R. and White, J. G. (2015). Environmental sustainability in higher education: what do academics think? *Environmental Education Research* **21**: 655–686. https://doi.org/10.1080/13504622.2013.879697

Cotton, D., M. Warren, O. Maiboroda, and I. Bailey. 2007. Sustainable development, higher education and pedagogy: a study of lecturers' beliefs and attitudes. *Environmental Education Research* **13**: 579–597. https://doi.org/10.1080/13504620701659061

Kim, M. and Diong, C.H. (2012). *Biology Education for Social and Sustainable Development*, Sense, Rotterdam. https://doi.org/10.1007/978-94-6091-927-5.

McKeown, R. and Hopkins, C. (2003). EE p ESD: Defusing the worry. *Environmental Education Research* **9**: 117–128. https://doi.org/10.1080/13504620303469

Wallis, R. (2023). Nature education in Australia – past, present and a desirable future. *Asian Journal of Biology Education* **15**: 22-35. https://doi.org/10.57443/ajbe.15.0_2

Wals, A. E. J., and J. Blewitt. 2010. Third-wave sustainability in higher education: Some (inter)national trends and developments. *In* Jones, P., Selby, D. and Sterling, S. (eds.) *Sustainability Education – Perspectives and Practice across Higher Education*, pp. 55–74. Earthscan, London, United Kingdom. https://doi.org/10.4324/9781849776516

WEBSITES

Australian Curriculum Assessment and Reporting Authority (ACARA) (undated) The Australian Curriculum. https://www.australiancurriculum.edu.au/ <retrieved: 06/08/2024>.

Australian Education for Sustainability Alliance. https://www.aaee.org.au/projects/australian-education-for-sustainability-alliance/ <retrieved: 06/08/2024>.

Environment Education Victoria. https://www.eev.vic. edu.au/eingana <retrieved: 06/ 08/2024>.

Green Choices. https://www.greenchoices.org/going-green/schools/teachers-resources <retrieved: 06/08/2024>.

NSW Government Website–Education. https://education.nsw.gov.au/teaching-and-learning/curriculum/sustainability/resources <retrieved: 06/ 08/2024>.

Sustainability in Schools. https://sustainabilityinschools.edu.au/resources <retrieved: 06/ 08/2024>.

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_29

Erratum

Erratum to: A Preliminary Study on Effect of Providing Linking Words in Concept Mapping for Representing Cell Biology Knowledge

This is an erratum to doi: https://doi.org/10.57443/ajbe.16.0_9 published by AJBE Vol. 16, 2024.

Original Error: On page 11, right column, 9 lines from the top, the reference to "Figure 3" is incorrect.
Correction: The correct reference should be "Figure 4".
Addition: The original paper did not include Figure 4, which should have been inserted immediately after Figure 3. Below is the missing figure along with its caption.

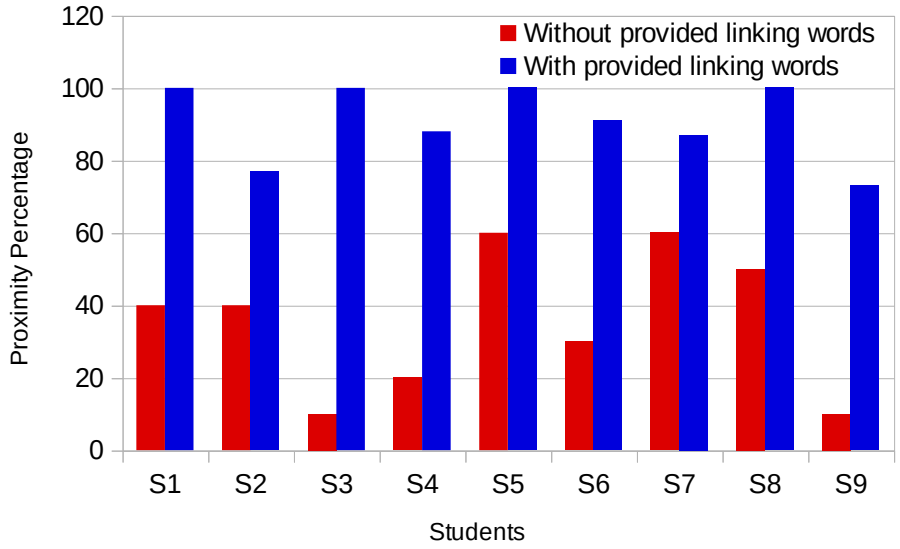


Figure 4: Graph showing higher proximity percentage of propositions with provided linking words when compared with criterion concept map.

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/ajbe.16.0_30

Country Report

Refined Malaysia's Pre-University Biology Syllabus with a Focus on Sustainable Development and STEM

Siew Wai, KWAN*

SMK, Vivekananda, Head of Biology Department for Pre-University Education

(Received: 17 October 2024; Accepted for publication: 18 October 2024)

As the global community increasingly emphasizes the importance of sustainability, education systems must align with these values. Recent PISA results highlight the challenges faced by Malaysian students in mastering STEM techniques, revealing gaps in critical thinking and problem-solving skills. In response, it is crucial for Malaysia to reorient its education system towards sustainable development and the integration of STEM principles. This manuscript reports on the Malaysian government's effort to enhance sustainable development and STEM education by refining pre-university programs, specifically the Sijil Tinggi Persekolahan Malaysia (STPM) Biology syllabus to integrate sustainability education and foster a deeper understanding of STEM. This revision aimed to equip students with not only theoretical knowledge but also practical skills relevant to addressing real-world environmental challenges. By embedding sustainability concepts within the syllabus, the initiative seeks to cultivate critical thinking, problem-solving abilities, and ethical decision-making in students. Furthermore, the updated syllabus encourages collaboration and innovation, preparing students to be involved in sustainability and scientific research. This restructuring reflects the government's commitment to developing a workforce equipped for the challenges of a rapidly changing global economy, especially in green technologies and sustainable industries. Ultimately, the refined STPM Biology syllabus ensures that students are prepared for further education or the workforce with relevant skills and knowledge.

Keywords: *Sustainable education, Pre-University Education, Biology Education*

***Author for correspondence**: kwansiewwai@yahoo.com

INTRODUCTION

There are a few pre-university programmes provided by the Malaysian Government. Sijil Tinggi Persekolahan Malaysia (STPM) is one of the most prominent programmes offered for students aged 18– 19 (Setapa et al., 2024; Sivalingam, 2020). This programme aimed to prepare students for tertiary education, and used to be the benchmark for entering into local universities as well as universities around the world (Qi & Binti Saharan, 2024).

In 2024, Malaysia's performance in STEM (Science, Technology, Engineering, and Mathematics) education showed a notable increase in STEM enrolment, with 45.73% of students in schools now participating in STEM programs (Ibrahim et al., 2024). The increment in students taking STEM education reflects some success in government initiatives to boost interest in these fields. This progress is critical for Malaysia's ambitions to enhance its technological and scientific capabilities. However, despite this positive trend in enrolment, the overall situation remains challenging. There is still a significant shortage of qualified STEM teachers, especially in rural areas, which hampers the quality of education. Schools in these areas often lack the necessary resources, such as modern

laboratories and proper equipment, which are essential for effective STEM education. Furthermore, the perception that STEM subjects are difficult continues to deter many students from fully engaging with these fields (Dost, 2024).

In addition, sustainable development has become a central theme in global policy discussions, emphasizing the need to balance economic growth, environmental protection, and social equity (Swärdh, Brodin, Pettersson, & Palstam, 2024). In response to this global trend, education systems worldwide are being urged to incorporate sustainability into their curricula. Malaysia, as part of its broader educational reform efforts, must consider how to integrate sustainable development into its pre-university Biology syllabus to prepare students for the challenges of the 21st century.

Hence, a task force was put into action to refine the current STPM Biology syllabus to ensure the competency of Malaysian's younger generations in this changing and challenging developing society few years ago (Sivalingam, 2020; Zariyawati, 2011). Recently, a restructured and refined Pre-University STPM Biology Syllabus was introduced. This new Biology syllabus will be implemented in year 2025.

CURRENT STATE OF PRE-UNIVERSITY BIOLOGY IN MALAYSIA

The current pre-university Biology syllabus (before the refining process) in Malaysia is well-rounded, covering fundamental topics such as genetics, evolution, ecology, and human physiology. However, the syllabus predominantly focuses on traditional biological concepts without sufficient emphasis on their relevance to sustainable development. While topics like ecology touch upon environmental issues, there is limited integration of broader sustainability concepts, such as the impact of human activities on the environment, biodiversity conservation, and the principles of sustainable resource management. The impacts of lacking these concepts integrated in the syllabus were revealed partially in the PISA results Malaysia achieved in the past few years. Hence, an effort was made in the national level to rectify the issue by refining the syllabus of all subjects offered in STPM curriculum.

IMPORTANCE OF SUSTAINABLE DEVELOPMENT AND STEM IN BIOLOGY EDUCATION

Sustainable development is integrated into the Biology syllabus for several reasons:

1. ***Holistic Understanding of Environmental Issues*:** Students need to understand the interconnectedness of biological systems and human activities. By studying sustainable development, they can appreciate the impact of their actions on the environment and learn how to mitigate negative effects through sustainable practices.
2. ***Preparation for Future Challenges*:** As future scientists, policymakers, or informed citizens, students must be equipped with the knowledge and skills to address global challenges such as climate change, food security, and biodiversity loss.
3. ***Fostering Responsible Citizenship*:** Education for sustainable development encourages students to think critically about their role in society and the environment, promoting values of stewardship, equity, and social responsibility.

CHANGES MADE IN THE REFINED STPM BIOLOGY SYLLABUS

The revised STPM (Sijil Tinggi Persekolahan Malaysia) Biology syllabus in Malaysia has undergone several significant changes to better align with current scientific developments and educational needs (Majlis Peperiksaan Malaysia, 2024). Here are some of the key changes:

1. ***Incorporation of Modern Biological Concepts*:** The new syllabus includes updates to reflect the latest advancements in biology. Topics such as genetic engineering, biotechnology, and molecular biology are given more emphasis to ensure students are up-to-date with current scientific knowledge.
2. ***Sustainable Development Focus*:** There is a greater integration of sustainable development topics, including environmental conservation, biodiversity, and the impact of human activities on ecosystems. This reflects a growing awareness of the importance of sustainability in biology education.
3. ***Enhanced Practical Components*:** The syllabus now places a stronger emphasis on practical skills and hands-on learning. Laboratory work, field studies, and investigative projects are more thoroughly integrated into the curriculum to develop students' practical and analytical skills.
4. ***Critical Thinking and Problem-Solving*:** The revised syllabus encourages critical thinking and problem-solving abilities by introducing more complex, real-world biological issues for students to explore. This includes case studies and problem-based learning activities.
5. ***Use of Technology in Learning*:** There is a greater emphasis on using digital tools and resources in the learning process. This includes online databases, virtual labs, and other digital platforms that can supplement traditional teaching methods.
6. ***Assessment Changes*:** The assessment structure has also been updated to include a wider range of evaluation methods. In addition to traditional exams, students are assessed through continuous assessment tasks that include lab reports, projects, and presentations.

These changes aim to make the STPM Biology syllabus more relevant to today's scientific landscape and to better prepare students for higher education and careers in the biological sciences.

CHALLENGES IN INTEGRATING SUSTAINABLE DEVELOPMENT AND STEM

The integration of sustainable development into the Biology syllabus presents several challenges:

1. ***Curriculum Overhaul*:** Introducing sustainability requires a significant overhaul of the existing curriculum. This includes updating teaching materials, redesigning lesson plans, and incorporating new assessment methods that emphasize critical thinking and problem-solving.
2. ***Teacher Training*:** Effective teaching of sustainable development concepts requires teachers to be well-versed in both Biology and sustainability. Continuous professional development is needed to equip teachers with the necessary knowledge and pedagogical skills. Teacher training was provided to new and in-service teachers immediately after the launching of the refined syllabus nationwide.
3. ***Resource Availability*:** Schools, especially in under-resourced areas, may lack the necessary materials and support to teach sustainability effectively. This includes access to up-to-date textbooks, digital resources, and opportunities for experiential learning through fieldwork or projects. Some of the centres offering STPM Biology study, especially centres in rural areas or with less enrolment, were relocated to a more centralised location to ensure better allocation of resources for teaching and learning Biology.

To address these challenges, experts are advocating for a more engaging and practical STPM Biology curriculum, with the aim of increasing awareness campaigns about the opportunities in Biology careers, and better training and incentives for STEM teachers. Additionally, there are calls for leveraging digital technology, such as educational

apps and gamification, to make STEM subjects more accessible and interesting to students.

CONCLUSION

The inclusion of sustainable development in Malaysia's pre-university Biology syllabus is a necessary step towards preparing students for a challenging future. By revising the curriculum to integrate sustainability concepts, Malaysia can foster a generation of students who are not only knowledgeable in Biology but also equipped with the skills and values needed to contribute to a more sustainable world.

REFERENCES

Dost, G. (2024). Students' perspectives on the 'STEM belonging' concept at A-level, undergraduate, and postgraduate levels: an examination of gender and ethnicity in student descriptions. *International Journal of STEM Education* **11,** 12 (2024). https://doi.org/10.1186/s40594-024-00472-9

Ibrahim, N., Mohamed, M., Seshaiyer, P., Rasid, N. S. M., Dalim, S. F., Salleh, M. F. M. and Yusoff, M. M. M. (2024). Enhancing prospectives educators' readiness through multidisciplinary collaboration in STEM education: An analysis of students enrolled in science and mathematics majors at a public university in Malaysia. *Asian Journal of University Education* **20**(2): 303–315. https://doi.org/10.24191/ajue.v20i2.27000

Majlis Peperiksaan Malaysia. (2024). *Biology 964: Syllabus and Specimen Papers.* Majlis Peperiksaan Malaysia.

Qi, C., and Binti Saharan, S. (2024). Analysis on students' academic performance in relation to the results of pre-university examination. *Engineering Headway* **6**: 173–182. https://doi.org/10.4028/p-gWn34t

Setapa, M., Safie, S., Mamat, M., Ramli, N. H., Mustafa, T., Nawi, F. A. M., Rahman, K. and Raman, S. M. A. (2024). Academic performance factors in Malaysia's public higher education institutions. In: M. Madah Marzuki et al. (eds.) *Proceedings of International Conference on Governance, Management & Social Innovation (ICGMSI 2023)*, pp. 4–15. Atlantis Press International BV. https://doi.org/10.2991/978-94-6463-425-9_2

Sivalingam, A. D. (2020). History of Malaysian education system: Year 1824 to 2020. *Social Sciences Education eJournal*. https://doi.org/10.2139/ssrn.3735372

Swärdh, E., Brodin, N., Pettersson, A., and Palstam, A. (2024). Time to rethink intended learning outcomes for sustainable development? A qualitative exploration and reflection of course syllabuses in Swedish undergraduate physiotherapy education. *Journal of Medical Education and Curricular Development* **11**. https://doi.org/10.1177/23821205241260599

Zariyawati, L. (2011). Malaysian education system reform: Educationists' perspectives. In: *Proceeding of the International Conference on Social Science, Economics and Art 2011*, pp. 107–111.

https://doi.org/10.57443/ajbe.a6.0_34

Research Paper

Utilizing Internet Memes in Senior High School Biology to Improve Gen Z's Academic Achievement, Attitude, and Self-efficacy

Alyanna Nicole D. CARLOS[1)], Emmanuel D. DELOCADO[1,2)*]

[1)] Department of Biology, School of Science and Engineering,
*[2)] Ateneo Institute of Sustainability, Ateneo de Manila University, PHILIPPI*NES

(Received: 05 August 2024; Accepted for publication: 17 November 2024)

Generation Z learners' short attention span challenges educators to design engaging teaching methods that capture their interest. This quantitative study investigates the effect of memes, which are popular internet media, on non-STEM Gen Z high school students' academic achievement, attitude, and self-efficacy in biology. Two groups of Grade 11 participants (n=243) were taught cellular division and genetics lessons through two different approaches. The results demonstrate that the experimental group which was taught using meme-infused materials had statistically significantly higher post-test scores (21.46 ± 4.41 out of 30; independent *t*-test = 0.00) than students who were taught with materials with no memes (17.74 ± 4.00). Additionally, administering the modified Attitude Towards Science Inventory (ATSI) reveals that there is a statistically significant positive overall attitude in sciences in the experimental group (Mann-Whitney U test *p*-value = 0.00). Also, there is a statistically significant Biology Self-Efficacy (BSE) score (*p*-value = 0.00) for the group with meme-infused materials. This was consistent across all three BSE dimensions, namely confidence in methods in biology, generalization and analyzing data, and application of biological concepts and skills. Analysis of the specific descriptors posit that memes assisted in managing students' anxiety towards biology and boosted their confidence in their perceived capacity in the subject matter. This study contributes to the growing literature on possible pedagogical tools and strategies to cater to the new generation of learners.

Key words: *biology education, cellular division, Generation Z learners, genetics, memes, pedagogical innovation*

***Author for correspondence:** edelocado@ateneo.edu

INTRODUCTION

For the past decade or so, substantial research has been done on millennial learners and their expectations in the classroom. Millennial learners are eager to receive feedback on their performance and they also favor collaborative tasks and technology-infused learning (McGuire and Williams, 2002; Monaco and Martin, 2007; Alexander, 2012; Schwartz *et al*., 2018). As scholars and researchers have just gotten a good grasp of the kind of learners that millennials are, a new generation of students have already filled the classrooms, namely the Generation Z (Gen Z) learners.

Gen Z is characterized as the generation born between 1997 and 2010 (Twenge, 2018; Nicholas, 2020; Manzoni *et al*., 2021). They are true digital natives who were raised with smartphones and mobile tablets they could barely fit in their baby hands, unlike millennials who grew up immersed in analog and have lesser exposure to digital technology than Gen Z. Having this much technological exposure and digital know-how, Gen Z possesses the ability to retrieve and disseminate information instantaneously (Nicholas, 2020). This technological savviness of Gen Z learners from their younger years, however, poses some chal-

lenges during their years in formal education. Results of a recent study showed that Gen Z learners have an average attention span of eight (8) seconds, which is much shorter than 12 seconds of millennials (Nicholas, 2020). Attention span can be defined as the presence of mind required to establish a sincere interpersonal engagement (Subramanian, 2018).

One of the pop culture materials that speak to the young generations is memes (Fig. 1), which are media, mostly images with texts, that may contain cultural references and social representations (Reddy *et al*., 2020). Knobel and Lankshear (2007) posited that personalities, scenes from movies and shows, famous songs, and tag lines, or combination thereof, as typical elements of memes. While many memes use references from movies and television shows, their meaning on social media might not necessarily reflect their original meaning. Memes generally develop and solidify their meaning through repeated use in the public sphere, typically online (Reddy *et al*., 2020). Thus, while the origin may be from a local reference, its usage in(on?) the internet allows the global online community to develop a common new meaning to it.

For example, Fig. 1 features a personality from an online video game show or stream. On social media, the image of him blinking is being used to signify confusion or disbelief on the events unfolding. With the addition of text in Fig. 1., the meme is taken to mean that the supposed first cell that underwent mitosis was in disbelief because of the unprecedented event. Typically, in memes, a popular culture reference mixed with scientific or technical content adds a layer of humor among the younger audience.

The use of memes in natural and social sciences classes has shown that it enhances students' mastery of the topic (Moraes, 2021; Kyrpa *et al*., 2022) and their classroom engagement (Dongqiang *et al*., 2020; Byosiere *et al*., 2021; Soler *et al*. 2021). While literature suggests memes improve academic performance, further exploration is needed in understanding how memes affect attitude and self-efficacy in the subject matter.

Thus, this quantitative study aimed to explore the effect of using memes in biology lessons in the academic achievement, attitude, and self-efficacy of Grade 11 non-STEM students. With the natural inclination of STEM students to science subjects, such as biology, this study focused on students who belong to non-science track students in senior high school (pre-university) who are required to take a science course as part of the national curriculum. In particular, this study explored the approach in topics which the said demographics historically found difficult, namely cellular division and genetics. This paper aims to contribute to the growing literature on the innovative method of teaching using memes that is effective for Gen Z's.

MATERIALS AND METHODS

Participant recruitment

The participants of the study were 243 Grade 11 non-STEM students belonging to six sections of a private high school in the Philippines. Taught by the same teacher, the sections who were invited to participate in the study were non-STEM strand, in

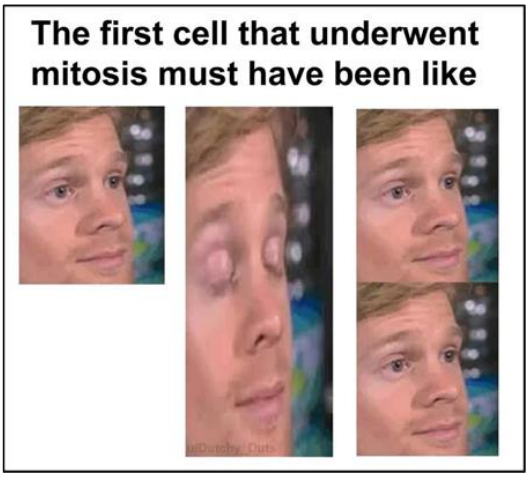


Figure 1: Sample meme using a social media reference
Image from https://i.redd.it/mjwlm7i22vj31.jpg.

order to guarantee that they were not given advanced science classes. Moreover, these sections were chosen because it was assumed that STEM section imbibes a general positive attitude and self-efficacy on the subject given their predisposition to the natural sciences and therefore would likely skew the results. Ethical clearance was secured from the Ateneo de Manila University's School of Science and Engineering Research Ethics Committee (SOSEREC_2023_010) and informed consent and assent were secured from the participants.

These classes were selected through cluster sampling by the fishbowl method. Three classes were randomly selected to be part of the experimental group while the other three classes comprised the control group. The control groups and the experimental groups were taught using the same materials with the difference that the materials for the experimental group was infused with memes.

Module development and validation

Materials developed in this study covered four topics, namely (1) Cellular Division, (2) DNA and RNA, (3) Central Dogma, and (4) Mendelian Genetics. These topics were chosen as these were among the least-learned competencies in science for non-STEM senior high schools from the previous school year. Two sets of parallel instructional materials were developed. One set contained memes in the instructor's slide deck and was used for the experimental groups, while the other set had no memes and were used for the control groups. The materials designed by us include lesson plans, PowerPoint Presentations (Appendix A), table of specifications, pre-test, post-test, and various activities. As part of the formative assessments, students were tasked to generate memes related to the topics.

The developed instructional materials were presented to four validators who were tasked to use the Department of Education (Philippines)'s official module evaluation standards. The validators of the module include two biology content experts, one English language expert, and one curriculum development expert. Additionally, two evaluators, namely one biology content expert and one anthropology expert, were invited to review the memes for scientific accuracy, relevance to the lesson, and appropriateness of the memes. This evaluation was done to ensure that the memes that were used in the module developed showed respect and cultural sensitivity, and do not violate, discriminate, or insult any individuals or cultural or ethnic groups. The materials developed in this study passed all the individual metric in the validation tools (data not presented in this study).

Incorporating memes in the lesson

Two types of memes were used in the module. The first set (Fig. 2) refers to the content-related memes whose role is to represent or repeat the discussion point in a humorous or creative way. The second set (Fig. 3) refers to icebreaker memes which do not necessarily deepen the lesson, but are inserted into the slide deck to deliberately pause briefly the discussion and/or to solicit feedback on whether the students still follow the lecture. Some memes were publicly available from the internet, while others were made using the available online templates from free websites that allow internet users to choose images and customize texts to generate their own memes such as Meme Generator (https://imgflip.com/memegenerator). It must be noted that all memes utilized in this study fall under Fair Use in the context of Philippine law, Section 185 of Republic Act No. 8293, which permits the use of copyrighted materials for purposes of education and research.

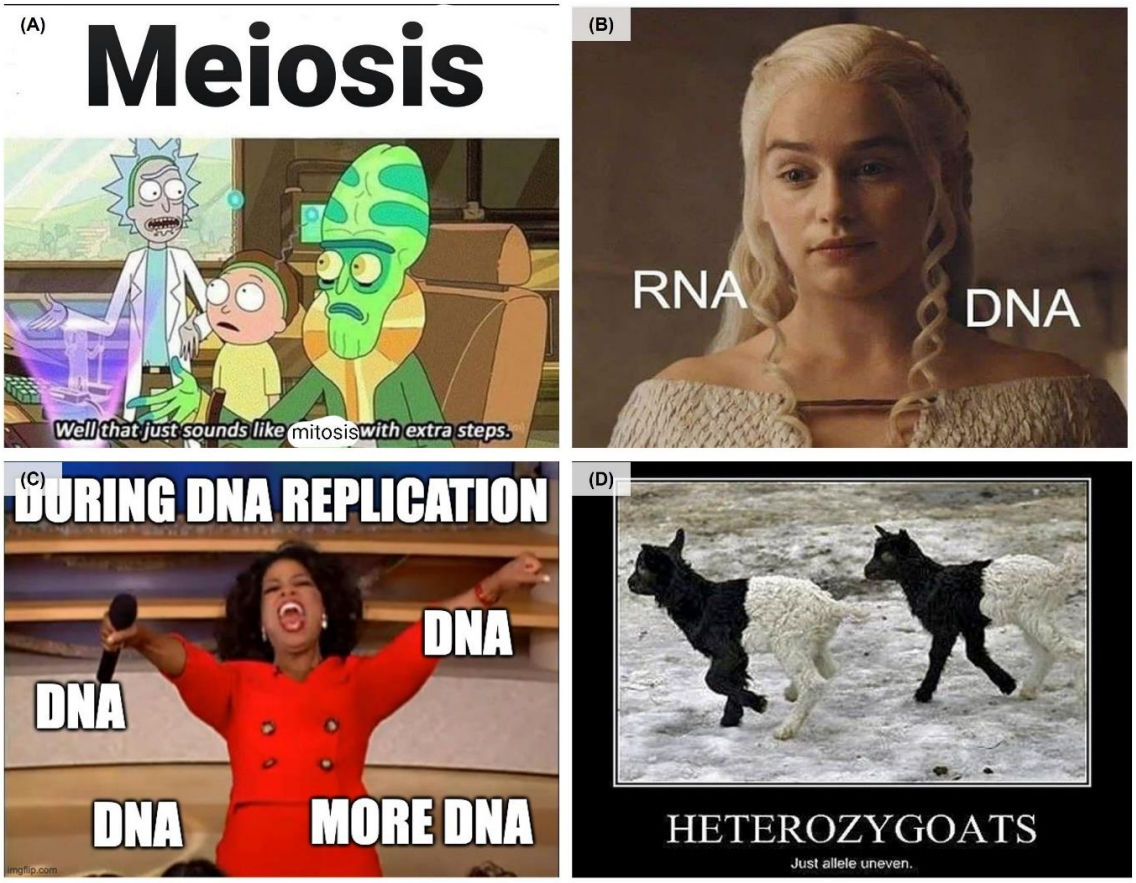


Figure 2: Sample content-related memes which are included in the slide deck

(A) Cellular Division, (B) DNA and RNA, (C) Central Dogma, and (D) Mendelian Genetics. Images were taken/adapted from (A) https://i.redd.it/euods92jfg241.jpg, (B) https://pbs.twimg.com/media/EqjyXnwXEAAHYDk.jpg, (C) https://i.imgflip.com/80oy4o.jpg, (D) https://i.pinimg.com/474x/2d/58/02/2d5802fc1c7faca10b69beb14cfaea2f--nerd-jokes-nerd-humor.jpg

Figure 3: Sample icebreaker memes which were inserted to assess their understanding

(A) cellular division and (B) the overall lesson. Images taken/adapted from (A) https://i.imgflip.com/80orsj.jpg, (B) https://giphy.com/gifs/youngertv-tv-land-tvland-l378wF1erD31LJm48 and https://giphy.com/gifs/laJU5IE8sU9AA

Most of the content-related memes and icebreaker memes were inserted within or after the informational slides about the lesson. For each of the four topics, an average of seven content-related memes and four icebreaker memes were included in the slide deck which ran for an average of 45 slides per topic.

Additionally, aside from the memes included in the module slide deck, one of the formative assessments employed in the lesson implementation entailed the participants from both the control and experimental groups to create their own content-related memes to demonstrate their understanding of Cellular Division and Genetics.

Assessing academic achievement in biology

To measure academic achievement, two parallel cognitive tests which were used as the module pre-test and module post-test were developed. Each test was designed to be a 30-item test which measured the understanding of the students of the topics presented at hand.

The scores in the pre-test were analyzed through an independent *t*-test to evaluate whether that the students in the control and experimental group have the same baseline knowledge in science. The scores in the post-test were analyzed in the same way to assess whether there was a significant difference after the module. Additionally, a paired *t*-test was used to analyze if there was a significant difference between the pre-test and post-test scores of the students in each group. For all these tests, if the *p*-value from the *t*-test is less than the 0.05 significance level, the null hypothesis is rejected.

Assessing attitude towards biology

To measure students' attitude toward biology, a modified and validated version of the Attitudes Toward Science Inventory (ATSI) originally developed by Gogolin and Swartz (1992) was administered to all participants after the module. Oducado's (2020) survey instrument validation rating scale (Appendix B) was used to validate the modified ATSI (Appendix C) to confirm whether the statements in the inventory reflect the Filipino learning context and were made to fit the lesson modules. It was presented to two validators who were chosen purposively based on their expertise on the content of biology curriculum, both of whom were the two biology content experts who also validated the modules. The modified ATSI is composed of 48-item Likert-type questions. Students answered each statement on a scale ranging from a value of 1 or strongly agree to a maximum value of 5 or strongly disagree. These statements were categorized into six constructs with eight items each: (1) perception of science, (2) anxiety toward science, (3) value of science in society, (4) self-concept in science, (5) enjoyment of science, and (6) motivation in science.

Since nominal level of measurement was used to measure the participants' attitude, the non-parametric Mann-Whitney *U* test was used to compare the results between the control and experimental groups. If the *p*-value is less than the significance level of 0.05, the null hypothesis is rejected. Mean scores of each statement in the ATSI were also computed and analyzed. The rating scales on the ATSI statements which were negatively stated were inverted in the data analysis to be consistent with the positively stated statements.

Assessing self-efficacy in biology

To assess students' self-efficacy in biology, a modified and validated version of the Biology Self-Efficacy (BSE) survey developed by Baldwin *et al*. (1999) was administered to all participants after the module. The modified BSE survey (Appendix D) consists of 23-item Likert-type ques-

tions which was also validated using Oducado's rating scale (Appendix B). Students evaluated the statements about their confidence in performing tasks related to the biology modules in Cellular Division and Genetics on a scale of 1 (totally confident) to 5 (not at all confident). The 23 statements were categorized into three dimensions: (1) methods of biology (statements 2, 3, 5, 6, 9, 12, 18, 19), (2) generalization to other biology/science courses and analyzing data (statements 8, 11, 14, 15, 17, 20, 21, 22, 23), and (3) application of biological concepts and skills (statements 1, 4, 7, 10, 13, 16). Data were analyzed similarly to ATSI results.

We conducted surveys on attitude and self-efficacy only at the end of the five-week lesson instruction in order to avoid students from experiencing survey fatigue. Hence, it would be valuable for future researchers to conduct surveys on these particular parameters before and after the intervention as a means to determine the accurate impact of memes on students' learning, especially if their lesson implementation and data gathering would span more than five weeks.

RESULTS

Students' reception of meme-infused materials

The participants from the control and experimental groups were tasked to create their own memes related to Cellular Division and Genetics. When they were asked about the task, they affirmed that creating their own memes related to their lesson was an effective strategy to enjoy the class. Additionally, some participants shared that their class had become more enticing and interesting since the teacher started incorporating memes in his slides. Other participants also claimed that memes helped them with lesson recall and retention.

Furthermore, the participants noted that the use of memes in the course was an effective method for them to review the material. This only proves that Hansen and Wilson (2023) were correct to assert that student-made memes encourage learners to think critically about the current topics they tackle in class. In relation to this, we made use of reverse image search to check whether the student-made memes were authentically produced by the students and were not simply downloaded from the internet. It has been revealed that a significant number of participants from the control group submitted already-existing downloaded memes while most of the participants from the experimental group generated their own memes. This implies that the participants from the experimental group were more inclined to create their own memes after being exposed to and taught using meme-infused teaching materials.

Effect on academic achievement

The participants from the experimental and control groups took a pre-test before the lessons on Cellular Division and Genetics were delivered and a parallel post-test after the module. While pre-test outcomes have a comparable mean of 13.29 and 13.09 for experimental and control group, respectively, the mean of the post-test scores of the experimental group is higher at 21.46 ± 4.41 than the control group at 17.74 ± 4.00 (Table 1).

The pre-test and post-test results of the control and experimental groups were treated using independent and paired *t*-test (Table 2). Independent *t*-test on the pre-test scores of the control and experimental groups (*p*-value = 0.69) confirmed that both groups had the same entry baseline knowledge on molecular genetics. While both experimental (*p*-value = 0.00) and control (*p*-value= 0.00) groups experienced an increase in academic achievement from pre-test to post-test, quantitative results demonstrate a statistically significant difference in the academic achieve-

Table1: Descriptive statistics results of the pre-test and post-test of the experimental and control groups

	Experimental group		Control group	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Mean ± SD	13.29 ± 2.57	21.46 ± 4.41	13.09 ± 3.37	17.74 ± 4.00
Min	8.33	11.67	8.33	9.67
Max	18.33	29.00	19.00	25.00
Mode	14.00	25.67	11.67	16.67
Median	13.33	21.67	12.00	17.67

Table 2: T-test results of the pre-test and post-test scores of the control and experimental groups

Null Hypothesis	***p*-value**
The median of differences between the control group's pre-test and experimental group's pre-test is equal to 0.	0.69
The median of differences between the control group's pre-test and post-test is equal to 0.	0.00
The median of differences between the experimental group's pre-test and post-test is equal to 0.	0.00
The median of differences between the control group's post-test and experimental group's post-test is equal to 0.	0.00

ment of students as supported by their post-test performance (*p*-value = 0.00) favoring the experimental group (mean = 21.46 vs. 17.74).

Effect on attitude toward biology

To assess attitude towards biology following the modules on Cellular Division and Genetics, students were asked to answer the modified ATSI after the module. Participants from both groups rated statements related to three constructs, namely perception of the science teacher (construct 1), value of science in society (construct 3), and enjoyment in science (construct 5), with a score interpreted as "Agree" (Table 3). This shows a positive attitude towards seeing the value of science in the real world and enjoying the lessons. Meanwhile, two constructs, namely having less anxiety toward science (construct 2) and witnessing self-concept in science (construct 4), recorded an "Agree" rating from the experimental group and an "Undecided" rating from the control group.

While Mann-Whitney *U* test on the attitude of the students toward biology revealed no statistically significant difference on each of the six ATSI constructs between the control and experimental groups, the overall ATSI scores showed that there is a statistically significant difference (*p*-value = 0.00) between the two groups (Table 4). This indicates that students taught with the aid of meme-infused materials had a more positive attitude towards the topic after the instruction compared to the students who were taught with materials lacking memes.

Effect on self-efficacy in biology

To assess self-efficacy of the population, the modified BSE was administered after the module. Results show that the experimental group felt "fairly confident" in all three dimensions, namely methods of biology (mean = 2.22), generalization to other biology/science courses and analyzing data (2.33), and application of biological skills (2.36), compared to the control group which rated

Table 3: Mean scores of the six constructs of the Attitudes Toward Science Inventory
(modified from Gogolin and Swartz, 1992)

	Experimental Group		Control Group	
ATSI Constructs	**Mean**	**Interpretation**	**Mean**	**Interpretation**
Construct 1: Having good perception of the science teacher	1.94	Agree	2.23	Agree
Construct 2: Having less anxiety toward science	2.27	Agree	2.57	Undecided
Construct 3: Seeing value of science in society	2.07	Agree	2.42	Agree
Construct 4: Witnessing self-concept in science	2.47	Agree	2.75	Undecided
Construct 5: Enjoying science	2.24	Agree	2.49	Agree
Construct 6: Forming sound motivation in science	2.53	Undecided	2.90	Undecided
TOTAL	13.52		15.36	

Table 4: Comparison of ATSI results using Mann-Whitney U test between the control and experimental groups

Null Hypothesis	*p*-value
Construct 1: The distribution of "Having good perception of the science teacher" is the same across categories of the control and experimental groups.	0.23
Construct 2: The distribution of "Having less anxiety toward science" is the same across categories of the control and experimental groups.	0.08
Construct 3: The distribution of "Seeing value of science in society" is the same across categories of the control and experimental groups.	0.20
Construct 4: The distribution of "Witnessing self-concept in science" is the same across categories of the control and experimental groups.	0.08
Construct 5: The distribution of "Enjoying science" is the same across categories of the control and experimental groups.	0.23
Construct 6: The distribution of "Forming sound motivation in science" is the same across categories of the control and experimental groups.	0.20
The distribution of the overall ATSI score is the same across categories of the control and experimental groups.	0.00

the dimensions as "somehow confident" (Table 5).

Moreover, the Mann-Whitney *U* test results for BSE (Table 6) revealed that there is a statistically significant difference on all three BSE dimensions (*p*-value = 0.00) favoring the experimental group.

DISCUSSION

Effect on academic achievement

These results confirm the positive effect of using memes in lectures in improving the academic achievement of students in science with statistically significant post-test scores (Table 2) between experimental group (mean = 21.46 ±

Table 5: Mean scores of the three dimensions of the Biology Self-Efficacy (Baldwin et al. 1999) survey

	Experimental Group		Control Group	
	Mean	**Interpretation**	**Mean**	**Interpretation**
Dimension 1: Methods of biology	2.22	Fairly Confident	2.77	Somewhat Confident
Dimension 2: Generalization to other biology/science courses and analyzing data	2.33	Fairly Confident	2.89	Somewhat Confident
Dimension 3: Application of biological concepts and skills	2.36	Fairly Confident	2.82	Somewhat Confident

Table 6: Comparison of BSE results using Mann-Whitney U Test between the control and experimental groups

Null Hypothesis	*p*-value
Dimension 1: The distribution of "methods of biology" is the same across categories of the control and experimental groups.	0.00
Dimension 2: The distribution of "generalization to other biology/science courses and analyzing data" is the same across categories of the control and experimental groups.	0.00
Dimension 3: The distribution of "application of biological concepts and skills" is the same across categories of the control and experimental groups.	0.00
The distribution of the overall BSE score is the same across categories of the control and experimental groups.	0.00

4.41) and control group (17.74 ± 4.00). Affirming the findings presented here, improvement of academic performance using memes was studied in various fields such as English for non-native speakers (Purnama, 2017), political science (Wells, 2018), philology (Kyrpa *et al*., 2022), and mathematics (Bini, 2021), as well as in natural science (Riser *et al*., 2020; Marymee, 2021; Moraes, 2021).

Memes were deemed to be helpful in improving students' mastery of the topic. For example, in the context of an introductory organic chemistry course, Marymee (2021) reported that the integration of topic-related memes in assessments improved students' understanding and retention of the material, and higher assessment marks. Moreover, whether used by the teachers or made by the students, memes were identified to pave the way for the development of critical thinking and scientific literacy of learners (Moraes, 2021; Riser *et al*., 2022), especially in the field of natural sciences such as biology, chemistry, and physics (Lopes, 2023).

Furthermore, the results of this study suggest that the students taught with meme-infused materials were able to understand and retain scientific information better than their counterparts from the control group. These results support the idea of Moraes (2021) which posited that memes are vital tools in the dissemination of scientific information due to the interesting appeal of the images to the younger generations.

Effect on attitude toward biology

The overall ATSI score (Table 3) of the experimental group (total = 13.52) is statistically

significant compared to the control group (total = 15.36). This signifies that the experimental group composed of non-STEM students has a more positive attitude towards the biology following the intervention compared to the control group. Koballa and Glynn (2007) and Schruba (2008) posited that the strategies the teacher uses in class heavily influence students' attitude towards the subject. A learning environment with varied teacher strategies and unconventional student tasks supplemented by student engagement fosters a strong positive attitude toward science among the students (Myers and Fouts, 1992; Ershler and Stabile, 2015; Brown, 2020; Cromby, 2022). Similar trend was also noted when memes were used in literature and language classes (Dongqiang *et al*., 2020; Adha et al., 2023), though not in a political science class (Galipeau, 2023).

One possible reason for the improvement in the attitude towards biology is the memes as being means to facilitate active learning. Teaching strategies and student activities that promote active learning are effective in establishing a positive attitude toward science subject matter (Koballa and Glynn 2007; Freeman *et al*., 2014; Cooper *et al*., 2018). Utilizing memes in lectures and meme-making itself can be described as entertaining because they break the class monotony. Moreover, the novelty and unconventionality of memes in lectures might be deemed effective in piquing student interest, and thus improving their attitude toward biology.

Moreover, the experimental group rated two constructs, namely having less anxiety toward science (construct 2; 2.27 vs. 2.57) and witnessing self-concept in science (construct 4; 2.47 vs. 2.75), as "Agree" compared to the "Undecided" rating from the control group (Table 3). In the classroom context, Covington (1992) described anxiety as a reaction to the possibility of failure which can be overwhelming for students, especially when they exert extra effort into a task because they feel incompetent. Such feeling might be natural for students chartering an unfamiliar topic (Mallow *et al*., 2010; Bryant *et al*., 2012), which is akin to non-STEM students taking on a pre-university science class.

Meanwhile, science self-concept is defined as one's perception regarding their general capability in science (Sarsani, 2007; Jansen *et al*., 2014, 2015). While this study treated academic achievement and attitude toward science as separate variables, several studies also reveal that a high level of self-concept in science is a positive predictor of academic achievement in science (Jansen *et al*., 2014; Zhang *et al*., 2021). Thus, the introduction of memes, as shown in this study, was able to alleviate such anxious feelings towards biology and was able to help build the students' perception regarding their ability toward the subject matter.

Effect on self-efficacy in biology

This study has shown that the experimental group has a higher self-efficacy score that the control group (p-value = 0.00) across three dimensions (Tables 5, 6), namely methods of biology (mean = 2.22 vs. 2.77), generalization to other biology/science courses and analyzing data (2.33 vs. 2.89), and application of biological concepts and skills (2.36 vs. 2.82). Across these dimensions, the experimental group rated the statements as "Fairly confident" compared to the control group which gave a "Somewhat confident" rating. Previous research shows that higher self-efficacy is related to lower anxiety toward science (Britner, 2008; Griggs *et al*., 2013; Ardasheva *et al*., 2018). The experimental group experienced lower levels of anxiety toward science (mean = 2.27 vs. 2.57, Table 3) and greater levels of self-efficacy in biology (p-value = 0.00, Table 6) compared to the control group. The

outcome indicates that the students from the experimental group had greater confidence in all three BSE dimensions compared to their counterparts from the control group after the lesson implementation with the use of meme-infused instructional materials. With memes embedded in the teacher lectures, our findings show that students felt more confident in understanding the concepts well, performing tasks better, and being successful in the course.

Improving self-efficacy in the classroom is important as it contributes to learning. Similar to the case of attitude towards science, while academic achievement and self-efficacy were treated as separate variables in this study, self-efficacy in science can be a strong predictor of learners' academic achievement (Tuan *et al*., 2005; Usher and Pajares, 2008; Ahmad and Safaria, 2013; Honicke and Broadbent, 2016). Students with greater self-efficacy in science are more confident in their abilities, more eager to accomplish science-related activities, and more determined in completing challenging science tasks (Baldwin *et al*., 1999; Britner and Pajares, 2006). In this study, the experimental group demonstrated a greater sense of self-efficacy as well as better academic achievement in biology compared to the control group. These findings suggest that the use of meme-infused materials is effective in improving students' self-efficacy and consequently, their academic achievement.

CONCLUSIONS

This study has shown that using memes in discussing Cellular Division and Genetics topics to non-STEM pre-university students improves their academic performance, attitudes towards science, and self-efficacy. This suggests that innovative teaching strategies that utilize materials which Gen Z's find relatable and accessible are beneficial for student's learning in biology. With the comparison of pre-test and post-test scores, there is a statistically significant difference in the academic achievement between the group which received meme-infused materials and the group which did not encounter the meme-centered intervention. Thus, the use of memes in lectures aid in the improvement of learning and academic performance of non-STEM Gen Z students, especially on the science concepts and competencies commonly perceived as complex and challenging by students.

Moreover, through comparison of ATSI and BSE scores, it was identified that the use of memes in tackling a difficult topic and the creation of memes by the students helped the participants develop a positive attitude toward biology and higher sense of self-efficacy in biology. Scanning the particular indicators, such effect was generated by helping the students manage their anxiety towards biology and by boosting their confidence in their capacity in the subject matter.

By examining the effect of internet memes on high school Gen Z students' academic achievement, attitude and self-efficacy in science, teachers can identify potential tools, instructional materials, and pedagogical strategies that they may utilize to better cater to this new generation of learners. High school science educators may benefit from the findings of this study by designing their lectures, assessments, and classroom management techniques with humorous elements like memes to improve student interest and success in class. Future explorations on the use of meme in biology education can focus on examining its impact on student motivation, belief, and learner engagement among others. Further studies can also delve into dissecting the effect of the timing of usage and nature of memes used in the classroom.

ACKNOWLEDGEMENTS

The first author expresses her utmost gratitude to DOST-SEI Capacity Building Program in Science and Mathematics Education (CBPSME) for the support for her graduate studies and this research. We also thank Dr. Crisanto Lopez, Ms. Maria Katrina Constantino, and Mr. Galvin Radley Ngo for their constructive inputs to this study.

REFERENCES

Adha, U. A., Rezeki, Y. S., Husin, S., Rosnija, E. and Rahmani, E. F. (2023) Students' attitudes towards internet memes in writing descriptive text. *Acitya: Journal of Teaching and Education* **5**(2): 244–261.

Ahmad, A. and Safaria, T. (2013) Effects of self-efficacy on students' academic performance. *Journal of Educational, Health and Community Psychology* **2**(1): 19-25.

Alexander, A. (2012) Understanding and meeting the needs of the millennials in the classroom: a literature review. Graduate Research Papers. https://scholarworks.uni.edu/cgi/viewcontent.cgi?article=1122&context=grp < Accessed, July 6, 2024>

Ardasheva, Y., Carbonneau, K. J., Roo, A. K. and Wang, Z. (2018) Relationships among prior learning, anxiety, self-efficacy, and science vocabulary learning of middle school students with varied English language proficiency. *Learning and Individual Differences* **61**: 21–30.

Baldwin, J. A., Ebert-May, D. and Burns, D. J. (1999) The development of a college biology self-efficacy instrument for nonmajors. *Science Education* **83**(4): 397–408.

Bini, G. (2021) How Spiderman can teach you math: The journey of memes from social media to mathematics classrooms. *Conference Proceedings. Proceedings of the 2020 Connected Learning Summit.*

Britner, S. L. and Pajares, F. (2001) Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering* **7**(4): 271–285.

Brown, J. D. (2020) What do you meme, Professor? An experiment using "memes" in pharmacy education. *Pharmacy* **8**(4): 202.

Bryant, F. B., Kastrup, H., Udo, M., Hislop, N., Shefner, R. and Mallow, J. (2012) Science anxiety, science attitudes, and constructivism: A binational study. *Journal of Science Education and Technology* **22**(4): 432–448.

Byosiere, S. E., Blackwell, E., Gordon, M. and Ventura, B. (2021) MEME: motivating engagement using meme examples. *The Journal of Interactive Technology & Pedagogy* https://jitp.commons.gc.cuny.edu/meme-motivating-engagement-using-meme-examples/ <Accessed: June 2, 2024>

Cooper, K. M., Downing, V. R. and Brownell, S. E. (2018) The influence of active learning practices on student anxiety in large-enrollment college science classrooms. *International Journal of STEM Education* **5**(1):1–18.

Covington, M. V. (1992) *Making the grade*. California: Cambridge University Press, 351 pp.

Cromby, A. (2022) A case for internet memes in education: a focus on mathematics and medical science. *Research in Teacher Education* **12**(1): 6–11.

Dongqiang, X., De Serio, L., Malakhov, A. and Matys, O. (2020) Memes and education: opportunities, approaches, and perspectives.

Geopolitical, *Social Security and Freedom Journal* **3**(2): 14–25.

Ershler, J. and Stabile C. (2015) The learning virus: An affective, constructivist movement shaped by ultrasociality in the age of social media. *New Directions for Teaching and Learning* **2015**(144): 5–21.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H. and Wenderoth, M. P. (2014) Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences* **111**(23): 8410–8415.

Galipeau, T. (2023) The impact of political memes: a longitudinal field experiment. *Journal of Information Technology & Politics* **23**: 437–453.

Gogolin, L. and Swartz, F. (1992) A quantitative and qualitative inquiry into the attitudes toward science of nonscience college students. *Journal of Research in Science Teaching* **29**(5): 487–504.

Griggs, M. S., Rimm-Kaufman, S. E., Merritt, E. G. and Patton, C. L. (2013) The responsive classroom approach and fifth grade students' math and science anxiety and self-efficacy. *School Psychology Quarterly* **28**(4): 360–373.

Hansen, J. and Wilson P. (2023) Increasing student engagement using 'meme based' exercise innovation. *Marketing Education Review* **33**(2): 113–117.

Honicke, T. and Broadbent, J. (2016) The influence of academic self-efficacy on academic performance: A systematic review. *Educational Research Review* **17**: 63–84.

Jansen, M., Schroeders, U. and Lüdtke, O. (2014) Academic self-concept in science: Multidimensionality, relations to achievement measures, and gender differences. *Learning and Individual Differences* **30**:11–21.

Jansen, M., Scherer, R., Schroeders, U. (2015) Students' self-concept and self-efficacy in the sciences: Differential relations to antecedents and educational outcomes. *Contemporary Educational Psychology* **41**: 13–24.

Knobel, M. and Lankshear, C. (2007) Online memes, affinities, and cultural production. *A New Literacies Sampler* **29**: 199–227.

Koballa, T. R. and Glynn, S. M. (2007) Attitudinal and motivational constructs in science learning. In: Abell, S. K. and Lederman, N. G. (eds.) *Handbook of research on science education*. Lawrence Earlbaum Associates.

Kyrpa, A., Stepanenko, O., Zinchenko, V., Udovichenko, H. and Dmytruk, L. (2022) Integration of internet memes when teaching philological disciplines in higher education institutions. *Advanced Education* **20**: 45–52.

Lopes, J. (2023). Research on memes in the teaching of natural sciences. *Brazilian Journal of Science Teaching and Technology* **16**:1–19.

Mallow, J., Kastrup, H., Bryant, F. B., Hislop, N., Shefner, R. and Udo, M. (2010) Science anxiety, science attitudes, and gender: Interviews from a binational study. *Journal of Science Education and Technology* **19**(4): 356–369.

Manzoni, B., Caporarello, L., Cirulli, F. and Magni, F. (2021) The preferred learning styles of generation Z: Do they differ from the ones of previous generations? *In*: Metallo, C., Ferrara, M., Lazazzara, A., Za, S. (eds) *Digital Transformation and Human Behavior. Lecture Notes in Infor-*

mation Systems and Organisation vol 37, pp. 55–67. Springer, Cham.

Marymee, K.B. (2021) *Using memes as educational vectors: analyzing under-standing amongst college students in introductory organic chemistry*. Thesis. University of California, Riverside.

McGuire, S.Y., Williams, D.A. (2002) The millennial learner: challenges and opportunities. *To Improve the Academy: A Journal of Educational Development.* **20**: 185–196.

Monaco, M. and Martin, M. (2007) The millennial student: a new generation of learners. *Athletic Training Education Journal* **2**(2): 42–26.

Moraes, I. T. S. (2021) Memes and science: a modern investigation. *United Inter-national Journal for Research & Technology* **2**(6): 37–46.

Myers, R. E. and Fouts, J. T. (1992) A cluster analysis of high school science classroom environments and attitudes toward science. *Journal of Research in Science Teaching* **29**(9): 929–937.

Nicholas, A. J. (2020) Preferred learning methods of Generation Z. *Faculty and Staff - Articles & Papers*. **74**. https://digitalcommons.salve.edu/fac_staff_pub/74_<Accessed Dec. 3, 2024>

Purnama, A. D. (2017) Incorporating memes and Instagram to enhance student's participation. *LLT Journal: A Journal on Language and Language Teaching* **20**(1): 1–14.

Reddy, R., Singh, R., Kapoor, V. and Churi, P. (2020) Joy of learning through internet memes. *International Journal of Engineering Pedagogy* **10**(5): 116–133.

Riser, D. K., Clarke, S. D. and Stallworth, A. N. (2020) Scientific memes: using the language of social media to improve scientific literacy and communication in lifespan development. *Psychology Learning and Teaching* **19**(3): 275–289.

Sarsani, M. R. (2007) A Study of the relationship between self-concept and adjustment of secondary school students. *Journal on Educational Psychology*. **1**(2): 10–18.

Schruba, A. E. (2008) *Evaluation of student attitude toward science and self-efficacy in a non-majors college biology course*. TCU Digital Repository. Thesis. Texas Christian University.

Schwartz, A. C., McDonald, W. M., Vahabzadeh, A. B. and Cotes, R. O. (2018) Keeping up with changing times in education: fostering lifelong learning of millennial learners. *Fostering Lifelong Learning of Millennial Learners* **16**(1): 74–79.

Soler, L. and Odedra, S. (2021) The magical effect of memes and gifs for feedback. *In*: Tasler, N., R.E. O'Brien, A. Spiers, A. (eds.) *Being Creative in the Face of Adversity - Annual #CreativeHE Collection 2021*, pp. 139–143. Creativity for Learning in Higher Education Community.

Subramanian, K. R. (2018) Myth and mystery of shrinking attention span. *International Journal of Trend in Research and Development* **5**(3): 1–6.

Tuan, H., Chin, C. and Shieh, S. (2005) The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education* **27**: 639–654.

Twenge, J. M. (2018) *iGen: Why today's super-connected kids are growing up less rebellious, more tolerant, less happy and completely unprepared for adulthood*. Atria, New York. 342 pp.

Usher, E. L. and Pajares, F. (2008) Sources of self-efficacy in school: Critical review of

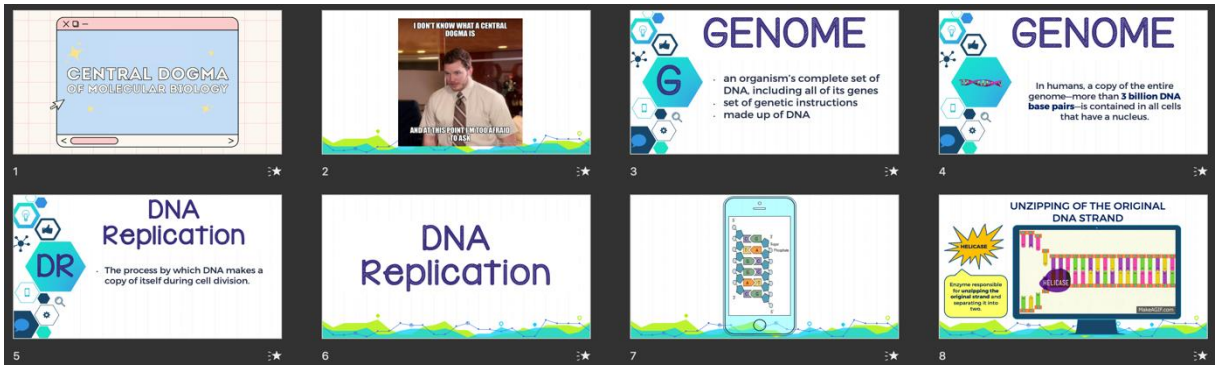
the literature and future directions. *Review of Educational Research* **78**(4): 751–796.

Wells, D. D. (2018) You all made dank memes: Using internet memes to promote critical thinking. *Journal of Political Science Education* **14**(2): 240–248.

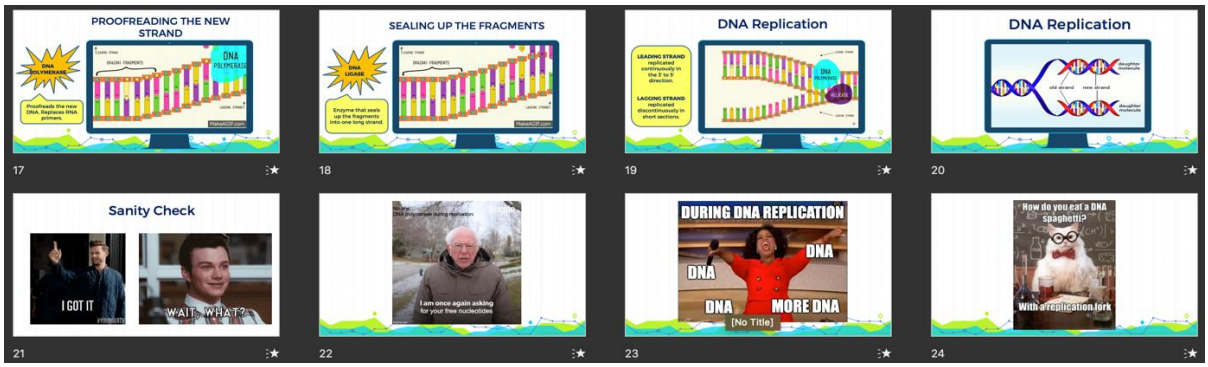
Zhang, F., Bae, C. L. and Broda, M. (2021) Science self-concept, relatedness, and teaching quality: a multilevel approach to examining factors that predict science achievement. *International Journal of Science and Mathematics Education* **20**: 503–529.

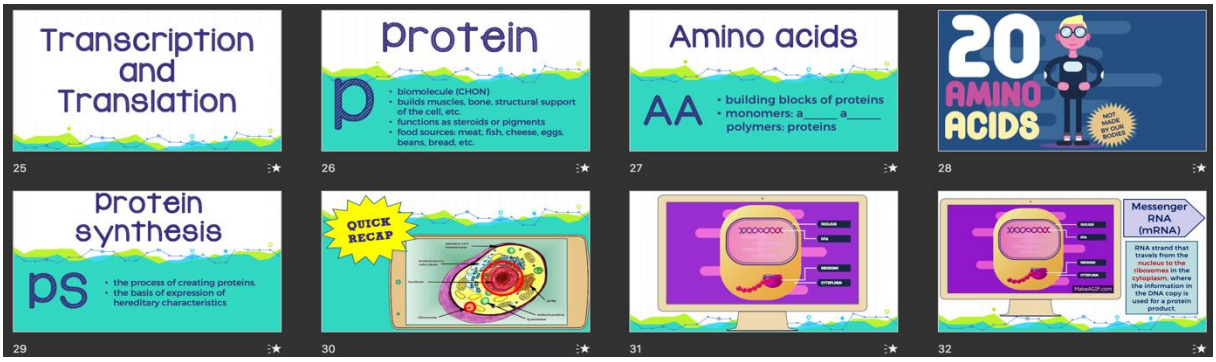
APPENDICES

Appendix A: Teacher's slide deck for a sample module



Slides 9–16: omitted





Slide 33–40: omitted

Appendix B: Validation tool for modified ATSI and BSE (Oducado, 2020)

Instruction: Please indicate your degree of agreement or disagreement on the statements provided below by encircling the number which corresponds to your best to your judgment.

1 – Strongly Disagree **2** – Disagree **3** – Undecided **4** – Agree **5** – Strongly Agree

1.	The items in the instrument are relevant to answer the objectives of the study.	1	2	3	4	5
2.	The items in the instrument can obtain depth to constructs being measured.	1	2	3	4	5
3.	The instrument has an appropriate sample of items for the construct being measured.	1	2	3	4	5
4.	The items and their alternatives are neither too narrow nor limited in its content.	1	2	3	4	5
5.	The items in the instrument are stated clearly.	1	2	3	4	5
6.	The items on the instrument can elicit responses which are stable, definite, consistent and not conflicting.	1	2	3	4	5
7.	The terms adapted in the scale in the scale are culturally appropriate.	1	2	3	4	5
8.	The layout or format of the instrument is technically sound.	1	2	3	4	5
9.	The responses on the scale show a reasonable range of variation.	1	2	3	4	5
10.	The instrument is not too short or long enough that the participants will be able to answer it within a given time.	1	2	3	4	5
11.	The instrument is interesting such that participants will be induced to respond to it and accomplish it fully.	1	2	3	4	5
12.	The instrument as a whole could answer the basic purpose for which it is designed.	1	2	3	4	5
13.	The instrument is culturally acceptable when administered in the local setting.	1	2	3	4	5
	TOTAL					

Comments/Suggestions:

Evaluator's name: _____
Evaluator's signature: _____
Date: _____

Appendix C: Attitudes Towards Science Instrument (ATSI), modified from Gogolin & Swartz (1992)

Perception of the science teacher (construct 1)

5. Earth and Life Science teachers show little interest in their students.
17. Earth and Life Science teachers make science interesting for me.
21. Science teachers present materials in a way that I understand.
27. Science teachers know when I am having trouble with my assignments.
31. Earth and Life Science teachers do not seem to enjoy teaching science.
40. Science teachers are willing to give me individual help.
44. Earth and Life Science teachers know a lot about science.
46. Science teachers do not like students to ask questions.

Anxiety toward science (construct 2)

7. I feel at ease in an Earth and Life Science class.
11. When I hear the word "science", I have a feeling of dislike.
20. I feel tense or upset when someone talks to me about Earth and Life Science.
25. It does not disturb or upset me to do written works and performance tasks in Earth and Life Science.
34. Working with science upsets me.
36. It makes me nervous to even think about doing science.
39. It scares me to have to take a science class, especially since I am in a non-STEM strand.
43. I have a good feeling toward science.

Value of science in society (construct 3)

1. Earth and Life Science is useful for solving the problems of everyday life.
9. There is little need for Earth and Life Science in most of today's jobs.
12. Most people should study some Earth and Life Science.
15. Earth and Life Science is helpful in understanding today's world.
23. Science is of great importance to our country's development.
24. It is important to know science in order to get a good job.
33. You can get along perfectly well in everyday life without science.
38. Most of the ideas in Earth and Life Science are not very useful.

Self-concept in science (construct 4)

4. I do not do very well in Earth and Life Science.
10. Earth and Life Science is easy for me.
16. I usually understand what we are talking about in Earth and Life Science.
19. No matter how hard I try, I cannot understand Earth and Life Science.
22. I often think, "I cannot do this," when a Earth and Life Science assignment seems hard.
30. I am good at working science labs and hands-on activities.
35. I remember most of the things I learned in science class when I was in junior high.
48. If I do not see how to do an Earth and Life Science assignment right away, I never get it.

Enjoyment in science (construct 5)

2. Earth and Life Science is something that I enjoy very much.
6. Doing science labs or performance tasks is fun.

13. I would like to spend less time in school studying Earth and Life Science.
18. I do not like anything about Earth and Life Science.
26. I would like a job that does not use any science.
28. I enjoy talking to other people about science.
29. I enjoy watching a science program/video on television or online.
45. Earth and Life Science is one of my favorite subjects.

Motivation in science (construct 6)

3. I like the easy Earth and Life Science written works and performance tasks best.
8. I would like to do some extra or unassigned reading in Earth and Life Science.
14. Sometimes I read ahead in our Earth and Life Science modules.
32. I like the challenge of science written works and performance tasks.
37. I would rather be told scientific facts than find them out from experiments and performance tasks.
41. The only reason I am taking Earth and Life Science is because I have to.
42. It is important to me to understand the work I do in Earth and Life Science class.
47. I have a real desire to learn Earth and Life Science.

Appendix D: Biology Self-efficacy (BSE) instrument, modified from Baldwin et al. (1999)

Methods of biology (dimension 1)

2. How confident are you that you could critique a lesson summary written by another student?
3. How confident are you that you could create an accurate meme about Cellular Division and Genetics?
5. How confident are you that you could learn about an Earth and Life Science lesson and feel sure about creating your own meme about it?
6. How confident are you that you could write about the mitotic and meiotic stages?
9. How confident are you that you could write about the process of creating monohybrid and dihybrid crosses?
12. How confident are you that you could write about DNA and RNA?
18. How confident are you that you could tutor another student on Cellular Division and Genetics?
19. How confident are you that you could understand a mitotic/meiotic diagram in a biology textbook (i.e. determine the stages)?

Generalization to other biology/science courses and analyzing data (dimension 2)

8. How confident are you that you will be successful in this course?
11. How confident are you that you will be successful in another biology course?
14. How confident are you that you would be successful in an ecology course?
15. How confident are you that you could analyze a monohybrid/dihybrid cross (i.e., look at the genotypes and phenotypes)?
17. How confident are you that you would be successful in a human physiology course?
20. How confident are you that you could tutor another student for this Earth and Life Science course?

21. How confident are you that you could ask a meaningful question that could be answered experimentally/through a hands-on activity?
22. How confident are you that you could explain something that you learned in this Earth and Life Science course to another person?
23. How confident are you that you could use a scientific approach to solve a problem at home?

Application of biological concepts and skills (dimension 3)

1. How confident are you that after being taught lessons in Cellular Division and Genetics, you could write a summary of the main points of the lessons?
4. How confident are you that after being taught lessons in Cellular Division and Genetics, you could explain its main ideas to another person?
7. How confident are you that after watching an informative video dealing with some aspect of biology, you could write a summary of its main points?
10. How confident are you that after watching an informative video dealing with some aspect of biology, you could explain its main ideas to another person?
13. How confident are you that after listening to a public lecture regarding some biology topic, you could write a summary of its main points?
16. How confident are you that after listening to a public lecture regarding some biology topic, you could explain its main ideas to another person?

Asian Journal of Biology Education, 2024
https://doi.org/10.57443/jabe.16.0_54

Country Report

Biodiversity-related Content Currently Taught in Upper Secondary Biology in Japan - Especially Biodiversity -related Terms Found in Textbooks

Nobuyasu KATAYAMA*, Teiko NAKAMICHI
Tokyo Institute of Biology Education

(Received: 05 September 2024; Accepted for publication: 17 December 2024)

In the current Japanese Upper Secondary School National Curriculum Standard, biodiversity is one of the main learning topics in biological subjects, particularly in Basic Biology. As part of a study on teaching biodiversity in upper secondary school biology classes, we examined the treatment of biodiversity-related contents and terminology in currently used ten Basic Biology textbooks and five Advanced Biology textbooks. There were considerable differences in content about biodiversity, its frequency, and the terms used in these textbooks. In Basic Biology textbooks, 7 - 17% of the 150 - 240 text pages were allocated to biodiversity-related contents. Most textbooks covered all categories which Sakir and Kim (2021) proposed. The number of biodiversity-related terms in each textbook ranged from 41 - 71, of which 20 - 44 were listed in the index, and 8 - 18 were treated as key terms. Key terms common to most textbooks were biodiversity, species diversity, alien species, endangered species, extinction, ecosystem services, and environmental impact assessment. In the Advanced Biology textbooks, the pages allocated to biodiversity-related contents were only 2 - 5% of the 270 - 428 text pages. Some of these textbooks were missing some of Sakir and Kim's categories. The number of biodiversity-related terms in each textbook ranged from 33 - 56, of which 14 - 28 were listed in the index, and 7 - 13 were treated as key terms. Examples of major key terms used in Advanced Biology textbooks included biodiversity, genetic diversity, species diversity, ecosystem diversity, disturbance, Allee's effect, inbreeding depression, vortex of extinction, and ecosystem services. Based on our findings, we argue that textbook editors/authors need to give more consideration to contents, terminology, and the arrangement of topics pertaining to biodiversity to help students fully understand the importance of biodiversity conservation.

Keywords: *Advanced Biology, Basic Biology, biodiversity-related terms, National Curriculum Standard, Japan, text-book survey, upper secondary school*

***Author for correspondence:** katayama@u-gakugei.ac.jp

INTRODUCTION

Sakir and Kim (2021) presented their report on the biodiversity-related contents in secondary school biology textbooks from Korea, Indonesia, and the United States of America. In their paper, they wrote that they intend to carry out the same study on biology textbooks from other countries such as Japan in future study. They will possibly choose one Japanese biology textbook as they chose only one textbook from each country in their research. However, in Japan, there are 10 different Basic Biology textbooks (In fact, 11 different textbooks were published, two of which were identical in contents and only differed in book size. Therefore, we consider them to be of the same type.) and five

Advanced Biology textbooks published and used nowadays, and there is a considerable difference in the contents between them. Even if Sakir and Kim were to select one each among these textbooks which is mostly used in Japanese upper secondary schools, the survey results might only reflect a portion of biodiversity education being conducted at upper secondary schools in Japan.

In Japan, a detailed textbook survey was conducted into how biodiversity conservation had been taught in upper secondary school biology subjects under the Upper Secondary School National Curriculum Standard (USS-NCS), which was revised four times between 1970 and 1999 (Kato, 2016a, 2016b). Additionally, surveys have been conducted on the treatment of invasive alien species in upper secondary biology textbooks published in 2012 (Doi and Hayashi, 2015) and in 2014-2015 (Higa, 2019). The latest revision of the USS-NCS was carried out in 2018, and the contents of the biology subjects "Basic Biology" and "Advanced Biology" in the USS-NCS, have already been reported by Nakamichi *et al*. (2023). However, no report has yet been published on the topics related to biodiversity and its conservation that are being taught under the current USS-NCS framework. According to the current USS-NCS (MEXT, 2018), biodiversity is one of the most important topics to be taught in the subject area of biology, particularly in Basic Biology, which more than 90% of students take during their time in upper secondary school (this percentage is estimated by the method of Nakamichi and Katayama, 2018, by using the data provided by The Jiji Press, 2024).

To find out what topics related to biodiversity are currently being taught in upper secondary school biology subjects in Japan, we surveyed the contents and terminology related to biodiversity in the current USS-NCS (MEXT, 2018) and its Guidelines (MEXT, 2021) as well as in currently used Basic Biology and Advanced Biology textbooks. In the present paper, we mainly focus on the terms found in these surveyed materials. We also have investigated what content and how much detail is provided in textbooks regarding biodiversity and its conservation, and what kind of organisms are introduced in them. We will report these results in detail in the future.

MATERIALS AND METHODS

USS-NCS and Its Guidelines

These materials were downloaded from the MEXT website (See References).

Textbooks Surveyed

There are five publishers (Daiichi Gakushusha Corp.; Jikkyo Shuppan Co., Ltd.; Shinkoshuppansha Keirinkan Co., Ltd.; Suken Shuppan Co., Ltd. ; Tokyo Shoseki Co., Ltd.) each of which has published two sorts of Basic Biology textbooks in 2022 and one Advanced Biology textbook in 2023 (See the list in the “Biology Textbooks Surveyed” section at the end of the text). For the convenience of the survey, we numbered textbooks.

Regarding Basic Biology textbooks, #01 and #02 are published by the same publisher, and the editors and authors of these textbooks are almost all the same. Similarly, a pair of textbooks #03 and #04, #05 and #06, #07 and #08, #09 and #10 are published by four different publishers (one for each pair), and the textbooks in each pair have almost the same editors and authors. (see Biology Textbooks Surveyed section at the end). Of the two Basic Biology textbooks published by each textbook publisher, one has easier contents than the other except for #05 and #06. In this paper, we call the former *E* (easy) edition, and the latter *O* (ordinary) edition.

Determination of Biodiversity-related Contents and Terms

For determining biodiversity-related contents and terms, we first referred to Kato's (2016a, 2016b) description on biodiversity, and the categorization of biodiversity and contents provided by Sakir and Kim (2021). However, there seemed to be some other topics related to biodiversity that were not included in their descriptions and categories. Thus, we listed terms found in the USS-NCS, its Guidelines, and Basic Biology and Advanced Biology textbooks that we thought were related to biodiversity. Any terms which described some relevance to biodiversity even if in only one textbook, were considered as biodiversity-related terms and the topics included these terms as biodiversity-related contents. These terms are shown in the table in the Appendix.

Data Collection

For the USS-NCS and its Guidelines, we searched terms related to biodiversity and examined what were described.

For textbooks, we collected and analyzed data in terms of the number of pages which include biodiversity-related contents, the number of biodiversity-related terms found in the text, and whether these terms were collected in the index and treated as key terms. In the textbooks, key terms were either grouped in the margins of the page or printed in bold in the text.

Terminology

When compiling the list of terms from the USS-NCS, its Guidelines, and textbooks, difficulties arose in translating Japanese terms into English. Sometimes a single term referred to two phenomena, but sometimes multiple terms with different Japanese spellings were used to refer to the same phenomenon.

As an example for the former, the USS-NCS and its guidelines used the same Japanese phrase SEIBUTSU NO TAYOUSEI to describe "the existence of organisms having a variety of different characteristics in the natural world" and "the degree of diversity of organisms in a certain area." However, some textbooks distinguished between the two, using SEIBUTSU NO TAYOUSEI and the compound term SEIBUTSU_TAYOUSEI to describe the former and the latter, respectively. Therefore, we distinguished them by using the terms, the diversity of organisms and biodiversity.

As an example for the latter, there were four different words/phrases for genetic diversity in biology textbooks as follows: IDENTEKI_TAYOUSEI, IDENTEKI NA TAYOUSEI, IDENSHITEKI_TAYOUSEI, IDENSHI NO TAYOUSEI. As the definitions of these words/phrases did not seem to be strictly the same, we distinguished the former two as genetic diversity and the latter two as gene diversity/the diversity of genes.

Thus, in the present paper, we have attempted to translate as closely as possible these terminological differences into English. Terminology issues are discussed in more detail in the Discussion section.

Data Analysis

For the convenience of data analysis, we classified the biodiversity-related contents and terms. To do so, we set three ranks of categories: superordinate categories, subordinate categories, and specific individual categories and classified each term found in the textbooks surveyed into the most appropriate specific individual category (See the table in the Appendix). For classifying these biodiversity-related terms, we referred to Sakir and Kim (2021). However, we did not follow their classification completely because their paper does not list all biodiversity-related terms, particularly there were no terms/examples for local biodiversity.

Therefore, our categorization and classification may be somewhat subjective, and thus our classification should be considered further.

In addition, the results of our survey are also somewhat subjective, since it is very difficult to determine whether various terms found in textbooks are related to "biodiversity," and whether it is necessary to distinguish between terms that are written in different Japanese spellings as described above.

We tried to find out whether Japanese biology textbooks contained topics that fit Sakir and Kim's (2021) categorization by referring to the terms listed in their report. However, the attempt was not completely successful because many terms found in Japanese textbooks were not found in their report.

RESULTS AND DISCUSSION

Biodiversity Contents in USS-NCS and Its Guidelines

According to the present USS-NCS (MEXT, 2018) and its Guidelines (MEXT, 2021), in Basic Biology, students are supposed to learn about the unity (commonality) and diversity of organisms in the first section "Unity and Diversity of Organisms" of Unit 1 "Characteristics of Organisms." In this section, the emphasis is on the commonality of living things, *i.e.*, that all living organisms have a lot of common characteristics because they descended from common ancestors. Furthermore, the diversity of organisms* in this unit does not indicate the same concept as biodiversity, since the term stresses that organisms are very diverse.

* From here on, biodiversity-related terms found in the USS-NCS and its Guidelines, as well as in biology textbooks, will be underlined.

Therefore, in Basic Biology, students learn about biodiversity (in the USS-NCS and its Guidelines, it was written as the diversity of organisms) in Unit 3 "Diversity of Organisms, and Ecosystems," particularly in the Chapter "Ecosystems and Their Conservation." In this chapter, there are two sections, "Ecosystems and Diversity of Organisms" and "Ecosystem Balance and Conservation." In the former section, it is recommended “to allow students to discover and understand the species diversity of organisms in ecosystems through observations and experiments on ecosystems and the diversity of organisms, and to relate and understand the species diversity and the relationships between organisms (MEXT, 2021).” In the latter section, it is recommended “to allow students to understand the relationship between ecosystem balance and artificial disturbance based on materials related to ecosystem balance, and to recognize the importance of ecosystem conservation (MEXT, 2021).” In addition, some related topics, such as the extinction of organisms and ecosystem disturbance by human activities which results in damaging the diversity of organisms, are recommended to be taught.

In the USS-NCS and its Guidelines, the content description for Advanced Biology does not indicate a specific chapter or section in which to teach biodiversity and related topics. Furthermore, there is no explanation about biodiversity-related topics, and no terms related to biodiversity other than conservation were found. Thus, we considered that biodiversity and its related topics possibly could be taught in Unit 5 "Communities and Their Environments" which comprises four chapters: "Populations," "Communities," "Matter Production and Cycle in Ecosystems," and "Ecosystems and Human Life."

Only seven biodiversity-related terms were found in the USS-NCS and its Guidelines. Among these terms, conservation was found

once in the content description for Advanced Biology while the other terms were found only in Unit 3 "Diversity of Organisms, and Ecosystems" of Basic Biology (Table 1).

Biodiversity Contents in Basic Biology Textbooks

Almost all topics related to biodiversity were dealt in the chapter "Ecosystems and Their Conservation" though in some textbooks a few biodiversity-related terms, such as the diversity of organisms, conservation, and extinction, were found and explained in the other sections. The number of pages allocated to this chapter ranged from 14 to 34, a difference of more than twofold among textbooks (Table 2). We simply compared the percentage of pages allocated to this chapter, but the comparison is not exact, because the size of these textbooks and the number of characters per page were not necessarily the same. Compared to the *O* edition from each publisher, the *E* edition had fewer pages of the main text, but the proportion of pages allocated to this chapter was slightly less or almost the same. Textbooks #03 and #04 published by the same publisher seemed to cover the topics in less detail than the others.

Most of the Basic Biology textbooks covered the topics that fit Sakir and Kim's (2021) categories except “biodiversity hotspots” (Table 3). As explained later, biodiversity hotspots were not included even in three Advanced Biology textbooks, and therefore a considerable number of students would have no opportunity to learn about this topic at upper secondary school. On “biodiversity measurement,” all textbooks mentioned environmental impact assessment which is an essential process for land development projects. Sakir and Kim (2021) reported that in the USA textbook there are three descriptions on biodiversity measurement, species richness, species evenness, and diversity indices. All Basic Biology textbooks referred to species richness as an indicator of biodiversity richness, and textbooks #03 and #04 mentioned species evenness, but no textbook referred to diversity indices.

Table 1: Terms and number of their occurrences in Upper Secondary School National Curriculum Standard and its Guidelines*

Terms	No. of occurrences
Diversity of organisms	10
Species diversity	2
Ecosystem balance	3
Disturbance	1
Artificial (anthropogenic) disturbance	1
Extinction	1
Conservation	6

* The USS-NCS guidelines contain some sentences that entirely quote the contents of the USS-NCS, so terms that appear in the overlapping parts were not counted.

Table 2: The number of main text pages and of chapter on “Ecosystems and Their Conservation” in Basic Biology textbooks

	Basic Biology Textbook (Number and edition)									
	#01 *O*	#02 *E*	#03 *O*	#04 *E*	#05	#06	#07 *O*	#08 *E*	#09 *O*	#10 *E*
Main text* pages	240	200	216	195	200	196	188	150	200	158
Chapter on “Ecosystems and Their Conservation”**	30	20	20	14	26	26	28	19	34	26
Proportion***	13	10	9	7	13	13	15	13	17	16

* Excluding endpapers, table of contents, reference materials at the beginning and end of the book, index, and colophon

** Excluding summaries of terms and topics, and exercises.

Table 3: Topics contained in Basic Biology textbooks that fit Sakir and Kim's (2021) categorization*

Category		Basic Biology textbook									
		#01	#02	#03	#04	#05	#06	#07	#08	#09	#10
Biodiversity definition		○	△	○	△	○	○	○	○	○	○
Biodiversity level	Genetic	○	○	○	×	○	○	○	○	○	○
	Species	○	○	○	○	○	○	○	○	○	○
	Ecosystem	○	○	○	×	○	○	○	○	○	○
Biodiversity value		○	○	○	○	○	○	○	△	○	○
Cause of biodiversity loss		○	○	○	○	○	○	○	○	○	○
Biodiversity conservation		○	○	○	○	○	○	○	○	○	○
Biodiversity measurement		○	○	○	○	○	○	○	○	○	○
Biodiversity hotspots		○	×	×	×	○	○	×	×	×	×
Local biodiversity		○	○	○	○	○	○	○	○	○	○

* ○: related topic(s) presented and well-explained, △: related topic(s) presented but explained little, ×: no related topics

The USS-NCS and its Guidelines instruct that in Basic Biology species diversity of organisms should be mainly dealt within the diversity of organisms. Therefore, in all textbooks, species diversity with its explanation (definition) was found in the main text though some textbooks additionally gave an explanation or definition of biodiversity (or the diversity of organisms) in the main text. Two textbooks (#02 and #04), both are *E* editions, included the term biodiversity (or the diversity of organisms) in the main text, but did not provide its definition (Table 3). In the other textbooks, biodiversity (or the diversity of organisms) together with the three levels of biodiversity were explained in the reference or extension column. Among the other textbooks, the definition of biodiversity was somewhat different – this would be reported in detail in the future. In some textbooks the definition of biodiversity was insufficient or the difference in definitions between biodiversity (or species diversity) and the diversity of organisms was not clear. For example, textbook #03 it is explained that "there are a variety of environments and a variety of organisms are living there. The existence of a variety of organisms like this refers to biodiversity." Textbooks #05 and #06 contained an unexplained statement that "the diversity of organisms which comprise an ecosystem is called biodiversity." In such cases some students could be confused because they learned that "the diversity of organisms refers to the diverse characteristics of the organisms living on Earth" in Unit 1 "Unity and Diversity of Organisms." This might come from terminology (using the term the diversity of organisms for biodiversity) – this will be discussed further in the *Issues in Terminology* section. One textbook of *E* edition (#04) did not mention genetic diversity and ecosystem diversity at all (Table 3). Students can learn more about biodiversity in Advanced Biology classes, but not all students take Advanced Biology. Therefore, we consider that an accurate definition of biodiversity and the three levels of biodiversity, which is essential to understand biodiversity principles, need to be taught in Basic Biology.

The other terms (topics) mentioned in the

USS-NCS and its Guidelines, ecosystem balance, disturbance, extinction, and conservation were found in all textbooks, but for disturbance and conservation, some textbooks did not give any explanation or definition, possibly because these words are often used in daily life. Regarding artificial (anthropogenic) disturbance, only four textbooks used this term and gave an explanation, while the remaining textbooks did not use this term, instead using the explanatory term "disturbance caused by human activities".

Table 4 shows the number of biodiversity-related terms found in each Basic Biology textbook. The total number of biodiversity-related terms found in the ten textbooks was 113, but the number of mentions in the textbooks ranged between 41 and 71 (55 in average). The number of biodiversity-related terms collected in the index considerably ranged from 19 to 44 (28 in average) depending on the textbook, approximately one-third to half of the terms presented in the text. Among the terms found in each textbook, 8 to 18 (14 in average) terms were treated as key terms, that accounted for more than one-tenth to one-quarter of the terms found.

Terms that were treated as key terms in the majority (five or more) textbooks are shown in Table 5. Biodiversity, and species diversity + the diversity of species were treated as a key term by six textbooks, and genetic diversity and ecosystem diversity were by four textbooks. Among terms occur in the USS-NCS and its Guidelines, extinction and disturbance were treated as key terms by five or more textbooks. However, the number of textbooks which treated the terms ecosystem balance, artificial disturbance and conservation as key terms was only two, two and one, respectively.

Among terms which are not mentioned in the USS-NCS and its Guidelines, alien species was treated as a key term by all textbooks. However, only four textbooks treated native species (indigenous species), which is the opposite term of alien species, as a key term, while eight textbooks treated the term endangered species, which is included in the native species category, as a key term. In the previous USS-NCS and its Guideline, it was recommended that alien species be dealt with an example of a factor affecting local biodiversity (Higa, 2019), so this term might have remained as a key term in the current textbooks.

Most textbooks considered environment impact assessment, which related to the measurement and conservation of biodiversity, and ecosystem services, which we can receive more as a result of biodiversity conservation, to be important terms.

Rapid eutrophication and global warming are considered to be causes of biodiversity decline or loss. In Table 5, eutrophication ranked high on the list, along with cyanobacterial blooms and red tides, while water blooms, which are considered a higher level concept

Table 4: The number of terms related to biodiversity found in each Basic Biology textbook

	Basic Biology textbook										Total
	#01	#02	#03	#04	#05	#06	#07	#08	#09	#10	
No. of terms found only in the text	53	44	71	56	63	61	56	41	56	50	113
No. of terms found in the text and index	22	19	44	32	43	20	24	23	32	25	84
No. of terms treated as key terms	8	9	8	18	14	17	17	16	15	13	37

Table 5: Biodiversity-related terms treated as key terms in Basic Biology textbooks

Terms	No. of text-books
Alien species	10
Environment impact assessment	9
Ecosystem services	9
Eutrophication	8
Endangered species	8
Extinction	7
Biodiversity	6
Species diversity + Diversity of species	5 + 1
Disturbance	5
Greenhouse effect	5
Greenhouse effect gases	5
Cyanobacterial blooms	5
Red tides	5

than cyanobacterial blooms, ranked lower. Greenhouse effect and greenhouse effect gases were treated as key terms by five textbooks, but global warming, the result of greenhouse effect, was treated as key term by four textbooks.

Biodiversity Contents in Advanced Biology Textbooks

As mentioned above, the USS-NCS and its Guidelines do not indicate in which unit and chapter topics related to biodiversity should be dealt with in Advanced Biology. Therefore, using some keywords related to biodiversity, such as biodiversity (genetic diversity, species diversity, ecosystem diversity), ecosystem balance, extinction of species, native and alien species, and conservation, as probes, we tried to find chapters where biodiversity-related topics are described. As a result, in every Advance Biology textbook, most terms were found in Unit 5 "Communities and Their Environments," particularly in the chapter "Ecosystems and Human Life" (Table 6). Therefore, most of the topics related to biodiversity were considered to be described in this chapter.

The main text pages of each textbook exceeded 350 except for textbook #A2. The number of pages allocated to the chapter "Ecosystems and Human Life" ranged from seven to 20, and the apportion rate was 2 - 5% (Table 7); the values are smaller than those of Basic Biology textbooks. It is reasonable because, according to NCS-USS, the learning contents of Advanced Biology are considerably different from Basic Biology. However, from the viewpoint of biodiversity education, the number of topics to be described in detail in the text would be restricted.

The terms found in Unit 1 "Evolution" were diversity, biodiversity, the diversity of organisms, genetic diversity, the diversity of genes, endemic species, extinction (of organisms), and mass extinction. These were briefly described in

Table 6: Number of biodiversity-related terms found in different units of Advanced Biology textbooks

	Advanced Biology textbook				
	#A1	#A2	#A3	#A4	#A5
No. of terms found in Unit 1*	5	7	5	6	4
No. of terms found in Unit 5**	47	30	49	31	53
No. of terms found in the chapter "Ecosystems and Human Life"	40	26	43	29	49
No. of terms found in the other Units***	6	1	2	8	4

* Unit 1: Evolution.

** Unit 5: “Communities and Their Environments” which includes the chapter "Ecosystems and Human Life."

*** The other units: Metabolic Activities, Gene Expression and Ontogeny, and Responses to Environmental Stimuli

Table 7: The number of main text pages and of chapter on "Ecosystems and Human Life" in Advanced Biology textbooks

	Advanced Biology textbook				
	#A1	#A2	#A3	#A4	#A5
Main text* pages	428	270	394	368	368
Chapter on " Ecosystems and Human Life"**	20	7	9	8	12
Proportion***	5	3	2	2	3

* Excluding endpapers, table of contents, reference materials at the beginning and end of the book, index, and colophon.
** Excluding summaries of terms and topics, and exercises.
*** Percentage of pages for the chapter on "Ecosystems and Human Life" to the number of pages in the main text.

the chapter "Phylogeny and Evolution" of this Unit. However, biodiversity here is likely to mean the presence of a variety of organisms on the earth, though we are not certain whether it indicates biodiversity at the global level.

The terms biodiversity and its synonym, the diversity of organisms, genetic diversity and its synonym, the diversity of genes, and extinction occurred repeatedly in multiple units. Textbooks #A1, #A4 and #A5 mentioned biodiversity or genetic diversity in the chapter "Genetic Engineering" of Unit 3 "Gene Expression and Ontogeny" along with the Cartagena Protocol on Biosafety, an international framework regarding the use of genetically modified organisms.

Table 8 shows whether Advanced Biology textbooks contained topics that fit Sakir and Kim's (2021) categorization. For the categories marked with a triangle in Table 8, related terms were found but the explanation was deemed insufficient. For example, textbook #A3, which we considered to give an insufficient definition of biodiversity, stated that "A wide variety of organisms coexist on earth. Biodiversity can be viewed from three perspectives: not only species diversity, but also genetic diversity within a species and ecosystem diversity." Most of the Advanced Biology textbooks provided a sufficient definition of biodiversity and clearly explained its three levels: genetic diversity, species diversity, and ecosystem diversity. All textbooks also provided some examples of causes of biodiversity loss due to human activities, such as habitat fragmentation, global warming, and environmental pollution. However, other categories were not covered fully, possibly due to space constraints in the textbooks. As with the basic biology textbooks, the term, biodiversity hotspots, was found only in two textbooks. The description of local biodiversity seemed to be insufficient. Textbooks #A1 and #A3 mentioned Satoyama (countryside

Table 8: Topics contained in Advanced Biology textbooks that fit Sakir and Kim's (2021) categorization*

Category		Advanced Biology textbook				
		#A1	#A2	#A3	#A4	#A5
Biodiversity definition		○	○	△	○	○
Biodiversity level	Genetic	○	○	○	○	○
	Species	○	○	○	○	○
	Ecosystem	○	○	○	○	○
Biodiversity value		○	△	○	○	○
Cause of biodiversity loss		○	○	○	○	○
Biodiversity conservation		○	△	○	△	○
Biodiversity measurement		△	×	○	×	△
Biodiversity hotspots		×	×	○	×	○
Local biodiversity		○	△	△	×	×

* ○: related topic(s) presented and well-explained,
△: related topic(s) presented but explained little, ×: no related topics

forests) and stated that it is one of the places rich in biodiversity, but no further details are provided. Textbook #A1 mentioned some native species and textbook #A2 mentioned only endangered native species, while textbooks #A4 and #A5 did not mention this topic at all. In addition to describing the local biodiversity, textbook #A3 seemed to explain biodiversity measurement by mentioning environmental impact assessment better than the other textbooks. In the other textbooks, biodiversity measurement was referred only briefly or not at all.

As described above, most biodiversity-related terms were found in the chapter "Ecosystems and Human Life" of Unit 5 "Communities and Their Environments" though some terms, such as genetic diversity and the extinction of organisms along with its related terms (*e.g.*, mass extinction and extinction vortex), were also found in other chapters or units.

The total number of biodiversity-related terms found in five Advanced Biology textbooks was 89. Of these, 47 were found in the index and 24 were treated as key terms. There was a considerable difference in the number of terms found in each textbook (33 – 56) which indicates the differences in topics covered in each textbook. There was also a nearly two-fold difference between the number of terms found in the index and the number of terms treated as key terms between the textbooks (Table 9). There were 37 terms that occurred in at least one Basic Biology textbook but not in any Advanced Biology textbooks.

Terms occurred in all five textbooks were as follows: biodiversity, the diversity of organisms, genetic diversity, the diversity of genes, disturbance, the Intermediate Disturbance Theory, extinction, Allee's effect, inbreeding depression, global warming, eutrophication, overexploitation, conservation, and coral reefs (the places where a rich biodiversity occur, so they should be conserved). Species diversity or its synonym, the diversity of species, and ecosystem diversity or its synonym, the diversity of ecosystems, both or either, also occurred in all textbooks. Most of these terms were found in most Basic Biology textbooks, but Allee's effect was not, and inbreeding depression, overexploitation and coral reefs were only in some Basic Biology textbooks.

Biodiversity, disturbance, and the Intermediate Disturbance Theory were indexed in all textbooks among 47 terms found in the index of at least one Advanced Biology textbook. Relevant terms indexed by four textbooks were genetic diversity, Allee's effect, inbreeding depression, extinction vortex, eutrophication, ecosystem services, and those by three textbooks were alien species, global warming, and greenhouse effect gases.

Terms treated as key terms by three or more textbooks are shown in Table 10. Only the term

Table 9: The number of biodiversity-related terms found in each Advanced Biology textbook

	Advanced Biology textbook					Total
	#A1	#A2	#A3	#A4	#A5	
No. of terms found only in the text	49	33	54	38	56	89
No. of terms found in the text and index	25	14	28	14	16	47
No. of terms treated as key terms	13	12	13	9	7	24

the Intermediate Disturbance Theory, which refers to the idea that ecosystems experience the highest diversity and stability at intermediate levels of disturbance (Dial and Roughgarden, 1998; this idea is generally called as the Intermediate Disturbance Hypothesis) , was treated as a key term in all textbooks. Among Basic Biology textbooks, only two (#5 and #6) published by the same publisher mentioned this idea as the Intermediate Disturbance Hypothesis and treated the term as a key term. Biodiversity and its three levels were treated as key terms by four textbooks. However, one textbook (#A5) treated only biodiversity as a key term, and another textbook (#A3) treated genetic diversity, species diversity and ecosystem diversity as key terms, but not actual biodiversity. The same as in Basic Biology, disturbance and ecosystem services appear to be important terms in Advanced Biology. Allee's effect, inbreeding depression, and extinction vortex were treated as key terms in three textbooks. These terms are related to species extinction, and while population extinction and species extinction occurred in some textbooks, they were not treated as key terms. In addition, habitat fragmentation and population isolation, which trigger this phenomenon, were only found in the indexes of two textbooks, and only one textbook treated the former as the key term, indicating that overall, they are not given much importance.

Other examples of the strangeness of the selection of key terms include, in one textbook, the term ecological corridor, a conservation method to avoid habitat fragmentation, was treated as a key term, though the term habitat fragmentation occurred in the text but not even in the index. In another textbook, the term, tidal flats, was treated as a key term, but the term, wetlands, which is a higher-level concept (Convention on Wetlands Secretariat, 1971), was not even included in the index, although the term occurred in the text.

Table 10: Biodiversity-related terms treated as key terms in Advanced Biology textbooks

Terms	No. of textbooks
Intermediate Disturbance Theory	5
Biodiversity	4
Genetic diversity	4
Species diversity + the diversity of species	2 + 2
Ecosystem diversity + the diversity of ecosystems	2 + 2
Disturbance	4
Ecosystem services	4
Allee's effect	3
Inbreeding depression	3
Extinction vortex	3

Selection and arrangement of topics related to biodiversity

Most of Basic Biology textbooks covered all categories mentioned by Sakir and Kim (2021), while in Advanced Biology textbooks some categories were missing or poorly explained (Tables 3 and 8). This may be because the USS-NCS and its Guidelines do not provide any specific recommendations regarding the selection of biodiversity-related topics for Advanced Biology. In addition, the substantial volumes of other topics may have significantly restricted the number of pages allocated to biodiversity-related topics.

Most upper secondary school students opt for Basic Biology but not for Advanced Biology. For example, in 2023, more than 90% of students took Basic Biology, but only about 20% took Advanced Biology (estimated from the data provided by The Jiji Press, 2024). Therefore, biodiversity and its related concepts should be taught in Basic Biology. Actually, in the current Basic Biology textbooks, topics on most of biodiversity-related categories, which

Sakir and Kim (2021) proposed, were covered (Table 3), and particularly the causes of biodiversity loss were described well.

However, we would like to point out that there were some issues regarding the selection of topics and their arrangement. As for "biodiversity conservation," most Basic Biology textbooks mentioned and explained nature and ecosystem conservation. Perhaps, the editors/authors of the textbooks were following the USS-NCS, which recommend "allowing students to realize the importance of ecosystem conservation (MEXT, 2018, p. 119)." As a result, teachers need to supplement their teaching to students that ecosystem conservation contributes to biodiversity conservation. Most textbooks also mentioned rare and endangered species and their protection. Regarding this, it is desirable to describe measures, not only *in situ* but also *ex situ*, to prevent their extinction, as in Indonesia and the United States biology textbooks (Sakir and Kim, 2021). In addition, some examples of biodiversity conservation at the international level as well as at the local level should be provided.

Regarding the category "biodiversity measurement," most textbooks only explained environmental impact assessment for appropriate land development. Other topics such as "how to measure biodiversity" or "biodiversity assessed by species evenness" should be added. Since topics related to local biodiversity seem to be mentioned only occasionally in textbooks, local biodiversity needs to be taught more comprehensively to set up a section like "Local Biodiversity in Japan." This section includes some representative sites such as coral reefs and mangrove forests in Ryukyu Islands, some countryside forests (Satoyama), and Ramsar Conservation-registered wetlands areas, as well as endangered native species and invasive alien species in Japan. In the current Basic Biology textbooks, the only topic related to the category "biodiversity value" was ecosystem services. Yamamoto (2015) suggested introducing the idea of environmental ethics when teaching topics in the unit "Diversity of Organisms, and Ecosystems." Environmental ethics is required not only for understanding biodiversity values but also for recognizing the necessity of biodiversity conservation.

Selection of indexed terms and of key terms

In the USS-NCS (MEXT, 2018) and its Guidelines (MEXT, 2021), it is recommended that "Focusing on important terms, approximately 200 to 250 words, the students should be instructed to understand the concepts related to those terms while using their thinking skills." Following this instruction, the number of key terms included in each *O* edition of Basic Biology textbook published in 2022 ranged from 190 to 249 (Nakamichi *et al.* 2023).

Key terms are considered to be those that are essential for learning important concepts or topics. Also, the terms included in the index are likely to be similar. How do textbook editors/authors decide on key terms? Perhaps they made a concept map for each topic in biology subjects and determined key terms. However, in some textbooks, the importance of some key terms is unclear. For example, in one textbook, ecosystem balance was not treated as a key term, but resilience was. The term resilience is a useful term in understanding a phenomenon, ecosystem balance, since ecosystem balance (ecosystem stability) is maintained by the resilience of an ecosystem. In this case, ecological balance should be considered a higher-level concept of resilience, so ecosystem balance is a more important term. Another example is one textbook that treated genetic resources as a key term, but biodiversity was not a key term. Abundant

genetic resources can be secured by the conservation of biodiversity. We cannot understand why the editors/authors of this textbook considered genetic resources to be more important than biodiversity in biology. A similar problem existed with collecting index terms, but as we have already shown some examples above, we do not mention them here. Editors/authors of biology textbooks should be careful with the selection of terms included in the index and treated as key terms.

For the selection of such key terms, Nakamichi (2020) has proposed establishing a hierarchical classification to evaluate the importance of terms, *i.e.*, higher concepts (highly comprehensive terms) are placed at level 1, middle concepts (lesser comprehensive terms) at level 2, and lower concepts (specific individual terms) at level 3 or 4. By establishing a hierarchy in this way, terms that are considered important (key terms) and that should be collected in the index can be selected. According to this proposal, we set three ranks of categories in the present paper, and classified each term found in the textbooks surveyed into the most appropriate specific individual category (see the table in the Appendix).

Issues regarding terminology

During the last decade, in Japan, some recommendations have been made about the terminology to be used in biology education at upper secondary schools and biology textbooks (Matsuura, 2013, Atsumi *et al*., 2018; JBSS-SCJ, 2019; Nakamichi, 2020). Partially in response to these recommendations, the current Guidelines on USS-NCS (MEXT, 2021) indicate the range of the number of terms used in teaching biology. Atsumi *et al*. (2018) also pointed out that the inconsistencies in the spelling of terms should be eliminated, but there are still a large number of such spelling inconsistencies found in biology textbooks.

As mentioned above, the textbooks surveyed contained two different Japanese spellings for biodiversity: a compound word SEIBUTSU-TAYOUSEI and a phrase SEIBUTSU NO TAYOUSEI (In our paper, we distinguished the former as biodiversity from the latter, the diversity of organisms). The current USS-NCS and its Guideline use the latter term consistently, so some textbook editors/authors might have followed suit. In Basic Biology, students learn about the diversity of organisms in Unit 1 and biodiversity in Unit 3. We think the terms should be used differently so that students do not confuse them. We would like to point out that the editors of the USS-NCS and its Guidelines need to be more careful with their terminology. (See Note) Similarly, the diversity of genes, the diversity of species, and the diversity of ecosystems should be distinguished from the terms for three biodiversity levels, genetic diversity, species diversity, and ecosystem diversity, respectively.

On the other hand, there were some terms that we treated as the same even if there was a slight difference in meaning. For example, the result of excessive logging can be expressed as “deforestation,” “forest destruction” or “forest loss.” However, in this case, we treated them the same because the measure that distinguishes between these three, *i.e.* the extent of logging, is not clear and “forest destruction” may cover the other two meanings.

Such variations in notation were found in many places, even in a single textbook, making it difficult to summarize the survey results. From an educational point of view, editors/ authors of biology textbooks should be careful with their terminology to avoid students’ confusion and misunderstanding.

Note

In the Japanese translation of the Convention on Biological Diversity (Biodiversity Center of Japan, undated), the translation of biological diversity (biodiversity) is SEIBUTSU NO TAYOUSEI (the diversity of organisms). This is a term that is exclusive to the Convention on Biological Diversity, and since the term has a strict definition in the Convention, *i.e.,* “"Biological diversity" means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (CBD Secretariat, 2016). Therefore, no one would misunderstand it as "the existence of organisms having a variety of different characteristics." However, in Basic Biology, students first learn that although organisms have a variety of forms, they have the same basic characteristics. The diversity of organisms in this context does not mean the biodiversity defined by the Convention on Biological Diversity. In biology education, we believe it is necessary to use two different terms, the diversity of organisms and biodiversity, to avoid misunderstandings among students.

ACKNOWLEDGEMENTS

We are grateful to Professor Robert Wallis of Federation University, Australia, for reading the original manuscript and giving us valuable suggestions for improving it. We are also grateful to Dr. Hideo Kitano, our colleague, for his helpful advice in conducting this research and compiling the results.

REFERENCES

Atsumi, S., Kasahara, M., Ichiisi, H., Ito, M., Katayama, T., Kimura, S., Shigeto, K., Shojima, K., Shiroishi, N., Takemura, M., Nishino, H., Hukui, T., Mayama, S., Muko, H. and Watanabe, M. (2018) Study on the technical terms of high school textbooks of biology based on the revised Courses of Study for the Senior High School in 2009. *Japanese Journal of Biological Education* **60**(1): 8–22. (in Japanese with English abstract) https://doi.org/10.24718/jjbe.60.1_8

Dial, R. and Roughgarden, J. (1998) Theory of marine communities: the intermediate disturbance hypothesis. Ecology 79 (4): 1412–1424. https://doi.org/10.1890/0012-9658(1998)079[1412:TOMCTI]2.0.CO;2

Doi, T. and Hayashi, T. (2015) Analysis of textbooks describing alien species changes in students’ recognition through lessons: Aiming to further development of environmental education in elementary school. *Journal of Science Education in Japan* **39**(3): 212-224. (in Japanese with English abstract) https://doi.org/10.14935/jssej.39.212

Higa, T. (2019) A study of textbooks’ treatment of foreign invasive species: Based on authorized textbooks of Living Environment Studies and Science for elementary schools, and Science for junior and senior high schools. *Journal of Science Education in Japan* **43**(4): 457-467. (in Japanese with English abstract) https://doi.org/10.14935/jssej.43.457

Joint Biological Science Subcommittee of the Committee on Basic Biology and the Committee on Integrated Biology, Science Council of Japan (JBSS-SCJ) (2019) *Selection of Important Terms in Biology Education at Senior High Schools (Revised edition)*. (in Japanese)

https://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-24-h190708.pdf

Kato, M. (2016a) Transition from nature conservation to biodiversity conservation described in senior high school biology textbooks. *Japanese Journal of Biological Education* **56**(3): 94-105. (in Japanese with English abstract) https://doi.org/10.24718/jjbe.56.3_94

Kato, M. (2016b) Transition of learning contents of the biodiversity concepts in senior high school biology textbooks: Through analysis of description of diversity or biodiversity. *Japanese Journal of Biological Education* **56**(3): 106-116. (in Japanese with English abstract) https://doi.org/10.24718/jjbe.56.3_106

Matsuura, K. (2013) *Tentative Proposal for the importance of Terms in Biology Education for Senior High Schools 2013*. (in Japanese) https://www.biol.se.tmu.ac.jp/documents/High_School_Biology_Terms-matsuura130325.pdf <retrieved 24/08/2024>

Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) (2018) *The Upper Secondary School National Curriculum Standard*. (in Japanese) https://www.mext.go.jp/content/20230120-mxt_kyoiku02-100002604_03.pdf

Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) (2021) *Guidelines on the Upper Secondary School National Curriculum Standard, 2018, Science Subjects and Inquiry-Based Study of Science and Mathematics*. (in Japanese) https://www.mext.go.jp/content/20211102-mxt_kyoiku02-100002620_06.pdf

Nakamichi, T. (2020) Consideration of important terms for the science subject "Basic Biology": Survey of senior secondary school biology teachers. *Japanese Journal of Biological Education* **61**(3): 150–159. (in Japanese with English abstract) https://doi.org/10.24718/jjbe.61.3_150

Nakamichi, T. and Katayama, N. (2018) Biology education in upper secondary schools at present in Japan. *Asian Journal of Biology Education* **10**: 7-16. https://doi.org/10.57443/ajbe.10.0_7

Nakamichi, T. Saigo, T. and Katayama, N. (2023) Latest Upper Secondary School National Curriculum Standard and Basic Biology textbooks in Japan. *Asian Journal of Biology Education* **15**: 13-21. https://doi.org/10.57443/ajbe.15.0_13

Sakir, N. A. I. and Kim, J. G. (2021) Comparing biodiversity-related contents in secondary biology textbooks from Korea, Indonesia, and the United States of America. *Journal of Biological Education* **55**(1): 17-30. https://doi.org/10.1080/00219266.2019.1643760

The Jiji Press (2024) Upper secondary school textbook adoption situation in 2024 – Interim report by the Ministry of Education, Culture, Sports, Science and Technology. *Naigi Kyoiku* (*Education in Japan and Foreign Countries*) No. 7140: 8-16, (in Japanese)

Yamamoto, Y. (2016) A practical study on introducing a perspective of environmental ethics into the field of ecology in "Basic Biology": Focusing on the core idea of deep ecology. *Journal of Science Education in Japan* **40**(1): 76-91. (in Japanese with English abstract) https://doi.org/10.14935/jssej.40.76

WEBSITES

Biodiversity Center of Japan, Ministry of the Environment (undated) *The Convention on*

Biological Diversity (translated into Japanese). https://www.biodic.go.jp/biolaw/jo_hon.html <retrieved 20/08/2024>

CBD Secretariat (2016) *Text of the Convention.* https://www.cbd.int/convention/text <retrieved 20/08/2024>

Convention on Wetlands Secretariat (1971) *Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention on Wetlands)* https://www.ramsar.org/sites/default/files/documents/library/current_convention_text_e.pdf <retrieved 03/10/ 2024>

BIOLOGY TEXTBOOKS SURVEYED

Basic Biology textbooks

Akasaka, K. *et al*. (2022) Upper Secondary School Basic Biology. Shinkoshuppansha Keirinkan Co, Ltd.

Akasaka, K. *et al*. (2022) Basic Biology *i* Version. Shinkoshuppansha Keirinkan Co, Ltd.

Asashima, M. *et al.* (2022) Basic Biology. Tokyo Shoseki Co., Ltd.

Asashima, M. *et al*. (2022) Basic Biology New Edition. Tokyo Shoseki Co., Ltd.

Mogami, Y. *et al*. (2022) Basic Biology. Jikkyo Shuppan Co., Ltd.

Mogami, Y. *et al*. (2022) Upper Secondary School Basic Biology. Jikkyo Shuppan Co., Ltd.

Shimada, M. *et al*. (2022) Upper Secondary School Basic Biology. Suken Shuppan Co., Ltd.

Shimada, M. *et al*. (2022) Basic Biology New Edition. Suken Shuppan Co., Ltd.

Yoshizato, K. *et al*. (2022) Upper Secondary School Basic Biology. Daiichi Gakushusha Corp.

Yoshizato, K. *et al*. (2022) Upper Secondary School New Basic Biology. Daiichi Gakushusha Corp.

Advanced Biology textbooks

Akasaka, K. *et al*. (2023) Upper Secondary School Biology. Shinkoshuppansha Keirin kan Co, Ltd.

Asashima, M. *et al*. (2023) Biology. Tokyo Shoseki Co., Ltd.

Mogami, Y. *et al*. (2023) Biology. Jikkyo Shuppan Co., Ltd.

Shimada, M. *et al*. (2023) Biology. Suken Shuppan Co., Ltd.

Yoshizato, K. *et al*. (2023) Upper Secondary School Biology. Daiichi Gakushusha Corp.

APPENDIX

Table: A proposed tentative categorization of biodiversity-related terms found in current Basic Biology textbooks and Advanced Biology textbooks.

Superordinate categories	Subordinate categories	Specific individual categories		Terms
Biodiversity	Biodiversity	Biodiversity		Biological diversity / Biodiversity
				Diversity of organisms
	Three levels of biodiversity	Gene level		Genetic diversity
				Diversity of genes / gene diversity
				Intraspecific diversity / Genetic diversity within a species
		Species level		Species diversity
				Diversity of species
		Ecosystem level		Ecosystem diversity
				Diversity of ecosystems
	Factors that maintain and enhance biodiversity	Ecosystem stability		Ecosystem balance / Ecological balance
				Resilience
		Disturbance		Disturbance
				Natural disturbance / Disturbance that occurs naturally
				Intermediate disturbance hypothesis (theory)
Evaluation of biodiversity (Biodiversity measurement)	Environmental impact assessment			Environmental Impact Assessment Law
				Environmental impact assessment
	Biological evaluation	Native species（Local biodiversity evaluation）		Native species / Domestic species / Native organisms
				Endemic species
				Native species / Native vegetation
				Rare species / Rare organisms
				Endangered species of wild fauna and flora
		Alien species		Alien species / Alien organisms
Causes of biodiversity decline or loss	General factors			Artificial disturbance / Anthropogenic disturbance
	Extinction	Extinction		Extinction
		Level and scale of extinction		Extinction of a population
				Extinction of a species
				Mass extinction
		Cause and principle of extinction	Isolation of a population and process of extinction	Fragmentation / Habitat fragmentation
				Isolation / Isolation of a population

				Local populations
				Allee's effect
				Inbreeding
				Deleterious genes
				Inbreeding depression
				Extinction vortex
				Population viability
			Settling down of alien species	Importation or intrusion of alien organisms, and their settling down
				Invasive alien species / invasive alien organisms
				Genetic pollution / genetic disturbance
	Other factors (Anthropogenic factors)	Global warming	Greenhouse effect	Greenhouse effect
				Greenhouse effect gases
			Global warming and its results	Global warming
				Climate change
				Coral breaching
				Desertification
				Salts accumulation / salinization
		Environmental pollution	Pollution	Pollution / environmental pollution
			Air	Air pollution
				Asid rain
			Water	Eutrophication
				Water pollution
				Ocean pollution
				Blue green algae / Cyanobacterial bloom
				Red tide
				Water bloom / algal bloom
				Microplastics
		Others	Overdevelopment and overexploitation	Habitat destruction
				Vegetation destruction
				Logging
				Deforestation / forest destruction / forest disappearance
				Overgrazing
				Slash and burn cultivation / swidden agriculture
				Overexploitation / overhunting / overfishing

Biodiversity value		Ecosystem services		Ecosystem services
				Supporting services
				Provisioning services
				Regulating services
				Cultural services
		Others		Genetic resources
				Natural capital
Conservation of biodiversity		Conservation and protection		Conservation
				Protection
		Others		Society with sound material cycles
	International level	Conventions, resolutions, and protocols	Convention on Biological Diversity	The Convention on Biological Diversity
				The Strategic Plan of the Convention on Biological Diversity, Nagoya Protocol
				Cartagena Protocol on Biosafety
			Protection of organisms and their habitat	The Convention on Wetlands of International Importance especially as Waterfowl Habitat
				Convention on International Trade in Endangered Species of Wild Fauna and Flora
				Sustainable Development
				Sustainable Development Goals / SDGs
			United Nations Framework Convention on Climate Change	Kyoto Protocol (Framework until 2020)
				Paris Agreement (Framework from 2020)
			Organizations	Conference of the Parties to the United Nations Framework Convention on Climate Change
				Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
				International Union for Conservation of Nature and Natural Resources
				Conservation International
		Conservation targets and conservation activities	Protection areas	Protected areas
				Ramsar Convention-designated wetlands / Ramsar sites
				Biodiversity hotspots
				Hotspots on biodiversity
				Hotspots
			Activities	Ecological footprint
				Biodiversity footprint

				Ecotourism
				Eco label
				Wise Use
			Systems	Certification Systems
				Forest Certification Systems
	Domestic level	Invasive Alien Species Act		Invasive Alien Species Act
				Specified invasive alien species
		Conservation of endangered species		The Law for the Conservation of Endangered Species of Wild Fauna and Flora
				Endangered species
				Extinct in wild
			Red list	Red list
				Red data book
		Conservation targets and conservation activities	Countryside areas	Countryside areas
				Satoyama / countryside forests
				Forest of mixed trees
			Wetlands	Wetlands
				Coral reef
				Tidal flat
				Mangrove / mangrove forests
			Forests	Forest environment tax
				Forest conservation / conservation of forest
				Afforestation
			Others	Water clean-up / water purification
				Extermination of invasive alien species
				Fish ladder / fishway
				Ecological corridor / green corridor
				Underpass
				Retarding water area / retarding basin
Other				Diversity

Report of the 29th AABE Biennial Conference (AABE2024) and Abstracts of the Papers Presented at the Conference

The 29th AABE Biennial Conference (AABE 2024) was held at the Faculty of Education, Ehime University, in Matsuyama City, Shikoku, Japan, from October 12 to 14, 2024. The conference was organized under the direction of Professor Heiwa Muko, the conference executive director from the same university. This year's theme was *Perspectives for global well-being: biology education in integrated learning*. A total of 199 participants, including volunteers, attended the conference, with representatives from Japan (90), Korea (21), Taiwan (1), the Philippines (40), Thailand (2), Malaysia (5), Indonesia (6), India (5), and Australia (2).

On October 12, registration began in the afternoon, and from 3 to 6 PM, approximately 90 attendees enjoyed an ex-cursion to Matsuyama Castle, located near the university. They were accompanied by 27 volunteers, including students from Ehime University and schoolteachers, who served as guides.

On October 13, the conference began at 9:00 AM with an opening address by Professor Kiyoyuki Ohshika, Chair of the AABE Executive Committee. This was followed by greetings from Professor Shigeyoshi Watanabe, President of the Society of Biological Science Education of Japan, a co-sponsoring organization, and Professor Heiwa Muko. The first keynote address was delivered by Professor Manabu Sumida from the Faculty of Education, Ehime University, titled *Transforming Science Education in the Society 5.0 Era: Diversity, Sustainability, and AI*. Afterward, from 10 AM, parallel oral sessions took place in four rooms, where participants presented their research and engaged in discussions. Following a lunch break with distributed bento boxes, the second keynote address was delivered by Dr. Aki Katoh from Ehime University, titled *Developing an innovative community-based science and technology program focusing on local regional issues incorporating entrepreneur-ship training*. The parallel sessions then resumed. A total of 51 oral presentations were delivered on this day.

In the evening, from 6 PM, a banquet was held in the university cafeteria, attended by 120 people. Professor Ohshika, Professor Muko, and Dr. Nobuyasu Katayama gave speeches, and Dr. Robert Wallis offered a toast. Attendees enjoyed local Ehime cuisine while deepening international exchanges. During the banquet, traditional Japanese songs and dances were performed, and the traditional game *Yakyuken* added excitement, with representatives from various countries competing in *janken* (rock-paper-scissors). The evening ended with a speech by Dr. Shigeki Mayama, Editor-in-Chief of AJBE, encouraging attendees to submit their presentations to the journal. The banquet concluded successfully.

On October 14, the third keynote address was delivered at 9 AM by Professor Kew-Cheol Shim from the Department of Biology Education, Kongju National University, Korea, titled *Biology Education in the Big Transformation Age*. Starting at 10 AM, 20 research posters were presented by junior and senior high school students (40 students), along with 48 general poster presentations and 7 workshops. Vigorous discussions and exchanges took place. After lunch, the fourth keynote address was given by Mr. Hideki Fujieda, Government School Inspector at the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, titled *About Biology Education in Japan*. From 3 PM, country reports were

presented by Dr. Robert Wallis (Australia), Dr. Narendra Deshmukh (India), Dr. Muruni Ramli (Indonesia), Dr. Kwan Siew Wai (Malaysia), and Dr. Maricar S. Prudente (Philippines), providing updates on recent educational developments in their countries. Since the representative from Malaysia was unable to attend, the report was presented as a video message.

At the General Assembly (Closing Ceremony), held from 4:40 PM, reports on the activities of AABE over the past two years, financial reports, and publication updates were presented. The title of *Emeritus Editor-in-Chief* was conferred upon Dr. Nobuyasu Katayama, the former Editor-in-Chief of AJBE, with unanimous applause, and a certificate was presented to him. The Best Presentation Awards were then announced for both oral and poster presentations, and the awardees were presented with certificates on stage. Finally, Professor Jun Euy Hong from Seowon University, Korea, gave an invitation speech for the 30th AABE Conference to be held in Korea in 2026, accompanied by a video introducing the location. The ceremony concluded after 6 PM with wishes for a reunion in two years' time.

On October 15, an optional post-conference excursion was held, with 60 participants. The group departed at 8 AM to visit Ehime University Junior High School and Senior High School by bus, where they observed classes. At the junior high school, students dissected squid to compare the anatomy of vertebrates and invertebrates. At the high school, participants observed the dissection of dried anchovies using tweezers, studying the nervous system, digestive system, and circulatory system, including the brain. After a lunch of coconut curry and salad at the Ehime Prefectural Cultural Center, the group visited Tobe Zoo. The excursion was a private event for AABE participants, who had the opportunity to learn from zookeepers about the animals' behavior and habits, with a special behind-the-scenes tour. Participants also enjoyed shopping at a Tobe pottery shop before concluding the day at the university at 5 PM.

The lectures, posters, and workshops presented at this conference are recorded here as part of the conference proceedings (note: these are not formally published, and submitting the research presented here as a journal article is not restricted by this record).

<Convention Theme & Rationale>

Perspectives for global well-being: biology education in the integrated learning

Large-scale natural disasters including the global spread of the novel coronavirus disease (COVID-19) and regional conflicts have forced us to make major restrictions and changes in societal activities. In addition to these social disruptions, the rapid development of cutting-edge science and technology is expected to bring about more uncertainty and complexity in our daily lives. This is not a temporary thing, but a characteristic of the with/after-corona society that we are about to enter. Developing next-generation human resources who can respond to the major changes in society and daily life called the VUCA era (Volatility, Uncertainty, Complexity, Ambiguity) is an urgent issue. In recent years, many have promoted STEM/STEAM education as one solution to this need.

This trend indicates that solutions to the difficult issues of modern society are not achieved within a single subject area, but rather with transdisciplinary efforts. An increasing number of schools today address one of the 17 goals established in the UN Sustainable Development Goals (SDGs) as a problem-

solving theme, but needless to say, achieving this requires learning in collaboration with diverse disciplines. While inquiry is at problem-solving's core, the introduction of new concepts such as resilience and diversity into the school education has become essential in recent years. In order to build a harmonious world where everyone can live in health, vitality, and peace; and achieve SDG's pledge to "leave no one behind", we need to challenge ourselves to conduct research to discover the essence of a new kind of biology education.

In light of this situation, the organizing committee set the theme of the conference as "Perspectives for global well-being: biology education in the integrated learning." We hope that AABE 2024 will be an opportunity to lead to new proposals through presentations of participants' innovative research and heated discussions.

****

<Keynote Address>

Transforming Science Education in the Society 5.0 Era: Diversity, Sustainability and AI

Manabu Sumida
Faculty of Education, Ehime University, 3, Bunkyo-cho, Matsuyama, Japan
sumida.manabu.mm@ehime-u.ac.jp

Today, the world is facing challenges not only from the pandemic, but also from the ongoing and ever accelerating pace of global warming, loss of biodiversity, demographic change, increasing inequity, social fragmentation, and threats to human well-being. Added to these are issues with fake news and scepticism regarding science and society. The significance and impact of education have been recognised, with quality science education being considered a right for everyone in the global context. This presentation extracts keywords for science education in the 21st century from an analysis of the works of Nobel laureates, including a case from Japan. The centres of

science have shifted over time, becoming more diverse and transnational. Instances of collaboration among researchers in geographically distant and disparate field-sharing roles are increasing. Science is expected not only to provide new knowledge, but also contribute increasingly to national development and society. In view of this trend, we would like to discuss, from the perspective of science education, the need to discover gifted and talented students in the region, the necessity of providing educational opportunities that transcend disparities, and the importance of international collaboration.

Developing an innovative communitybased science and technology program focusing on local regional issues: Incorporating entrepreneurship training

Aki Kato[a]*, Heiwa Muko[b], Ryoji Takahashi[c] and Hidemitsu Uno[a]

[a]*Ehime University, Matsuyama, Ehime 790-8577, Japan*

[b]*Faculty of Education, Ehime University, Matsuyama, Ehime 790-8577, Japan*

[c]*Graduate School of Science and Engineering, Ehime University, Matsuyama, Ehime 790-8577, Japan*

*Corresponding Author: kato.aki.sq@ehime-u.ac.jp

The Japan Science and Technology Agency (JST) provides support to universities to develop advanced educational programs in Japan. Ehime University was granted funding by JST in 2023 for a second high school student project. We built systematic training programs during our first JST project. In this second project, the program is being enhanced and expanded throughout the island of Shikoku. We recognized the urgent needs for fostering well-trained, innovative leaders of for the next generation who will be active in the region while understanding their connection to the world. The major concept of this project is to start with junior and senior high school students in providing scientific and entrepreneurship training. Universities and local communities are working together through university-level classes and individual research projects and instruction in entrepreneurship, and to provide cross-cultural adaptability through exchange with foreign researchers. In the field of biology, as our students conduct research various regions, they also learn how to communicate what they learn to the local community. From the perspective of integrated learning, it is necessary to develop highly motivated students through topical research in local biology education. We will introduce our three areas of focus: independent research, involving the local community, and entrepreneurship activities.

Biology Education in the Big Transformation Age

Kew-Cheol Shim

Department of Biology Education, Kongju National University, Gongjudaehak-ro 56, Gongju-si, Chungnam-do, South Korea

skcshim@kongju.ac.kr

The future society will have been influenced increasingly by digital technology and climate change. Also, future society will be volatile, uncertain, complex and ambiguous (VUCA) or turbulent, uncertain, novel, and ambiguous (TUNA). Digital transformation driven by digital technology is having a huge impact on the economy, culture, and even education. We need transformational approach to the changes in the fundamental attributes of a socioecological system in anticipation of climate change and its impacts. In biology education, learning contents have the science of climate change well established, and an objective source of scientific information on climate change or crisis. Thus, the future society can be called big transformation age. The transformative competency is needed for students in response to future society, and teaching & learning tools for biology education have been rapidly transforming in big transformation age: Using sensors, digital inquiry tools, VR/AR, etc. We need to develop the educational capabilities necessary for future society and provide education for future generations preparing the big transformation age.

Japan country report: About Biology Education in Japan

Fujieda, Hideki

Ministry of Education, Culture, Sports, Science and Technology (MEXT), Tokyo, Japan

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has established curriculum standards for elementary, junior high, and high schools in Japan to ensure that

all schools throughout the country provide a consistent level of education. These curriculum standards are called the "Courses of Study". Schools are not separate from society, but are part of it. Therefore, the "Courses of Study" are revised approximately every 10 years, in order to review the competencies required to deal with modern issues such as globalization, rapid informatization, and technological innovation. The most recent revisions were carried out in 2017-18. The "Courses of Study" define considerations for the curriculum in general and the treatment of the number of class hours, as well as the general objectives, contents, and treatment of content for each subject, etc. The creation of textbooks and lesson timetabling are based on these guidelines. The curriculum emphasizes scientific inquiry into natural objects and phenomena, as well as helping pupils to make connections between the subject and their daily lives.In elementary and junior high schools, there are 4 domains in the subject area of "Science" : energy, particles, life, and the earth, and biology is covered in the life domain. In senior high schools, biology comes under the subject area of "Science", and is taught in "Basic Biology" or "Advanced Biology" classes. In addition, the progression of content from elementary school to high school is taken into consideration, as well as the effective implementtation of learning activities to cultivate pupils' competencies.For reference, here is the website of the "Courses of Study" (tentative translation) for elementary school science.

****

<Parallel Lecture Seminars>

Ectoparasites of Avian Species Visiting Selected Fruit Orchards of Davao City, Mindanao Island, Philippins

Elsa May Delima-Baron[a,b]*, Marian Dara T. Tagoon[b], and Lyre Anni E. Muraoc[c]
[a]Research, Publication, and Innovation Center, San Pedro College, 12 Guzman St., Davao City, Mindanao, Philippines
[b]School of Business Management, Education, Arts and Sciences, San Pedro College, 12 Guzman St., Davao City, Mindanao, Philippines
[c]Biological Sciences and Environmental Studies Department, College of Science and Mathematics, University of the Philippines-Mindanao, Bago Oshiro, Davao City, Mindanao, Philippines
*Corresponding author:
elsa.delima.baron@gmail.com

Ectoparasites are essential in disease transmission in several hosts, including avian species. Studies on ectoparasites of birds in various habitats are substantial, but there is minimal information about bird ectoparasites from fruit orchards, thus the conduct of this study. Birds were captured via mist netting in two preselected fruit orchards and dusted afterward for ectoparasite collection before release. Ectoparasites were identified based on their morphological features. Twenty-eight avian species (N=468 individuals) were identified in the surveyed fruit orchards, of which 32% were Philippine endemic. Nine species (N=24 individuals) were captured, all of which are known to occur in areas near human settlements. Ectoparasites were collected from feather dustings of 13 captured non-breeding individuals representing five of the nine bird species. The abundance, as well as the type of ectoparasites among captured birds, varied among bird species. One *Todiramphus chloris* individual had a heavy infestation. A total of 1630 ectoparasites were collected, belonging to 24 taxa: 14 feather mites, one flea, and nine lice. Most ectoparasites collected were feather mites (Order Acari, Suborder Astigmata, Family Analgoidea) and chewing lice (Order Phthiraptera). Data revealed that despite a high degree of disturbance, fruit orchards do harbor and allow the existence of several birds, including endemic species. Despite the low capture rate, most bird individuals were infested with ectoparasites. This data reiterates previous reports that wild birds are important hosts of several ectoparasites including those found in fruit orchards.

Introduction of 'Biology Karuta': To draw out an attitude of proactive engagement and to consolidate knowledge

Ai Iguchi
Kawaguchikita Senior High School , Saitama Prefecture, Kawaguchi-city, Japan
kotaki.ai.6a@spec.ed.jp

The current courses of study in Japan assess students' "attitude towards independent learning", "knowledge and skills" and "ability to think, judge and express". Allowing students to engage in a variety of activities and expressions will lead to the retention of knowledge while drawing out students' independence. Therefore, in high school biology classes, 'Biology Research' and 'Biology Karuta' have been implemented.The specific activities are: report writing, report presentation and Q&A session based on the biology research; creation of picture cards and songs for the Biology Karuta; voting; and the Biology Karuta competition. This time, we would like to introduce 'Bio-Karuta'. Karuta is a traditional Japanese game played mainly during the New Year. We have been playing 'Biology Karuta' in analogy with it. In a post-implementation questionnaire, more than 90% of the students said: 'I enjoyed playing Karuta'. 'My knowledge of the classification of organisms has increased'. 'My knowledge of the characteristics of living organisms has increased'. As per the aim, the students were able to work on their own initiative, have fun with their friends and consolidate their knowledge of biological classification and the characteristics of organisms. The relevant parts of this content in the courses of study are chapter 1: Biological diversity in 'Basic biology' and chapter 1: Biological evolution and systematic taxonomy in 'Biology'.

PROBES: PRoblem-Based Explorations in Science

John Donnie A. Ramos[1,2] and Anna Cherylle M. Ramos[3]
[1]College of Science
[2]Research Center for the Natural Sciences
[3]College of Education University of Santo Tomas, Manila, Philippines

The Philippines' Matatag Science Curriculum prioritizes a learner-centered approach, emphasizing inquiry, collaboration, innovation, and scientific exploration. This focus aligns perfectly with the national emphasis on Science, Technology, Engineering, and Mathematics (STEM) education, aiming to cultivate critical thinkers and problem solvers who contribute to national progress. Building upon this foundation, this paper introduces PROBES (Problem-based Explorations in Science), an innovative framework presented during a nationwide training for high school science teachers. PROBES leverages the inquiry-based and problem-solving strengths of the Matatag curriculum and integrates them with the Engineering Design Process (EDP) to create a dynamic learning environment. The EDP, a cyclical process used by engineers, provides a structured approach to problem-solving within PROBES. This process involves defining problems, researching possibilities, brainstorming solutions, building prototypes, testing, and refining based on results. By integrating the EDP, PROBES fosters active investigators by encouraging students to drive their own learning journey through contextual problem-solving activities. They delve into research, experiment with solutions, and analyze findings, leading to a deeper understanding of scientific concepts and their real-world applications. The session will walkthrough participants through the PROBES framework, designed to promote active learning, contextual understanding, and a more engaging classroom experience. Ultimately, PROBES empowers science learners to become future-ready scientists who can address societal issues with science and make a positive impact on the world.

Perception of Science Gifted Children on the Value of Ecological Transformation Education in Discussion and Debate Activities Using Documentary Films

Youngmi Choi
Creative Education Center, Jeju National University, 61 Iljudong-ro, Jeju, Republic of Korea
ychoi@office.jejunu.ac.kr

To confront climate change and global crisis, ecological transformation education in the Republic of Korea does not only focus on the coexistence of the environment and humans but also sustainability based on ecology changeovers in an extensive range of fields. This study aims to analyze science-gifted children's discourse in discussion and debate activities using environmental documentary films and examine their epistemic value on ecological transformation education, such as life respect, sustainability, and ecological · environmental sensitivity. Using epistemic

network analysis, I analyzed the discourse of twelve elementary school students from a university-affiliated science gifted education center to reveal the co-occurrence pattern of the subject's perspectives on ecological issues, problems, and solutions. As a result, the three epistemic network models were generated as the relationship between ecology and humanity, inquiry into the ecological problems, and practice and participation in ecological transformation. The first epistemic network model showed two different stances regarding the vegetarian diets of humans and their utterance types and connections. In the second module, the ENA model embodied the science-gifted students' perception reflected in their description of inevitable ecological problems in the future per periods. Lastly, the third model represented the discourse collected from the discussion on solving prospects in energy, sea, and agriculture. To improve science-gifted students' epistemic value on ecological transformation education, it needs to support them in breaking the stereotype that humans are superior to other living organisms and possessing the willingness and responsibility to live harmoniously as members of the earth's biosphere.

Teachers' Perceptions of Higher Secondary School Biology Topics: A Case Study

Sandhya A. Thakur[a] and Narendra D. Deshmukh[b]
[a]*Ret. S. K.Somaiya Vinay Mandir Junior College, Vidya Vihar, Mumbai, India*
[b]*Homi Bhabha Centre for Science Education, TIFR, Mumbai, India*
*Corresponding Author: sandhyajit@gmail.coma

It is well known that the quality and extent of learners' achievements are determined primarily by teachers' competence, subject matter knowledge, sensitivity to teaching and teachers' motivation. The paper presents a case of teachers' perceptions & experience of teaching topics either easy or difficult in Biology in higher secondary schools (Grades 11 & 12). This case study is important because it is observed that these teachers' have to teach a complete syllabus in an academic year while they may not be comfortable teaching each topic in the syllabus. In this study, eight experienced biology teachers from eight different higher secondary schools participated and data collected through questionnaires, interviews, classroom observations, and analysis of instructional materials. The teachers' questionnaire focused on morphology, physiology, the topics of the syllabus, such as: classification, cytology, genetics, evolution, animal systems, ecology, biotechnology, and plant anatomy. The data was qualitatively analysed to describe the teachers' perceptions & experience of teaching topics either easy or difficult in biological sciences provided by the teachers in questionnaires & interviews. Topics such as, morphology, physiology, plant anatomy, ecology, etc. were found interesting to teach and can be made concrete by using diagrams, examples, specimens, etc. However, classification, cytology, genetics, evolution, and biotechnology topics were found difficult in memorizing due to scientific names and technical terminology. The findings reveal that students' active participation, explanations with examples and use of technology and combining theory with related practical play a significant role in handling the situation. It is also found that teachers face difficulties in comprehending and teaching complex biology concepts because of the historical character of biology and high content levels in textbooks. It is recommended that elements of the classroom techniques include teachers' intentions, knowledge of textbook content, pedagogical knowledge, students' curiosity and level of interest, teachers' autonomy, and time constraints. These findings may help to create the teaching and learning materials. This study has implications for both pre-service and in-service teachers' education and also for policy makers.

Creating The Ideal Fish: A program placing "life history" into perspective

Toshiro Saruwatari[a,b]*,
[a]*Atmosphere and Ocean Research Institute, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba, Japan*
[b] *Seikei Education and Research Center for Sustainable Development, 3-1-3 Kichijojikitamachi, Musashinoshi, Tokyo, Japan*
*Corresponding Author: tsaruwat@aori.u-tokyo.ac.jp

The fundamental difference between living resources we utilize as food, such as vegetables and fish, and non-living resources

such as petroleum and coal, is that the former reproduce and regenerate as part of a natural process. So, in theory, mankind should be able to use living resources for generations to come, so long as they are utilized and managed properly. In order to do so, it is relevant that life history of each and every organism is understood as a member of intertwined ecosystem. But, is the concept of life history or life cycle truly understood by the mass? To enhance understanding of life history, a lecture program was created. In outreach programs and lectures at various levels, from middle school to graduate school, students create the ideal fish based on what they have learned from through the lectures and their imagination. Descriptions on morphology, ecology, reproduction, relationship with humans must be provided. Each student present their ideal fish in a show and tell form or as a paper report depending on the occasion. By creating their ideal fish, the whole life history of that species comes into student's perspective, from eggs, larva, juvenile, young and adults and how they survive and reproduce, guaranteeing the presence of the next generation. Examples of ideal and unique creations will be shown at this presentation.

Adaptive, Innovative and Effective Practices in Teaching Biology: Experiences from the Philippines

Maricar S. Prudente[a]*, Socorro E. Aguja[b], Ronilo Antonio[a] and Dave Arthur Robledo[a]
[a]*Department of Science Education, De La Salle University, Manila 1004 Philippines*
[b]*Graduate Studies Department, De La Salle Araneta University, Malabon 1475 Philippines*
*Corresponding Author:
maricar.prudente@dlsu.edu.ph

Quasi-experimental studies that showcase adaptive, innovative and effective experiences in teaching Science in the Philippines are presented. Firstly, a study that dealt with the effective use of Metacognitive Argument Driven Inquiry (MADI) approach in developing students' conceptual understanding and argumentation skills is described. In the MADI approach, several metacognitive strategies were explicitly embedded in the biology lessons. The impact of the MADI approach on students' conceptual understanding resulted in an effect size of d=0.600, indicative of large positive effect on students' conceptual understanding. After exposure to MADI approach, students made high-quality arguments consisting of accurate and complete claim, appropriate and sufficient evidence, and appropriate and sufficient reasoning that link evidence to the claim. In another study, innovative instructional practices for online education using Home-based Biology Experiments (HBEs) were investigated. The study aimed to determine the effects of home-based biology experiments on students' knowledge gains, self-efficacy, and perceived levels of engagement. Students' knowledge gains were determined by comparing the results of the pre- and post-test questionnaires. While the self-efficacy, engagement, and perceptions of all participants (N=839) were investigated using the post-test questionnaire results only. Moreover, students' and teachers' feedback were gathered during focus group discussions. Findings revealed significant increase in knowledge gains after doing the HBEs. Students' self-efficacy and perceived level of engagement were likewise significantly improved. Collectively, these studies underscored the integration of metacognition and experiential learning in the design and implementation of adaptive and innovative instructional materials and practices to ensure effective and meaningful learning experiences for the students.

Diatom-based STEM education for problem solving in global river environmental issue

Shigeki Mayama[a]*, Karthickbalasubramanian[b], Utkarsha Tikhole[b], Kazuhiro Kato[c], Hiroshi Omori[d] Asuka Kumagai[e], Kumiko Kosakai[f], Hiroko Sano[g]
[a]*Advernced Support Center for Science Teachers, Tokyo Gakugei University, Koganei, Tokyo 184-8501, Japan*
[b]*Biodiversity & Palaeobiology Group, Agharkar Research Institute, Pune 411004, India*
[c]*Faculty of Liberal Arts, The Open University of Japan, Mihama, Chiba, 261-8586, Japan*
[d]*Graduate School of Agricultural and Life Sciences, University of Tokyo, Bunkyo, Tokyo113-0032, Japan*
[e]*Tokai University Sagami Junior & Senior High School, 3-33-1 Sonan, Minami, Sagamihara,*

Kanagawa 252-0395, Japan
[f]*Tokyo Gakugei University Senior High School 4-1-5 Shimouma, Setagaya, Tokyo 154-0002, Japan*
[g]*Tokyo Metropolitan Koishikawa Secondary School, 2-29-29 Honkomagome, Bunkyo, Tokyo, Japan*
*Corresponding Author:mayama@u-gakugei.ac.jp

We have been conducting educational activities for over decade in multiple countries, using diatoms as indicator organisms of river water quality, to understand river environments globally from a scientific perspective and to think about solutions to problems independently. In the practices and surveys conducted before the COVID-19 pandemic, Indian students expressed concrete opinions on improving the river environment after the classes, while Japanese students only suggested abstract improvement methods. To address this, we introduced STEM methods and conducted classes in Japan that combined diatom specimens from various countries in the past and present, ecosystem simulators, videos and photos, statistical data related to water quality, and internet searches. During the COVID-19 pandemic, we conducted classes in three schools in Japan. The results showed that even with different lesson plans, students' final thoughts were similar. Last year, we conducted classes in both Indian and Japanese schools and surveyed students' thoughts on rivers before and after the classes. Indian students showed similar results to past surveys, while Japanese students initially had similar reactions to the past, but after the classes, they began to refer to improvement and maintenance through collective efforts. After conducting classes in both countries, we held an interactive session using Zoom. Indian students asked various questions to the Japanese students, and Japanese students responded to all of them. Indian students could learn about the experiences of improving river environments in Japan, and Japanese students could broaden their international perspectives, both of which left a positive impression of the interactive session.

Assessment of Genetic Determinism Beliefs: Development and Validation of a Culturally Adapted Tool for Korean Society

Sunyoung Shin[a], Minsu Ha[b]*
[a]*Department of Science Education, Seoul National University, Seoul 08826*
[b]*Department of Biology Education, Seoul National University, Seoul 08826*
*Corresponding Author: msha101@snu.ac.kr

This study aims to develop and validate a culturally adapted version of the Public Understanding and Attitudes towards Genetics and Genomics (PUGGS) tool to assess genetic determinism beliefs among Korean university students. Genetic determinism is the view that individual characteristics, behaviors, and diseases are primarily determined by genes. Such beliefs can lead to essentialist thinking and cognitive biases, reinforcing stereotypes and prejudices against certain groups, potentially leading to discrimination and justifying inequalities. To address this, key factors of genetic determinism beliefs were extracted from prominent discussions in Korean online communities. These factors include intelligence, social class, talent, and physical traits. New items reflecting these factors were developed and integrated into the existing PUGGS tool. Pilot tests and expert reviews were conducted to ensure cultural appropriateness and comprehensibility. The revised tool was then administered to Korean university students. This study investigates (1) attitudes towards genetic determinism beliefs among Korean university students, (2) the effectiveness of the culturally adapted PUGGS tool, and (3) the socio-demographic factors influencing these beliefs. Data analysis includes reliability and validity tests and factor analysis to identify key influencers of genetic determinism beliefs. The findings aim to provide a comprehensive understanding of genetic determinism beliefs among Korean university students and offer foundational data for educational strategies and policy-making to mitigate the negative impacts of these beliefs. This study underscores the importance of culturally sensitive tools in accurately assessing and addressing genetic determinism.

Integrating Philippine Endemic Species in Biology Lessons

Jericca A. Gunda
Biology Unit, Philippine Science High School Agham Road, Diliman, Quezon City, Philippines
jagunda@pshs.edu.ph

Filipino students are more familiar with foreign species such as lions, tigers, and giraffes and

are less familiar with Philippine endemic species. The low awareness might be due to foreign references used in school and to foreign mainstream movies/videos which are more popular than their local counterparts. Integrating Philippine endemic species in Biology lessons might help increase student awareness and promote higher concern towards the welfare of such species. There are different ways of promoting endemic species in the classroom. One is by using recitation stickers with pictures and local names of these species. Another is by using endemic species as examples in lessons. The most effective way of getting to know the Philippine endemic species, according to students, is by researching about these species as part of their requirements/assessments. Integrating the endemic species helped students appreciate and care more for what species we have in the country, and hopefully translate to more active participation in promoting the welfare of these species.

Interdisciplinary Learning in Biology: Bridging Disciplinary Boundaries for Enhanced Learning and Retention in Middle and Senior Secondary Schools

Neeta Bisht
Department of Biology, The Hyderabad Public School, Begumpet, 1-11-87 & 88, S.P. Road, Begumpet, Hyderabad, India
neeta.bisht@hpsbegumpet.org.in

Interdisciplinary learning represents an innovative approach that merges the objectives and methodologies of two or more disciplines as opposed to a traditional monodisciplinary approach which is inadequate for solving the multifaceted challenges of the modern world. This paper aims to assess the effectiveness of interdisciplinary teaching of Biology across Middle, Secondary, and Senior Secondary schools, correlating it with enhanced student knowledge and increased retention. The study was carried out to broadly connect Biology learning with other disciplines like Physics, Chemistry, Geography, and Art. A pedagogical study was carried out assessing the lesson plans of Biology teachers and their effectiveness through the lens of an interdisciplinary approach. The study involved 1200 students from grades 7-12 and a set of formative assessments designed to evaluate the broad integrated understanding were administered. Results indicate a strong correlation between the interdisciplinary approach and its significance in improvement in both comprehension and practical application of concepts and better retention of concepts as evident in the marks scored in the formative assessment. The study advocates for the wide-spread adoption of interdisciplinary teaching methodologies across the Middle and Senior & Senior Secondary schools in Biology elevating student engagement and academic attainment. The interdisciplinary approach helps students develop lifelong learning skills essential for their future education.

Effect of treatment with a microscale pressurizer on the germination rate of plant seeds

Fukutaro Enda, Naoshi Watanabe*
Miyagi University of Education, Professional Schools for Teacher Education, 149 Aramaki, Aoba-ku, Sendai, Japan
*Corresponding Author: nao-wtnb@staff.miyakyo-u.ac.jp

This study investigated the effect of pressurization (0.2-1.0 MPa, 600 s, 20 °C) using a microscale pressurizer on the germination of plant seeds. The plant seeds used in this study were five species (crown daisy, tomato, carrot, parsley and Japanese parsley) that were selected mainly from plant seeds with low germination rates, as indicated by the Japanese Ministry of Agriculture, Forestry and Fisheries. The control population underwent pressurization of 0.1 MPa for comparison. The germination rate of Japanese parsley tended to increase by 62.5% at 0.2 MPa and by 125% at 0.5 MPa. In contrast, the germination rate of crown daisy tended to decrease by 42.5% at 0.2 MPa. No significant differences were observed for other seeds or under other pressurized conditions. This study's results are of great significance because they show the effectiveness of the microscale pressurizer. The microscale pressurizer enables microscale physiological hydrostatic experiments on animals and plants and can be used for teaching in exploratory activities. It can also overcome problems related to seed germination that can hinder teaching in science classes in elementary and junior high schools. The ability to promote stable seed

germination through pressure treatment can ensure greater learning opportunities for students. The increased germination rate of plant seeds leads to sustainable management of forests, and this research is relevant to and contributes to the achievement of SDGs 4 and 15.

Comparing Science Curriculum Design of Thailand with Japan: A closer look at biology contents in middle school science curricula

Witchayada Nawanidbumrung
Graduate of Human Sciencest, Waseda University, 2 Chome-579-15 Mikajima, Tokorozawa, Saitama 359-1164
w.nawanid@fuji.waseda.jp

The national science curriculum plays a crucial role in shaping science teachers' approaches to teaching science in actual classrooms. Conducting a cross-cultural comparison can allow us to identify similarities and differences in learning outcomes, content arrangement, and pedagogical approaches emphasized in different contexts. This can provide us with broader understandings and perspectives of how our science teachers should be supported to teach science more effectively and how our students can be encouraged to construct a more well-rounded and robust understanding of science. Hence, this study aims to compare Thailand's science curriculum design with Japan's, focusing on biology contents at the middle school level. This study is a descriptive research analysis of documentary analysis. To conduct a cross-cultural analysis, the Basic Education Core Curriculum (BECC) and IPST science textbooks were used to understand Thailand's middle school science curriculum. The Course of Study for Middle School (CSMS's English version on MEXT's official website) and Dai-Nippon science textbooks were used to understand those of Japan. A content analysis of the two countries' science curricula revealed notable similarities and crucial distinctions. For the goal of science education, cultivating students as scientifically literate citizens is seemingly emphasized in both science curricula since they display science learning processes commonly associated with scientific investigations and studentcentered inquiry experiences. However, some characteristics of both curricula are different, such as the total times used in teaching biology concepts, required biology concepts, and their arrangement in each lower secondary school grade level.

Which organisms live in aquarium water?: "Aquarium PCR": exploring DNA technologies via practical learning experiences

Nobuaki Asakura[a]*, Ami Nishimura[b] and Daichi Ona[b]
[a]*Department of Biochemistry and Biotechnology, Faculty of Chemistry and Biochemistry, Kanagawa University, Rokkakubashi 3-27-1, Kanagawa-ku, Yokohama, Japan*
[b]*Department of Material and Life Chemistry, Faculty of Engineering, Kanagawa University, Rokkakubashi 3-27-1, Kanagawa-ku, Yokohama, Japan*
*Corresponding Author: asakura@kanagawa-u.ac.jp

The need to better understand living creatures and the environment has become increasingly important due to environmental issues such as climate change and loss of biodiversity. Biology plays a crucial role in promoting a healthy lifestyle. Advances in molecular biology techniques such as recombinant DNA and DNA diagnosis, and more recently genome editing, have increased the need to understand the nature and application of these techniques. It is expected that individuals have a comprehensive understanding of these techniques, highlighting the increasing significance of biology education. Given this background, we focused on DNArelated techniques that facilitate the examination of biodiversity at the DNA level. To this end, we developed an experiment aimed at teaching these techniques through the practical application of environmental DNA detection, primarily for high school students. We named this experiment ‘Aquarium PCR’ (polymerase chain reaction), which comprises four steps, i.e., DNA isolation from aquarium water, PCR, electrophoresis of the PCR products, and DNA detection using a fluorescent stain. Several species of freshwater fish, including Japanese medaka, were kept together in the same aquarium. DNA was isolated from the aquarium water and selective primers were designed and used to detect DNA from specific freshwater species. In addition, universal primers developed for fishes by Miya et al. (2015) were also used to amplify DNA. The specificity of our primers for amplifying DNA was verified through restriction

analysis. This sequence of experiments provides high school students with an excellent opportunity to learn about DNA-related technologies.

An Earth and Life Science Course for the Rest of Us: Students' Conflicted Stories of Participation

Victor Lorenzo E. Wong[a]*, Mary Geraldine C. Yumang[a], Leah D. Madrazo-Panes[a], Julyvern C. Simyunn[b], Frederick T. Talaue[c]
[a]*Faculty, De La Salle University-Integrated School, Philippines*
[b]*Member, Biology Teacher Association of the Philippines (BIOTA), Philippines*
[c]*Faculty, Bro. Andrew Gonzalez FSC College of Education, De La Salle University, Philippines*
*Corresponding Author: victor.wong@dlsu.edu.ph

The goal of scientific literacy has become crucial in conversations about school science reform to address complex and interdisciplinary sustainability issues confronting our communities. Redesigning our Earth and Life Science (EALS) course, which all senior high school students from various academic tracks other than STEM take, allowed us to begin reimagining science learning for all - from merely learning concepts to mobilizing scientific knowledge for engaging participation in socio-ecological issues. A focus group discussion and interview were used to elicit students' perceptions and experiences to gain a holistic understanding of the impact of the revamped EALS curriculum. Through inductive thematic data analysis, we surfaced the tensions in students experienced: (1) overwhelming study load vs foundational college preparation; (2) perceived irrelevance to their academic track vs meaningful real-life application; (3) communication struggles during the pandemic vs active collaboration and immersive learning. We reflect on tensions in student stories to articulate a pedagogical framework necessary for teachers' collective guidance in future course iterations. Restructuring the course based on these insights can foster a more inclusive and engaging learning environment, ultimately empowering students to develop a deeper appreciation for the sciences and their relevance to the lives of our communities.

Using C. elegans for Early Detection of Cancer in Dogs and Cats

Umbhorn Ungkulpasvich*, Eric di Luccioa and Takaaki Hirotsua
Shonan R&D Center, Hirotsu Bio Science Inc., 4-1 Kioi-cho, Chiyoda-ku, Tokyo, Japan
*Corresponding Author: Umbhorn@hbio.jp

In the United States in 2023, an estimated 65.1 million dogs and 46.5 million cats lived as pets. The annual incidence of cancer among these animals is estimated at 4 million cases, with mortality rates of 47% in dogs and 32% in cats. Dogs experience cancer incidence that is 2.5 times higher than that of humans, which may be linked to their shorter lifespan, genetics, and higher prevalence of diseases. Regular cancer screenings are recommended for pets, but advanced techniques like CT and MRI scans are limited by cost and anesthesia requirements. A new screening method called N-NOSE has been developed to detect cancer in pets using the chemotaxis behavior assays of Caenorhabditis elegans (C. elegans) to detect cancer in urine samples. Previous research has shown that C. elegans are strongly attracted to cancer urine while avoiding healthy urine samples. In this clinical study, N-NOSE was used to detect cancer in the urine of dogs and cats. The chemotaxis index values in cancerous and healthy animals differed significantly ($p < 0.01$ for dogs and $p < 0.04$ for cats). The N-NOSE method is highly accurate, with areas under the ROC curve of 0.8114 and 0.7851 for dogs and 0.7667 and 0.9000 for cats in different urine sample dilutions. The study suggests that N-NOSE could be a simple and convenient method for early-stage cancer screening in dogs and cats. Currently, N-NOSE is already a commercial success for dogs and cats cancer screening in Japan.

Understanding adolescents' knowledge and attitudes towards vaccinations and vaccine-preventable diseases: Perspectives from India

Anupama Das[a], Sandhya Koushika[b], Gauravi Mishra[c], and Arnab Bhattacharya[a]
[a]*Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India*
[b]*Dept. of Biological Sciences, Tata Institute of Fundamental Research, Mumbai, India*
[c]*Dept. of Preventive Oncology, Tata Memorial Hospital, Mumbai, India*
*Corresponding Author: anupamadas@hbcse.tifr.res.in

The Universal Immunization Program (UIP) in India has not adequately emphasized adolescent immunization with most government initiatives targeted towards early childhood vaccination. The study addresses the dearth of evidence in India on vaccination information needs of adolescents. An exploratory qualitative study was carried out with grade 9–12 students after COVID-19 vaccinations were introduced stagewise in India for children aged 12–18. Semi-structured interviews conducted between November 2022–February 2023 with 16 students across socioeconomic strata (SES) in Mumbai, India, to ascertain their knowledge and attitudes towards vaccines and vaccine-preventable diseases. Excluding chickenpox and COVID-19, students' awareness of diseases was limited to examples listed in the science textbooks. Lower SES students reported getting measles, mumps, cholera, and typhoid in childhood. Vaccine safety and sideeffects emerged as the top concerns among students. Parents, doctors, and teachers were viewed as reliable and trustworthy sources of vaccine information. Students felt that schools did not provide adequate vaccine information. Though unsure about its "truthfulness", the media was still a preferred source of information. Our observations provide insights into the COVID-19 experiences and concerns of adolescent students. Most students were unaware of the Human Papillomavirus (HPV) and showed low intent to get vaccinated, which is concerning, given the Indian government's plan to introduce it into the UIP. Hence, a study on their perspectives would be vital in achieving sustainable development goals of good health and well-being. Science education and teachers have a crucial role in fostering scientific literacy about vaccination among students, especially in this post-COVID-19 era.

The practice of visiting lessons of observation and experiment using insects for elementary school life environmental studies by university students

Tomomi Sawa[a]*, Misaki Hada[b], Yuki Okumura[a], Yutaka Nakamatsu[a]
[a]*Faculty of Education, Kogakkan University, 1704 Kodakushimoto-cho, Ise-shi, Mie, Japan*
[b]*Misono Elementary School, 1074-9 Ise-shi, Misono-cho Nagaya, Mie, Japan*
*Corresponding Author: t-sawa@kogakkan-u.ac.jp

The curriculum guidelines for Life Environmental Studies state the following goals: "Students should be able to think about their own relationship with nature, notice the goodness and splendor of these things and their relationship with themselves, and cherish nature. Through contact with and involvement in nature, they should be able to devise and enjoy them, realize the goodness and importance of activities, and improve their own play and life," etc. Given these facts, experiential learning is emphasized in life environment studies, and actually observing plants and animals in the outdoors is an important activity. In this study, we developed observation and experiment materials using live insects in order to learn about animals and plants to be aware of when observing nature in the field, and also to learn about insects' habitats and food, thereby cultivating a perspective when observing nature. The class will (1) classify insects and non-insects. (2) Learn about the relationship between insects' habitats and food sources. (3) To learn about dangerous plants and animals. In addition to basic content such as an explanation of insects prior to the third grade science class, the class also touched on more advanced content. Team-teaching classes were conducted by university students for first- and second-year elementary school students in the prefecture, and a questionnaire survey was conducted for students before and after classes. In this presentation, we will report our analysis of the developed teaching materials and the results obtained from the questionnaire survey.

Exploring How Teachers Navigate Tensions When Developing Assessments in a Professional Learning

JaeBin Lee, Soo-Yean Shim*
Department of Science Education, Seoul National University 1, Gwanak-ro, Gwanak-gu, Seoul, Korea
*Corresponding Author: sys7829@snu.ac.kr

Educational assessments provide opportunities to evaluate and improve the effectiveness of curricula or teaching methods. In developing these assessments, educators often encounter tensions—moments of explicitly confronting competing demands or juxtaposed ideals about assessments or education. This study aimed to explore the tensions that arise when teachers

develop assessments within a professional learning community, how they manage the tensions, and how the tensions affect the assessment development process. To this end, we formed a professional learning community with four middle school science teachers in Korea. The teachers had eleven 90-minute meetings to collaborate on developing and reflecting on assessments. We recorded the teachers' discourse and gathered artifacts from the meetings. We transcribed and qualitatively analyzed the teachers' discussions about assessments. Our findings showed that the teachers identified and managed three main types of tensions while developing and implementing assessments. The tensions were between the goals of: 1) "eliciting diverse answers from students" and "scoring with fair criteria," 2) "focusing on the processes of learning to guide student growth" and "grading to measure learning outcomes," and 3) "using group assessments for efficiency" and "using individual assessments to evaluate each student's learning." These tensions emerged when the teachers discussed how to realize their goals for teaching and learning while considering institutional requirements. By addressing these tensions, the teachers developed concrete strategies for assessments focused on reform-oriented goals in science education. This study provides implications for supporting teachers' professional learning about assessments and collaboration.

Enhancing Critical Thinking Skills in High School Biology Education Through Real-Life Scenarios: An assessment of conceptual understanding

Narendra D Deshmukh
Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India.
ndd@hbcse.tifr.res.in

Critical thinking has become an important skill of the 21st century to cater for complex challenges. However, it also fosters allied life skills such as organizational skills, planning, open-mindedness, and communication skills among school students. The researchers used Scriven and Paul's definition of critical thinking as a guide and developed a framework adapted from Barnett's model: Think-Reflect-Act approach. The current study aimed to identify the extent to which 42 grade six & 41 grade nine students demonstrated critical thinking through carefully crafted real-life scenarios. Qualitative data is gathered through real-life scenarios on biological concepts and analyzed by categorizing information to understand themes and insights. According to the findings of the study, the use of real-life scenarios teachers can help students to develop critical thinking and problem-solving abilities in various ways. It shows that localized and contextualized learning activities promote a better understanding of the lesson. The findings also emphasized that critical thinking is a crucial skill that has the potential to benefit students in solving complex reallife problems. Therefore, it is essential to prioritize the teaching and learning of critical thinking in biology education. The study recommends adopting real-life scenarios strategies in teaching school biological concepts, in addition to conducting conceptual understanding. Hence, future study is suggested to develop and produce localized and contextualized instructional materials such as modules and worksheets for other learning competencies in biological sciences.

Study on Observation Method of Microtubules by Microscope in High School -Effects of Microtubule Inhibitors and Potential for Inquiry Activity Materials-

[a]*Takeshi Katayama, [b]Masahito Nozaki, [c]Susumu Tanaka & [d]Mizuki Hino
[a]Faculty of Human Development, Takasaki University of Health and Welfare, 58-2 Nakaohrui-machi, Takasaki, Gunma, Japan
[b]Municipal Ota High School, 1510 Hosoya-machi, Ota, Gunma, Japan
[c]Faculty of Health and Welfare, Takasaki University of Health and Welfare 37-1 Nakaohrui-machi, Takasaki, Gunma, Japan
[d]International Research Institute of Disaster Science,Tohoku University, 2-1 Seiryo-cho, Aoba-ku, Sendai, Miyagi, Japan
*Corresponding Author: katayama@takasaki-u.ac.jp

Since 2013, pictures of the cytoskeleton have been included in all Japanese high school biology textbooks, as the Courses of Study state that "to deal with the structure and function of cytoskeletons". However, these pictures are taken by fluorescence microscopy

or confocal laser microscopy using the fluorescent antibody method, and students cannot observe the cytoskeleton because these instruments are not available in high schools. Therefore, we proposed the immunoenzyme technique that can be observed with an optical microscope for students in high schools at this conference in 2018, and introduced a method for observing the cytoskeleton using silkworm (Bombyx mori) blood cells, which are readily available in Japan, at this conference in 2022. In this conference, we will introduce a method for observing microtubules in A6 cells which are Frog (Xenopus laevis) cell line derived from kidney that can be easily cultured by high school students. Microtubule inhibitors have been used as anti-cancer drugs (paclitaxel), gout medications (colchicine), and pesticides (propyzamide). We will discuss the results of observations of microtubule behavior using these drugs and their potential as teaching materials for high school students' inquiry activities.

Wetlands as Classrooms: Advocating for local ecosystems through collaborative classroom-based research: A preliminary biological survey of Sasmuan-Bangkung Malapad Critical Habitat and Ecotourism Area

Sheila S. Cabrala*, Joshua Allen Canlasa, Aris Condoya, Cielo Donaa, Wise Janzen Dangkulosa, Princess Lachicaa, Kim Ji Wona, Cristina Yvette Pinedaa , Kyle Sherwin Poncea, Christine Samsona, Marlon dL Subaa, and Roberto C. Pagulayana

Department of Biological Sciences, College of Arts and Sciences, Angeles University, Foundation, Mac Arthur Highway, Angeles City, Philippines

*Corresponding Author: cabral.sheila@auf.edu.ph

Wetlands are ecosystems where land and water interact. The Sasmuan Bangkung Malapad Critical Habitat and Ecotourism Area (SBMCHEA) is a mangrove islet created through the deposition of volcanic sediments. It lies within the Sasmuan Pampanga Coastal Wetland (SPCW), which in 2021 was declared as the Philippines' 8th Wetland of International Importance. SPCW is composed of inter-connected mudflats, mangroves, and a river ecosystem. It is an important stopover for migratory birds on the East AsianAustralasian Flyway. The river system is also of economic, historical, and cultural significance to municipalities along its banks. Despite these, there is a dearth in available data on its biological diversity. The main objective of this study is to fill that void. Specifically, it aimed to determine the status of the wetland by measuring select physico-chemical parameters of the water and conducting a preliminary survey of its biological diversity (plankton, mangrove and fish). The study was conducted as part of the requirements for the course Freshwater Ecology by BS Biology students. Results of the physico-chemical parameters show that total dissolved solids (TDS) and dissolved oxygen (DO) were slightly higher than those for class C waters as defined by DAO 2016-08 and DAO 2021-19. Diatoms made up majority of the phytoplankton identified, while nauplius larva were the most common zooplankton identified. Five mangrove species were also identified with their conservation status under IUCN also being identified. Of the fish samples collected, 15 species were identified. This includes the endemic Leiopotherapon plumbeus, which is listed as vulnerable by IUCN.

Students' Procedural Understanding During Inquiry-Based Practical Work: Preliminary Findings of Fermentation Experimentation

Nur Fadhila Baharudin[a], Hidayah Mohd Fadzil[b] and Rohaida Mohd Saat[a]*

[a]*Department of Mathematics and Science Education, Faculty of Education, University of Malaya 50603, Kuala Lumpur, Malaysia*

[b]*Department of Mathematics and Science Education, Faculty of Education, University of Malaya 50603, Kuala Lumpur, Malaysia*

*Corresponding Author:hidayahfadzil@um.edu.my

During inquiry activities, students frequently fall into the habit of mechanically following textbook steps, which causes them to lose sight of the activity's purpose and prevents reflective engagement. This lack of student autonomy during practical work results in a poor grasp of procedural understanding and biology concepts. To address this problem, an in-depth qualitative study was conducted using a guided inquiry-based approach. The guided inquiry activities were framed around

questions related to fermentation concepts and measurement guidelines, without providing specific experimental procedures. This qualitative case study involved 17 upper secondary school students from two sites, who participated in a scientific investigation on 'Yeast Fermentation'. Data were collected through interviews and observation of classroom discussions and analysed using the constant comparative method of analysis. The findings reveal that students involved in guided inquiry practical work were able to design experiments and evaluate the investigative process logically. However, this procedural understanding was achieved only after overcoming uncertainties, making multiple attempts and failures, and seeking guidance from peers and teachers. These results provide valuable insights into the challenges and successes related to procedural understanding in biology education, emphasising the significance of practical work in fostering deeper learning and engagement among students.

Unveiling Robotics Technology in Biology Educatione

Genevieve A. Pillar[a]*, Socorro E. Aguja[b] and Maricar S. Prudente[c]
[a]*Applied Sciences Area, De La Salle Santiago Zobel School, Muntinlupa, Philippines*
[b]*Graduate School Department, De La Salle Araneta University, Malabon, Philippines*
[c]*Department of Science Education, De La Salle University Manila, Philippinesepartment, Institution*
*Corresponding Author: pillarga@dlszobel.edu.ph

Robotics is a cutting-edge technology in science education that is becoming an essential part of modern curricula. Research findings indicate that incorporating robotics into the curriculum can greatly improve students' thinking and self-directed learning abilities. For biology teachers, it is crucial to find engaging and innovative ways to offer students authentic, unique, and relevant learning experiences. Studies have shown that robotics fosters skills vital for success in the Fourth Industrial Revolution, including creativity, critical thinking, decision-making, and complex information processing. Integrating robotics in biology education involves students working collaboratively on research projects addressing life science issues and concerns. During the project-making tasks, students are guided by their science teachers, robotics coaches, and research experts. This research showcases three exemplary projects namely: 1. VERTIBOT - an automated vertical garden robot designed to tackle the issue of farming in urban areas; 2. MAGDRAUBOT - a robot employing hydroponics and magnetism to provide alternative farming techniques; and 3. SENTRY - a robot designed for pandemic safety measures, featuring temperature checking, disinfection, movement barriers, and notification processes. Narratives from students highlight how their problem-solving and creative thinking skills are manifested in the design and development of these robot projects. These projects demonstrate the potential of robotics to enrich biology education and equip students with essential skills for future challenges. By exploring these projects and their outcomes, this research underscores the transformative potential of robotics in education, fostering not only academic growth of the students but also essential life skills.

Effects of Students Planning and Managing Lessons in InquiryBased Biology Classes

Hiroko Sano
Tokyo Metropolitan Koishikawa Secondary School, 2-29-29 Honkomagome, Bunkyo city, Tokyo, Japan
irosophie@gmail.com

The new course of study in Japan, which has been in effect since 2022, promotes the improvement of classes by incorporating the process of inquiry. Many teachers in Japan are trying to incorporate inquiry in their classes, but few teachers are conducting inquiry in their classes because they distinguish between inquiry activities and classes. At the same time, the curriculum of the new course evaluates students on three perspectives: “Fundamental knowledge and skills”, “Ability to think, to judge, to express themselves” and “Attitude of proactive learning”. It can be used not only to provide feedback to students on their evaluations and to further develop their qualities and abilities, but also to improve classes for student development. Therefore, it is necessary to integrate the classes and evaluation of inquirybased classes. I am working on improve my inquiry-based classes,

and on exploring evaluation methods to integrate the classes and evaluation. In this presentation, I will introduce inquiry-based biology class of the field of molecular biology that all 5th grade students of our secondary school take. While the students planned their objectives, hypotheses, and verification plans, the research plans that were most evaluated were conducted experimental classes in which students actually planned, prepared, and operated.The preparation and management of classes by the students improved the skills necessary for the students' inquiry. In particular, the assessment of lesson preparation led to an improvement in the verification plan, among other things.

Epistemic Cognition in Science Education Practices in Japan: Case of Biology Classrooms

Denis Dyvee R. Errabo[a,b,c]*, Keigo Fujinami[b] and Tetsuo Isozaki[b]

[a]*Japan Society for the Promotion of Science, Post doc Fellow*

[b]*Graduate School of Humanities and Social Sciences, Hiroshima University, Hiroshima, Japan*

[c]*Department of Science Education, De La Salle University Manila, Philippines*

*Corresponding Author: denis.errabo@dlsu.edu.ph

Japan's strong PISA rankings have sparked renewed interest in global education. Understanding Japan's epistemic fluency in science education practices is essential for gaining insight into their consistent academic success. Epistemic fluency demonstrates justified beliefs, the "process," and "ways of knowing." Anchored on the epistemologies in practice framework, we aimed to examine the students' objectives for constructing knowledge and their awareness of how to engage in that process. Notably, we seek to answer the question: How do biology classrooms develop epistemic fluency in Japan? The study employed a grounded theory research design. Our research strategy integrated school immersion, examining the classroom environment and closely observing the teaching methods used by the teachers. The classroom immersion occurred in three schools, where we observed seven elementary, lower, and upper secondary classes. We meticulously documented our observations through field notes, video recordings, and photographs. We enhanced our data by conducting focused group discussions and interviewing the teachers. Then, we coded our recordings and constantly compared them with our field notes. Our peers carefully reviewed the coded transcripts during the observation to ensure their accuracy and validity. We used Marrying's inductive content analysis to explicate epistemic fluency into themes. Our research findings indicate that biology classroom demonstrates epistemic fluency through practical and real-life learning experiences. The students were actively involved in scientific exploration and fully engaged in hands-on scientific skills. The design of the classrooms accommodated inquiry innovatively and interactively. In addition, studying biology promotes self-reflection, which helps foster a deeper understanding.

Empowering Curious Minds: Exploratory Teaching through Immersive Learning using the GLOBE Program Protocols

Josephine Joy T. Antalana

Biology Unit, Curriculum and Instruction Division, Philippine Science High School – Central Luzon Campus, Lily Hill, Clark Freeport Zone, Pampanga, Philippines

jjantalan@clc.pshs.edu.ph

In pursuit of transcending the confines of the classroom, exploratory teaching embraces a dynamic approach as students delve with varied skills which prioritizes discovery, scientific inquiry, and active engagement within the learning process. In this study, GLOBE Program protocols were emphasized and explored. For a span of two weeks, students embarked on an immersive learning journey focused on exploring different Earth System protocols covered by the GLOBE Program. The main target of the program is to provide students with opportunities in making significant environmental observations and collecting environmental data using the GLOBE Program. New GLOBE student accounts were created to submit data to the GLOBE Observer app, the GLOBE Data Entry and checked using the GLOBE Visualization System. A total of 249 data submissions by the students were reported, including 88 data collected in Atmosphere Protocol – Clouds; 17 data collected in Hydrosphere Protocol - Mosquito Habitat Mapper; 108 data collected in Biosphere Protocols - Land Cover,

Biometry Tree Heights, and 36 data collected in Pedosphere Protocol - Vegetation Covers. Students have continuously worked together on case studies, engaged in hands-on GLOBE activities and fieldwork using the GLOBE Protocols. Evidently, the students have developed a greater understanding of the environment around them while gaining essential insights into scientific procedures through activities like observing cloud conditions, reporting mosquito breeding sites, measuring tree heights, and evaluating soil moisture and land covers. It was also imbibed to have a strong connection to the global environment which ignited a love for environmental stewardship and preservation.

Teaching materials for indicator species surveys

Gentatsu Okamoto
Department of Science, Ikeda Senior High School attached to Osaka Kyoiku University 1-5-1 Midorigaoka, Ikeda, Osaka, Japan
gentatsu0311@gmail.com

In Osaka, the survey of indicator species by high school students was conducted as a project for the 40th anniversary of the Osaka High School Biology Education Research Association, and has been conducted almost every five years since then. The main purpose of the survey is to encourage high school students to pay attention to the nature around them through the survey. In addition, teachers have analyzed the results of the surveys conducted by the high school students and published reports. Therefore, through the survey of indicator species, I have attempted to create teaching materials to foster qualities and abilities. The survey was conducted same items as the Osaka High School Biology Education Research Association's Survey of Indicator Species Method A. I used the Google Form to the survey, because it is easy to aggregate the survey items and export them as a spreadsheet for later analysis. In the first year, analysis groups were formed for each survey item in class before the summer vacation, each group analyzed the results during the summer vacation, and the analysis results were presented in class after the summer vacation. Next year, I improved so that individual research would be conducted. Through these activities, the students' interest in nature around them, ability to analyze and utilize data, and presentation skills improved. In the future, we would also like to conduct this survey at each high school in Osaka and build a culture in which Osaka high school students survey and analyze the ecosystem of Osaka.

Exploring DNA experiments using rice crackers common in Asian countries

Yijie Liu[a], Akiho Ishii[b], Emiko Matsuhisa[b], Naoki Arai[c], Nobuaki Asakura[c]*
[a]*Department of Material and Life Chemistry, Faculty of Engineering, Kanagawa University, Rokkakubashi 3-27-1, Kanagawa-ku, Yokohama, Japan*
[b]*Kanagawa University Junior and Senior High School, Daimura-cho 800, Midori-ku, Yokohama, Japan*
[c]*Department of Biochemistry and Biotechnology, Faculty of Chemistry and Biochemistry, Kanagawa University, Rokkakubashi 3-27-1, Kanagawa-ku, Yokohama, Japan*
*Corresponding Author: asakura@kanagawa-u.ac.jp

The Human Genome Project commenced in 1990 and concluded in 2003. The project yielded the complete nucleotide sequence of the human genome, a crucial component of human biology. Following this historical achievement, thousands of genes were identified that are responsible for our physical and mental health. This knowledge has facilitated the development of genetic diagnostic methods that can be used to predict the onset of disease and the effects of treatments. Genetic diagnosis has the potential to contribute significantly to our well-being. However, knowledge of DNA-related technologies is not yet widespread. The importance of biological education is becoming increasingly evident. Here, we propose a new DNA experiment using rice crackers to facilitate learning about DNA technologies. Rice crackers, or rice cakes, are commonly eaten in Asian countries, particularly in Japan. Two kinds of rice cultivars are used to make rice crackers: glutinous rice and non-glutinous rice. In each glutinous rice cultivar, one of two types of DNA mutations in the waxy gene that encodes a granule-bound starch synthase was identified. Glutinous rice and non-glutinous rice can be distinguished by

examining the waxy gene. Furthermore, DNA isolation from rice crackers was successful despite the ultra-processed nature of the food. Based on these findings, we have developed an experimental procedure to determine which type of rice is used in rice cracker production. This educational exercise offers junior and senior high school students a valuable opportunity to gain firsthand experience with DNA-related technologies. Details will be reported in the presentation.

Community-based Micro-watershed Resource Conservation: Impact Assessment of Anthropogenic Activities on the Water Quality of Barangay Irisan Watershed in Baguio City Biology Project-based Learning Approach

Melissa Ann B. Kindipan*, Arfe G. Castillo, Jesus Amador Saldeo, Joe Mark A. Aglolo, John Kevin Skyler T. Balinsat, Tristan Dale C. Dulay, Kristoff Freidrich D. Tapnio, Danielle Raissa Grace D. Valentin, Desha Janallie B Charongen, Arianna, Karina D. Millondaga, Cyprielle Anne M. Salas, Quiana Anjoelli P. Tamayo, Althea Lorein A. Valenzuela, Solborn B. Balawas, Jasmin Renee S. Colayco, Shaina Sonia I. de Guzman, Danielle Loureine P. Mayo, Maria Angela Francesca U. Yabut, Korinne Alea D. Adeban, Ivan Jonah T. Farnacio, Antoine Joeval M. Ginez, Rakel Alexis Z. Matias, Jem Bernice A. Estavillo, Tabitha Chloe Q. Kadatar, Princess Yana L. Nuqui, Amiel Ely M. Palis, Jelina Micah P. Zamora, Keisha Louise B. Aloot, Janella Andrea D. Caisip, Yzel Kathreen E. Castro, Jazsy Gaverielle A. Dando, Samantha Danielle L. Haduca, Jared Usher K. Bacwaden, Rya Lorin M. De Mesa, Jana Janel B. Visperas, Zaria Gabrielle E. Lu, Geo Joshua L. Smith, Zoe Samantha R. Garcia, Fiona Kirstie A. Suñaz, Gabriel V. Mariñas, Edward Dunn Nicoli A. Castillo, Ethan Joseph B. Dumaya, Jose V. Olarte, Yna Ayessa B. Catalig, Maria Sophia B. Hiponia, and Patricia Maegan C. Laguitao

Philippine Science High School-Cordillera Administrative Region Campus Purok 12, Irisan, Baguio City, Philippines

*Corresponding Author: mbkindipan@carc.pshs.edu.ph

Irisan, the largest barangay in Baguio City, Philippines, is fortunate to have local water springs that serve as a primary source for household water in at least 6 out of 28 zones despite the city confronting a myriad of water security challenges. However, there is a lack of data regarding the status of these local water springs and the absence of a comprehensive conservation plan. This study addressed this knowledge gap by conducting an assessment of the water quality, biodiversity and microclimate of the watershed in Purok 9 in collaboration with local stakeholders. Employing standard methods, the study evaluated water quality particularly, dissolved oxygen, total suspended solids, pH, temperature and fecal coliforms over four months to capture temporal variations. The results of the study revealed the presence of E. coli in both source and household water samples, indicating potential fecal contamination. Biodiversity assessments revealed a rich array of flora and fauna species, highlighting the ecological significance of the area. Meanwhile, microclimate analysis unveiled distinctive temperature patterns, with Purok 9 exhibiting a lower temperature of up to 5 degrees Celsius difference compared to neighboring areas, alongside a reduced UV index. Such insights offer valuable inputs for ecosystem management and conservation efforts in the city. The results of this project-based learning and collaborative study approach were presented to the local government as basis for policy formulation and future projects.

One practical example of agriculture-based inquiry learning from its treatment in biology education

UTSUNOMIYA Shunsei*, KOYAMA Akinori

**Fujisawa Shoryo High School, Address,7-1-3, Zengyo, Fujisawa, Kanagawa, Japan*

*Corresponding Author: utsunomiya@shoryo.ed.jp

With future population growth in the world, a number of issues related to the environment and energy are receiving renewed attention. Among these, those related to food are the most pressing: the SDGs and other global initiatives to solve food problems are gaining momentum around the world. In Japan, there are many issues that need to be faced, such as a decrease in the number of bearers due to the ageing of the farming population and the large amount of food waste. We believe that it is

worthwhile to address these social issues once again in school education. Against this background, we introduce a practical case study from our school in which an inquiry-based study centred on agriculture was conducted in a science (biology) class. The school does not have an agriculture department and does not have any agricultural know-how, so the exploratory learning was done by hand. For example, the exploratory learning was conducted by setting issues based on soil analysis and ecological observations of the fields ploughed by the students. Continued practice is needed in the future, so we report on the current practice and results, and then describe future prospects.

Instructional Supports and Contexts for Facilitating Elementary School Students' Scientific Argumentation

Hoon Jeong & Soo-Yean Shim*
Department of Science Education, Seoul National University

The study aimed to explore instructional supports and contexts that influence the level and patterns of small-group argumentation activities among elementary students. To achieve this, a 9-lesson unit was developed focusing on constructing an explanatory model and argumentation about "What will happen to the ecosystem if bees disappear?" The unit was implemented over 5 weeks in two 5th-grade classes. Video recordings of the entire classroom, small-group activities, and class outputs were collected and qualitatively analyzed. The results revealed that instructional contexts and supports that enhanced students' argumentation activities were as follows. First, students engaged in higher levels of argumentation when provided with a space to freely discuss ideas, especially when: 1) recognizing the inadequacy of ideas, 2) attempting to express ideas in scientific terms rather than everyday language, 3) selecting ideas for presentation, and 4) discussing the ways to express ideas. Second, students' argumentation levels increased when teachers and researchers showed interest in students' thoughts through guided facilitation or supported logical step-by-step thinking. Lastly, students' argumentation levels increased when they acknowledged and attempted to reach consensus on the differences in their claims. These findings provide insights that can support students' scientific practices and agentic learning.

Perspectives for global well-being: The perception of TVET graduate students about chat-GPT integration in science-biology learning

Muhammad Nazirul Amin Zulkefli[a], Noorafizah Daud[b] and Zulkefli Daud[c]*
[a]*Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.*
[b]*Education Faculty, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia.*
[c]*Institute of Teacher Education Malaysia, Temenggong Ibrahim Campus, 80350 Johor Bahru, Johor, Malaysia.*
*Corresponding Author: zulmydinamik@yahoo.com

Science-biology learning is still an issue for some students at various levels of study. The integration of chat-GPT in learning can affect the learning landscape of students more positively based on the good acceptance of this artificial intelligence (AI) technology at the global level. Accordingly, this study was conducted to examine the perception of TVET graduate students about the integration of chat-GPT in science-biology learning. The online survey was answered by 60 respondents. Cronbach's alpha was calculated to be greater than 0.8. Data were analyzed using descriptive and statistical analysis including t-tests. The findings of the study show that most respondents have a very positive perception towards the integration of chat-GPT in sciencebiology learning. This findings show that science-biology learning problems among students especially at higher levels can be minimized through chat-GPT integration, in addition to its very flexible implementation.

Microplastics Detection in Water Samples from Sumaguing Cave in Sagada, Philippines: An Emerging Threat?

Carmina S. Dalida[a,b]
[a]*Integrated Science Unit, Philippine Science High School-Main Diliman Quezon City, Metro Manila, Philippines*
[b]*College of Education, University of the Philippines Diliman Quezon City, Metro Manila, Philippines*
csdalida@pshs.edu.ph

Microplastic pollution poses a significant environmental threat, contaminating diverse ecosystems, including subterranean environments. This study aims to detect and characterize microplastics in water samples from Sumaguing Cave in Sagada, Philippines. Water samples were collected from three natural pools inside the cave to assess the extent of microplastic contamination. The samples underwent a filtration process using alpha-cellulose filters to isolate potential microplastics. The retained particles were then subjected to a chemical digestion process through wet peroxide oxidation (WPO) to remove organic matter, facilitating the clear identification of microplastics. Stereo-microscopy was employed to examine the filtered residues, allowing for the identification and quantification of microplastics based on their morphological characteristics. The analysis showed varying concentrations of microfibers across different sampling sites, which may be made of polyester and nylon. The findings of this study indicate that microfiber plastics have permeated subterranean water systems, suggesting widespread environmental dispersal and highlighting the vulnerability of the Sumaguing cave ecosystems to anthropogenic pollution, which may be brought on by tourism activities in the Sagada. The presence of microfibers in seemingly pristine cave environments implies the need for comprehensive monitoring and targeted mitigation strategies to address microplastic contamination. This study also recommends further research to increase understanding of the pathways through which microfibers infiltrate subterranean water in Sumaguing cave, and their potential impacts on cave-dwelling organisms.

Evaluation of the Effectiveness of Environmental Education: Activities on Plant Dyeing for Indigenous Elementary School Students in Taiwan

Shyue-Cherng Liaw[a]* and Wan-Jiun Chen[b]
[a]*Department of Geography, National Taiwan Normal University, 162, Section 1, Heping E. Rd., Taipei City 106, Taiwan*
[b]*Institute of Natural Resource Management, National Taipei University, No. 151, University Rd., Sanxia Dist., New Taipei City 237303, Taiwan*
*Corresponding Author: liaw@ntnu.edu.tw

This project adopts the action research method to evaluate the effectiveness of environmental education activities focused on plant dyeing for indigenous elementary school students in Taiwan. Through site planning, instructional design, and course execution, the project involves in-depth observation and understanding of student behavior and responses during classes, with continuous adjustments for teaching methods. The project uses the Atayal Living Museum as the teaching site and collaborates with the local Lunpi Community Development Association and the nearby Datong Elementary School. We establish an environmental education facility based in the Lunpi community and develop suitable environmental education courses. In addition, we applied qualitative research methods such as data collection, analysis, and participant observation, along with quantitative methods like environmental education-related questionnaires to conduct this study. We focus on senior students at Datong Elementary School. The objective is to explore the effectiveness of environmental education courses in enhancing environmental literacy and to understand the students' thoughts and feelings during the course instruction. The action research at the Atayal Living Museum focuses on the Atayal tribe's plant dyeing techniques, complemented by instruction from handicraft teachers to highlight the museum's "Art and Humanities" features. During the implementation of the action plan courses, student behavior is observed, followed by another round of environmental literacy questionnaires and student feedback forms. The analysis includes research diaries, student learning worksheets, and feedback presentations, ultimately discussing the relationship between environmental education courses and environmental literacy.

Aiming to advance genetic literacy in high school students Focusing on the relationship between genetic analysis technology and society

Yoko Inoue[a]*, Emi Utsuno[b], Sakae Itoga[c] and Fumio Nomura[d]
[a]*Department of Molecular Life Sciences, Tokai University School of Medicine, 143 Shimokasuya, Isehara City, Kanagawa Prefecture 259-1193, Japan*
[b]*Department of Clinical Genetics, Chiba University Hospital, 1-8-1 Inohana, Chuo-ku, Chiba City, Chiba Prefecture 260-8677, Japan*
[c]*Department of Applied Genomics, Kazusa DNA*

Research Institute, 2-6-7 Kazusa-kamatari, Kisarazu City Chiba Prefecture, 292-0818, Japan
[d]Division of Clinical Genetics, Chiba Foundation for Health Promotion & Disease Prevention, 32-14 Shinko, Mihama-ku, Chiba City, Chiba Prefecture 261-0002, Japan
*Corresponding Author: CBD02820@nifty.com

Molecular biology has recently become the center of learning contents in high school biology. In modern society such molecular biology techniques are used for clinical diagnosis and personal identification tools for victims in various disasters and in criminal investigations. Therefore, the Ministry of Education in Japan has made a major revision in order to make high school biology directly connect to modern biology based on molecular science, (2009). Moreover, High School Science Curriculum Guideline (2018) has put emphasis on inquiry-based learning and the importance of relevance to society and daily life. Here we developed a two-day novel teaching material to help high school students understand molecular biology by performing a lesson on genetic diagnosis based on the DNA experiment and then analyzing changes found in the students' pre- and post-questionnaires and -tests. The experiment lesson was given on the first day. On the second day lectures on genetic diagnosis, pregnancy, childbirth and women's life planning were given by three medical staff. And then a presentation on hereditary breast and ovarian cancer was given by a patient. After that, students were divided into several groups and discussed two case studies related to whether or not they would undergo genetic diagnosis. As a result, we could clarify the following; 1. The students recognized the benefits and the limitations of genetic diagnosis and realized the importance of DNA analysis in the society. 2. They could realize diverse viewpoints through group discussions. 3.These lessons led to enhance genetic literacy in high school students.

Effects of Temperature on the Antibiogram, Biofilm, and Biopigment Production in *Pseudomonas aeruginosa* Clinical Isolates

Jennifer Joyce E. Gaytano[1,2] and Julieta Z. Dungca[1,3]*
[1]Graduate School, Centro Escolar University, Manila, Region Zip Code Country
[2]School of Medical Technology, Centro Escolar University, Manila, Region Zip Code Country
[3]School of Science and Technology, Centro Escolar University, Manila, Region Zip Code Country
*Corresponding Author: jzdungca@ceu.edu.ph

*Pseudomonas aeruginos*a is a notorious nosocomial pathogen owing to its resistance to multiple antibiotics and biofilm formation. This study investigated the effects of one week exposure at different temperatures on the antibiogram and biofilm-formation in *Pseudomonas aeruginosa*. A total of 30 isolates from clinical specimens were collected from a tertiary hospital. The preexposure minimum inhibitory concentration (MIC) was determined against the eight antibiotics: Amikacin (30µg), Gentamicin (10µg), Ciprofloxacin (5µg), Piperacillin Tazobactam (100/10µg), Ceftazidime (30µg), Cefepime (30µg), Imipenem (10µg), and Meropenem (10µg). About 80% of the isolates were found to be multiple drug resistant mostly to the beta lactam antibiotics. One isolate was resistant to all the test antibiotics. One isolate was resistant to all the test antibiotics. The post exposure MIC was taken after one week exposure at 24°C, 37°C, and 42°C. The biofilmforming activities after 48 hours were determined using the crystal violet assay. Results showed that increasing the temperature from 24°C to 42°C did not significantly affect the MIC ($p>0.05$) but has a significant effect on the biofilm formation, with lower temperature (24°C) favoring increased biofilm compared 37°C and 42°C. In addition, pigment production was observed at 24°C, and became more pronounced at 37°C, but inhibited at 42°C. In conclusion, the ability of *Pseudomonas* to produce biopigment and biofilm was found to be temperature-dependent. This study underscores the importance of routine antibiotic surveillance for a directed and more efficacious treatment of *Pseudomonas* infection.

Creating Evaluation Criteria for High School Students' International Collaborative Research Results and discussion descriptions in the field of biology through peer assessment with explicit evaluation criteria

Yoriko Ikuta[a], Sujika Ngamsa-ard[b], Toru

Tanigaki[a], Katsuko Sanai[c]
[a]*Nara Prefectural Seisho High School, 525 Gose, Nara, Japan*
[b]*Chulalongkorn University Demonstration Secondary School, 254 Patumwan, Bangkok, Thailand*
[c]*National Institute for Educational Policy Research, 3-2-2 Kasumigaseki Chiyoda-ku, Tokyo, Japan*
*Corresponding Author: yorikoi670@e-net.nara.jp

In order to solve social issues on a global scale, there is a need to promote international collaborative research together with like-minded countries and regions. Therefore, it is important for high school students to experience international collaborative research at the high school level. However, there are few studies on the evaluation criteria necessary for students to reflect on each other's research in international collaborative research. Therefore, we conducted international collaborative research with High School A in Thailand and Nara Prefectural High School B in Japan to develop evaluation criteria for peer assessment in the result/ discussion writing phase and to clarify students' improvements. Evaluation criteria were created based on Goto (2013) and the criteria of the peer assessment table at Nara Prefectural Seisho High School, and peer assessment was conducted on the task of "describing the results and discussion of the group's research". As a result, more students fulfilled the criteria for the revised draft in the evaluation criteria of "Conducts multifaceted studies and discussions," "Interprets the data obtained from the results," and "Describes the method of statistical analysis conducted in the research." These results suggest that the creation of evaluation criteria and the implementation of peer assessment with clearly stated evaluation criteria in the international collaborative research allowed students to set up situations in which they collaborated with each other, and improved their scientific literacy.

Square peg in a round hole? Investigating biology education for sustainable development curriculum practices of selected Filipino teachers

Louie B. Dasasa
College of Education, University of Santo Tomas, Manila, Philippines
lbdasas@ust.edu.ph

Considerable effort has been dedicated to integrating Education for Sustainable Development (ESD) into formal curricula through extensive research. A significant body of research has delved into integrating education for sustainable development into the intended, formal curriculum, with a focus on curriculum integration audits. In the Philippines, environmental literacy is one of the goals of the biology curriculum. However, despite this, the integration of education for sustainable development remains localized to social studies, with unclear integration procedures in the biology curriculum. Hence, there is a pressing need to investigate how other subjects, particularly science and biology, integrate ESD into the formal taught curricula. This qualitative inquiry, which underscores the urgency of the situation, delves into how Filipino biology teachers integrate ESD into their classrooms. Practices of integrating ESD are explored through a two-pronged approach: focus group discussions with selected K-12 teachers and document analysis of lesson plans and curriculum documents. Thematic analysis was utilized to analyze focus group data, while content analysis was employed to scrutinize the curriculum documents. Findings reveal the absence of formal procedures to integrate ESD in biology lesson plans, leading to variation and occasional confusion in the integration of ESD. Moreover, this study discovered that ESD, while familiar, is not fully comprehended by biology teachers. Factors influencing this include the misalignment of pre-service biology teacher training and induction programs, as well as the lack of relevant inservice training. Recommendations include looking at ESD integration beyond formalistic procedures and focusing on the intersections of ESD and the hidden curriculum.

Virus Education's Current Status and Issues in Japanese Elementary and Junior High Schools

HIDAKA Tsubasa
Department of Science Education, Osaka Kyoiku University, 4-698-1 Asahigaoka, Kashiwara-Shi, Osaka-Fu 582-8582, Japan
hidaka-t63@cc.osaka-kyoiku.ac.jp

This study is a basic research aimed at systematizing modern Japan's virus education. To elucidate the current characteristics of

virus education, this study analyzed the curriculum guidelines written by the Ministry of Education, Culture, Sports, Science and Technology as well as the textbooks for all compulsory courses (all grades, subjects, and publishers) approved by the Ministry. The curriculum's current status and issues were then derived. The analysis revealed no descriptions of viruses in the elementary school curriculum guidelines, but the supplementary explanation section of junior high school health and physical education did contain a description of viruses. Furthermore, the analysis of textbooks revealed publishers' descriptions of viruses, as follows: some in 5th-grade math; some in 6th-grade social studies; all in 6th-grade physical education; all in 7–9th-grade health and physical education, home economics, social studies, and technology; in 8thgrade science; in 8–9th-grade moral education; and some in 9th-grade Japanese. The following information will be presented at the conference: details of the curriculum guidelines and textbooks' content, analytic results in terms of grade ladders and aspects of content systematics, differences in characteristics between subjects, and discussion points obtained through the study.

The Development and Evaluation of Virtual Laboratory Modules in Human Anatomy and Physiology

Rissa A. Lasap[a,b,c]* and Virginia Sobremisana[b]

[a]*Department of Biological Sciences, Centro Escolar University-Manila Campus, Manila, Metro Manila*

[b]*Graduate School, Rizal Technological University, Boni, Mandaluyong City, Philippines*

c Department of Biology, University of San Agustin Iloilo City, Philippinesepartment, Institution

*Corresponding Author: ralasap@ceu.edu.ph

The development of technologies had transformed the way we delivery of instruction and one aspect is through virtual laboratory activities. This article aims to developed virtual laboratory and its effects on BS Nursing student achievement at the University of San Agustin, Iloilo City. The developed virtual laboratory was incorporated in the university learning management system and was used in their HAP laboratory. Teachers and students evaluated the developed virtual laboratory using adopt questionnaires from study of Dadiz et.al, (2014) using the Likert Scale. The teachers and the students both strongly agree that the developed virtual laboratory is effective in terms of objectives and content (X=4.34; X=4.66), clarity (X= 4.4; X = 4.7), presentation (X= 4.42; X =4.64), relevance (X=4.2; X=4.64) and technical characteristics (X = 4.72; X = 4.38). To find out how developed virtual laboratory affects student performance, a one group pre-test posttest design was been conducted. Student achievement scores were compared before and after using the developed virtual laboratory. For that purpose, a set of 60 items quiz was developed. To determine the difference in pretest and posttest scores T-test for dependent sample was used. The pretest mean score of was 36.88 while posttest mean score was 53.51. Data showed that mean test scores increased after administering the developed virtual laboratory. Further, students' motivation using the developed virtual laboratory was measured using ARCS model. Results showed that fvalue of 0.8578 using one-way anova indicates no significant difference among means of ARCS model.

The level of awareness about the integration of artificial intelligence technology (AI) in basic science-biology learning among huffaz students

Zulkefli Daud[a]*, Muhammad Nazirul Amin Zulkefli[b] and Noorafizah Daud[c]

[a]*Institute of Teacher Education Malaysia, Temenggong Ibrahim Campus, 80350 Johor Bahru, Johor, Malaysia*

[b]*Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia*

[c]*Education Faculty, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia*

*Corresponding Author: zulmydinamik@yahoo.com

Academic exposure in basic science-biology may be less in-depth in most Huffaz Centers because the main target is mastering the memorization of the Quran. This study aims to identify the level of awareness about the integration of artificial intelligence (AI) technology in learning related to basic science-biology among students at Huffaz Center. A total of 67 students at one of the Huffaz Centers

were involved in answering the questionnaire online. Data were analyzed descriptively and statistically including t-test. Overall, the study found that some students have a relatively high level of awareness while others have a moderate level of awareness. The majority of students understand about AI in the development of today's technology world. The findings of this study show that students should be exposed to AI as often as possible to increase their level of awareness. The use of AI in Hufaz Centers in the future should be encouraged not only in academic learning but also in memorizing the Quran, so that the learning interaction is always resistant to global changes.

Four teachers' differences in classroom management approaches (CMA): A case study in the Philippines

Lea C. Garcia
Science Department, University of the Philippines Rural High School Paciano Rizal, Bay,Laguna, Philippines
lcgarcia@up.edu.ph

This case study determined whether four teachers' CMA varies based on years of teaching. Specifically, it compared two Grade 8 teachers from each set of beginning and experienced teachers with respect to facilitating skills, personality construct and metacognitive techniques dimensions. Data obtained from observations and interview on cell division and Mendelian genetics was qualitatively analyzed. The beginning teachers and one experienced teacher had stronger CMA than the other experienced teacher. Specifically, the other experienced teacher showed not much facilitating skills, less metacognitive techniques and failed to project a strong personality. The experienced teacher should be encouraged to retool and upgrade skills by attending trainings and workshops. This case study serves as a basis for school heads' planning of programs for continuous professional development on classroom management. For a more generalized conclusion, it is recommended to consider a greater population size as well as apply a specific statistical tool.

Basic research on the contents related to explain scientific phenomena in arithmetic and Japanese language textbooks for elementary school in Japan: Focusing on biological matters

Asami Ohnuki[a]*, Miori Miyoshi[b]
[a]*Department of Child Care and Primary Education, Shirayuri Universiy, 1-25, Midorigaoka, Chofu-shi, Tokyo, Japan*
[b]*Graduate School of Humanities and Social Sciences, Hiroshima University, 1-1-1 Kagamiyama, Higashi-Hiroshima, Hiroshima, Japan*
*Corresponding Author: asami@shirayuri.ac.jp

In elementary school, the concepts related to living things might be constructed through not only science learning but also other subjects' learning. This study examined the contents about living organisms in arithmetic and Japanese language textbooks for elementary school in Japan. The approved textbooks that were most used in public primary schools of Tokyo were analyzed. The arithmetic textbooks used multiple species of animals in a variety of situations and contained the basic contents necessary for explaining living things from a scientific perspective, such as classification and tabulation. In Japanese language textbooks, several biological contents were included in the characters in the stories and in the events described in the explanatory texts. It was suggested that the understanding about the contents in the texts construct the basic images about the living things which would be learned in science, such as lives of insects and/or plants. On the other hand, there were disconnection parts between the contents in science and other subjects. For example, Bacillus natto was in the Japanese language text of the third grade but it was not the content of the science of the same grade and fermentation is not the science curriculum in elementary school. It was found that fundamental scientific explanation of biological phenomena and images of lives would be constructed through the learning in arithmetic and Japanese language classes. This work was supported by JSPS KAKENHI Grant Number JP23K20749 and JP24K00465.

AI-Driven Science Teaching: Insights, Challenges, and Opportunities

Anna Cherylle M. Ramos[a,d]* and John Donnie A. Ramos[b,c]
[a]*College of Education;* [b]*College of Science;*

[c]*Research Center for the Natural Sciences, University of Santo Tomas, Manila, Philippines*
[d]*Faculty of Education, Ontario Tech University Ontario, Canada*
*Corresponding Author: amramos@ust.edu.ph

This paper explores the potential of Artificial Intelligence (AI) to revolutionize science education drawing on insights from a workshop on AI in Education held during a national conference in the Philippines. Teacher participants emphasized the myriad of AI tools available for teaching and recognized their potential to enhance creativity, efficiency, and student engagement in science education. Both the workshop and the broader study emphasize the need for AI as an integral part of innovative science education, highlighting its capacity to transform teaching and learning practices. The study acknowledges challenges specific to science teachers, such as ensuring equitable access to technology for conducting experiments, accessing scientific databases, and utilizing advanced analytical tools, which were identified. Ethical considerations regarding the use of AI in scientific research and the importance of maintaining data integrity and privacy in laboratory settings were also emphasized. The study underscores the transformative potential of AI in science education while emphasizing the need for thoughtful implementation strategies, collaboration among educators and technology experts, and ongoing teacher professional development, which are essential to maximizing the benefits of integrating AI into the science curriculum. Overall, the findings envision a future where AI significantly improves science education by creating a more engaging and accessible learning environment for the next generation of scientists.

Development of Teaching Materials for Enhancing to Understand of Biodiversity in Collaboration with Aquarium and Zoo: About SDGs Worksheets and Virtual Specimens Using ICT

Kiyoyuki Ohshikaa*, Eri Furukawab and Hiroyuki Furuichic
[a]*Department of Science Education, Aichi University of Education, Kariya, Japan*
[b]*Aichi Science Teaching Materials Development Lab, Kariya, Japan cGakuden Elementary School Inuyama, Japan*
*Corresponding Author: ohshika@auecc.aichi-edu.ac.jp

Currently, human, and industrial development is having a serious impact on the world's biodiversity. Many species are extinct or on the verge of extinction, and the survival of various ecosystems is at risk. Therefore, teaching materials for thinking about biodiversity are necessary in biology education. On the other hand, in modern education, digitalization of education is progressing rapidly due to the development of ICT. Along with this, there is an urgent need to develop digital teaching materials that take advantage of the characteristics of ICT. Therefore, in this research, in order to solve the above social and educational issues, we had collaborated with aquariums and zoos and have developed teaching materials that utilized their resources. Two teaching materials we have developed are as below: 1. SDGs worksheets for marine ecosystem, 2. Virtual Skelton specimens for understanding mammals mainly. The SDGs worksheets were developed in collaboration with an aquarium. The aim was to understand the issues that microplastics have on living things and think about marine biodiversity through observing aquatic life in an aquarium. The virtual skeletal specimens were developed in collaboration with zoos. We have developed a virtual specimen that can be moved in three dimensions based on skeleton specimens from more than 10 animals including monkeys and elephants. These specimens can be viewed on tablets and other devices at schools. Through detailed and comparative observations, they can be used to understand animal structures and learn about animal evolution.

Opportunities for Internationalization of Biology Research during the Pandemic and Beyond: the Microbiology Curriculum Perspective

Marie Christine M. Obusan
Microbial Ecology of Terrestrial and Aquatic Systems Laboratory, Institute of Biology, College of Science, University of the Philippines Diliman, National Capital Region, Philippines

The rationale for internationalization has been the subject of discussions and debates in Philippine academic institutions, especially in relation to changing academic calendar and

shifting paradigms in designing curriculum considering global standards and demands. In addition, the recent pandemic experience has taught us to rethink and adjust our ways of doing Biology in order to adapt to the dynamics of diverse cultures, systems, and practices at the international level. The advancement of global standards and outcomes for Biology education also means we need to facilitate complex thinking that goes beyond basic recall of facts, to enable our students, who would become Biologists, to apply problem-solving solutions to real-world biological problems, as has been shown by the response of Biologists in dealing with COVID-19. It is in this viewpoint that I will present case studies for internationalization, as experienced in the field of Microbiology, using (1) online resources for in silico analyses (e.g., MiGA, KBase), (2) available data for analyses from local and international databases (e.g., NCBI), (3) protocols for analyzing available data (e.g., scoping review, molecular docking for finding viral inhibitors) and platforms for remote mentoring and learning. Based on these case studies, there are many prospects for the revision of the Microbiology curriculum.

Game Based Learning Approach on Strategic Thingking Skill and Understanding Concepts of Virus Material of Senior High School Student

Hajar Syifa Fiarani*, Bevo Wahono, Dennisha Ratna Aulia

Department of Biology Education, Jl. Kalimantan Tegalboto No.37, Krajan Timur, Sumbersari, Kec. Sumbersari, Kabupaten Jember, East Java 68121, Indonesia

*Corresponding Author:ranivia16@gmail.com

This study aims to develop media puzzles with a game based learning approach to improve Strategic Thingking Skill and Understanding Concepts of Virus Material of Senior High School Student. The types of tests to determine the influence of puzzle game media on students' understanding of concepts are pre-test and post-test which are structured based on indicators of students' conceptual understanding, namely: 1) translation, 2) interpretation, 4) extrapolation. Observations were carried out by giving questionnaires to determine the influence of Strategic Thinking Skills on students and then analyzing the data that had been obtained in the form of pretest, post-test and questionnaire scores. After obtaining the final value, analysis was carried out as a Normality Test, Homogeneity Test and Independent Sample t-Test. The linearity test is carried out to test whether there is a relationship between variablescontrol (puzzle game) on students' conceptual understanding is linear or significant. if the resulting significance value more than 0.05, it can be said that there is no significant influence on students' conceptual understanding between the control class and the experimental class. If the resulting significance value is less than 0.05 then there is a significant influence on students' conceptual understanding between the control class and the experimental class. Based on these researches, it can be expected that puzzle media with a game based learning approach is feasible and effective for use in High School Students.

Application of the online teaching material for biological course to secondary education and construction of the English version

Shito, T.T.[a], Totsuka, N.M.[a], Kogure, Y.S.[a], Mizutani, H.[a], Takahashi, M.[a], Ueda, L.L.[a], Furukawa, R.[b],Togane, D.[b], Kuraishi R.[b], Fujita, R.[c], Fujisawa, Y.[d], Yazawa, K.[c], Uchiyama, M.[e] and Hotta, K.[a]*

[a]*Department of Bioscience and Informatics, Faculty of Science and Technology, Keio University, Yokohama, Japan.*

Department of Biology, Research and Education Center for Natural Sciences, 4-1-1 Hiyoshi, Kouhoku-ku, Yokohama, JAPAN.

[c]*Keio Futsubu School Hiyoshi-honcho, Kohoku-ku, Yokohama, Japan.*

[d]*Keio Girls Senior High School, Mita, Minato-ku, Tokyo, Japan.*

*Corresponding Author: khotta@keio.jp

We have developed an online teaching material simulating field biological course, VRinkai (V for "virtual" and Rinkai meaning "marine biological course" in Japanese) since 2021, due to limited usability of marine biological stations during the COVID-19 pandemic. VRinkai contains over 400 photos of marine organisms collected in marine biological courses in the past decade. In addition, the terrestrial version of VRinkai was established with over 200 more photos of

insects, amphibians, and reptiles. Students can enjoy learning classification of species at each taxonomic rank by catching randomly emerging animals in a game-like way. We have been demonstrating the educational effect of VRinkai in our university courses and it was expected to be applicable for secondary education as well. Also, English version was expected for global use. In this study, we updated VRinkai by adding new functions that allow teachers to create their original database and manage students in each class or group. Students can upload photos of local animals/plants taken in their field training. The updated version of VRinkai was applied to the class practices in junior and senior high schools. Registered data were automatically introduced in the biological classification games and in the hierarchical view which are used to compare the differences of multiple biotas. A questionnaire survey demonstrated that VRinkai is an effective teaching material for enhancing interest and active learning in biological classification, evolution, and bio-diversity in secondary education. We currently making an English version, thus VRinkai is now expected for applying to global education courses.

Diagnosing and remediating elementary students' misconceptions about 'Growth of Plants' through drawing Unveiling misconceptions using drawing and crafting solutions for conceptual change

Rani Prasad[1], Narendra D. Deshmukh[2] & Rafikh Shaikh[3]
[1]*School of Education, Tata Institute of Social Sciences, Mumbai, India*
[2]*Homi Bhabha Centre For Science Education, TIFR, Mumbai, India*
[3]*Centre of Excellence in Teacher Education, Tata Institute of Social Sciences, Mumbai, India*
raniprasad010@gmail.com, ndd@hbcse.tifr.res.in & rafikh.shaikh@tiss.edu

This study identified misconceptions held by elementary-grade students about the "Growth of Plants". It investigated the reasons behind the misconceptions about a government Hindi Medium School in the suburban area of Mumbai, Maharashtra, India. The drawing method was used to identify the misconceptions, followed by interviews with ten Grade 3 and Grade 5 students to understand their underlying reasons. After diagnosing the misconceptions, four sessions were prepared and planned accordingly to remediate the students' mis-conceptions. A thematic analysis for a holistic understanding of parts of plants and plant growth, including the drawing and interview analysis, was adopted for the study. Two main research questions guided this study: to diagnose students' misconceptions about plant growth and to assess the effectiveness of the "Hands-on Constructivist Pedagogical Approach" in remediating these misconceptions. The study employed conveni-ence sampling to select 51 elementary students from mixed-grade classes (Grades 3 and 5) for practicality and accessibility. Data was collected using pre- and post-drawing tests, interviews, and classroom observations while taking the sessions as a participant observant. This study revealed the effectiveness of drawing methods to diagnose misconceptions; some were similar to those in previous studies, such as the fact that seeds are not alive and attributing anthropomorphic explanations for the growth of plants. The hands-on constructivist pedagogical approach involving collaborative learning led to conceptual change, evidenced by the post-tests (drawings and interviews) conducted.

A dragonfly population survey based on the number of its nymph exuviae observed in a school biotope: Usefulness of exuviae in biology and environmental education

Yukio Terashima
Naruto University of Education, Naruto, Tokushima, Japan
yterashima@naruto-u.ac.jp

In recent years, there has been growing global concern about the impact of pesticide use and climate change on biodiversity and ecosystem. Particularly in Asian countries such as Japan, where paddy rice is widely grown, there is deep concern about the negative impact on aquatic animals. For example, a drastic decline in dragonflies has been reported, although the causes are not fully understood, and continuous monitoring surveys are still needed. In this study, we simply estimated the change in dragonfly population by counting the number of their nymph exuviae over four years in a small artificial pond at a teacher training college in Japan. The number of the exuviae

counted there decreased continuously throughout the four years, and the results were consistent with many previous reports indicating a decline in dragonflies. Immobile exuviae can be easily collected and counted by anyone, including students, while rapidly moving adult dragonflies are technically difficult to count visually. In this presentation, we report the results of this monitoring study and propose the usefulness of exuviae as teaching materials in biology and environmental education, including other educational applications.

****

<Poster Session>

How biodiversity is taught in upper secondary school biology in Japan

Nobuyasu Katayama* and Teiko Nakamichi
Tokyo Institute of Biology Education, Tokyo, Japan
*Corresponding Author: katayama@u-gakugei.ac.jp

In the current Japanese Upper Secondary School National Curriculum Standard, biodiversity is one of the main learning topics in biology. To find out how biodiversity is taught in upper secondary school biology classes, we examined the treatment of biodiversity and related content in ten Basic Biology textbooks and five Advanced Biology textbooks which are currently used. There were considerable differences in content, its amount, and terms used by textbooks. In Basic Biology textbooks, 7 - 16% of the 150 - 240 text pages were devoted to biodiversity and related content. The number of terms on biodiversity and related content in each textbook ranged from 40 - 66, of which 19 - 44 were listed in the index, and 8 - 18 were key terms. Key terms common to most textbooks were biodiversity, species diversity, alien species, endangered species, extinction, ecosystem services, and environmental impact assessment. In the Advanced Biology textbooks, the pages allotted to biodiversity and related content was only 2 - 5% of the 270 – 428 text pages. The number of terms on biodiversity and related content in each textbook ranged from 33 - 48, of which 14 - 27 were listed in the index, and 7 - 13 were key terms. Examples of major key terms include biodiversity, genetic diversity, species diversity, ecosystem diversity, disturbance, Allee's effect, inbreeding depression, vortex of extinction, and ecosystem services. The survey results indicate that the content, terminology, and learning methods should be considered for students to recognize the importance of biodiversity conservation.

Learning to recognize the importance of biodiversity and the danger of its loss

Teiko Nakamichi* and Nobuyasu Katayama
Tokyo Institute of Biology Education, Tokyo, Japan
*Corresponding Author: teikonakamichi@hotmail.co.jp

According to the National Curriculum Standard, students should discover and understand the diversity of species in ecosystems through conducting observations and experiments in the unit "Biodiversity and Ecosystems" of Basic Biology. However, since this unit is placed at the end of the course, due to time limitation, it often ends up conveyed through "knowledge-based teaching". Instead of a teacher-centered approach, "Proactive, interactive, and authentic learning" is recommended to students for recognizing the importance of biodiversity and taking action to solve related issues. To help students find problems to investigate, we propose introducing the Planetary Boundaries concept which indicates that the loss of biodiversity is one of the key issues of concern. Planetary Boundaries' diagrams provide a visual framework for considering several other key issues, such as the nitrogen cycle and climate change, at the same time. This will encourage students to consider integrated inquiry on global issues, to become more aware of them, and to contemplate how to respond to them. Thus, the introduction of the Planetary Boundaries concept into Basic Biology classes could be a seed for further learning about biodiversity. Furthermore, it is desirable for students to conduct their own investigations not only within a particular subject but also across subjects. For this purpose, "Period for Inquiry-Based Cross-Disciplinary Study", which is newly established in the upper secondary school curriculum to aim to cultivate the qualities and abilities that

will enable students to discover and solve problems on their own, is applicable for studying further.

Potential of Pseudomonas sp. from Mindanao endemic frog (*Limnonectes magnus*) in degrading polymer wastes in a micro-scale set-up

Chriztean Erika V. Ganiera[a]*, Nino J. Matucol[a], David Jeiel T. Jimenez[a], Marian Dara T. Tagoon[a], and Elsa May D. Baron[b]
[a]*School of Business Management, Education, Arts and Sciences, San Pedro College, Davao City 8000, Davao del Sur, Mindanao Philippines*
[b]*Research, Publication, and Innovation Center, San Pedro College, Davao City 8000, Davao del Sur, Mindanao, Philippines*
*Corresponding author: ceganiera@gmail.com

The study investigated the capacity of cutaneous bacterial isolates: *Pseudomonas* sp., *Enterobacter* sp., *Bacillus* sp., and *Streptomyces* sp. from three Mindanao endemic frog species for the biodegradation of polymer wastes in a micro-scale set-up. The isolates were identified based on morpho-cultural features, biochemical tests, and 16srRNA gene sequencing results. The polymer wastes tested were shampoo packets, surgical gloves, facemasks, and rubber shoe soles, which were prepared as cut and uncut and of varying sizes (5x5 and 1x1 cm), washed and subjected to moist heat sterilization before inoculation of bacterial isolates. Biodegradation capacity was measured as a change in mass, appearance, and density 60 days after bacterial inoculation. Results reveal no significant difference in the mass and appearance of all treatments based on polymer type, form, and size. However, a significant change in the density of polymer wastes of 1x1 cm size treated with Pseudomonas sp. was noted. The findings suggest that Pseudomonas sp. from the skin of *Limnonectes magnus*, a Mindanao endemic frog, can potentially degrade polymer wastes. Additional studies are necessary to verify this initial finding.

Development and Validation of Empathy-S Instrument

Angel Anthony R. Camua*[a,c], Isabel N. Panagsagan[b], & Zelea Jean N. Sabile[a]
[a] MAEd Biology Education, College of Education, University of the Philippines Diliman, Diliman, Quezon City, Philippines
[b]MAEd Chemistry Education, College of Education, University of the Philippines Diliman, Diliman, Quezon City, Philippines
[c]Department of Biological Sciences, Centro Escolar University-Manila Campus Manila, Metro Manila

The pandemic has brought a radical shift from face-to-face to remote learning modalities. The students' learning situation through synchronous and asynchronous science learning are faced with the challenge of learning concepts individually and collaboratively. This paper developed the Empathy-S instrument, measuring student's empathy while learning in the new normal. In this case, the researchers initially drafted the instrument, pilot tested for content and construct validation by six experts and 426 students in the municipality of Muntinlupa. The final instrument consisted of 14 items out of the original 38-item 5-point Likert scale instrument with a content validity index (CVI) = .84. Four components were accepted with considerable Eigenvalues and scree plot inflexions using principal factorial analysis (PCA) with orthogonal rotation using Varimax with Kaiser normalization. After reliability analysis, two components (1 and 2) were retained with Cronbach's α = .83 and .71, respectively.

Antioxidant and Antimitotic Activity of Propolis Ethanolic Extract (PEE) from Philippine Stingless Bee (*Tetragonula biroi* Friese)

Avril Ley Ann V. Recto
Biology & Agriculture Unit, Philippine Science High School – CALABARZON Region Campus, Department of Science and Technology. Sitio Sampaga West, Batangas City, Philippines
arllave@cbzrc.pshs.edu.ph

Natural products like bee propolis have drawn attention to their possible therapeutic potential in the search for alternative cancer treatments that target cell division and counteract reactive oxygen species (ROS). The present investigation aims to explore the antimitotic and antioxidant properties of Propolis Ethanolic Extract (PEE) obtained from *Tetragonula biroi* Friese Propolis from *T. biroi* Friese was extracted with 96% ethanol to produce the propolis ethanolic extract (PEE), then the DPPH radical scavenging assay was used to evaluate its antioxidant activity. The results showed a 100% inhibition rate that was comparable to

positive control, gallic acid. The Allium cepa test was used to assess the antimitotic activity of PEE, and the results showed a strong association (r=0.923) between higher PEE concentrations and a lower mitotic index. Microscopic examination showed that most of the cells were in prophase, indicating that PEE may be able to stop mitosis early on like that of several anti-tumor medications. The results highlight PEE's potential to counteract unchecked cell division and hinder ROS activity, which can be associated with its potential as a cancer treatment.

The Role of Metacognitive Skills in Developing Communicative Proficiency in Higher Education RFDT Instruction

Bea Hana Siswati* and Suratno
Faculty of Education, University of Jember
Jl. Kalimantan Tegalboto No 37, Jember, Indonesia
*Corresponding Author: beahana.fkip@unej.ac.id

This study aims to investigate the correlation between metacognitive skills and communicative proficiency at the implementation of Reading, Finding, Discussing & Talking (RFDT) instruction. Metacognitive skills, which encompass individual's awareness and control over their own thinking processes, are examined in relation to enhancing students' communicative skills, particularly in the context of RFDT-based learning in the Educational Profession course. Employing a quantitative approach with a correlational design, this study used 123 second-semester students undertaking the Educational Profession course as the research samples. The research instruments included essay questions to measure the levels of metacognitive skills and a validated communicative proficiency questionnaire. The data were analyzed using Pearson correlation statistical techniques to test the research hypotheses. The results show a significant positive correlation between metacognitive skills and communicative proficiency in RFDT instruction ($r = 0.56$, $p < 0.01$), indicating that students with higher metacognitive skills tend to have better communicative proficiency. The implications of this research highlight the importance of integrating metacognitive skill development strategies into the educational curricula, especially in higher education, to enhance students' communication effectiveness. Further recommendations include the implementation of teaching methods that encourage self-reflection and control over thinking processes as an effort to improve the quality of learning and students' communication skills.

The Effect of AI-based Carbon Neutrality Education in Korea

Yang Sunghee[a] and So Keumhyun[b]*
[a]*Omgung Elementary School, 47039 23 Omgung-ro 191 Sasang-gu , Busan, Korea*
[b]*Science Education, Busan National University of Education, 47503 24 Gyodae-ro Yeonje-gu, Busan, Korea*
*Corresponding Author: sokh@bnue.ac.kr

This study aimed to investigate the impact on elementary school students' environmental sensitivity and creative problem-solving ability after conducting experiential and activity-based carbon neutral education based on AI tools for elementary school students. We analyzed the results of a pre- and post-survey on environmental sensitivity and creative problem-solving ability by applying AI-based carbon neutral education program to 25 sixth-grade elementary school students. The results of this study were as follows. First, the AI-based carbon neutral education program was effective in improving the environmental sensitivity of elementary school students. Significant changes appeared in the overall areas of sensitivity, aesthetic and emotional stability, and sympathy and compassion after the class. Second, AI-based carbon neutral education programs was effective in improving elementary school students' creative problem-solving ability. It can be seen that AI tool-based carbon-neutral education has had a positive impact on elementary school students' creative problem-solving ability. Third, the AI-based carbon neutral education program has a significant impact on changes in elementary school students' perception of the environment. As a result of analyzing interviews with students, it was found that this program has a meaningful effect on elementary school students, such as improving their interest in environmental pollution and behavioral practice. As described above, the AI-based carbon neutral education program was effective in improving elementary school students' environmental sensitivity and creative problemsolving ability and is believed to have a positive impact on changes in their

perception of the environment.

The Effect of Forensic Science Project Classes on Elementary Students' Science Inquiry Skills and Science Interest

Joo Eungi[a] and Bae Jinho[b]*
[a]*Myougone Elementary School, 46772 147 Myeongjigukje 6-ro, Gangseo-gu , Busan, Korea*
[b]*Science Education, Busan National University of Education, 47503 24 Gyodae-ro Yeonje-gu, Busan, Korea*
*Corresponding Author: bb@bnue.ac.kr

In this study, we sought to determine the effect of forensic project classes on elementary school students' science inquiry skills and science interest. For this purpose, a forensic project class (7 sessions) was developed, and 26 students from one class at an elementary school in Metropolitan City B were formed as a single experimental group and the forensic project class was conducted. To conduct this study, we conducted a pre- and post-survey on scientific inquiry skills and science interest and analyzed the results. The results of this study are as follows. First, forensic project classes had an overall positive effect on improving elementary school students' science inquiry skills. There was a significant improvement in the post-test average compared to the pre-test. Significant changes were observed in both basic inquiry skills and integrated inquiry skills, which are sub-categories of science inquiry skills. Second, forensic project classes had an overall positive effect on improving elementary school students' science interest. There was a significant improvement in the post-test average compared to the pre-test. Significant changes were observed in all sub-categories of science interest: interest in science-related activities, interest in science related occupations, and science anxiety. In conclusion, the forensic project class had a positive effect on elementary school students' science inquiry skills and science interest, so it is expected that it can be used as a class to improve students' science inquiry skills and science interest in elementary school science education in the future.

Using Board Games to teach Carbon Neutrality in Korea

Lee Hyeongcheol[a], Choi Ilhoon[b] and So Keumhyun[a]*
[a]*Science Education, Busan National University of Education, 47503 24 Gyodae-ro Yeonje-gu, Busan, Korea*
[b]*Myungjin Elementary School, 46524 159 Hwamyeong New Town Road Buk-gu, Busan, Korea*
*Corresponding Author: sokh@bnue.ac.kr

This study aims to develop students' environmental awareness and self-efficacy by using a board game as a teaching tool for carbon neutrality education, and to increase their ability to solve environmental problems related to carbon footprint and take action in their daily lives. In the course of the game, participants must connect the wooden fence tiles to create a forest to trap carbon. Students must also utilize carbon neutral action tiles to earn extra points or avoid carbon neutral obstruction tiles, which adds a strategic element to the game related to environmental literacy. Through the game, students learn about interaction with nature, social responsibility, the importance of economic decisions, and the need to be carbon neutral. Students explore how to use different strategies to most efficiently trap carbon and contribute to environmental protection by taking carbon neutral actions. Choices made in the game can inspire students to take sustainable actions in real life, which is a key goal of carbon neutrality education. Students used the board game in class for a total of two periods. The improvement of students' environmental literacy and self-efficacy toward carbon neutrality was evaluated before and after the board game class. The results showed that the environmental literacy and understanding of elementary school students were significantly improved. The students who participated in the interviews were able to think about the importance of carbon neutrality and express various opinions on the effectiveness of environmental literacy and carbon neutrality education.

Equipping Tomorrow's Educators: The Impact of Research-Infuse Learning on ESD Competencies in Biology Learning, Indonesian cases

Rini Solihat[a]*, Ari Widodo[b] and Riandi[b]
[a]*Biology Education Study Program, Universitas Pendidikan Indonesia, Jl.Dr Setiabudi No.229, Bandung, Indonesia*
[b]*Science Education Study Program, Universitas*

Pendidikan Indonesia Jl.Dr Setiabudi No.229, Bandung, Indonesia
*Corresponding Author: rinisolihat@upi.edu

This research-driven inquiry delves into the profound influence pre-service teachers wield as catalysts for ESD competencies. Our study aims to illuminate the transformative potential of research in molding these budding educators into impassioned advocates for sustainable practices and unwavering ESD champions. Our exploration is driven by a deep desire to uncover the intricate connections between research-infused learning experiences and the acquisition of ESD competencies. Preliminary findings have unveiled a compelling narrative: research experiences empower pre-service teachers to cultivate a profound understanding of sustainability concepts, as well as the intricate interplay between social, environmental, and economic dimensions. Through these experiences, they not only acquire knowledge but also harness the power to envision innovative teaching practices that seamlessly integrate ESD principles into their future classrooms. Furthermore, our research underscores the incredible potential of research-driven ESD education to nurture a profound sense of agency and a steadfast commitment to sustainability within preservice teachers. These empowered individuals are motivated to step forward as change agents, not just within the confines of their classrooms but also within their communities and broader educational settings. This research, beyond its contribution to the ever-evolving landscape of ESD competencies, offers profound insights into the pedagogical strategies and curricular enhancements that can empower pre-service teachers to drive sustainable change.

Evaluation of the effectiveness of environmental education using environ-mental DNA analysis: Is it effective even for people who hesitate to touch living things?

Ryota P Kitani[1], Tatsuya Saga1, Minoru Kasada[2], Mieko Kiyono[1], Masayuki Sato[1], Atushi Ushimaru[1], Toshifumi Minamoto[1]
[1]*Graduate School of Human Development and Environment, Kobe University, Japan.*
[2]*Field Science Center for Northern Biosphere, Uryu Experimental Forest, Hokkaido University, Japan*

Biota survey is used as one of the methods of environmental education, but it has several challenges. The difficulty in identifying multiple species cannot fully exploit the diversity of species. Moreover, education that involves direct contact with organisms can have a negative effect on people who hesitate to touch them. It is therefore necessary to develop a new environmental education tool that overcomes these challenges. Environmental DNA (eDNA) analysis, a novel method of surveying biota by analyzing the DNA of organisms present in the environment, has the potential to address these problems. Multiple species can be detected by eDNA analysis without specialized morphological knowledge. In addition, as the field process of this analysis only involves water sampling, it can be carried out by amateurs, including those unfamiliar with organisms. In this study, we investigated whether a survey of local biota using eDNA analysis could be used as an environmental education tool. An educational program using eDNA analysis was designed in three parts: a preliminary explanation of ecology and eDNA, sampling of river water, and a workshop lecture using an eDNA analysis result. We implemented this program during class time in three Japanese high schools. The results of questionnaire surveys suggested that students' interest in biodiversity and ecosystem services increased through the program. Some questions about interest in biodiversity improved more for students who said they were not good at organisms. This study is the first to show that environmental education using eDNA analysis can be effective when implemented during school hours.

Learning for Science & Society in Primary School and Middle School Science, Korea

Kew-Cheol Shim[a], Kyoungho Kim[b] and Youngjoon Shin[c]*
[a]*Department of Biology Education, Kongju National University, Gongjudaehak-ro 56, Gongju-si, Chungnam-do, South Korea*
[b]*Department of Science Education, Gongju National University of Education, Ungjin-ro 27, Gongju-si, Chungnam-do, South Korea*
[c]*Department of Science Education, Gyeongin National University of Education, Sammak-ro 155, Manan-gu, Anyang-si, Gyeonggi-do South Korea*
*Corresponding Author: yjshin@ginue.ac.kr

Learning for Science & Society are introduced in New Revised Version of National Science Curriculum, Korea. The new science curriculum consists of a total of five areas, with Science & Society added to the existing four areas of Movement and Energy, Matter, Life, Earth & Space. The Science & Society area focuses the role of science in individuals and the sustainable development of society. Learning contents of the Science & Society area have 'science & safety', 'science & sustainable society', and 'science & careers' in primary school science and middle school science (from 3rd to 9th grades). The Science & Society area has three core ideas on the following: Science and technology acquired through scientific inquiry contribute to human welfare and to be used for overcoming disaster situations. Science and technology contribute to a sustainable society by providing ways to efficiently use resources and energy. The development of science and technology affects the shape of future society and jobs, and individuals prepare for their lives by exploring the shape of future society and career paths. We expected students understand the interrelationship between science, technology, and society, and develop the ability to participate and practice as democratic citizens in solving individual and social problems through learning Science & Society area.

Practice of visiting lesson for 6th grade elementary school students on the material cycle in ecosystems using LEGO blocks as molecular models

Koshi Ninomiya[a], Miyu Tanaka[b], Hiroshi Matsutani[c],
Yuki Okumura[d], Tomomi Sawa[d], Yutaka Nakamatsu[a,d]*
[a]*Graduate School of Education, Kogakkan University 1704, Kodakushimoto-cho, Ise, Mie, Japan*
[b]*Kida Elementary School, 1478 Kamiji-cho, Ise, Mie, Japan*
[c]*Obata Elementary School, 663-1 Motomachi, Obata-cho, Ise, Mie, Japan*
[d]*Faculty of Education, Kogakkan University 1704, Kodakushimoto-cho, Ise, Mie, Japan*
*Corresponding Author: y-nakamatsu@kogakkan-u.ac.jp

In sixth grade elementary school science, students learn about the cycle of carbon dioxide, water, and other substances through photosynthesis and respiration, and learn about the food-eat-eat relationship between organisms. Nakamatsu et al. (2023) and Matsutani et al. (2023) developed educational materials on the mechanisms of photosynthesis and respiration using molecular models made with LEGO blocks from the LEGO Corporation, as well as materials for observing the food-eating relationship among organisms using live insects. In this study, we practiced a 90minute delivery lecture at an elementary school using those teaching materials. This class used a team-teaching method, with the participating university students divided into three roles: facilitator, assistant for observations and experiments, and coordinator. Questionnaires were administered before and after the class to examine changes in the children's knowledge and understanding, interest, and motivation for learning. As a result, the children's knowledge and understanding of material cycles and food chains among organisms improved from before to after the class. In addition, the inclusion of observations and experiments on the food chain using live insects is thought to have increased the children's interest in insects and the food chain.

Potential of Mobile Microscopes as Tools for Citizen Science Promotion

Isao Tsuzuki[a] and Masashi Hayakawa[b]
[a]*Life is small Projects, Shirane, Asahi-ku,Yokohama, Japan*
[b]*Osaka University, 1－1, Yamadaoka,Suita-City, Osaka, Japan*
*Corresponding Author: goodbye.tamakou@gmail.com

Mobile microscopes are used by attaching single lens to the camera hole of smartphones or tablet PCs. These microscopes have been developed by Kuniaki Nagayama et al., based on Löwenhoek's monocular microscope, (Nagayama et al. 2013). The features of these microscope are as follows. 1) It is compact and convenient to carry around. 2) Observed images can be recorded on smartphones and other devices and shared over the Internet. With these microscopes, anyone can enjoy the microscopic world at home or outdoors. "Life is small Projects (LISP)" (launched on Facebook in 2015) is a voluntary group that aims to promote citizen science by giving workshops etc. using mobile microscopes. The

following examples show the advantages of mobile microscopes in school education. 1) Group discussions were easily held while viewing images of blood flow in fish fins on tablet PC (Yamanoi et al., 2023). 2) Using tablet PC for each student in a special-needs class enabled continuous observation of killifish development. 3) In a Cambodian high school biology class where microscopes are poorly available, exploratory cell observation became possible (Tsuzuki et al., 2021)..LISP intends to develop and practice methods of utilizing the mobile microscopes and to compile collection of case studies of observations using them in the kitchen and other familiar places in order to promote citizen science. We would like to exchange opinions on what kinds of observation targets are appropriate, and what kind of utilization methods are possible and effective for school education and citizen science. https://www.facebook.com/groups/life.is.small

Integration Post-Harvest Processing Technology of Java Long Pepper (Piper retrofractum Vahl.) for Curriculum Development in Vocational Schools

Sulifah A. Hariani[1]*, AD Corebima[2], Siti Zubaidah[3], Umie Lestari3, Kamalia Fikri[1]
[1]*Jember University*
[2]*University of Kanjuruhan Malang*
3State University of Malang, Indonesia
*Corresponding Author: sulifah.fkip@unej.ac.id

This research aims at analyzing the post-harvest handling and processing of Java long pepper (Piper retrofractum Vahl.) in Java as information for farmers and agricultural counseling workers, as well as to develop learning material on post-harvest learning for vocational school students. The methods used in this research were a survey supported by an interview with farmers of P. retrofractum in Java Island, Indonesia, regarding the handling of P. retrofractum post-harvesting. The results of the analysis of post-harvest P. retrofractum handling were used to develop learning material for vocational students in the Plantation Plant Agribusiness program. The best stages of post-harvest P. retrofractum handling which follow the standard process are initial sorting, washing, weighing, blanching, final sorting (grading), packaging or labeling, and storage. The results of the learning material development indicate that the learning material is valid and can be applied in the learning process of vocational schools related to the necessary competencies of analyzing and evaluating post-harvest plantation plants.

Integrating Local Wisdom of Traditional Dance into Biological Science Module in Plantation Area School

Kamalia Fikri*, Rasmiyana, Suratno, Slamet Hariyadi and Arif Fatahillah
Biology Education, University of Jember, Jl. Kalimantan 37, Jember, Indonesia
*Corresponding Author: kamalia.fkip@unej.ac.id

One of well-known plantation area is Kalibaru plantation, involving in remote area. The Kalibaru plantation community has local wisdom specifically on traditional dance. This study aims to develop a biological science module based on traditional dance in plantation areas. This research is development research. Data collection techniques using a questionnaire assessment or student responses to the module, needs analysis questionnaire and expert validation questionnaire. This traditional dance-based module development research design uses the four-D model proposed by Thiagarajan and Semmel. The results of the development research show that the validity level of the traditional dance-based module that has been developed reaches 84% in terms of material experts, 83.4% in terms of media experts, 77.5% in terms of linguists, 88.85% in terms of teachers (users), this indicates that the validity level of the traditional dance-based biological science module is feasible and can be continued in the next test. Based on the trial, the results of the questionnaire assessment or response of junior high school students are included in the agreed category with a score of 773 which means that students understand the material, understand the language used in the module and are interested in the appearance of the module.

Collaborative Curriculum-Based Water Quality Research: Integrating Chemistry and Biology in the Study of Irisan Watershed, Baguio City. Biology and Chemistry education in the integrated learning

Fangayen, Mayla Grace L.*, Kindipan,

Melissa Ann B., Aloot, Keisha Louis B., Caisip, Janelle Andrea Dm., Castro, Yzel Kathreen E., Dando, Jaszy Gaverielle A., Haduca, Samantha Danielle L., Bacwaden, Jared Usher K., De Mesa, Rya Lorin M., Lu, Zaria Gabrielle E., Smith, Geo Joshua L., Visperas, Jana Janel B.
Philippine Science High School-Cordillera Administrative Region Campus
*Corresponding Author: mfangayen@carc.pshs.edu.ph

This study showcases a collaborative, curriculum-based approach to water quality research, integrating chemistry and biology disciplines within an educational framework. Conducted by students from Philippine Science High School- Cordillera Administrative Region, the research focuses on the Irisan Watershed in Purok 9, Irisan, Baguio City, classified as Class AA. The project aimed to evaluate the water's suitability for agricultural and household use through both physicochemical and microbiological analyses. Chemistry students assessed temperature, total suspended solids, pH, dissolved oxygen, and biochemical oxygen demand, concluding that the water is generally safe for use, though they recommend further routine testing. Biology students investigated the presence of Escherichia coli as an indicator of fecal contamination. Using membrane filtration and Eosin-methylene blue (EMB) agar, they analyzed samples from the main source, a storage tank, and a household faucet. While no bacterial growth was found in the main source, contamination was detected in the storage tank and faucet, suggesting issues with sanitation or environmental factors like animal waste. This interdisciplinary project underscores the importance of integrating chemistry and biology education to tackle real-world environmental and health issues. It highlights the necessity for regular water quality monitoring and maintenance of storage facilities to ensure safe water for local residents. Recommendations include routine cleaning of storage tanks and monthly water assessments to identify and mitigate contamination sources, promoting the community's health and safety through an educational lens.

Development of Teaching Materials Using Resources in Zoo Practice with 4th Grade Elementary School Students Using ThreeDimensional Teaching Materials

Hiroyuki Furuichi[a]* and Kiyoyuki Ohshika[b]
[a]*Gakuden Elementary School, Inuyama, Japan*
[b]*Department of Science Education, Aichi University of Education Kariya, Japan*
*Corresponding Author: bbc_hiro2001@yahoo.co.jp

Zoo have variety of effective resources in biology education where many animals are kept and exhibited. It is promoted to use of educational facilities like a zoo for school science by the Course of Study in Japan. However, it is educational issue that many school could not visit zoo as the place of field trips.So, in this study, we have developed ICT teaching materials that can be used online using animal skeletal specimens of the various educational resources zoo have. We have developed 11 materials of mammals, with most of them being monkeys.By posting the teaching material platform as 3D data on the web, Students can observe these skeletons from all directions, including enlarging, reducing, and rotating. A class practice using this teaching material was conducted with fourth grade elementary school students. As a result of the practice, over 90% of the students responded that they were interested in the skeleton. Additionally, over 90% of the students responded that the 3D data was very realistic. Furthermore, over 90% of students responded that they would like to go to the zoo and learn science more. Based on this research, we believe that we have been able to develop useful biological teaching materials.

Development of Scientific Concept Assessment Based on Understanding by Design Curriculum

Sangeui Lee*, Seongjae Lee, Mira Ha and Minsu Ha
[a]*Science Education, Seoul National University, Seoul National University, 1, Gwanak-ro, Seoul, Republic of Korea*
*Corresponding Author: leese0708@snu.ac.kr

Understanding by Design aims for conceptual understanding, which involves transferring concepts to new situations or problem-solving scenarios, leading to enduring understanding. In this process also known as deep learning, learners develop practically applicable knowledge. In science education, deep learning is a significant goal. This study aims to develop an assessment model to achieve this goal and to

understand students' ability. To make this assessment model, we first refer to the achievement standards within the curriculum to identify key questions that confirm these standards. Familiar materials from textbooks are selected to pose these key questions, and problems are created using these materials along with the related scientific theories or conceptual content. The problem items are designed to start from a low-level explanation stage and progressively evaluate higher-level competencies through stages of interpretation, application, perspective, empathy, and self-knowledge. Additionally, the items are developed in a process-oriented manner, so that earlier items help in understanding and solving subsequent items. This approach will promote a deep understanding of scientific concepts and assess students' thinking skills and competencies.

Rethinking of Mendelian Genetics Curriculum: Critical Discussion-Based Education on Students' Genetic Determinism

Seungah Park
Department of Science Education, College of Education, Seoul National University, Seoul, Republic of Korea

Emphasis on certain knowledge in biology, especially in genetics, may inadvertently or intentionally contribute to biases and discrimination that could potentially divide individuals. Therefore, carefully selecting which biological concepts to emphasize in education is crucial and comes with responsibilities. Conventional introductory genetics education, based on Mendelian genetics, can perpetuate a deterministic view that genes are destiny, even after students learn otherwise. Research indicates that middle school students who focus heavily on single-gene traits in Mendelian genetics might start to develop or strengthen a belief in genetic essentialism. In response, we suggest a shift from the current Mendelian genetics curriculum to a revised approach that prioritizes interactions and phenotypic diversity, thereby mitigating genetic determinism among students. In the current context, where snippets of genetic determinism blend seamlessly with scientific discourse, it is essential that education does more than just convey genetic concepts accurately; it should also promote genetic literacy, equipping students to critically assess the portrayal of genetics in the media. Critique creates space to explore alternatives and is particularly effective in educational activities that focus on collaborative construction of knowledge. Thus, encouraging students to critically discuss Mendelian genetics can effectively reduce genetic determinist thinking, enhancing the role of science education in fostering a more equitable and inclusive society.

Analysis of free inquiry activities of college freshmen major in Biology Education

Hong Jun euy[a]*, Dong Hyo Kwan[a] and Park Heon Woo[b]
[a]*Dep.t of Biology Education, Seowon University, south Korea, Cheongju-si Chungbuk, Korea*
[b]*Dept. of Science Education, Chuncheon National University of Education, south Korea Chuncheon-si Ganwon-do, Korea*
*Corresponding Author: june0572@naver.com

Inquiry generally refers to the process of acquiring new knowledge that a person did not know before, or the activity of reproducing such a process. In other words, it simply refers to the pursuit of truth, information, and knowledge, and it is established as an important educational goal in the 2022 revised science curriculum in Korea. Inquiry learning does not mean that students should discover new knowledge or create new theories, but rather that they should reproduce as faithfully as possible the thinking process or method that the first researcher (scholar) went through when discovering the knowledge or theory. have This study analyzed a task in which students enrolled in the biology education department of a college of education were given radish seeds and were asked to grow them for at least two weeks and submit the results. Ten radish seeds were distributed to all students, and they were asked to set their own variables and observe the radish seeds sprouting and growing. In this study, 23 freshmen enrolled in the Department of Biology Education at the College of Education were given guidance on the inquiry in the first week of March 2024, had them design an inquiry, and begin their own inquiry. The report was to be submitted by the end of May. . If students did not sprout or failed in their

quest, they were given radish seeds and were allowed to experiment again. Since this study was an experiment targeting students enrolled in the biology education department of a college of education, it can be said to have the meaning of examining the inquiry activities they have learned up to high school.

Environmental Talks with Future Generations Global science communication program as project-based learning

Masashi Miyako, Hidenobu Murayama*
Sapporo Nihon University Junior and Senior High School, 5-7-1 Nijigaoka Kitahiroshima-shi, Hokkaido, Japan
*hidenobu.murayama@sapporonichidai.ed.jp

Environmental Talks with Future Generations is a global science communication program. Its purpose is to enhance the will to solve environmental problems as well as internationalism by having high school students talk about global environmental issues with other school students, students from overseas, graduate students, etc. In FY2023, in addition to students from Japan, high school students from Bangladesh also participated. The graduate students participated as a facilitator were from Bangladesh studying at Hokkaido University. 12 sessions were held in total from July to February, using both online and onsite. These sessions included four online lectures by foreign researchers and one beach-based plastic sampling. In the second half, we focused on the issue of marine plastics and explored what high school students can. Applicants were given the opportunity to work with Bangladeshi students who will visit Japan to create a panel discussion and to present their suggestion in front of large audience. Finally, eight applicants created effective materials and proposed solutions. The students who participated in the project increased their confidence in communicating in English, became more familiar with environmental issues, and realized the importance of not only researching but also taking action. According to the students' self-evaluations, they felt that their ability to expand their ideas and metacognitive abilities had improved. However, only students who participated in the panel discussion were able to improve their ability to plan, execute, and reflect. It is necessary to examine what elements comprise the competency of internationalism and how it can be evaluated.

An Analysis of Peer Evaluations on Scientific Inquiry Exploring Students' Evaluation Levels and Patterns

Seoyeon Lee[a] and Minsu Ha[b]
[a]*Department of Science Education, Seoul National University, Gwanak-ro, Gwanak-gu, Seoul, RepublicofKorea*
[b]*Department of Science Education, Seoul National University, Gwanak-ro, Gwanak-gu, Seoul, RepublicofKorea*
*Corresponding Author: lsy030330@gmail.com

This study aimed to analyze peer evaluations conducted to assess students' scientific inquiry abilities. Students' hypotheses and experimental designs were evaluated through the peer evaluation system 'Peer Evaluation Encouraging Reflection (PEER).' The analysis focused on assessing the quality of peer evaluations and understanding students' evaluation behavior patterns. It is expected that PEER will improve students' ability to critically evaluate their scientific work and promote a deeper understanding of scientific methods.

Environmental Consciousness of Senior High School Students: Basis for Innovative Environmental Education (EE) Approaches

Ian Ismael E. Marces, Roselle D. Urbano, Jovita Balbuena, Maculeta E. Omiles, Eufrecina Jean D. Ramirez*
Graduate School, Centro Escolar University, Manila, Philippines
*Corresponding author: edramirez@ceu.edu.ph

This study investigated the level of awareness of environmental principles and issues among senior high school students, as well as the impact of gender, academic strand, grade level, and school type on their environmental sustainability initiatives and practices. Majority of the 770 respondents were female, enrolled in STEM strand in public schools. Results revealed that the respondents demonstrated significant awareness of sustainability principles and current environmental issues (Mean=3.33; SD=0.749). However, when it comes to practicing sustainability, responses indicated that these principles were only "often" practiced (Mean=2.93; SD=0.546). Notably, the level of awareness and practices

varied significantly across academic strands. The results unveiled a low positive correlation (r=0.296) between the respondents' level of awareness and their practices. While students exhibited awareness of environmental principles and issues, they expressed a need for guidance on how to translate this awareness into meaningful action for the environment. Hence, there is a clear need for environmental initiatives that motivate students to actively engage in protecting and preserving the environment. Integrating "Education of, in and for the Environment" teaching learning activities will enhance students' environmental awareness and practices. This approach aims to cultivate environmental consciousness among students and empower them to contribute positively to environmental sustainability efforts.

Practical use of experimental teaching materials using glowing lichen: Focusing on the lichen substance lichexanthone

Kazuki Nakabayashi* and Shunji Takeshita
Hiroshima University, 1 - 1 - 1 Kagamiyama, Higashihiroshima, Japan
*Corresponding Author: m246269@hiroshima-u.ac.jp

The purpose of this study is to develop a learning program by combining experimental teaching materials of lichen. Lichen is a symbiont of fungi and algae. Although it has some features related to the contents of biology textbooks in Japanese high schools, there is a small number of teaching materials using lichens. In this study, we focused Hypotrachyna osseoalba (Vain.) Y.S.Park & Hale, a species of the foliose lichens. This species contains lichexanthone, one of the secondary metabolites of lichens (lichen substances). Because of this substance, the thallus of this species exhibits yellow fluorescence by ultraviolet light. The following experiments were examined. First, the crystals of lichen substances were observed by using microcrystal tests. These crystals showed different morphologies. Second, TLC was carried out to isolate lichexanthone. Consequently, one spot showing yellow fluorescence was identified as lichexanthone based on the Rf value. Thirdly, the lichen substance was extracted from the TLC spot and crystallized. The crystals showed the same morphologies as lichexanthone. Furthermore, the crystals exhibited yellow fluorescence by ultraviolet light. These results demonstrated that the yellow fluorescence of the lichen thallus is due to lichexanthone. From these experimental processes, an inquiry-based learning program was proposed, and evaluated practicality by implementing it in the actual class.

Examination of experimental and observational teaching materials regarding nitrogen fixation using cyanobacteria (*Nostoc commune)*

Motoka Nakamura*, Momomi Kikuchi and Yui Tanazawa
Faculty of Agriculture, Department of Production Agriculture, Tamagawa University
6-1-1 Tamagawagakuen, Machida, Tokyo, 194-8610, Japan
*Corresponding Author:
mnakamura@agr.tamagawa.ac.jp

Nitrogen fixation in ecosystem is covered in high school biology courses such as "Life phenomena and materials" and agricultural subjects "Agriculture and environment", and gives students deeply understanding of the interactions between living things in ecosystems and adaptive evolution. However, there are not many opportunities for learning through experiments and observations in actual classes, because it takes a lot of time to select the optimal target organism and their cultivation. Therefore, this research aims to create teaching materials for observation and experimentation on the subject related to nitrogen fixation using a method for simple and appropriate evaluation of nitrogen fixation ability through microscopic observation and analysis of metabolic activity of cyanobacteria (*Nostoc commune*). In general, nitrogen fixation of cyanobacteria is affected by the moisture and nitrogen condition of the habitat, so in this research, we evaluated the nitrogen fixation ability (such as ammonia content and nitrogenase activity) of them under culture conditions with high and low nitrogen concentration and moisture. As a result, it was found that the nitrogen fixation ability of them is positively affected by dry and low nitrogen conditions, and in this condition, it is appropriate to measure nitrogen fixation ability and observe nitrogen-fixing sites (heterogeneous cells). Thus, we conclude that it is possible to treat *Nostoc commune* as a target organism for teaching materials through

the evaluation of nitrogen fixation ability under optimal moisture and nitrogen conditions.

Effect of deposition as a phosphorus source: Empirical study at the early stage of primary succession in volcanic soil

Sae Katayama*, Masaki Tateno
Nikko Botanical Garden, Graduate School of Science, University of Tokyo, Nikko, Tochigi, Japan.
*Corresponding Author: saekatayama.nbg@gmail.com

Phosphorus is an important plant nutrient for plant growth during the early stages of primary succession in volcanic soils. In immature volcanic soils, *Fallopia japonica* seedlings absorb inorganic nitrogen from wet deposition to colonize. The effect of deposition as a source of phosphorus was not well understood, so we investigated it. We tested the effects of deposition by treating *F. japonica* seedlings with wet deposition or distilled water in volcanic soils. The experiment was conducted at the Nikko Botanical Garden, and the deposition collected there was confirmed to contain phosphorus. *F. japonica* grown on volcanic soils with wet deposition exhibited higher phosphorus contents and growth rates than those grown with distilled water. These findings suggest that *F. japonica* grows gradually during primary succession and builds up phosphorus cycle, absorbing a very small amount of phosphorus from deposition. The remaining question is how the phosphorus came to be included in deposition. We hypothesized that plant matter (pollen and fallen leaves from nearby forests) could be blown away by the wind and included in deposition, providing phosphorus. As a result of verification, very small amounts of plant-derived components were confirmed in the deposition. It is unclear whether very small amounts of plant-derived components are the source of phosphorus in deposition, and this is an issue for the future.

Plan for a biology class that fosters "hometown pride"

Teruki Hirata
Nakamura Gakuen Girls' Junior & Senior High School 7-13-30 Torikai Jonan-ku, Fukuoka, Japan
terukiyoryo@yahoo.co.jp

As globalization progresses, lifestyles and values diversify, and the inheritance of our country's culture and traditions is at stake. In order to ensure that we carry on our culture and traditions to the next generation, I believe that now is the time for education that fosters "hometown pride (patriotism)". This is fostered primarily in moral education, as indicated in Japanese Courses of Study. However, I examined whether students could develop hometown pride by strongly engaging with local organisms in biology classes and in integrated studies. Italians are historically and traditionally known for their strong hometown pride (Campanilismo). So to get a better understanding of the way hometown pride is fostered, I have been conducting surveys and interviews with Italians and people involved in the Italian food industry since 2018 regarding hometown pride. Based on these results, I also asked the students to plan lessons and events aimed at fostering hometown pride, which made me and the students reaffirm the importance of hometown pride and gave me many ideas for practices that would foster hometown pride. Furthermore, I have been involved in several practices related to be fostering hometown pride under the SGH (2015-2019) and WWL (2020-2024) programs for the development of global human resources at my school. I will present these practices as well. I hope that in the future there will be even one more global human resource who is proud of their hometown.

Development of teaching materials about tidal flat ecosystem

Haruka Kobayashi*, Kiyoyuki Ohshika
**Graduate School of Education, Aichi University of Education, Kariya, Japan bDepartment of Science Education, Aichi University of Education, Kariya, Japan*
*Corresponding Author:
sumikkogurashi0802@icloud.com

Tidal flats formed at river mouth are important natural environments that provide an ecosystem for biological diversity. Currently, conservation of tidal flats is an urgent issue, because more than 40% of Japan's tidal flats have disappeared over the past 50 years due to land reclamation. So, it is important to learn about tidal flats in order to promote their conservation. However, it is difficult for children to visit the tidal flats in school education. Therefore, in this study, we have developed teaching materials to help

children to learn about tidal flats in school. We have developed the three teaching materials for learning about tidal flats, targeting Fujimae Tidal Flat, which is a representative example of the central area of Japan. The teaching materials are as below: 1. Online Video. 2. Resin specimens. 3. Role-playing activity. The on-line video allows children to understand the process of formation of tidal flats for 30 seconds, which takes about six hours from high tide to low tide. Resin specimens can help children understand the structures and characteristics of living things in tidal flats. In role-playing activity, children can play the roles of tidal flats creatures and help them to understand the tidal flat creatures and help them to understand the tidal flat ecosystem and food chain. We had practiced the class lessons using these teaching materials for elementary school children. As a result of the class practice, it was cleared that these teaching materials was good efforts for children to understand about tidal flats. 7

Development of Teaching Materials for Resin Specimen of Insects to Understand of Body Structure and How They Grow

Ayane Mukai[a]*, Kiyoyuki Ohshika[b]
*[a]*Graduate School of Education, Aichi University of Education, Kariya, Japan*
[b]*Department of Science Education, Aichi University of Education, Kariya, Japan*

Insects are the living organisms that many children are most familiar with and most interested in, so they are suitable as a first living animals that children learn in elementary science classes. Through raising and observing insects, children learn about their body structures and how they grow. Recently, the number of children who dislike insects or unable to touch them is increasing. Therefore, in this study, we have developed teaching material of insect resin specimen that allows all children to learn about insects. Butterflies, dragonflies, and grasshoppers are introduced in Japanese elementary school science textbooks. We have developed resin specimen teaching materials for these three species. Three advantages of resin specimen teaching materials are as below: 1. Observable from all directions. 2. Observable at any time of the year. 3. Observable without touching the insects directly. Through observation in all directions, they can understand the body structure of insects, such as the number of legs and shape of mouth. Children can observe various forms of insects at any time. And children who dislike insects can observe them because they don't touch insects directly. As a result of the class practice, all children were able to observe resin specimen teaching materials. And many children were able to understand insect structures and how they grow.

Tracing flower visits of honeybees in an urban beekeeping hive A collaborative effort involving citizen science, inquiry-based learning, and biological research

Ayaha Takagi[a], Kazuma Yoshimura[b], Shota Okamoto[b], Hiromasa Inoue[c] and Taro Harada[d]*
[a]*School of Education, Okayama University, 3-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530, Japan*
[b]*General Course, Soshi Gakuen High School, 7-38 Shimoifukunishimachi, Kita-ku, Okayama 700-0054, Japan*
[c]*Head Office, Maruta Industry, Co., Ltd. 6-36 Honmachi, Kita-ku, Okayama 700-0901, Japan*
[d]*Faculty of Education, Okayama University, 3-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530, Japan*
*Corresponding Author: tarohara@okayama-u.ac.jp

The flower-visiting behavior of honeybees in urban beekeeping hives is of ecological interest and affects important features of honey products. The Okayama Honeybee Project 'Momotaro Honey Lab.' is an urban beekeeping project run by a private company. It provides a foundation for citizen science by disseminating environmental education among individuals through the cooperative efforts of local communities and educational institutions. As part of this project, a survey was conducted to identify plants visited by bees through microscopic observation of pollens to support inquiry-based learning among high school students. Pollen composition was found to vary with time of year, suggesting that bees visit the flowers of plant species with heterochronic blooming. To supplement these results, we performed DNA-based analyses in our university laboratory by utilizing our research equipment and expertise in plant molecular biology. We detected DNA sequences from cherry blossoms in honey collected in April, partially confirming high

school pollen analysis results. We are currently working to identify nectar and pollen source plants by DNA metabarcoding targeting the ITS2 region using Oxford Nanopore Technologies, a thirdgeneration sequencing technology. This study identifies plants that play an important role in urban beekeeping through a collaborative approach and promotes understanding of the importance of biodiversity by revealing relationships between plants and insects and can contribute to education for sustainable development (ESD).

Class Practice to Improve Observation Skill for Junior High School Students

Kie Kawase[a]*, Kiyoyuki Ohshika[b]
*[a]*Graduate School of Education, Aichi University of Education, Kariya, Japan*
[b]Department of Science Education, Aichi University of Education, Kariya, Japan

In this study, I had practiced the science lesson for junior high school students to improve observation skill, which is one of the process skills in scientific inquiry. In junior high school science classes in Japan, drawing is commonly used to record observations of objects. Additionally, mastery of drawing techniques is required by students. Therefore, when students do observations, they tend to pay more attention to the way of the drawing than observing the features of objects. So, as the aim of improving the significance and skills of observation, we have developed the program using sunflower seeds. As a result of the class practice, the first observation in the first half of the class, students had insufficient observation records because they were focusing on how to draw records. However, during in the second observation in the second half of the class, they were able to capture the characteristics of the objects being observed and draw detailed observation records. Additionally, many students were able to understand the significance of observation, and learn about importance of recording results.

A study on the cross-curricular learning of natural environment conservation in science and morality education

Miyuki Kato
Department of Child Eduction, Kawamura Gakuen Woman's University, 1133sageto, Abiko, Chiba, Japan
*Corresponding Author: m.katou@kgwu.ac.jp

Issues related to natural environment conservation are often addressed in the context of trans-science. In order to tackle the issues, it is essential to balance scientific data with the development or protection of areas and the responsibility to conserve living organisms and nature. This study aims to identify the learning content regarding conservation of living things as explained in Japanese junior high school curriculum guideline and textbooks for science and morality education. Therefore, the purpose of this study is to clarify the current status and problems in cross-curricular conservation education. In science, the current Ministry's curriculum guideline for junior high school contains the mutual interrelationships among living things in the final unit of science section, and in a teaching guideline for the curriculum, it is described that human activities have made change to the balance of the natural world. The later also mentions climate change and alien species should be touched upon. On the other hand, in morality education, the same guideline contains reverence for life and a sense of awe, and a teaching guideline for the curriculum encourages students to humbly accept nature, perceive an emotional connection with nature, and become aware of nature conservation. Hence, morality textbooks contain learning contents related to these topics. Additionally, while elementary school students learn about the food-chain, most do not study ecosystems or other biodiversity conservation in science education. The gap indicates the possibility that many first grade junior high students might discuss conservation of living thigs without a scientific foundation.

Why do people hate insects? Elucidating Causes and Developing a Design for Learning Environments

Juri Yoshizawa
Faculty of Education, Kagawa University, Saiwaicho 1-1, Takamatsu Citym Kagawa Prefecture, Japan
yoshizawa.juri@kagawa-u.ac.jp

It is becoming increasingly difficult to handle live insects in the third grade "Insect Morphology" unit at elementary school. One of the reasons

for this is that students and teachers "hate insects". Therefore, when there are many students and teachers who hate insects, classes are conducted using specimens and digital teaching materials. However, it has been pointed out that classes that do not deal with live insects do not provide a correct understanding of the body structure of insects. Teachers who teach in these classes also have a hate of insects. Why does this hate of insects arise? In a preliminary survey of elementary school teachers, the applicant revealed that they hate the "shape" and "movement" of insects. However, it is unclear what characteristics of insect shape and movement cause this hate. In this study, we clarified the characteristics of insect hate through a detailed investigation of the "shape" of insects.

Cultivating a Sense of Attachment to Nature and Interest in Nature and Science through Experiential Agricultural Learning - Through a Questionnaire Survey of High School Agricultural and General Education Students-

Tomomi Yamaguchia
Aichi Prefectural Inazawa High School
Address,11 Kase, Hirano-cho, Inazawa-shi, Aichi-ken, Japan
yamaguchi4662@aichi-c.ed.jp

In Japan, since the Meiji Era, when science was established, a rationalistic view of science based on Western science and a unique Japanese view of science that fosters a love of nature have coexisted (Ogawa, 2006). To nurture children in the age of VUCA, it is important to nurture the five human senses that cannot be replaced by AI. To this end, we conducted a questionnaire survey on the sense of attachment to nature and interest in nature and science among high school students in an agriculture course, focusing on the nature-loving sentiment unique to Japan.In this limited survey of agricultural high school students, a sense of attachment to nature and animals was fostered through hands-on agricultural learning. The results also suggest that the students' interest in nature and science has increased, and that they may have a positive attitude toward newly discovered scientific findings, rather than a bias toward nature worship in solving global problems.

Microscopic observation method using side illumination to promote three-dimensional images

Hiroyuki Yamashita
Faculty of Education, Okayama University of Science, Ridai-cho 1-1 kika-ku, Okamaya City, Japan
yamashita@ous.ac.jp

Optical microscopes are extremely useful teaching tools, and are frequently used in Japanese science education from elementary school to high school to study biological observation, but in most cases, observations are made using transmitted light. When observing through transmitted light, the image obtained from the sample is generally flat, and it is not possible to obtain a threedimensional image like with a binocular stereomicroscope or an electron microscope. However, binocular stereomicroscopes are limited to low magnification, and unfortunately cannot provide images as high as optical microscopes. Originally, biological cells are assembled in a threedimensional manner, and the inability to assemble a three-dimensional image using only twodimensional images, as in the past, may encourage misconceptions about biological cells. In a questionnaire survey conducted on second-year university students, most students were unable to describe the stomata of plants as a three-dimensional image. Therefore, the purpose of this research was to make it possible to obtain three-dimensional images by devising side illumination, thereby making it possible to reproduce the image of biological cells three-dimensionally. Taking as an example the observation of stomata in leaves, which is common in biological observation, by adjusting the illumination brightness and incidence angle of side illumination using LEDs, it was observed that the guard cells had a convex shape and the stomata had a concave shape. In this presentation, observation methods while comparing images obtained with transmitted light and images taken with side illumination will be reported and discussed.

Development of observation and experiment teaching materials for sixth grade elementary school science class. -Observation and experiment of the material cycle in an

ecosystem using LEGO blocks as molecular models-

MATSUTANI Hiroshi[a]*, TANAKA Miyu[b], NINOMIYA Kosh[c], OKUMURA Yuki[d], SAWA Tomomi[d], NAKAMATSU Yutak[a,c,d]
[a]*Obata Elementary School, 663-1 Motomachi, Obata-cho, Ise, Mie, Japan*
[b]*Kida Elementary School, 1478 Kamiji-cho, Ise, Mie, Japan*
[c]*Graduate School of Education, Kogakkan University, 1704, Kodakushimoto-cho, Ise, Mie, Japan*
[d]*Faculty of Education, Kogakkan University, 1704, Kodakushimoto-cho, Ise, Mie, Japan*
*Corresponding Author:
matsutanihiroshi1004@gmail.com

In the sixth grade science unit "Organisms and the Environment," students learn that there is a food-eat-eat relationship between organisms and that organisms interact with the surrounding environment through respiration, photosynthesis, and transpiration, and through oxygen, carbon dioxide, and water. To understand chemical transformation, the concept of particles such as molecules and atoms is necessary. This concept formation is difficult not only for elementary school students but also for junior high school students, and it's reported that it's important to introduce particle images from elementary school in order to solve the problem. In also Based on these facts, this study developed educational materials to learn about the material cycle and energy transfer in ecosystems through photosynthesis in plants and respiration in living organisms by building molecular models using LEGO blocks. We also developed educational materials to observe the food chain using the corn's young leaves (producer), *Mythimna separata* (phyto-phagous), and *Andrallus spinidens* (zoophagous). In nature, food webs are almost always formed by several interlocking food chains. Food webs are maintained when populations of various organisms are connected and biodiversity is maintained. We developed a teaching material in which each Jenga is represented as a population of an organism, and the relationship between populations in an ecosystem is represented by a pyramid of stacked Jengas. This teaching material teaches that high biodiversity leads to the maintenance of ecosystems.

Development and practice of teaching materials utilizing sea animals in aquariums in Japan

Eri Furukawa[a] and Kiyoyuki Ohshika[b]*
[a]*Aichi Science Teaching Materials Development Lab, Kariya, Japan*
[b]*Department of Science Education, Aichi University of Education, Kariya, Japan*
*Corresponding Author: ohshika@auecc.aichi-edu.ac.jp

It was emphasized the use of social educational facilities like zoo and aquarium in the new Course of Study for Japanese elementary school issued in 2017. In the Course of Study, it is important that students think of the perspectives of commonality and diversity in the life science. Therefore, zoos and aquariums that keep and exhibit many various animals are suitable facilities for learning about the commonalities and diversity of life for students. There are many educational materials developed in which elementary and junior high schools and zoos collaborated with. However, there are only a few cases in which elementary and junior high schools and aquariums did. So, we have developed the teaching materials to make better use of aquariums in biology education for elementary school science. We have developed worksheets that allows elementary school students to study about animal behavior and ecosystem by observing animals at aquariums. In order to verify the validity of the developed teaching materials, we have conducted a class practice for 2nd and 4th grade elementary school students. By using these worksheets at the aquarium, many students were able to become familiar with sea animals and learn about the sea environment.

Developing teaching materials for high school biology to understand environmental viruses: PCR methods to detect viruses in aquatic environments

Chieko Uchiyama[a] and Masaharu Takemura[b]
[a]*Junior & Senior High School at Komaba, University of Tsukuba, 4-7-1 Ikejiri, Setagaya-ku, Tokyo 154-0001, Japan*
[b]*Graduate School of Science, Tokyo University of Science 1-3 Kagurazaka, Shinjuku-ku, Tokyo 162-8601, Japan*
*Corresponding Author:
uchiyama.chieko.ge@un.tsukuba.ac.jp

Understanding “environmental viruses,” which are the viruses that are part of the global ecosystem, is crucial for gaining a deep understanding of viruses. Viruses have a significant impact on ecosystems and the evolution of living organisms through their interactions with them and other viruses. However, it is difficult for high school students to focus on and research viruses. We developed teaching materials for high school students which focuses on environmental viruses. It familiarizes the students with the viruses, and helps them confirm their existence through experiments. We targeted T4-like phages that exist in many aquatic environments for the experiments. We used two types of filters to collect viruses from water samples. We extracted DNA from the sample using a simple extraction method, and then amplified specific sequences of T4-like phages using PCR. The participants were third-year high school students, and a descriptive survey was conducted after class, which revealed that it was focused on the relationship between viruses and the entire ecosystem and it could be an opportunity for them to feel connected to viruses. Additionally, we found that by changing the combination of the two types of filters, giant viruses, such as Mimivirus, could be detected. We hope that the existence of environmental viruses will be widely recognized in the future through lesson plans and practices utilizing the experimental teaching materials developed in this study.

Implementing Online Classes Combined with the Observation of Animal Derivatives

Hiroki Omoto[a]* and Kengo Satomi[b]
[a]*Adventure World, Katata2399, Shirahama-cho, Nishimuro-gun, Wakayama, Japan*
[b]*Benesse Science Class Kamiooka Branch 1-3-8 Bessho, Minami-ku, Yokohama-shi, Kanagawa, Japan*
*Corresponding Author: h-omoto@aws-s.com

Adventure World is a theme park in Wakayama Prefecture, home to 120 species and 1,600 animals, including giant pandas. The park also emphasizes educational outreach, offering 70 programs annually to 2,000 children. Since COVID-19, online classes have increased, providing more opportunities for distant children. However, these often became lecture-based due to the lack of close animal interactions. To address this, Adventure World developed online learning content in collaboration with Benesse Science Class, an extracurricular science workshop provider. The content included observing animal feces and skull specimens sent to the classes in advance. These animal derivatives classes were conducted on December 26 and 27, 2023, with 23 primary school students. The keepers gave lectures and guided observations via Zoom. In the "feces class", the students classified the feces of giraffes, zebras, rabbits, and lions. However, 90% of the students confused giraffe and zebra feces. This was likely due to the misconception that the size of the animal correlates with the size of its feces. We will utilize this gap in future introductions to digestion to motivate students. In the "skull specimens class", the students classified the skull specimens of zebras, lions, and brown bears. However, some students mistook a lion's skull for a brown bear's, suggesting that adding feeding videos can help learn the relationship between tooth shape and diet more exploratory. Overall, students engaged in the exploration more actively than usual, resulting in high satisfaction. Therefore, combining online classes with animal derivatives was considered useful in motivating students to explore.

Basic research for developing teaching materials on “ecology and the environment”: Focusing on the diversity of photobionts in the lichen family Cladoniaceae

Yuto Komiya* and Shunji Takeshita
Graduate School of Humanities and Social Science, Hiroshima University, 1-1-1, Kagamiyama, Higashi-hiroshima, Japan
*Corresponding Author: m243677@hiroshima-u.ac.jp

The aim of this study is the development of teaching materials using features of lichens. Lichens are symbiotic organisms belonging to fungi. The lichen body consists of fungal hyphae and algal cells. Algae called "photobionts" provide photosynthetic products to fungi called "mycobionts", and fungi provide water, inorganic matter, and a stable habitat to algae. Therefore, this symbiotic relationship is considered mutualistic. *Asterochloris* (Trebouxiophyceae, Chlorophyta) is a genus commonly found in many lichens, for example, *Cladonia* and *Pilophorus* of the Cladoniaceae, *Stereocaulon*

and *Lepraria* of the Stereocaulaceae, and others. Although *Asterochloris* is widely distributed across the world, research on its species diversity has been insufficient in Asia, Africa, and the Neotropics. In this study, we examined the photobiont diversity of the Cladoniaceae in Japan. As a result, five clades of *Asterochloris* were recognized as the photobionts of Japanese Cladoniaceae by genetic analysis. In the global distribution of each clade, three clades were widely distributed, and two clades were found only in Japan. The widely distributed three clades were classified into two types: one type was distributed in the temperate to subarctic regions of the Northern Hemisphere, and the other was found in the tropical to temperate regions of both the Northern and Southern Hemispheres. This genetic diversity and the distribution differences of photobionts suggested that each photobiont occupied its niche relative to temperature. This lichenological topic would be useful for learning about the relationship between living things and the environment.

Development of teaching materials to verify the laws of inheritance using Japanese rice fish "Medaka" (*Oryzias latipes*)

Shigeyoshi Watanabe
Faculty of Education, Kumamoto University, 2-40-1 Kurokami, Kumamoto, Japan
shige@educ.kumamoto-u.ac.jp

"Medaka" (*Oryzias latipes*) is a small freshwater fish commonly found in rice field and streams in Japan. The body color of Medaka varies depending on the expression, size, and distribution of melanophores, xanthophores, and leucophores present in the epidermis. The expression of melanophores is determined by the combination of the B and b alleles, and it has been revealed that the black-brown body color is a dominant trait. In this study, basic research was conducted on crossbreeding experiments using commercially available Medaka in order to utilize their body color genetics in secondary science and biology. Three types of medaka with different body colors (black, orange, and white type) were prepared. The genotypes related to melanophores were BB or Bb for the black type, and bb for the orange and white types. In crossbreeding experiments between black and orange types, or black and white types, all F1 generations were black-brown in color. Therefore, it is inferred that the genotype of the black type used in the experiments is BB. Next, crossbreeding experiments were conducted between F1 individuals, and the expression of melanophores in developing eggs was examined. In the experiment conducted in 2023, from one pair of F1 generations obtained by crossing a black type with an orange type, 315 eggs with melanophore and 122 eggs without melanophore were obtained, with a segregation ratio of 2.58:1. In my presentation, data from ongoing experiments will be reported and a comprehensive discussion will be provided.

Observation of phagocytosis by lepidopteran larvae hemocytes using fluorescent ink as a foreign substance

Yuki Okumura[a], Shiho Nagashima[b], Hiroshi Matsutani[c], Tomomi Sawa[a] and Yutaka Nakamatsu[a]*
[a]*Faculty of Education, Kogakkan University, 1704, Kodakushimoto-cho, Ise, Mie, Japan*
[b]*Tokyo Nerima, Tokyo, Japan*
[c]*Obata Elementary School, 663-1 Motomachi, Obata-cho, Ise, Mie, Japan*
*Corresponding Author: y-nakamatsu@kogakkan-u.ac.jp

In the basic biology of high school, the observation of phagocytosis by hemocytes can be easily observed by using lepidopteran larvae and india ink as foreign substances following the method of Sawa and Nakamatsu (2014). However, in the class, 42.9% of students could not find the phagocytosed hemocytes by themselves without the assistance of university students. In this study, we aimed to develop a foreign substance and an observation method to allow students to find phagocytosed hemocytes independently. We focused on materials that emit fluorescence, and examined the types of foreign substances and experimental conditions that are suitable. As a result, the most suitable experimental condition for teaching was using Mythimna separata larvae belonging to the family Lepidoptera and yellow fluorescent ink diluted 500 times with physiological saline and a reaction time of 15 minutes. In addition, hemocytes that showed phagocytosis to fluorescent ink could be easily observed by

installing a flashlight-type UV light in the microscope. It is thought that students can easily observe the blood cells that show phagocytosis by finding fluorescent foreign substances in the dark field using only UV light and then recognizing the outline of blood cells in the light and dark fields using both halogen light and UV light.

Development and implementation of teaching materials for phytoremediation: Aiming to understand the importance of biodiversity

Fumi Nakanishi*[a] and Yutao Xub
[a]*Graduate School of Teacher Education, Tokyo Gakugei University, 4-1-1 Nukui-kita, Koganei, Tokyo, Japan*
[b]*Tokyo Hinoki Foreign Language School, 2-29-7 Kitazawa, Setagaya-ku, Tokyo, Japan*
*Corresponding author: fuminaka@u-gakugei.ac.jp

The issue of lead contamination in water and soil, resulting in poisoning, is a major global concern. Phytoremediation refers to the method of using plants to purify the environment, which is expected to have a negligible impact on the environment. Furthermore, it is being evaluated for its potential use in effectively dealing with lead contamination. Conveniently, lead compounds, such as lead nitrate, are used in middle and high school curricula in Japan. We expected that incorporating experiential learning on phytoremediation could enhance students' comprehension of the utility of plants and the importance of biodiversity. Additionally, we anticipated that this approach would stimulate their interest in ecosystem conservation and facilitate accessibility to related technologies. Therefore, we developed teaching materials for conducting lead purification experiments using plants and conducted practical lessons, achieving the following results: 1) We developed a colorimetric method using rhodizonate appropriate for the quantification of Pb2+ in high school settings. 2) We established a simple culture system for the protonema of Funaria hygrometrica, which has been demonstrated to have potential for use in phytoremediation. 3) We devised an experimental system to assess and contrast the lead purification capabilities of different plant materials within 5–10 min. 4) With the aid of these experimental systems, we conducted four distinct types of practical lessons. As a result, most students favorably viewed the lessons, highly evaluated the plants' ability to purify the environment, and demonstrated heightened awareness of biodiversity and natural environment conservation.

The effects of cross-disciplinary inquiry-based learning: Enhancing self-efficacy and growth mindset through the integration of science research and biology education

Makiko Kameda[a]* and Shigeo Wada[b]
[a]*Junten Senior High School. 1-17-13 Oji Honcho, Kita-ku, Tokyo, Japan*
[b]*Nihon Pharmaceutical University, 10281 Komuro, Ina-machi, Kitaadachi-gun,Saitama, Japan*
*Makiko Kameda: kameda@junten.ed.jp

Inquiry-based learning is being introduced worldwide to achieve efficient knowledge acquisition and develop 21st-century skills. At our school, we offer an inquiry-based science research class where students set their research themes and engage in two years of inquiry activities, including hypothesis formulation, experimentation, data analysis, and discussion. Similarly, biology classes incorporate these inquiry steps, allowing students considerable freedom in their experiments. This presentation examines the synergistic interaction between the inquiry-based science research class and biology education. Results show that data analysis and graphing skills acquired in the inquiry program significantly enhanced the quality of biology experiment reports, facilitating high-quality discussions. Conversely, the knowledge and skills gained from biology experiments fostered the development of new hypotheses and deepened inquiry activities in the science research program, creating a synergistic effect. Through two years of inquiry activities, students also improved their presentation skills, including poster presentations. According to a survey, more than 90% of the students reported that they "gained perseverance, grit and selfconfidence through inquiry-based science research class," demonstrating the benefits of sustained work on a single theme. The synergistic interaction between subjects enhanced students' critical thinking, problem-solving skills, and self-efficacy, contributing to an improved growth mindset. Enhanced self-efficacy is crucial for fostering students' belief in their

abilities and independence in tackling tasks, underscoring the positive impact of integrating inquiry-based learning with biology education.

Designing STEAM Instructional Plans for Remote Online Learning: Teachers' Insights and Hindsight

Eden Joy Alata[a]* and Elen Joy Alata-Bruza[b]
[a]*Centro Escolar University, School of Science and Technology, Manila Philippines*
[b]*St. Scholastica's College, High School Unit Manila, Philippines*
*Corresponding Author: edenalata@gmail.com

Science, technology, engineering, arts, and mathematics (STEAM) education equips students to address real-world problems. It is an educational model that develops the creative, The COVID19 pandemic prompted the Philippine education to shift to remote learning mode. This challenging time called for teachers' creativity and resourcefulness especially in their Science classes. This descriptive study presents stories of public and private school Science teachers on the design of STEAM instructional plans for remote learning. The study examines the opportunities and challenges they experienced as well as the strategies they employed in their attempt to innovate and enhance the learning experiences of their students. The teachers highlighted the following as essential to successful design and implementation of STEAM instructional plans: (1) extensive and reasonable teacher training; (2) justifiable standards and expectations during implementation; (3) proper allocation of resources; (4) enhanced parent and student awareness; and (5) intensive industry partnership. Inequality should also be addressed for full realization of STEAM curriculum in the Philippines. Findings and recommendations guide designers, implementors, and instructional supervisors in crafting teacher trainings and establishing support systems to optimize the use of STEAM curriculum design in remote learning.

Learning Related to Climate Change in High School Science, Korea

Youngjoon Shina and, Kew-Cheol Shimc*
[a]*Department of Science Education, Gyeongin National University of Education, Sammak-ro 155, Manan-gu, Anyang-si, Gyeonggi-do, South Korea*
[b]*Department of Biology Education, Kongju National University, Gongjudaehak-ro 56, Gongju-si, Chungnam-do, South Korea*
*Corresponding Author: skcshim@kongju.ac.kr

Learning contents related to climate change have been introduced in National Science Curriculum, Korea. Inquiry activities related to climate change of Environment & Energy area in Integrated Science subject are on the following: Explore changes in the Earth's heat balance due to global warming, and Design future scenarios for ecosystems and the Earth system. New subject has been developed according to new revised national science curriculum for climate change education: Climate Change & Environmental Ecology for high school students, which has contents of characteristics of climate and environmental ecology, climate crisis and environmental ecological changes, and our efforts to respond to the climate crisis. The subject is aimed at understanding the seriousness of environmental and ecological changes due to climate change, and exploring the efforts of humanity and society to respond to the climate crisis, creatively and actively solving various social problems based on interest and curiosity in natural phenomena and scientific experiences in everyday life. We expected that these learning contents related to climate change should contribute to learning for climate change education and education for sustainability.

Development of a Generative AI-based Chatbot Service for Life Science Education

InKeun Yu[a] and Hyoung-Yong Park[b]*
[a]*Dodam Elementary School 217, Cheongna canal-ro, Seo-gu, Incheon, Republic of Korea*
[b]*Dept. of Science Education, Gyeongin National University of Education, 62 Gyesan-ro, Gyeyang-gu, Incheon, Republic of Korea*
*Corresponding Author: hypark@ginue.ac.kr

This study aims to develop an artificial intelligence chatbot service that can be utilized in science subjects' teaching and learning processes, offering a practical and effective solution. The goal is to design a life science education program using the developed chatbot, demonstrating its realworld application. Through prompt engineering on generative artificial intelligence based on large language models (LLMs), modules applicable to various teaching-learning contexts in science classes

were developed, and the educational applicability was explored. The chatbotbased educational model was applied to the 5th-grade unit "Various Living Things and Our Lives." For each lesson of the selected unit, prompts aligned with the learning objectives were developed and applied to the chatbot. The interactions between students and the chatbot were analyzed to investigate the usability. The results showed that the developed chatbot could be a handy teaching-learning tool for generating questions and responses tailored to learners' responses and levels, facilitating discussions, suggesting search content, and summarizing, evaluating, and providing feedback on learners' responses. In lessons aimed at researching and understanding scientific knowledge or concepts, the chatbot demonstrated its ability to excel as a teaching assistant. In lessons focused on students' understanding and application of learning content, it was confirmed that activities such as self-evaluation, discussion, and unit summary could be carried out through interactions with the chatbot. In particular, the chatbot has shown that it can interact with students whenever and wherever they need it, without time and space constraints. This feature is expected to make personalized and adaptive learning more feasible as it can provide timely feedback that matches the student's level.

****

<Poster Presentations by Junior High and High School Students >

The Evaluation of the biodiversity of Atsubetsu Minami Forest Park for conservation: Consideration of economic value based on biomass estimation

Akira Sawada*, Ryohei Yahata
Sapporo Nihon University Junior and Senior High School, 5-7-1 Nijigaoka Kitahiroshima-shi, Hokkaido, Japan
*akkiakira0313@gmail.com

Every tree measurement is one of the vegetation survey. Following this method, we identified the species of tree living in that area and measured circumference at breast height. This method allows us to obtain basic data to clarify the characteristics of the vegetation and its changes over time. Atsubetsu Minami Forest Park (Atsubetsu Ward, Sapporo City, Hokkaido) is a nature park located near our school. We set up three plots in Atsubetsu Minami Forest Park, and have conducted surveys for two years, and attempted analyzes the date obtained in our survey using a variety of methods. The results showed that although this forest is a park near a residential area, it has significant biomass comparable to that of a natural forest and has great economic value. We will continue to observe the ecological characteristics of this space by conducting continuous observations in conjunction with other surveys, for example Environmental DNA analysis. In addition, we will make some suggestions for forest conservation based on our research. On the day of the announcement, we will also report on the results of the third survey conducted in April 2024.

Comparison of firefly habitat and research pond environment and study of firefly induction methods

Urabe Mizuki, Kikuchi Yuto*
Fujisawa Shoryo High School, Address,7-1-3, Zengyo, Fujisawa, Kanagawa, Japan
*Corresponding Author: utsunomiya@shoryo.ed.jp

In Japan, there are many events to observe fireflies. The light emitted by fireflies attracts not only Japanese people but also tourists. However, firefly habitats have been declining, and become a problem in recent years. The cause of this problem is said to be the deterioration of their habitat environment. We are interested in this issue, and we wondered that the cause of this issue might be the lack of conditions which fireflies can live, as the environment they inhabit becomes increasingly polluted. In Japan, it is well known that it is important that rivers must be clean and that the habitat must be inhabited by organisms that are food for fireflies. However, we believe that there are other conditions that are essential for fireflies to inhabit, and that these unknown conditions may be a factor in this study. The purpose of this study was to clarify the conditions for fireflies to inhabit. Our school has a research pond. Since fireflies have been

observed in the area where our school is located, we used the research pond for this study. The content of the experiment is to use the research pond as a habitat for fireflies, and to make the pond environment more suitable for fireflies to live in. To conduct this experiment, we first conducted a survey of the environment of firefly habitats in the nearby area to identify their species that live there. Later, we will conduct a separate survey of the environment inhabited by fireflies of a different species found in this study, and make comparisons. In addition, we will conduct preliminary research in order to create an environment that will allow fireflies to inhabit the research pond in a few years.

Allelopathic effects of *Papaver dubium* on other plants in the field

Mei Towatari*
Tokyo Metropolitan Koishikawa Secondary School, 2-29-29 Honkomagome, Bunkyo city, Tokyo, Japan
*Corresponding Author: maytowmei@gmail.com

Currently I am researching with the aim to find out which plants are affected by the allelopathy of *Papaver dubium*, and how it affects them. I observed the species of plants that grows around *Papaver dubium* in the field. And noticed that only few specific species of plants were growing in that area. From this, I speculated that in the field the Allelopathy of *Papaver dubium* would have a small effect on these specific plants. To research this, I focused my attention on one of the species of plants often seen growing around *Papaver dubium*, *Oxalis corniculata*. Therefore, I am researching the allelopathic effects of *Papaver dubium* on *Oxalis corniculata*. I will present the results of this research. Additionally, from prior research, growth of *Raphanus sativus* var. *sativus* that were planted in soil where *Papaver dubium* had died had been reduced, compared to *Raphanus sativus* var. *sativus* that weren't planted in the soil where *Papaver dubium* had died. I built a hypothesis that dead *Papaver dubium* remaining in the soil contain allele-chemicals and have an allelopathic effect on the plants that grow there. To study this, I am comparing the growth of plants in agar medium with and without *Papaver dubium*.

Findings of the Exotic Species *Sagra Femorata* (Coleoptera: Chrysomelidae) on *Pueraria Lobata* (Fabaceae) around the Isuzu River in Ise

KATSUDA Marin
Kogakkan High School, 138 Kusube-cho, Ise, Mie, 516-8577, Japan

It is important to evaluate the effects of exotic species on native species and on the environment. *Sagra femorata* (Drury) (Chryso-melidae) is originally distributed in Southeast Asia. Adults of *S. femorata* are among the best fascinated leaf beetles because they are about 20mm long, often brilliantly colored and metallic, and males of this species have greatly enlarged hind legs. Despite the enlarged femora, they do not jump. On account of this, *S. femorata* are collected mercilessly and sold for jewelry or trinkets or to collectors worldwide. In the same way, adults of *S. femorata* had been sold as pet insects in Matsusaka City, Mie prefecture. Then, in 2006, individuals of this species were found in fields in Matsusaka and were confirmed by the establishment in the same regions in 2009. On July 2021, I was found a dead body of *S. femorata* adult on the bank of the Isuzu river in Ise City, Mie prefecture, about 30 km away from Matsusaka. *Sagra femorata* lay their eggs on the stem of *Pueraria lobata* (Willd.) Ohwe (Fabaceae). Larvae cause galls in the stem of *P. lobata.* Galls caused by *S. femorata* were found in plants on the bank along the Isuzu river. In this study, some of the galls collected were dissected to determine the developmental stages and monitored periodically to confirm the emergence of adult *S. femorata.* In addition to these data, the sex ratio of *S. femorata* and biological information based on the observations were recorded.

Investigating the habitat of *Aphelocheirus nawai* using environmental DNA analysis

Tomoharu Hino[a]*, Ryota Kitani[b], Yuta Kunimasa[b], Toshifumi Minamoto[b]
[a]*Junshin high school Japan, GSC Hyogo*
[b]*Graduate School of Human Development and Environment Japan, Kobe University*
*tomas123tomo3@ymail.ne.jp

Aphelocheirus nawai is a rare aquatic insect living in Japanese streams. And, the abundance is decreasing because the water

quality is worse than before. They are listed as vulnerable in the red list of Japan, and need to be protected. To protect their habitat, much information about the species is needed; however, to obtain enough information is difficult by directly taking method. The goal of this study was to search the habitat of them. Because using conventional method is difficult to take and find them, and the surveys should cover a wide range of areas, we used environmental DNA (eDNA) survey for this species, which has the advantage of being fast and searching in wide areas. The eDNA survey can provide the information on habitats of target organisms by only taking a little of water in an aquatic environment. First, we have successfully developed an analytical system specific to them. Second, I sampled water at 49 locations of streams in Hyogo, Kyoto, and Okayama prefectures and examined eDNA using our new system. In the result, we could find it in 5 points. They also responded at previously reported locations. The study shows Creating a tool to easily examine their habitats and suggesting new habitats for them.

Possible serious effects of the sunscreen ingredient benzophenone on freshwater ecosystems: Assessing environmental impacts with euglena

Daiki Naito*
Junten Senior High School, 1-17-13 Ohji Honcho, Kita-ku, Tokyo, Japan
*2220414@junten.ed.jp

Benzophenone, hereafter referred to as BP, is widely used as a UV absorber in various everyday products such as sunscreen worldwide. BP has been detected in 95% of the world's wastewater, raising significant environmental concerns in recent years. Although we depend on freshwater area in various ways, the precise impacts of BP on freshwater ecosystems remain insufficiently explored. This study aims to clarify the effects of BP on freshwater ecosystems. To this end, we conducted experiments using euglena, a keystone organism supporting freshwater ecosystems, and several crops as representative species. Our findings reveal that even at concentrations onetenth of those found in Japanese freshwater and seawater area, BP reduced euglena production by 40%. Furthermore, observations of crops exposed to BP indicated a decrease in cell division and growth suppression. Given the foundational role of producers in ecosystems, the harmful effects observed on euglena suggest potential cascading effects throughout the ecosystem, potentially leading to species extinctions at higher trophic levels. Our results highlight the serious implications of BP contamination for freshwater ecosystems. Importantly, the introduction of activated carbon to euglena cultures, simultaneously with BP, mitigated its negative effects, resulting in a 30% increase in euglena production. This highlights the potential efficacy of activated carbon in reducing the effects of BP in freshwater ecosystems.

Enhancing Butyric Acid Bacteria Content in Traditional Japanese Nukazuke Pickles

Seira Hosaka* and Riku Singu
Junten Senior High School, 1-17-13 Oji Honcho, Kita-ku, Tokyo, Japan
*Corresponding author: 2010331@junten.ed.jp

Clostridium butyricum is a type of intestinal bacterium that produces butyric acid. Butyric acid produced by *Clostridium butyricum* is absorbed into the intestine and is known to suppress allergic and inflammatory reactions by stimulating the immune system and increasing regulatory T cells. Although butyric acid bacteria are rarely found in food, nukazuke (pickles made in a rice bran bed), a traditional Japanese food, is one of the few foods that contain butyric acid bacteria. The flora contained in nukazuke is thought to change depending on the vegetables pickled in it and what is added to the rice bran bed, but the vegetables and pickling methods that increase butyric acid bacteria in nukazuke have not yet been investigated. Therefore, we aimed to clarify what kind of things increase butyric acid bacteria in pickles by pickling various vegetables and dietary fibers in the rice bran bed. If we could establish a method of making pickles with high butyric acid bacteria content, people would be able to easily prepare and consume this beneficial food at home, thereby improving intestinal health.

Isolation of Benzophenone-Degrading Microorganisms from Soil

Koya Bushida* and Kunihito Hirose
*Junten Senior High School, 1-17-13 Oji Honcho, Kita-ku, Tokyo, Japan
*Corresponding author: 2320314@junten.ed.jp

Benzophenone is a UV absorber widely used in sunscreens. It has been detected in wastewater globally, leading to the contamination of rivers and seawater. Benzophenone is known to have adverse effects on aquatic organisms, such as causing coral bleaching and affecting the spawning behavior of fish. Additionally, it inhibits cell division in algae and plants, which are primary producers in ecosystems, thereby halving their productivity. The widespread presence of benzophenone in the environment poses a serious threat to ecosystems. Identifying organisms that can degrade benzophenone may help mitigate these negative effects. Previous studies suggest that benzophenone in soil can be degraded by certain organisms. Therefore, we hypothesize that soil micro-organisms capable of degrading benzophenone exist. This study aims to isolate such micro-organisms. We will cultivate microorganisms from soil samples containing high concentrations of benzophenone and screen for those capable of degrading benzophenone.

Electrical Stimulation-Induced Pharyngeal Protrusion and Its Associated Body Regions in Planaria

Yuki Yumoto* and Matsuri Hori
Junten Senior High School, 1-17-13 Oji Honcho, Kita-ku, Tokyo, Japan
*Corresponding author: 2320322@junten.ed.jp

Planarian feeding behavior involves navigating towards food, protruding the pharynx from the ventral side, and ingesting food through the pharynx. While pharyngeal protrusion is a critical component of this process, the underlying mechanisms governing feeding behavior and pharyngeal control remain poorly understood. In our study on planarian contraction responses to electrical stimulation, we observed pharyngeal protrusion in planaria which had their head cut off. This contradicts the previous study that the central nervous system controls pharyngeal protrusion. We hypothesize that investigating the pharyngeal protrusion response to electrical stimulation can shed light on the mechanisms of pharyngeal control. We aimed to identify the specific body region responsible for pharyngeal protrusion in response to electrical stimulation by examining individuals with only the head, abdomen, tail with pharynx, and intact bodies. Our findings revealed that pharyngeal protrusion occurred in the head, abdomen, and tail regions but not in the whole-body. Further experiments are planned to elucidate the mechanisms controlling pharyngeal protrusion.

Oviposition behavior and ovarian development of "tongtonging" *Cotesia kariyai* female adults that do not oviposit

Aoi Kobayashi
Kosei Junior High School, 5-53 Ichinoki, Ise-shi, Mie, Japan
t-sawa@kogakkan-u.ac.jp

Parasitization rate does not reach 100% when 10 *Mythimna separata* larvae and 50 *Cotesia kariyai* (Ck) larvae are placed in the same small space and left for a certain period of time. As a factor, a female Ck wasp was found that repeatedly pierced the ovipositor tube against unparasitized *M. separata* larvae and injected venom but did not oviposit (Tong-tonging) (Kawahara, 2021). Tongtongued *M. separata* larvae are not oviposited by other Ck, allowing them to develop into pupae and adults. This suggests that the oviposition behavior of tong-tonging Ck may be responsible for maintaining the population of *M. separata* in the field when the parasitization rate of Ck is high. However, if the tong-tonging Ck does not oviposit to *M. separata* larvae until it dies, then the tongtonging Ck cannot produce any progeny of its own. Kawahara (2021) showed that tong-tonging Ck have delayed ovarian development compared to Ck that show normal oviposition behavior. Based on this, we observed and experimented with tong-tonging Ck, predicting that their ovaries would develop over time and they would become capable of ovipositing. The results showed that the ovaries of tong-tonging Ck developed over time, with about 90% of tong-tonging Ck ovipositing. The tong-tonging Ck is thought to maintain unparasitized *M. separata* larvae by delaying the time of oviposition compared to other Ck, and to produce its own progeny.

The Spot Roles for the Seven-Spotted Ladybird (*Coccinella septempunctata*)

Sumire Koizumia
Dalton Tokyo Junior & Senior High School, Tokyo , Japan

The seven-spotted ladybird *Coccinella septem-punctata* has spots on its elytra, which may vary in proportion from one individual to another. The aim of this study is to estimate the effect of varying temperatures on the size of the spots among the breeding conditions of the ladybird and to discuss the basis for this. In addition, image analysis using the database Global Biodiversity Information Facility (GBIF) was used to consider the significance of the spots on the ladybird's elytra to the ladybird themselves. In these studies, pupal spot changes were observed to be remarkable, although changes in adult spots were not observed to a great extent. Furthermore, differences were found in the proportion of seven-spotted ladybird spots between those found in East Asia and those found in other regions of the world. The study indicated that factors such as subspecies of the seven-spotted ladybird and their activities were related to the size of their spots. The study concludes that the spots have a role in maintaining body temperature and create a pattern that composes its warning colouration.

Awareness Activities on the Ecology and Conservation of Otters in Japan: Promoting a Correct Understanding of Environmental Conservation through Zoos and Aquariums

Yuka Mukaia
Ehime Prefectural Matsuyama Minami Highschool, 11-1 Suehiro-cho,Matsuyama City, Japan
arareballet1120@icloud.com

There are currently 13 species of otters in the world, 12 of which are declining in population, and 5 are listed as endangered on the IUCN Red List. In order to repeat the tragedy like the tragedy of the extinction of the Japanese otter, we are conducting research with the aim of promoting a correct understanding of coexistence with otters. Currently, the 140 zoos and aquariums that are members of JAZA, as many as 45 have otters. In addition to the frequent posting of otter-related photos and videos on social media. Their popularity as pets since the late 2010s, and the existence of otter elections, tell us that otters are very popular in Japan. The excessive popularity of otters has led to international problems, including smuggling. In this study, we considered the general perception and ideal image of otters from two aspects. First, we used data mining technology to quantitatively analyze people's level of understanding using articles from the Yomiuri Shimbun. Second, we explored the ideal state of otters through interviews with otter keepers, focusing on the problems and sense of crisis caused by the gap between ideals and reality. Furthermore, to evaluate the improving of people's awareness and educational approaches to this problem, we created a poster summarizing the environment surrounding otters and displayed it at Tobe Zoo for a while we conducted interviews with visitors and considered about the effects.

Applying Genome Editing Technology to the Breeding of Dwarf Blue Jabba Banana (Ice Cream Banana)

Fuko Shigekawa
Ehime Prefectural Matsuyama Higashi Highschool, 2-2-12 Mochida, Matsuyama City, Japan
sigefuko@gmail.com

I have been cultivating ice cream bananas in my garden for the past six years. This cold-tolerant variety can thrive in Japanese temperatures. However, despite their adaptability to the climate, ice cream bananas often suffer damage from strong typhoon winds, leading to stem breakage. To address this issue, I aim to develop a typhoon-resistant variety of ice cream banana by utilizing genome editing technology to reduce their height. Prior to initiating genome editing, I investigated genes associated with dwarfism in ice cream bananas. Concurrently, we attempted to induce callus formation from ice cream banana tissues. Successful callus induction and identification of dwarfism-related genes will enable us to introduce mutations using the Agrobacterium method, ultimately isolating dwarf plants with shorter stature. Our initial step involved identifying genes influencing the height of ice cream bananas. Using the amino acid sequences of D11 and SD1 from rice, a monocot species similar to ice cream bananas, we searched the ice cream banana genome database and identified several candidate genes. Future plans include sequencing PCR

products derived from the ice cream banana genome to design guide RNAs for genome editing. For callus induction, various tissues, including roots, petals, pistils, stamens, and ovule, were cultured on callus induction medium. Callus formation was observed exclusively in tissue containing ovule. I believe that this study will contribute to the future of banana breeding.

Establishment of Conservation Methods Based on the Luminescence Cycle of *Luciola cruciata* and its Habitat

Kaho Onoue*, Mizuki Hamasu*, Miyu Yamamoto* and Aimi Tsuji*
Kumamoto Prefectural Amakusa High School, 557 Hondo, Hondo Town, Amakusa City, Kumamoto Prefecture, Japan
*Corresponding Author: miyazaki-h-jm@mail.bears.ed.jp

We have been studying the luminescence cycle of firefilies named *Luciora cruciata*. Although most fireflies in Kyushu region are of the 2-second type, the luminescence cycle of fireflies living in Amakusa was found to be of the 3-second type. Also, the luminescence cycle was found to be shorten at higher temperature. It was also found that the luminescence cycles became longer as the moonlight became brighter. Since we humans seem to have a negative impact on fireflies' growth, we are trying to make the best shelter where fireflies can glow in normal luminescence cycles. We are to build green curtains with a plant called *Momordica charantia*, which would keep the shelter cool enough for fireflies.

Relationship between *Aspergillus oryzae* (Koji) and light in Japanese traditional fermented foods

Rinko Kodama[a]*, Yoshitaka Ano[b]
[a]*Ozu South Junior High School, 1005, Ozu, Ozu-city, Ehime, 795-0012, Japan*
[b]*Graduate School of Agriculture, Ehime University, 3-5-7, Tarumi, Matsuyama, Ehime, 790-8566, Japan*
*Corresponding author: jrdr-ehime@ed.ehime-u.ac.jp

My grandfather makes amazake and miso, Japanese traditional fermented foods. Amazake is a sweet, non-alcoholic drink made by breaking down rice starch and converting it into glucose. In contrast, Miso, especially barley miso, is a specialty of Ehime Prefecture, and is a flavorful seasoning paste made by breaking down barley protein into amino acids. These are important foods in Japanese cuisine, and fermentation by Koji is indispensable for making them. I focused on the fact that my grandfather's traditional brewery that produce fermented foods has a very dark environment. The purpose of this research was to determine the relationship between Koji (*A. oryzae*) and light. The target strains were those used by my grandfather. Further, the experimental technique was conducted at home, without resorting to university facilities. Koji was cultivated under five different light environments (light through red, blue, and green underlays, bright and dark places). Rice- Koji for making amazake and Barley-Koji for making miso were compared under these various light conditions. The results showed that Rice-Koji activity decreased in bright light, and the effect of red light was less compared to blue and green. On the other hand, Barley-Koji activity also decreased in bright light. The details of the effect of light color on Barley-Koji are currently under investigation. Based on these results, the use of red light is the most effective way to create a safe environment for breweries. This research has the potential to enhance the manufacturing environment for Japanese traditional fermented foods.

Beetles intestinal bacteria IV

Yu Fujimori* and Takuto Miura
Nirasaki High School, Science Club, 3-2-1 Wakamiya, Nirasaki City, Yamanashi Prefecture, Japan
*Corresponding Author: yu1120flf@gmail.com

The Japanese rhinoceros beetle (*Trypoxylus dichotoma septentrionalis*) inhabits regions south of Honshu in Japan. During its larval stage, it uses woody material as a nutrient source. The decomposition of the woody material is carried out by intestinal bacteria (derived from the soil), which establishes a mutualistic relationship between the larvae and the intestinal bacteria. The decomposed humus is excreted as feces. This study investigates the soil improvement capability of the rhinoceros beetle through humus decomposition. We hypothesized that if the intestinal bacteria were activated, the ability of the rhinoceros beetle to decompose humus

would naturally improve. Therefore, we conducted an experiment to investigate the conditions that activate the intestinal bacteria. From our experiments and previous studies, it was found that the intestinal bacteria are activated by three environmental factors in the current conditions. First, an anaerobic environment is necessary. However, since the soil is already anaerobic, its importance is considered low. Second, pH levels play a role; the intestinal bacteria are activated in an alkaline environment. Third, temperature affects activation; a range of 25-30°C is optimal for activation. Since the rhinoceros beetle is ectothermic, the temperature inside its intestinal is significantly influenced by the external environment.

Environmental DNA analysis for understanding the dynamics of wild fish in Sozu River, Japan

Taiga Kuno[a], Hisato Takeuchi[b] and Sonoko Shimizu[b]*
[a]*Ehime Prefectural Uwajima higashi High School, Ehime 798-0066, Japan*
[b]*South Ehime Fisheries Research Center, Ehime University, Ehime 798-4292, Japan*
*Corresponding Author:
shimizu.sonoko.mh@ehime-u.ac.jp

For sustainable use of fish resources, it is important to continuously investigate the distribution of fish and their dynamics. However, existing survey methods based on fish sampling are not easy to implement because they require a great deal of labor. On the other hand, in recent year, survey method using "environmental DNA (eDNA)" released form aquatic organism have been developed. In this study, to evaluate the validity of eDNA analysis in fish resources research, we investigated the seasonal dynamics of ayu (*Plecoglossus altivelis*) and other wild fish in Sozu River in Ehime prefecture, Japan, using eDNA analysis. We analyzed the eDNA samples collected from April 2020 to November 2021 at 9 sites in the Sozu River. These samples had been obtained by filtration of the river water using a membrane filter, and been frozen at -30°C. We extracted total DNA from the samples using a commercial DNA extraction kit, and quantified fish eDNA by real-time PCR. In the analysis of ayu eDNA, relatively low concentration of the eDNA were detected in March to early April. After that, the eDNA concentrations increased by July, and eDNA was also detected at the most upstream site. Furthermore, although ayu eDNA concentration decreased in October to November, the concentration was relatively higher in lower reach. These eDNA dynamics were similar to known life cycle of ayu, so we thought that eDNA analysis is effective tool for understanding the dynamics of wild fish in a river.

Hemostatic effects of *Portulaca oleracea* and *Chamaesyce maculatani* II

Tomoho Yasuda, Noa Sato and Natsuki Yoshimatsu*
Nara Prefectural Seisho Senior High School of Math and Science, 525, Gose City, Nara, Japan
Yorikoi670@e-net.nara.jp

The hemostatic effects of *Portulaca oleracea* and *Chamaesyce maculata* are known, but the mechanism has not been elucidated. The purpose of this study was to show that these plants transform fibrinogen into fibrin. These plants were added to a fibrinogen solution and the absorbance value for each plant was measured. The absorbance values of the experimental plots were defined by samples containing distilled water and either *Portulaca oleracea* or *Chamaesyce maculata* with fibrinogen subtracted from blank samples without fibrinogen. The results showed that the absorbance values of the experimental plots were significantly greater than those of the control when *Portulaca oleracea* was added (t-test $p < 0.05$), while there was no significant difference for Chamaesyce maculata (t-test $p > 0.05$). This data suggests that *Portulaca oleracea* converted fibrinogen into fibrin. It is known that thrombin cleaves fibrinogen, exposing polymerization sites and resulting in fibrin monomers. These monomers then polymerize to form fibrin polymers, which are stabilized by transglutaminase (factor XIIIa), leading to hemostasis (Takeo et al. 2013). Transglutaminase is also known to be present in plants. From previous research and these results, it is suggested that the transglutaminase in *Portulaca oleracea* converted fibrinogen into fibrin. Experiments are currently ongoing to clarify the enzymatic activity responsible for the transformation of fibrinogen into fibrin. The results of these experiments will also be presented at the seminar.

The relationship between butterfly flight and physical characteristics

Jin Yoshinoushi, Mao Joko, Nozomi Hashimoto, Kai Utsunomiya and Yuta Wakayama*
Ehime Prefectural Matsuyama Minami High School, Suehiro-machi, Matsuyama, Japan
*Corresponding Author:wakayama-yuuta@school.esnet.ed.jp

We became interested in the mechanism of flapping the wings of insects. When we examined the studies conducted in the past, it was reported that *Prantica sita* (Asagi Madara in Japanese), flies in an energy-saving way compared to other butterflies in a study by Toyooka et al. Therefore, we decided to investigate the relationship between the weight and wing area of butterflies and the flap count of butterflies of different families. To begin with, we collected these types of butterflies in the open field. Then, used your smartphone to take a picture. Then, based on the footage, we counted the number of times the butterflies flapped their wings. Next, the collected butterflies are wrapped in medicine wrappers and weighed using an electronic balance. Then, Image J was used to measure the area of the wing. A exponential approximation was found between flap count and body weight (coefficient of determination $R^2 = 0.525$), flap count as well as between the flap count and wing area (coefficient of determination $R^2 = 0.9231$). A linear approximation was observed between wing area and body weight (coefficient of determination $R^2 = 0.792$). Therefore, it can be seen that there is a correlation between these relationships. I would like to add data on long-term migration of Asagi Madara and compare them with general butterflies. In addition, I would like to look for other butterfly species with different specific characteristics excluding Asagi Madara.

Regeneration process and survival rate of the *Dugesia japonica* from head fragments

Ayumi Murakami, Asumi Iga, Itsuki Hatanaka, Daigo Kinoshita and Kenichi Sasaki*
Ehime Prefectural Matsuyama Minami High School, Suehiro-machi, Matsuyama, Japan
*Corresponding Author:sasaki-kenichi@school.esnet.ed.jp

The *Dugesia japonica*, a species of planarian a kind of flatworm native to Japan, has a very high regenerative ability, but when it is cut, it has been confirmed by Ogami et al. that individuals regenerating from head fragments do so more slowly than other fragments. Based on this, we will investigate the process of regeneration of head fragments, the changes in survival rate and regeneration speed when changing the environment, and the differences seen in individuals after regeneration. As an experimental method, the *Dugesia japonica* were made to fast for 10 days. The heads were cut off and the rest were discarded. After that, all head pieces were reared side-by-side in a tank. The number of days required for regeneration and the number of days that survived were plotted on a graph. Next, we will conduct the same experiment by changing various aspects of the water temperature. If there are some changes in the manner of regeneration, we will conduct further experiments to clarify their causes. Through these experiments, we will investigate in detail the regeneration of head fragments of the planarian.

****

<Workshop>

Let's try VRinkai!! –online teaching material for field biological course–

Shito, Takumi T.[a], Totsuka, Nozomu M.[a], Kogure, Yuki S.a, Mizutani, Hina[a], Takahashi, Marina [a], Ueda, Lina L.[a], Furukawa, Ryohei[b], Togane, Dai[b], Kuraishi, Ritsu[b], Fujita, Ryosuke[c], Fujisawa, Yusuked, Yazawa, Kazuaki[c], Uchiyama, Masato[e] and Hotta, Kohji[a]*
[a]*Department of Bioscience and Informatics, Faculty of Science and Technology, Keio University, Yokohama, Japan.*
[b]*Department of Biology, Research and Education Center for Natural Sciences 4-1-1 Hiyoshi, Kouhoku-ku, Yokohama, JAPAN.*
[c]*Keio Futsubu School, Hiyoshi-honcho, Kohoku-ku, Yokohama, Japan.*
[d]*Keio Girls Senior High School Mita, Minato-ku, Tokyo, Japan.*
*Corresponding Author: khotta@keio.jp

We have developed an online teaching material

simulating field biological course, VRinkai (V for "virtual" and Rinkai meaning "marine biological course" in Japanese) since 2021. VRinkai contains over 600 photos of marine and terrestrial organisms collected in field biological courses in Keio University and other academic field research. Students can upload photos of local animals/plants taken in their field training. Uploaded data were automatically introduced in the biological classification games, which students can enjoy learning classification of species at each taxonomic rank by catching randomly emerging animals. Also, VRinkai allow teachers to create their original database and manage students in each class or group. According to these groups, biological hierarchy view is generated which are used to compare the differences of multiple biotas. VRinkai is an effective teaching material for enhancing interest and active learning in biological classification, evolution, and biodiversity. Today, we'll show demonstration of VRinkai. You will need only your smartphones, tablets, or PC. Photos of animals/plants are optional. Let's enjoy!!

Development of Natural Science Books for International: Students from English—Speaking Areas and Kanji (Chinese Characters) Using Aareas II

Tomoko Kaga
Ritsumeikan University (Until March 2022)

An electronic poster was presented at the 28th Asian Biological Education Association Biennial Conference in the Philippines, held online on April 28-30, 2022. Because the conference was not held face-to-face due to the COVID-19 pandemic, we were unable to provide a printed booklet to participants. This time, we would like to ask participants to read it and help us improve it. The purpose of this research is to develop bilingual teaching materials in both English and Japanese that are easy to understand for students who wish to study natural sciences using either Japanese or English. As a first step, we have produced a bilingual Japanese-English book by Professor Emeritus Osamu Mitamura entitled "Looking at the world's lakes can help us understand how people live: A proposal for comparative limnology." This book is a compilation of the results of Professor Emeritus Mitamura's research on lakes around the world together with local researchers. It is intended to help international students learn about lakes around the world and become interested in environmental conservation. It includes many photos of lakes and other things. This time, ruby text has been added to the Japanese text, and the English text is displayed alternating every few lines. We would like to ask those who have received the Japanese-English bilingual book to fill in a questionnaire. Please send the answer to Kaga's address (aureliakaga1143☆gmail.com). Please change ☆ to @.

Teaching materials to taste the mechanism of flow of genetic information, "Transcription and Translation", based on the wheat germ cell-free protein synthesis system in vitro

Takeshi Katayama[a,b]*, Hidenori Hayashi[b,c] & Yaeta Endo[b]
[a]*Faculty of Human Development, Takasaki University of Health and Welfare, 58-2 Nakaohrui-machi, Takasaki, Gunma, Japan*
[b]*Proteo-Science Center, Ehime University, 3 Bunkyo-cho, Matsuyama, Ehime, Japan*
[c]*Graduate School of Education, Ehime University, 3 Bunkyo-cho, Matsuyama, Ehime, Japan*
*Corresponding Author: katayama@takasaki-u.ac.jp

The wheat germ cell-free protein synthesis system is a practical method for synthesizing recombinant proteins in test tubes, developed by Professor Emeritus Yaeta Endo of Ehime University. Since the system is prepared from wheat embryos, it is less susceptible to codon bias thus does not require codon optimization of the template, and produce quality of heigh molecular eukaryotic proteins in a large amount beside the system solved the bio-hazardous issues. In Basic Biology in Japanese high schools, the Courses of Study states that "An overview of transcription and translation deals with the genetic information flow from DNA base sequences to mRNA base sequences for transcription and from mRNA base sequences to amino acid sequences via tRNAs for translation". In high school, protein expression experiments have been performed by transformation of Escherichia coli, but because these were genetic recombination experiments, aseptic manipulation and measures to prevent spreading were necessary.

Therefore, we developed an experimental teaching material kit utilizing a wheat germ cell-free protein synthesis system. In this kit, mRNA of the target protein is first expressed, and transcription can be confirmed by checking mRNA expression with an RNA-specific visualization reagent. Then, translation is confirmed by expressing a protein using the produced mRNA and showing the presence of the protein. In this workshop, you will be able to experience the expression of GFP based on GFP mRNA. This kit is expandable, so we would appreciate your feedback after the experience. For more information on the "Transcription and Translation Experiment Kit," please see below.
http://www.cfsciences.com/jp/CFS-EDU.html.

Development of experimental materials using insects for kindergartens and nurseries, elementary schools, junior high schools, and high schools

Yutaka Nakamatsu*, Koshi Ninomiya, Yuki Okumura and Tomomi Sawa
Faculty of Education, Kogakkan University, 1704, Kodakushimoto-cho, Ise, Mie, Japan
*Corresponding author: y-nakamatsu@kogakkan-u.ac.jp

The Biology Laboratory and the Science Education Laboratory in the Faculty of Education at Kogakkan University are developing teaching materials for observation and experiments using insects according to the curricula of kindergartens and nursery schools, elementary schools, junior high schools, and high schools. The materials used are *Mythimna separata*, a butterfly order, Parasitoid wasps that parasitize it, and stinkbugs that feed on it. *M. separata* is a primary consumer of corn leaves and is a holometabolous insect. In the laboratory, *M. separata* is reared successively on artificial diet. *M. separata* larvae also have a large fluid volume and hemocyte count, making them suitable for hemocyte observation and immunization experiments. M. separata larvae have several parasitoid wasps. Among them, Cotesia kariyai (Ck) is an endoparasitoid that oviposits about 100 eggs at a time, and its larvae grow and develop by feeding on the blood plasma and fat bodies of *M. separata* larvae. Female Ck adults have a high urge to spawn at any time, so oviposition behavior can be easily observed. *Andrallus spinidens*, which is zoophagous, is a hemimetabolous insect that grows and develops by feeding on butterfly insects such as *M. separata* larvae. We are using these insects to develop educational materials that enable students to learn about insect growth and development, the food chain, the origins of ecosystems, the concept of parasitism, and immunity. The materials for first and sixth grade elementary school students and high school students will be discussed in detail in oral and poster presentations.

Development of Virtual Observation Materials for Vegetation Succession Utilizing the Metaverse and 360-degree Images

Daisuke Saiga[a], Kenichi Yoshidomi[b], Shunji Takeshita[b]
[a]*Minokaya Junior High School, Totttori, Japan*
[b]*Hiroshima University Hiroshima, Japan*
*Corresponding author: saiga.dsk@gmail.com

Virtual reality (VR) technology is used in many fields. In addition, a virtual space called the "Metaverse" has been constructed on the Internet. And the Metaverse is used as a place for games and communication using VR technology. So far, many teaching materials have been developed for the educational use of VR technology, such as spatial understanding of geological formations using Google Earth. However, most of these teaching materials are designed to be viewed by individuals and are not intended for discussion by multiple students. Therefore, by placing digital content, e.g., 3D models and so on, in the Metaverse, students can participate in learning activities in the same space, and cooperative learning may be possible. In science education, field observations are effective in enhancing a learning attitude. However, it is hard to implement such experiences in schools due to various restrictions. In the present study, we focused on VR technology to solve this problem. And we constructed a teaching material in the Metaverse that deals with the content of vegetation successions. And we place 360-degree photos of vegetation at different stages in the Metaverse space. That space is created in "DOOR." "DOOR" is a web-based VR platform supplied by NTT QONOQ. This service is no app installation

required. Access is available via the browser of a smartphone or tablet device. In this workshop, we will demonstrate the virtual observation materials we have created. Through the workshop, we would like to discuss the possibilities and utilization of VR content.

Learn ancient techniques by making a replica bronze mirror! Educational activities Archaeological Museum at Matsuyama City

Akiko Kodama
Archaeological Museum at Matsuyama city, 67-6,Minamisaiin-cho Matsuyama City, Japany
*Corresponding Author: kodama133@cul-spo.or.jp

The Archaeological Museum at Matsuyama City and its associated facilities were opened in Matsuyama General Park on October 31, 1989, as part of the Matsuyama City 100th anniversary project. The Archaeological Museum at Matsuyama City is an affiliated facility of the Buried Cultural Properties Center. The museum is not only a specialized institution for researchers but also a place where the general public and tourists can relax and where children and students can go on field trips. Therefore, the museum engages in exhibitions, education, public relations, publications, and the collection and storage of artifacts through a series of excavation surveys. Knowledge of science and biology is also important in archaeology. Various items such as pollen, plant fragments, animal bones, etc., contained in excavated materials can provide valuable information. For example, at the Hasaike Kofun site, the type of fly discovered revealed details about ancient life. In this workshop, you will learn about ancient technology by making a replica bronze mirror. A replica bronze mirror polished with compound will make a beautiful souvenir.

Introduction of some handmade teaching materials and tools used in biology classes

Shunji Takeshita[a]*, Ayane Maga[b] and Kei Tokuda[c]
[a]*Graduate School of Humanities and Social Sciences, Hiroshima University, 1-1-1, Kagamiyama, Higashi-hiroshima City, Hiroshima, Japan*
[b]*Innoshima High School, Innoshima, Onomichi City, Hiroshima, Japan*
[c]*Hiroshima Grobal Academy, Osakikamijima, Toyota District, Hiroshima, Japan*
*Corresponding Author: stakesh@hiroshima-u.ac.jp

In the field of biology education, various teaching materials and tools are used, whether commercially available or handmade. The reasons why teachers make their own teaching materials or tools, even though there are many convenient commercially products, are that they are expensive (not given the budget to purchase them), but it may also be because they do not match their classes or teacher's requests. In fact, many teachers may have used teaching materials made by themselves in their classes. The speaker has teacher trainee students work on developing teaching materials as their assignment. The reason is that developing teaching materials requires a deep understanding of the purpose and content of the learning, knowledge and skills in manufacturing, and ideas, and it will be useful for students who will become teachers in the future. In this workshop, some of the teaching materials and tools that the speaker has devised or that students has devised in classes will be introduced, for example, paper crafts of flowers, musclebone models, eyeball model, handmade microscopes, adapter of microscope-smartphone, and etc. All of these are inexpensive, easy to make and fully practical. Some of them would be provided as easy making kits, and instructed on how to make them. We would like to have you actually hold them in your hands, and discuss your impressions with us.

****

<Country Report>

Teaching sustainability in Australian schools

Robert L. Wallis
Chair, Animal Ethics Committee, Federation University Australia, P.O. Box 663, Ballarat, Victoria, Australia. 3353Address, City, Country

The Australian national curriculum has been adopted by Education Ministers in all Australian states and territories. There are eight key learning areas, including Science, in the Foundation to Level 10 program and three

cross-curriculum priorities that include Sustainability. Thus, Sustainability is not taught as a separate discipline, but is integrated into the key learning areas wherever possible. There are three Organizing Areas relevant in the curriculum for teaching about Sustainability: Systems, World Views and Futures. Teachers have access to an array of resources to help in their teaching, including lesson plans, field work suggestions and work samples. In the senior secondary school curriculum (levels 11 and 12), Sustainability is again taught through established disciplines and subjects, including Biology, Geography and Earth & Environmental Science. The latter field may be taught under different titles – in New South Wales, for example, Earth & Environmental Science is a distinct Subject in levels 11 and 12, while in Victoria there are two so called Study Designs that cover the key learning area: Environmental Science and Outdoor and Environmental Studies. This presentation will include examples of how Sustainability is taught in Australian primary and secondary schools. Keywords: Sustainability education, Australian schools, cross-curriculum teaching.

Country Report from AABE India Chapter: Biological Sciences & Environmental Education for Sustainability

Narendra D Deshmukh
Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, V. N. Purao Road, Mankhurd, Mumbai, India
*Corresponding Author: ndd@hbcse.tifr.res.in

India is a megadiverse country with high biological diversity and contain many species exclusively indigenous, or endemic, to them. India also contains four of the world's 34 biodiversity hotspots or regions that display significant habitat loss in the presence of high endemism. In India Biology Education in Schools across the primary, middle, and secondary levels has been scrutinized to match the standards prescribed by the New Education Policy (NEP) 2020. This policy has significant implications for biology teaching, including experiential learning, higher-order assessment methods, and the integration of environmental education. This intends to bring the teaching of Biology across the Indian curriculum on par with the international curriculum. The NEP emphasizes a holistic approach & multi-disciplinary approach covering climate change, sustainable development, conservation and management of biological resources and biodiversity etc. The health and well-being of individuals remains a key aspect for success in all other aspects of life. Under the umbrella of the Asian Association for Biology Education (AABE), India Chapter has been working actively in biology education from kindergarten to college level. Apart from research in the area of biology education, health education & environmental sustainability, various teacher training workshops, conferences & seminars, competition & exhibition has been organized to, promotes biology & environmental education & awareness that leads to action for sustainable development. Climate Change programs of India focus on climate literacy, knowledge exchange and public awareness as well as participation, using interactive educational methodologies.

Biology Education in Indonesia: The New Curriculum Setting

Murni Ramli
Department of Biology Education, Faculty of Teacher Training and Education, Sebelas Maret University, Jl. Ir Sutami No 36 A Kentingan, Surakarta 57126, Indonesia
*Corresponding Author: mramlim@staff.uns.ac.id

As a large archipelagic country ranked the 2nd in biodiversity index in the world, Indonesia faces many issues in biology education and preparing biology teachers who will serve all high schools around the country. There are about 39,052 high schools spread over 34 provinces in the country. Standardizing the educational quality in all schools is a big challenge for the country. The new curriculum focuses on giving more autonomy to teachers to design learning based on the culturally responsive pedagogical approach and giving more chances for students to do independent learning. New approaches are introduced, i.e. the interdisciplinary and integrated biology with chemistry and physics, reducing the content of learning to the essential one (i.e. for grade 10: biodiversity, virus, innovation in biology technology, ecosystem, and climate change), adopting the understanding by design approach in constructing the lesson, more

project-based activities, focusing the learning outcomes on demonstrating the understanding of the biology concepts to solve local, national, and global problems, and facilitating differentiate learning. Moreover, six science practices must be nurtured to understand biological phenomena (a. observing, b. asking questions, c. planning and carrying out investigation, d. analyzing and interpreting data, e. evaluating and reflecting, and f. communicating the results).

Refined Malaysia's Pre-University Biology Syllabus With A Focus On Sustainable Development And STEM

Dr Kwan Siew Wai
SMK Vivekananda, Head of Biology Department for Pre-University Education, Jln Rozario, Kuala Lumpur, Malaysia
kwansiewwai@yahoo.com

As the global community increasingly emphasizes the importance of sustainability, education systems must align with these values. Recent PISA results highlight the challenges faced by Malaysian students in mastering STEM techniques, revealing gaps in critical thinking and problem-solving skills. In response, it is crucial for Malaysia to reorient its education system towards sustainable development and the integration of STEM principles. This manuscript reports on the Malaysian government's effort to enhance sustainable development and STEM education by refining pre-university programs, specifically the Sijil Tinggi Persekolahan Malaysia (STPM) Biology syllabus to integrate sustainability education and foster a deeper understanding of STEM. This revision aimed to equip students with not only theoretical knowledge but also practical skills relevant to addressing real-world environmental challenges. By embedding sustainability concepts within the syllabus, the initiative seeks to cultivate critical thinking, problem-solving abilities, and ethical decision-making in students. Furthermore, the updated syllabus encourages collaboration and innovation, preparing students to involve in sustainability and scientific research. This restructuring reflects the government's commit-ment to developing a workforce equipped for the challenges of a rapidly changing global economy, especially in green technologies and sustainable industries. Ultimately, the refined STPM Biology syllabus ensures that students are prepared for further education or the workforce with relevant skills and knowledge.

Immersive Technologies in Teaching Biology in the Philippines: Transforming Distance Learning Experience and Outcomes

Maricar S. Prudente
President, Biology Teachers Association of the Philippines Inc., Department of Science Education, De La Salle University, Manila 1004 Philippines
maricar.prudente@dlsu.edu.ph

The use of immersive technologies such as Augmented Reality (AR) in biology education offers a substantial advantage in improving student performance, especially for senior high school students in the post-pandemic educational contexts. These findings were revealed in a systematic review of published studies on the impact of AR in teaching and learning of biology, which yielded a moderate overall effect size at 0.62. While, a group of science teachers in the Philippines developed AR modules to teach complex cell biology topics. These AR-based lessons were perceived to be useful and effective in promoting learning gains ($t = 2.268$; $n= 32$; $p =0.030$). In another study, using the remote learning setup, Improvised Insect Traps (IITs) were used to provide an authentic learning experiences in teaching and learning insect taxonomy at home. Results revealed that IITs effectively improved students' self-efficacy beliefs ($Z=0.033$, p-value=0.022, $g=0.68$). In an effort to provide a proper forum for discussion and further exchange about relevant technologies in biology education and research, the Biology Teachers Association of the Philippines (BIOTA Phils. Inc.) had Immersive Technologies for its theme during its 58th Annual Conference last April 18-20, 2024, in Boracay Island, Aklan, Philippines. Plenary talks and discussions underscored the need to focus future research in exploring the use of other immersive technologies and investigate its long-term impacts. Integration with other emerging educational technologies to further enhance student learning and engagement was also emphasized during the convention.

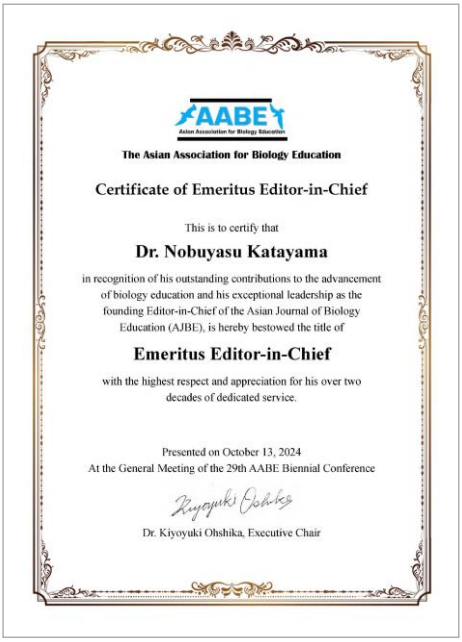
The Conferral of the Title of Emeritus Editor-in-Chief

During the General Assembly of the 29th AABE Conference (AABE 2024), held in Matsuyama, Japan, on October 13, 2024, the Asian Association for Biology Education (AABE) unanimously approved the bestowal of the title of Emeritus Editor-in-Chief to Dr. Nobuyasu Katayama in recognition of his exceptional contributions to the field of biology education.

Dr. Katayama identified the need for a peer-reviewed international journal dedicated to biology education in Asia and led the establishment of the *Asian Journal of Biology Education* in 2002. Over the next 20 years, he served as its Editor-in-Chief, overseeing the publication of 14 volumes that significantly advanced both research and practice in the field. His vision and leadership have left an enduring legacy within the association and beyond.

At the ceremony, Dr. Ohshika, Chair of the AABE Executive Committee, introduced Dr. Katayama's remarkable achievements, highlighting his dedication and the lasting impact of his work. This honor recognizes not only his past accomplishments but also his enduring influence on the academic community.

The AABE is proud to recognize Dr. Katayama's outstanding contributions by awarding him the title of Emeritus Editor-in-Chief. His efforts will continue to inspire the association's commitment to advancing biology education across Asia.



AABE
Asian Association for Biology Education

The Asian Association for Biology Education

Certificate of Emeritus Editor-in-Chief

This is to certify that

Dr. Nobuyasu Katayama

in recognition of his outstanding contributions to the advancement of biology education and his exceptional leadership as the founding Editor-in-Chief of the Asian Journal of Biology Education (AJBE), is hereby bestowed the title of

Emeritus Editor-in-Chief

with the highest respect and appreciation for his over two decades of dedicated service.

Presented on October 13, 2024
At the General Meeting of the 29th AABE Biennial Conference

Kiyoyuki Ohshika

Dr. Kiyoyuki Ohshika, Executive Chair

From the Editor-in-Chief

AJBE Vol. 16 features seven research papers/reports, a report with abstracts from the 29th AABE (AABE2024) held this year in Matsuyama, Japan, and other related content. Due to the extensive number of presentations at AABE2024, the page count has increased significantly, making this the largest volume in AJBE's history, spanning 136 pages.

I would like to take this opportunity to express my sincere gratitude to the members of the editorial board and Dr. Shigeaki Atsumi, Dr. Cheung-Ming Chow, Dr. Miyuki Kato, Eva B. Macugay, PhD, and Dino T. Tordesillas, PhD for their invaluable contributions to the peer review process over the past two years. Their dedication and efforts have been instrumental in advancing the journal's quality and reach.

As Editor-in-Chief of AJBE, I see it as my mission to improve the journal continually. My vision is to encourage more researchers to submit their work, ensure the regular publication of high-quality papers, and have these papers widely read worldwide, ultimately contributing to advancements in biology education. To achieve this, we have implemented DOI assignments, registered with J-Stage, and introduced Online Fast publication. This year, we focused on expediting the peer review process, asking reviewers to complete reviews within three weeks whenever feasible. Rapid peer review and publication are essential in today's academic landscape, and I deeply appreciate the cooperation of reviewers in achieving this goal.

Looking ahead, we aim to obtain Creative Commons certification, enhance the AJBE website, and register with the Directory of Open Access Journals (DOAJ). These initiatives will strengthen the journal's credibility and attract more high-quality submissions. Our long-term goal is to have AJBE indexed in the Journal Citation Reports (JCR). As an intermediate step, inclusion in Clarivate's Emerging Sources Citation Index (ESCI) and SCOPUS is essential.

Additionally, converting articles currently provided in PDF format into full-text XML for publication in HTML format while continuing to offer PDF versions is an important subject for consideration. This transition will broaden access to our content. HTML formatting enhances accessibility for non-English-speaking readers by leveraging continuously improving AI translation technologies. These efforts are expected to increase the visibility of AJBE articles and, consequently, their citation opportunities.

Finally, I kindly ask for the continued cooperation and support of AABE members and all those involved in biology education as we strive to further elevate AJBE's impact and reach.

Dr. Shigeki Mayama (mayama@u-gakugei.ac.jp)