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A Home-based Experiment with Myxomycetes for Teaching Basic Ecological Concepts

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Abstract: Learning through home-based experiments (HBEs) is vital to supplement educational experiences of students. Myxomycetes are safe, non-toxic, and broadly distributed protists found in most terrestrial habitats, and therefore are good model organisms for home-based learning activities, particularly in teaching biology to high school students. In this paper, we present a home-based experiment to teach basic ecological concepts using myxomycetes. Students set up moist chambers with materials that are readily available at home and conduct a taxonomic diversity assessment. We provided a sample lesson plan, outlined material costs for comparison, and discussed alternative home-based learning activities with myxomycetes across different educational levels.

Keywords: learning activity, moist chambers, pedagogy, secondary education, teaching strategy

Introduction

The education sector has struggled to flourish during times of man-made or natural crises, as seen during the global COVID-19 pandemic (Dillon and Avraamidou 2020). A shift to an online learning medium was the only viable solution for many educational institutions amidst community lockdowns and home quarantines. However, the implementation of online learning system encounters numerous problems, particularly in many developing countries such as the Philippines. Toquero (2020) mentioned that while many educational institutions in the Philippines immediately incorporated online education using online sites like Google Classrooms, most teachers were unprepared to use modern technology or shift to online education. Marquez et al. (2020) also noted that school children had to take charge of their own learning as their families and teachers faced limitations in assisting them.

Home-based experiments are great reinforcement tools for learners of all ages. While HBEs are recognized as helpful instruments for learning, these must still adhere to specific criteria. Robledo (2021) stated that HBEs must be safe, ethical, with tangible outcome/s, promote reflection for students, allow collaboration, are affordable, use readily available materials, and are modifiable. Learning science through home-based experiments can also enable students to practice improvisation skills, and the utilization of certain home equipment (Caruana et al. 2020). HBEs can be an excellent alternative in the absence of natural science laboratories (Neves et al. 2017; Easdon 2018). There are several home-based experiments designed for various scientific fields that students can perform to promote home learning. A laboratory-at-home, 3D-printed, low-cost experimentation, for instance, has made it possible to teach thermal engineering concepts at a satisfactory rate to undergraduate students (Larriba et al. 2021). For biology, a home-based activity regarding the phytoremediation of textile dyes was conducted by high school learners, even amidst the COVID-19 pandemic (Vezza et al. 2021). For a botany class, a home-based activity that determines the water-holding capacity of various types of bryophytes and tracks the development of germinating seeds was successfully implemented (Gya and Bjune 2021). To encourage ecological learning, group field activities can be transformed into individual home assignments where students are instructed to get creative in building sampling quadrats from materials readily available in their respective homes or in nearby areas such as tree branches, bamboo sticks, shovels, and other items (Creech and Shriner 2020) or simply explore their own backyards for living specimens (dela Cruz and Eloreta 2020). Other examples of home-based biology experiments include creating make-shift apparatuses used in keeping microcosms (e.g., an aquarium), and manufacturing an alternative Winogradsky column (Thompson and Thompson 2012).

Myxomycetes being widely distributed and safe to use, would be ideal candidates for home-based learning activities in biology at different educational levels. Winsett et al. (2022) indicated that myxomycetes, as used in education, may refine the critical thinking and observational skills of students, while also encouraging students' involvement in science. The authors gave a full range of educational activities using slime molds adaptable for all ages. A photoguide developed by Macabago and dela Cruz (2012) introduced a tool that aids in the observation of myxomycetes. Dela Cruz et al. (2012) have also used myxomycete-based taxonomic guides to evaluate students' perception on the use of printed dichotomous keys and web-based identification guides. Recently, McDonald (2022) created a visual key of slime molds for children, which may be used in virtual or onsite classrooms. In this paper, we describe a simple myxomycete-based learning activity using home materials to teach basic ecological concepts. Furthermore, we designed and conducted this learning activity within the setting of rural and urban environments. An estimation of material costs is also presented alongside corresponding challenges and alternative solutions we encountered during the demonstration and development of this home-based experiment.

Development of the Home-Based Experiment with Myxomycetes

In this home-based experiment, students will use the moist chamber culture technique to grow myxomycetes. They will collect data on species occurrence and compute the taxonomic diversity index (also known as S/G ratio) as a measure of diversity.

Choice of substrates. Leaf litter with leathery leaf texture has been proven to serve as effective spore traps for myxomycetes that are dispersed by air in the environment (Redeña-Santos et al. 2017) and are therefore ideal bait for this learning activity. However, the teacher may also instruct the students to use other substrata such as twigs, woody vines, tree barks, dried inflorescences, and other similar materials where myxomycetes are known to thrive to serve as alternative or sources of the organisms for direct preparation of moist chamber cultures.

Preparation of baits and moist chamber cultures. The dried leaf litter are initially cut into postage stamp size, placed in mesh bags made with a nylon material (12 cm x 9 cm; pore size at 2 mm), and sterilized with a home pressure cooker for 15 minutes. Since the learning activity is designed to capture airborne myxomycete spores, sterilization is a necessary step to prevent growth of myxomycetes already in the litter. Twelve (12) spore trap baits with leaf litter are prepared and then hung using clothes hangers on home balconies and in backyards (Figure 1). To test the feasibility of this learning activity, we set up 6 baits in an open field to simulate the backyard condition commonly seen in rural areas and 6 baits on a home balcony to test a limited space which is a common scenario under urban setting. The spore trap baits were exposed for 4 and 8 weeks. Three baits were then processed after the 4th week of exposure while the remaining baits were collected on the 8th week.

Following exposure, moist chamber cultures were prepared based on the standard protocol of Stephenson and Stempen (1994). Briefly, the leaf litter were placed on disposable Petri dish lined with absorbent paper towel and submerged overnight with distilled water (Figure 1). Chilled boiled water is also useful where sterilised or distilled water is not available. We also prepared another set of moist chamber cultures, but with plastic container (12 cm in diameter, 4 cm in height) in lieu of the disposable Petri plates, to test the idea of using common household materials. Overall, we have prepared 24 moist chambers. Since the home-based experiment will be performed individually by the student, the number of moist chambers for this learning activity is reduced as opposed to the number used in ecological research studies for easy manageability. However, the teacher may assign the students to group where data obtained by the individual students are combined and/or compared. A portable digital pH meter was used to take the pH readings of the substrates and the excess water was emptied after 24 hours. Alternatively, a narrow range pH paper such as the Advantec Narrow Range pH Test Papers [https://www.coleparmer.com/, product item GZ-59201-11 (pH range 6.2 to 7.8)] can be used. The moist chambers were incubated under diffuse light at ambient room temperature (22–25°C) and observed for myxomycetes for 8 - 12 weeks (Dagamac et al. 2012).

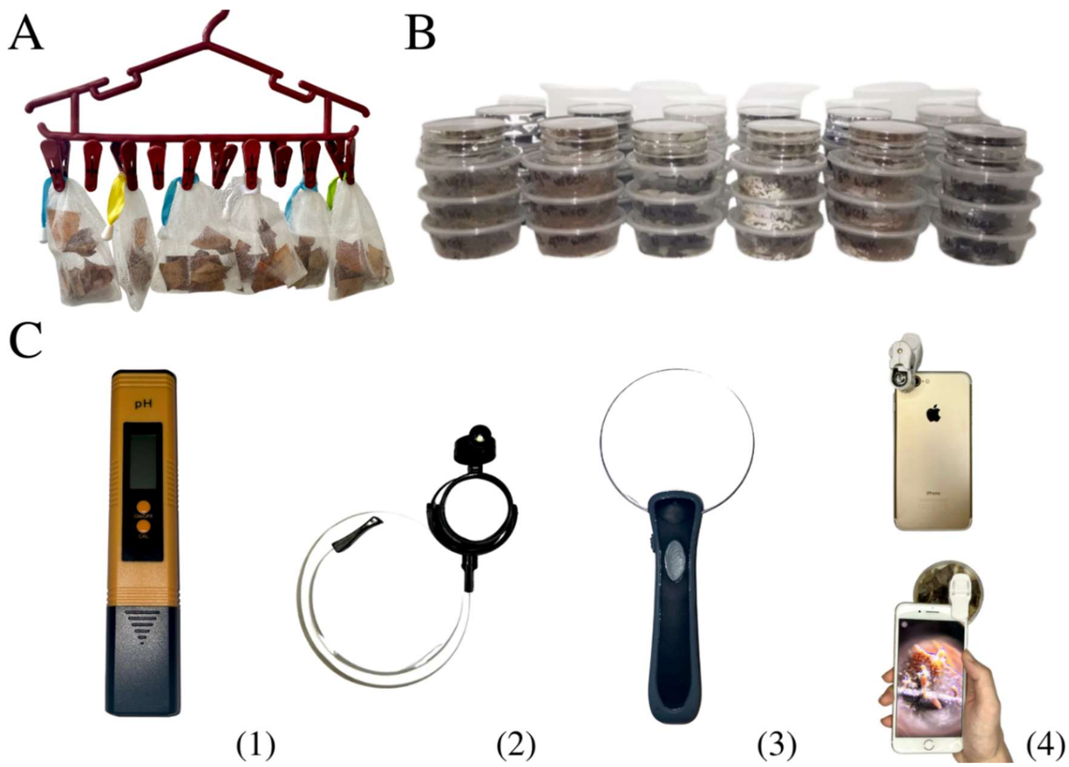

Figure 1. [A] Spore trap baits hung with a clothes hanger. [B] Moist chamber cultures using Petri dish (upper layer) and plastic containers (lower layer). [C] Materials used for checking pH of substrates and observing myxomycetes: (1) portable digital pH meter, (2) jeweler's eyepiece, (3) magnifying glass, and (4) attachable macro lens for mobile phones.

Observation of myxomycetes and data analysis. Petri plate and plastic container moist chambers are observed weekly for the presence of myxomycetes either in the form of plasmodia and/or fruiting bodies. The number of moist chambers positive for myxomycetes is recorded to compute the moist chamber productivity as described in the paper of Dagamac et al. (2012). We used a magnifying glass or a jeweler's eyepiece to observe the fruiting bodies of the myxomycetes. Identification of species was done by comparing morphology with characters in web-based identification guide (http://slimemold.uark.edu/) and published literature, e.g., Stephenson and Stempen 1994, Keller and Braun 1999. Myxomycete experts may also be consulted by the students for species identification.

The documentation of the collected species can be done with mobile phones or any hand-held camera. There are numerous macro lenses that can be attached to cameras or phones for macrophotography and would be ideal for recording fruiting bodies. Figure 2 shows some of the representative species we recorded in this learning activity. A table with species list and the corresponding frequency or number of records is then generated as the final output of the student for graded assessment. The students will also provide information about species richness (i.e., number of species and genera) and compute the taxonomic diversity index as the ratio of species and genera as similarly described in the studies of dela Cruz et al. (2021) and Lim et al. (2021). Table 1 shows the results of our home-based experiment to demonstrate this learning activity.

However, for teaching other ecological concepts, the teacher may opt to gather and pool all data from the students within the class for the computation of different diversity indices. To illustrate this strategy, in a class of 30 students, the pooled data would correspond to 360 moist chambers since each individual student would have 12 moist chambers. Using the collated data, the students can proceed with quantifying diversity through the computation of the different diversity indices as described by Magurran (2004): Shannon index of variety [H_S], Gleason index of species richness [H_G], and Pielou's index of species evenness [E]. Other indices such as Fisher's Alpha Index [FAI] and Simpson Index [SI] as described by Chao and Shen (2010) can also be computed as observed in many ecological studies in myxomycetes, e.g., Cabutaje et al. 2021, Pecundo et al. 2020, 2021.

For computation of these diversity indices, students may utilize free downloadable statistical software such as the Species Prediction and Diversity Estimation (SPADE, available at http://140.114.36.3/wordpress/software_download/) and the Paleontological Statistics Software Package for Education and Data Analysis (PAST, available at https://www.nhm.uio.no/english/research/infrastructure/past/).

Table 1. Sample table that can be generated from the home-based myxomycete learning activity[a].

	Rural Setting (Open space scenario)		**Urban Setting** (Limited space scenario)	
	Petri dish MC	**Plastic MC**	**Petri dish MC**	**Plastic MC**
Number of Moist Chambers (MC)	6	6	6	6
% MC productivity	100	100	100	100
Arcyria cinerea (Bull.) Pers.	2	4	4	4
Diderma effusum (Schwein.) Morgan	1	0	0	0
Diderma hemisphaericum (Bull.) Hornem.	0	1	0	0
Perichaena depressa Lib.	0	1	0	0
Stemonitis fusca Roth	3	0	0	0
Total number of records	6	6	4	4
Total Number of Genera (G)	3	3	1	1
Total Number of Species (S)	3	3	1	1
Taxonomic diversity index (S/G)	1	1	1	1

[a] Data are derived from our actual experiment.

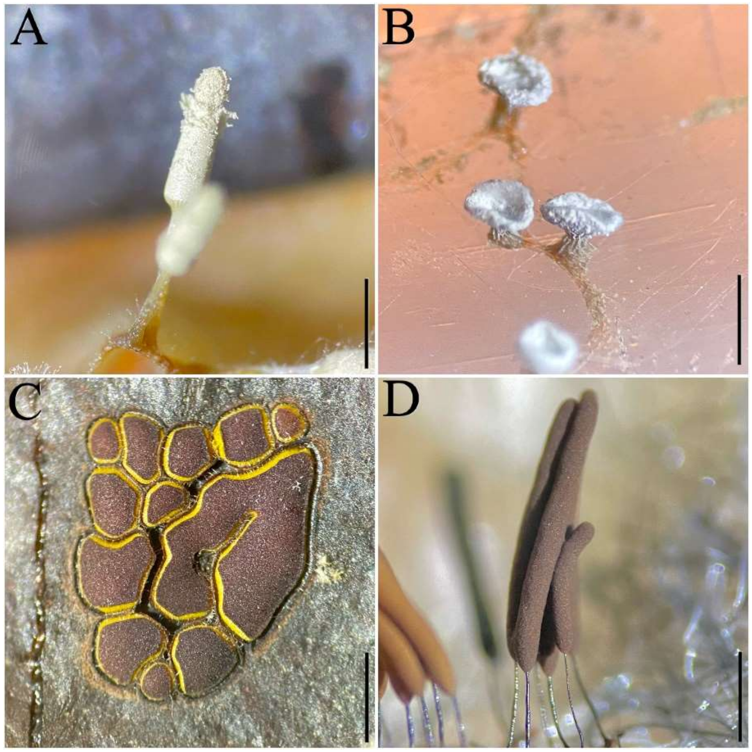

Figure 2. Representative species of myxomycetes recorded from our moist chamber cultures: (**A**) *Arcyria cinerea* (Bull.) Pers., Petri plate moist chamber, (**B**) *Diderma hemisphaericum* (Bull.) Hornem., Petri plate moist chamber, (**C**) *Perichaena depressa* Lib., plastic container moist chamber, and (**D**) *Stemonitis fusca* Roth, plastic container moist chamber. Scale bar = 1.5 mm.

Sample lesson plan. We also developed a sample lesson plan that teachers can use in their classes (Table 2). While the learning activity is conceptualized for high school students, a modification of the tasks will render the learning activity applicable to learners at primary schools or at tertiary level. For example, teachers may assign learners at primary school to do the moist chamber cultures with the aid of their parents and monitor their cultures within a limited period for the presence of myxomycetes.

In this modified activity, the learners need not do the species identification and diversity assessment. As suggested in Winsett et al. (2022), the activity can then introduce the scientific method concept, make the learners understand the life of and experience how to be a scientist, and raise awareness on myxomycetes among young learners. For the undergraduate students, the lesson plan for high school students can be adapted, but with more moist chambers and includes species identification and computation of diversity indices. Students may also use different substrates for baits and do comparative ecological studies, e.g., between study sites or substrates (microhabitats) based on results obtained by the different members of the class. Alternatively, a mini-research project can be assigned to the undergraduate students with this home-based experiment where they can compare the community assemblages of myxomycetes.

Table 2. A sample lesson plan on the home-based myxomycete learning activity.

Lesson Title	**Myxo is in the house! A home-based experiment with myxomycetes**
Recommended grade level	Grades 9-10 (14 – 16 years old) Allotted time: 1.5 – 3.0 hours Grades 11-12 (16 – 18 years old)
Learning Objectives	At the end of the learning activity, the student is expected to: (1) set up spore trap baits and moist chamber cultures (2) observe, identify, and list species of myxomycetes, and (3) compute diversity indices (e.g., taxonomic diversity index or S/G ratio).
Materials Needed	*For preparation of spore trap baits*: ▪ substrate: leaf litter ▪ mesh bags made up of nylon material ▪ clothes hangers ▪ scissors and strings ▪ home pressure cooker *For preparation of moist chamber cultures*: ▪ 12 plastic containers (12 cm in diameter, 4 cm in height) ▪ paper towel ▪ distilled water ▪ pH meter or pH paper *For observation and documentation of myxomycetes*: ▪ magnifying lens or jeweler's eyepiece ▪ mobile phone with macro lens
Prior skills and understandings	The teacher begins the class activity with a short lecture on basic information about myxomycetes, e.g., on taxonomy, distribution, ecology. Videos on myxomycetes, e.g., the "Slime Molds: When Micro becomes Macro" by Journey to the Microcosmos available at https://youtu.be/elqwn7k2Wwk, and images of fruiting bodies can be shared with students to make them be familiar with these organisms.
Instructions	1. The teacher groups the students into teams of 3-4 members. While the home-based activity is conducted individually, grouping the students facilitates collaboration and engagement through sharing of resources and data. 2. The teacher tasks the students to collect leaf litter from their own backyard or nearby nature areas. Students collect the substrates in brown paper bags. 3. The student is then tasked to cut the leaf litter into postage stamp sizes and placed inside the mesh bag. A total of 12 spore trap baits will be prepared by the student. This will be sterilized with home pressure cooker for 15 minutes. Student must secure the assistance of adults in sterilizing their baits. 4. The spore trap baits are hung with clothes hangers in an open area, e.g., home balconies or open spaces in the garage or backyards, for 4 and 8 weeks. 5. Following exposure, the student will gather the spore trap baits (6 baits on the 4th week and the remaining 6 baits on the 8th week) and the leaf litter is placed in plastic containers lined with paper towel as moist chamber cultures. The substrates are flooded overnight with distilled water, after which pH is determined with portable pH meter or narrow range pH paper and the excess water is removed. A total of 12 moist chambers are expected per student. The moist chamber cultures are placed

	in cabinets under diffuse light and observed weekly by the students with an aid of a hand lens or jeweler's eyepiece for the presence of myxomycetes. The student records his/her observation. Documentation of the fruiting bodies of myxomycetes can be done through cameras of mobile phones. Ideally, a macro lens fitted to the phone camera will give better images. 6. The student will identify the myxomycetes by comparing morphologies of their fruiting bodies with published literature and/or online identification guide. Student tabulates results of his/her observation. 7. The student will count the number of species and genera and then compute the taxonomic diversity index (TDI) as the ratio of species and genera. A lower TDI value indicates a higher taxonomic diversity. The student compares the computed TDI value with that of the other students. In addition, the student records the number of moist chambers positive for myxomycetes and compute the % moist chamber (MC) productivity as the number of positive moist chambers over the total number of moist chambers prepared for the study multiplied by 100. 8. To conclude the learning activity, the teacher asks the students to reflect on the lessons learned. Alternatively, the teacher may ask the students to design a call for action in raising awareness of myxomycetes or on promoting biodiversity conservation and habitat protection.
Assessment	Student will submit a student worksheet, i.e., a table of species list, their corresponding number of records, and computations of various diversity indices. Alternatively, oral or poster presentation of research outputs can be done in class. The student outputs are graded with a grading rubric prepared by the teacher.

Feasibility. In this learning activity, we aimed to use materials that are readily available at home, and hence, plastic containers are suggested for the preparation of moist chamber cultures. We did a cost analysis to show the amount each student will invest in preparing the home-based experiment (Table 3).

Challenges and solutions in conducting the learning activity. As we did the learning activity in our homes, we observed some challenges that the teachers and students should be aware of when conducting this home-based experiment.

(1) This learning activity use leaf litter as substrates for the spore trap baits to gather airborne spores of myxomycetes. The choice of leaf substrate is crucial for the success of trapping airborne myxomycete spores. However, other substrata such as twigs, woody vines, tree barks, dried inflorescence, etc, can also be used. Alternatively, the spore baiting step can be skipped and the collected substrata are cut and directly plated on moist chamber setups. In case spore baiting will be performed by the students, the teacher should remind the students to find the best location in their homes to ensure that the spore traps are not disturbed by any human activities.

(2) Online shops such as Amazon, can be used to purchase the materials (i.e., portable pH meter, pH paper, macro lenses for mobile phones, etc.) needed for the study, and delivery of these materials may sometimes take time. This must be taken into consideration when assigning the students their take-home tasks and determining the deadline for the submission of student outputs.

(3) In the absence of disposable Petri plates, we used plastic containers as moist chambers. To save costs and to promote the value of recycling, the teachers can instruct the students to use empty plastic food containers that are readily available at home.

(4) Species identification requires a certain degree of expertise. In this learning activity, students are encouraged to do their identification by comparing fruiting body description. The teacher must

include in the preliminary lecture a discussion on how species identification is conducted. Alternatively, students may consult experts in the field through email correspondence. Such activity teaches the value of communication and provides a real-life learning experience for the students as scientists often communicate with colleagues for research collaboration and exchanges of information.

Table 3. Cost analysis of materials and equipment needed for the myxomycete home-based experiment.

<table>
<tr><th>Petri Plate-Based
Moist Chamber</th><th colspan="2">Price for 12 Samples
(in US $)</th><th>Plastic Container-Based
Moist Chamber</th></tr>
<tr><td colspan="4">Materials for spore trap baits</td></tr>
<tr><td>mesh bag (12 pieces)</td><td colspan="2">$ 1.16</td><td>mesh bag (12 pieces)</td></tr>
<tr><td>clothes hanger (2 pieces)</td><td colspan="2">$ 0.58</td><td>clothes hanger (2 pieces)</td></tr>
<tr><td colspan="4">Materials for moist chambers</td></tr>
<tr><td>disposable Petri dish
(12 pieces)</td><td>$ 2.16</td><td>$ 0.94</td><td>plastic container
(12 pieces)</td></tr>
<tr><td>paper towel</td><td colspan="2">$ 0.53</td><td>paper towel</td></tr>
<tr><td>digital pH meter[a]</td><td colspan="2">$ 3.87</td><td>digital pH meter</td></tr>
<tr><td>(narrow range pH paper)[b]</td><td colspan="2">($ 17.06 per 200 strips)</td><td>(narrow range pH paper)</td></tr>
<tr><td colspan="4">Materials for myxomycete observation</td></tr>
<tr><td>magnifying glass</td><td colspan="2">$ 0.97</td><td>magnifying glass</td></tr>
<tr><td>macro lens for mobile phones[a]</td><td colspan="2">$ 2.44</td><td>macro lens for mobile phones</td></tr>
<tr><td>Total</td><td>$ 11.71</td><td>$ 10.49</td><td>Total</td></tr>
</table>

[a]Digital portable pH meter and macro lenses can be purchased from any local or international online shops, e.g., digital pH meter (brand: Basnge) from https://shopee.ph/ ($3.76) or www.amazon.com/ ($10.99).
[b]Advantec MFS 7010060, pH test paper, pH 6.2-7.8, available at www.amazon.com/ ($ 17.06).

Concluding Remarks

Myxomycetes are ideal model organisms for home-based learning activities and can be used to promote life appreciation and raise awareness on the important roles of microorganisms in nature. Home-based experiments with myxomycetes can also be used to teach and gauge understanding of basic ecological concepts. What makes the home-based myxomycete experiment unique is its versatility of use at different educational levels. The use of materials and equipment readily available or easily purchased makes the implementation of the learning activity easy at home. With the recognition of online learning as a viable mode of instruction, the development of home-based experiments is highly encouraged to supplement learning in the absence of or in limited face-to-face interaction.

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References

Cabutaje EM, Pecundo MHP, dela Cruz TEE. 2021. Diversity of myxomycetes in typhoon-prone areas: a case study in beach and inland forests of Aurora and Quezon Province, Philippines. Sydowia 73: 113-132.

Caruana DJ, Salzmann CG, Sella A. 2020. Practical science at home in a pandemic world. Nat Chem. 12(9): 780-783.

Chao A, Shen TJ. 2010. [Internet] Program SPADE (Species Prediction and Diversity Estimation). Program and User's Guide. [cited 2022 Mar 2]. Available from: http://chao.stat.nthu.edu.tw.

Creech C, Shriner W. 2020. DIY ecology class: transitioning field activities to an online format. Ecol Evol. 10(22): 12437-12441.

Dagamac NHA, Stephenson SL, dela Cruz TEE. 2012. Occurrence, distribution, and diversity of myxomycetes (plasmodial slime molds) along two transects in Mt. Arayat, National Park, Pampanga, Philippines. Mycology 3(2): 119-126.

dela Cruz TEE, Eloreta MFBM. 2020. Myxomycetes in our backyard: Species exploration amidst the COVID-19 pandemic. Antoninus Journal. 6. http://theantoninus.com.ph/archives/60/.

dela Cruz TEE, Pangilinan MVB, Litao RA. 2012. Printed identification key or web-based identification guide: an effective tool for species identification?. J Microbiol Biol Educ. 13(2): 180-182.

dela Cruz TEE, Fabul RPDG, Romero FPR, Cruz MCB, Cabutaje EM. 2021. Diversity of myxomycetes from forest habitats leading to Casaroro and Pulang Bato Falls in Negros Oriental, Philippines. Slime Molds 1: V1A9.

Dillon J, Avraamidou L. 2020. Towards a viable response to COVID-19 from the science education community. J Activist Sci Technol Educ. 11(2): 1-6.

Easdon J. 2018. Stay at home laboratories for chemistry courses. J Chem Educ. 97(9): 3070-3073.

Gya R, Bjune AE. 2021. Taking practical learning in STEM education home: examples from do-it-yourself experiments in plant biology. Ecol Evol. 11(8): 3481-3487.

Keller HW, Braun KL. 1999. Myxomycetes of Ohio: their systematics, biology and use in teaching. Ohio Biological Survey. 13(2).

Larriba M, Rodríguez-Llorente D, Cañada-Barcala A, Sanz-Santos E, Gutiérrez-Sánchez P, Pascual-Muñoz G, Álvarez-Torrellas S, Águeda VI, Delgado JA, García J. 2021. Lab at home: 3D printed and low-cost experiments for thermal engineering and separation processes in COVID-19 time. Educ Chem. Eng. 36: 24-37.

Lim ARU, Silva RMN, Lesaca GRE, Mapalo VJC, Pecundo MH, dela Cruz TEE. 2021. First survey of myxomycetes in successional and mangrove forests of Negros Oriental, Philippines. Slime Molds 1: V1A7.

Macabago SAB, dela Cruz TEE. 2012. Development of a myxomycete photoguide as a teaching tool for microbial taxonomy. J Microbiol Biol Educ. 13(1): 67-69.

Magurran AE. 2004. Measuring biological diversity. Oxford: Blackwell. 256 p.

Marquez LP, Olivar M, Brijuega CE, Ombao RP, Cerio WC, Baes FD. 2020. Education and COVID-19: experiences and insights from a developing country. ACCESS: Contemporary Issues in Education. 40(1): 84-90.

McDonald P. 2022. A key to common genera of slime molds - for children and beginners. Slime Molds 2: V2A10.

Neves BHS, Altermann C, Gonçalves R, Lara MV, Mello-Carpes PB. 2017. Home-based vs. laboratory-based practical activities in the learning of human physiology: the perception of students. Adv Physiol Educ. 41(1): 89-93.

Pecundo MH, Dagamac NHA, dela Cruz TEE. 2020. A comparative diversity study of myxomycetes in the lowland forests of Mt. Malasimbo and Mt. Siburan, Mindoro Island, Philippines. Karstenia 58(2): 275-291.

Pecundo MH, Espiritu LM, Carillaga RLG, Samaniego AFE, Cabutaje EM, dela Cruz, TEE. 2021. First report of myxomycetes in the karst forest of Minalungao National Park, Nueva Ecija, Philippines with updates on the limestone-inhabiting myxomycetes of the Philippines. Curr Res Environ Appl Mycol. 11(1): 230-247.

Redeña-Santos JC, Dunca JAU, Duong VT, Dagamac NHA. 2017. Myxomycetes occurring on selected agricultural leaf litter. St Fungi. 2(1): 171-177.

Robledo DA. 2021. Biology at Home: The six attributes of home-based biology experiments (HBEs) for remote authentic learning. Psychology 58(3): 4319-4323.

Stephenson SL, Stempen H. 1994. Myxomycetes: a handbook of slime molds. Oregon: Timber Press.

Thompson RB, Thompson BF. 2012. Illustrated guide to home biology experiments: all lab, no lecture. U.S.A.: Maker Media, Inc.

Toquero CM. 2020. Challenges and opportunities for higher education amid the COVID-19 pandemic: the Philippine context. Pedagogical Res. 5(4): em0063.

Vezza ME, Sosa Alderete LG, Agostini E. 2021. A homemade laboratory applied to the phytoremediation of textile dyes by high school students in the context of the COVID-19 pandemic. J Biol Educ. 1-12. DOI: 10.1080/00219266.2021.2006269

Winsett KE, dela Cruz TEE, Wrigley de Basanta D. 2022. Myxomycetes in education: the use of slime molds in promoting active and engaged learning. In: Rojas C, Stephenson SL, editors. Myxomycetes: Biology, Systematics, Biogeography and Ecology, 2nd ed. London: Academic Press. p. 533-563.