DOI: 10.2478/jtes-2022-0014

sciendo

Journal of Teacher Education for Sustainability,
vol. 24, no. 2, pp. 19–33, 2022

Using Citizen Science Tools for Distance Field Study of Botanical Cycle Disciplines in Times of Pandemic and Beyond

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Abstract

Humanity has existed in special living conditions since March 11, 2020 when WHO declared COVID-19 a global pandemic. This coronavirus disease has already taken more than 6.55 million of people's lives from almost 625 million of officially confirmed cases of people infected around the world at the beginning of October 2022. Lot of university lecturers, teachers and researchers are concerned by new challenges in the education and science process. Therefore, many new recommendations and methodologies have been published for effective teaching in the pandemic time focusing on different forms of distance digital education. Certainly, the process has been actual for biological disciplines too where the biggest problems appeared with the organisation of field courses. Every country and even every university have been looking for optimal ways within their epidemic situation according to country restriction rules. Therefore, we have generalized this experience, as well as developed protocols on example of iNaturalist platform (*https://www.inaturalist.org/*) for effective use of citizen science tools not just for distance learning of botanical cycle disciplines in the pandemic time and beyond, but also for collecting valuable data about plant distribution during this process. We present a future-oriented vision of the solution of biodiversity and sustainability education.

Keywords: botany, citizen science, distance education, field practice, pandemic, SARS-CoV-2

Introduction

Humanity has lived under special conditions since March 11, 2020, when the World Health Organization declared COVID-19 as a global pandemic. This corona virus disease has already taken more than 6.55 million people's lives from the almost 625 million of officially confirmed cases of infected persons around the world at the beginning of October 2022 (Worldometer, 2022). Nobody knows when the pandemic is going to be stopped, because new variants of SARS-CoV-2 appear (Callaway, 2021; Statens Serum Institut, 2022).

The COVID-19 pandemic has changed many aspects of our life significantly, including the education on plant science, thus causing negative effects on fundamental investigations, applied projects, nature conservation as well as the quality of future cadres who attended university during this special period of time (Baldini, 2020; Crimmins et al., 2021; Wicaksono & Teixeira da Silva, 2020). As a consequence, field research, starting from its logistic organization up to authorization by the competent territorial authorities, and visits to herbaria have been strongly affected, while also many recurring conferences, symposia, and celebrations have been postponed or cancelled (Baldini, 2020). The COVID-19 pandemic has disrupted the timing and substance of conservation research, management, and public engagement in protected areas around the world, including interruptions of long-term research and monitoring on the health of ecosystems and wildlife populations, while time-sensitive management practices, such as control of invasive plants and restoration of degraded habitat, have been delayed (Miller-Rushing et al., 2021). At the same time, plant scientists with limited work or research conditions during the pandemic, alleviated their work through alternative approaches, e.g., *in silico* research, or they spent more time on writing research papers, while some kind of research received more priority during the pandemic, especially those studies focused on medical and social aspects (Wicaksono & Teixeira da Silva, 2020). Also, citizen science projects have been impacted by pandemic-related restrictions in different ways that most likely depended on their specificity. For example, in the USA, eButterfly (*https://www.e-butterfly.org/*) and Nature's Notebook (*https://www.usanpn.org/natures_notebook*) showed a decline in the number of participants and number of observations submitted during the spring of 2020, and iNaturalist (*https://www.inaturalist.org*) and eBird (*https://ebird.org*) showed growth in both measures, while there was also a widespread increase in observations in urban areas (Crimmins et al., 2021). Almost the same results were obtained for Columbia, where record distributions at iNaturalist and eBird were compared during the strictest phase of the COVID-19 lockdown in 2020 to the same periods in 2015–2019. The overall participation in both platforms during the lockdown was high compared to previous years, but records that were concentrated on highly-transformed regions received lower sampling efforts, and fewer species were recorded (Sánchez-Clavijo et al., 2021).

Meanwhile, a lot of scientists, lecturers, teachers and specialised organisations are concerned about new challenges in the education process. Therefore, many new recommendations and methodologies for effective teaching during pandemic times have been published, focusing on different forms of distance education (Armstrong-Mensah et al., 2020; Espinosa et al., 2021; Fayed & Cummings, 2021; Kapenieks & Kapenieks, 2020; Kumar et al., 2021; Kummitha et al., 2021; Morrison et al., 2021; Pokhrel & Chhetri, 2021; Rapanta et al., 2020; Reiss, 2020; Rudyatmi et al., 2021; Schnell et al., 2021; The United Nations, 2020). Certainly, the process has been topical for biological discip-

lines too where the biggest problems are related to the organisation of field courses (Scott et al., 2012; Wolinsky, 2021) which represent powerful experience promoting the development of new generations of creative scientists, enhancing environmental literacy, and instilling social responsibility in our citizens (Fleischner et al., 2017). Every country and even every university have been looking for optimal ways to cope with the epidemic situation according to country's restriction rules (Wolinsky, 2021). Though, it is impossible to say that such distance education was something absolutely new, the presently used methods were not sufficiently developed at that moment and not popular among university teachers of disciplines of botanical cycle (Biel & Brame, 2016; Goff et al., 2018; Naranjo-Morán et al., 2020; Nowak et al., 2020; Smith & Hill, 2019). Moreover, the situation has been aggravated, because volunteers and specialists of plant science and botany are getting older and the decreasing number of junior scientists causes a pessimistic view regarding the conservation of plants (Crisci et al., 2020; Pearson et al., 2011; Wheeler et al., 2004).

For example, most of the botanical field practices were postponed from spring and early summer to the autumn of 2020 or to spring and early summer of 2021 in Bulgaria, Hungary and Slovakia. This was done in the hope that the use of classic approaches to carry out field practices within courses of botanical disciplines would become possible again. Basically, this aim was reached, though these universities took risks. However, the students from the Luhansk Taras Shevchenko National University (Starobilsk, Ukraine) and many other Eastern European universities had their field practices in time. Actually, university teachers did not have any clear algorithm at that time, but they acted spontaneously to organize an effective education process during distance field practices under the new conditions. Students worked individually getting their personal tasks and contacting lecturers by different types of video telephony (MS Teams, Zoom, Google Meet, Skype), online chat services and available messengers (Viber, WhatsApp, Facebook etc.) for consultations and checking their work results, as well as they used Moodle, a popular learning platform, for sharing some educational materials. However, our colleagues from Kherson State University (Ukraine) also used the iNaturalist website and its app for their field course on plant taxonomy where students had to publish their observations on plant identification (*https://www.inaturalist.org/projects/sistematiki-vischih-sudinnih-roslin-2-kurs-fbge-hdu)*. We know that almost the same approach has been applicable in Belarusian State University (Minsk, Belarus) (personal communication by V. Tikhomirov). Two iNaturalist projects were created for students of the first (*https://www.inaturalist.org/projects/kiberroscha-2020*) and the second (*https://www.inaturalist.org/projects/kibervolozhin-2020*) year of study in which each student had to publish specified numbers of plant species from different habitats and plant families.

The Swedish University of Agricultural Sciences (SLU) has developed and constantly improved own algorithm for distance student field teaching which includes a number of different methods (video excursions, photo exchange, virtual meetings, the use of the mobile app Pl@ntNet (*https://plantnet.org*) and a learning management platform, etc. that come under four broad headings (Introduction, Self-learning, Reflection and Assessment). As evaluation scores show, this way is successful, because the students obtain knowledge and marks which are almost identical in comparison with the results of the classic educational process (Auffret et al., 2022).

There are no details about distance field teaching in botany at the University of Göttingen (Germany), but the common difficulties connected with the current pandemic

stimulated the creation of an R package, BotanizeR (*https://gift.uni-goettingen.de/shiny/BotanizeR/*). It is an online application designed to help botany students to find and distinguish plant diagnostic characters, memorize plant species, and train identification skills (Weigelt et al., 2021). The app has been connected to several databases like FloraWeb (a website about the flora of Germany; *https://floraweb.de/*) and the Online Atlas of the British and Irish Flora (*https://www.brc.ac.uk/plantatlas/*), however, there are possibilities to upload datasets for any regions, as shown already by authors for Indonesia.

New York University (the USA) presented three different solutions developed during the pandemic to address the challenges of adapting an experiential hands-on activity, an interactive lab, and a research project for remote learning (Morrison et al., 2021). One of them has been entitled Backyard Biodiversity, the remote activity capitalized on the diverse range of natural environment students during the pandemic, retaining the same learning objectives as the in-person version: 1) Observing local adaptation of plant traits, 2) Comparing plant diversity in different locations, and 3) Identifying examples of convergent and divergent evolution. Plant identification was mostly accomplished through Seek (*https://www.inaturalist.org/pages/seek_app*), a free application that uses smartphone cameras to identify plants and other organisms in real-time through machine learning. At the same time, the teaching of Field Botany and Taxonomy has been carried out with the use of an online learning platform that contains a series of modular lessons about the major groups of plants (wildflowers, trees and shrubs, ferns, and grasses) as well as iNaturalist platform at the University of Rhode Island (USA) (Brown & Maynard, 2021). It is worth noticing that the Botanical Society of America does not stay aside from the problems in botanical distance learning, so the organisation has collected some resources that may provide useful information for teaching botany online, in addition to some general biology resources: *https://botany.org/home/resources/online_resources.html*

Remote courses and training of students in botany, taxonomy, and plant systematics have been carried out with using virtual collections at the University of Saskatchewan (Canada) where the most important role belongs to virtual herbaria (Cota-Sánchez, 2020).

There is no doubt that distance education, as any other process, has advantages and disadvantages. Therefore, students reported negative experiences of distance learning such as lack of social interaction, network instability and reduced concentration, as well as positive experiences such as time and location flexibility, comfortable educational environments and smooth interactions (Al-Mawee et al., 2021; Shim & Lee, 2020). Taking into account difficulties encountered due to the pandemic, previous education approaches and developments, we would like to make our own contribution to improving distance learning of biological disciplines by this publication, especially the process of field learning. At the same time, it is vital for us, as plant scientists and nature conservationists, to provide the constant process of data gathering which would be minimally dependent on epidemic situations. Thus, we have developed protocols, for example, of the iNaturalist platform for the effective use of citizen science tools not just for distance learning of botanical cycle disciplines during the pandemic and beyond, but also for collecting valuable data about plant distribution during this process.

Materials and Methods

iNaturalist has been chosen for this study because it is the most popular multilingual citizen science platform at the global scale which allows collecting distribution data of all beings of our planet using smartphones or photo cameras with laptops / personal computers. It contains more than 117 million of observations of almost 397 thousand species which have been gathered by more than 2.4 million observers on October 3, 2022 (*https://www.inaturalist.org/observations*). The website and relevant application have already been used in the education process actively (Echeverria et al., 2021; Hernawati et al., 2020; Panitsa et al., 2021; Unger et al., 2021; Young et al., 2021a). This platform has already shown its effectiveness in the monitoring of local biodiversity (Young et al., 2021a), including invasive species (Keet & Richardson, 2022; Pittarello et al., 2021; Young et al., 2021b), the discovery of new species for science (Winterton, 2020), the study of modern changes in species ranges (Jones et al., 2019; Pedruzzi et al., 2022), and the search of answers to some ecological questions (Putman et al., 2021; Vardi et al., 2021). Also, iNaturalist provides a standardized and cost-efficient enhancement to specimen collection and curation that can be easily adapted for specific research purposes or other collection types beyond herbaria (Heberling & Isaac, 2018). Moreover, its collected data even provided input to regulatory decisions in the USA and Canada (Young et al., 2019). Also, an important moment is that identification accuracy at iNaturalist is usually adequate for many research goals, although this may vary across taxonomic groups (Hochmair et al., 2020), and also the quality of data may be affected in case of their collection by the young citizens (Panitsa et al., 2021). The last, but not the least, advantage of this citizen science platform is that it shares its records in the international network "Global Biodiversity Information Facility" (GBIF: *https://www.gbif.org/*) which offers open and free access to biodiversity data about all types of life on the Earth under financial support by governments and organizations from a number of participating countries around the world (Heberling et al., 2021).

Some task examples during distance learning have been prepared using study materials from "Guide to Exercises in Botany" that has been published for courses of Botany, including Plant Anatomy and Morphology, as well as Plant Taxonomy, and Medical Botany for students of the following specialties: Forestry, Agronomy, Plant Protection, Ecology and Environmental Protection, Landscape Architecture and Veterinary Medicine (Tashev et al., 2022). This publication is suitable for describing our idea because of its universality, but contains outdated views on plant taxonomy; therefore, we have been selective in its use. However, we recommend using the updated taxonomic information from the Plant Phylogeny Poster (PPP) Project, which provides data in more than 30 languages (Cole, 2022; Cole et al., 2021).

Results

Preconditions: Each participant of distance field courses of the botanical cycle, including the course teacher/s, has to have a smartphone or a photo camera with a possibility to transfer taken pictures to a laptop or a personal computer later. Also, it is vital to have access to the internet in any form (Wi-Fi, broadband, mobile connection, etc.). The last condition is not obligatory during field work, but it is very important during data processing at home or any other suitable place.

Preparation before field work for all participants of distance field courses of the botanical cycle, including the course teacher/s: you should become a member of iNaturalist community. It is an easy process, as shown by our personal experience of iNaturalist website and its app using, as well as taking into account the established age limits by platform founders, all operations with the profile registration, photographing and the next uploading of the obtained pictures are understandable and available for people of age 13 and older. First of all, you should open its website (*https://www.inaturalist.org/*), by pushing the button "Sign up". Next, it is necessary to fill out all relevant fields (email, username, password and password confirmation), to allow licensing your photos, sounds, and observations, so scientists can use your data, to give your consent allowing iNaturalist to store and process limited kinds of your personal information in order to manage your account, and to accept the terms of service and privacy policy. Then, you should push the button "Create an Account". After that you will be transferred to your private page where you see an offer: "Get outside, and observe an individual organism. Pick something wild and take a clear, full frame photo. If you already have a photo of something wild, add it now. You can also use the iNaturalist mobile apps to record observations". If you are going to use a smartphone (not a photo camera) during your field work, it is obligatory to install iNaturalist mobile apps from Google Play or App Store depending on a mobile operating system which is set in your device. Lastly, it will be a good choice to start training in the use of the iNaturalist platform before your field work within the course to figure out how this website and its app work. You should follow the next recommendation for it: *https://www.inaturalist.org/pages/getting+started*

Also, you will get an information letter by email from iNaturalist about the next possible steps to get you on your way to observing and identifying the natural world. Some of these steps are the same as described above, others do not have direct relation to our topic. Finally, each student has to disclose their own username or nickname to the course teacher/s.

The exclusive part of preparation for the course teacher/s before field work: first of all, you should create your own project which will collect pictures taken by your students. It is possible to do this from your personal page: you should choose the option "Projects" at the main menu, after that you will be transferred to the relevant part of your profile where you see the button "Start a Project" which you should push. Further, there will be offers to create "Collection Projects" or "Umbrella Projects", differences among them you can learn in descriptions at the webpage. In the current case, we offer to create a "Collection Project", for which you should push the button "Get Started". Now it is possible to start filling out the form for your new project. You will be able to fill out most fields intuitively, but in case of any difficulties or doubts, the main recommendations can be found at iNaturalist guide: *https://www.inaturalist.org/pages/managing-projects #traditional.* At the same time, some important steps in the context of your education aims are clarified below. Namely, in the chapter "Observation Requirements", you should specify the included taxa correctly. It will depend on the topic of the field course, nevertheless, in the case of disciplines of the botanical cycle, please, choose "Kingdom Plantae" and/or "Kingdom Fungi". If you teach a more specific field course, like "Flowering Plants" or even "Monocots", there is no problem narrowing down the choices. Also, you have to include your students in this project here, i.e., to input their usernames which you got from them before. Also, do not forget to check the box in the field "Only display observations from project members (people who have joined the project)" to

only include observations made by users who have joined this project. There is the obligatory field "Include Places" in this chapter; however, if you do not have special requests to the field of your field course, it is possible to specify continents where your students are at that moment. If these requests are, and they are different from common areas like borders of a country or a municipality or a national park of which the iNaturalist database already consists, then, firstly, you have to create your own polygon which will be limiting the area of the field course (follow the next recommendations for it: *https://www.inaturalist.org/posts/6694-how-to-create-an-inaturalist-yard-list*), and after that you will be able to add this area to the field "Include Places". You can fill out the rest of options in the project form according to your personal requests or to leave them by default as it is offered by the citizen science platform. Finally, you should push the button "Done". The correct choice of all options according to your field course requests will make your work significantly easy. In any case, the possibilities to correct the project settings stay from the main project page (the button "Edit project"). Also, there is the other button "Project Journal", using which you will be able to leave common tasks and announcements for your students.

Last thing, students should join the created project so that you will see their observations. To do so: firstly, you should inform the correct name of the project to them; secondly, they using the search option should find the relevant project and push the button "Join". Everything is ready for work after the last action.

However, you can use another way, significantly more focusing on personal work with each student. You have to create individual projects for each student following the recommendations above that will allow you to observe the process for completing your assignments. It means you will create "Collection Projects" again, but in the field "Include Users" you will specify just one student using his/her username. When all students' projects are ready, to avoid chaos among them, you should create an "Umbrella Project" which will join all students' projects and allow following them in their single places. The algorithm of the "Umbrella Project" creation is almost the same as the "Collection" one, but in the field "Observation Requirements" you should include all students' projects which you would like to join. It is logical to do such an "Umbrella Project" for a single academic group or students of the same year of education.

Course tasks: there are a lot of opportunities, we give just some examples below, because the content and volume of field courses may be different at each university.

Each teacher can ask students to take pictures and upload 10 native or alien species of plants which have simple and compound leaves, as well as 3 species of plants with leaves of ovate, hastate, spatulate, lanceolate, linear, cordate, trifoliate, deltoid, obovate (and any other) shapes in an iNaturalist relevant project within the field course "Plant Morphology". Actually, such tasks may concern diversity shapes of any vegetative or generative organs and fruits of plants. However, after observation uploading, it is important that each student or student team will provide the relevant list with species names or links to their observations in which it is clearly specified which leaf shape or other target object is represented on each observation to the teacher.

Also, the teacher can offer to take pictures and upload 10 species of native or alien plants from 10 leading families in the flora of the region, where the student is located, and also 3 plant species of any other 25 families from the local flora in an iNaturalist relevant project within the field course "Plant Taxonomy". As in the previous example, each student or student team has to provide their relevant lists to the teacher, but there

is a condition according to which the plant from each observation must be identified to the species level by the author of the observation before other iNaturalist users will have done it.

If you teach the field course "Plant Ecology", then your tasks for students may be like this: take pictures and upload 25 native species of plants from each zonal type of vegetation of the region, where the student is, and 10 ones from each azonal type in an iNaturalist relevant project. The task can be narrowed to the search for some specific species in some specific communities. In any case, students will have to pass their lists with relevant observations to you, as well as confirm their own ability to identify plant species without outside help.

During geobotanical explorations with filling out relevant forms where the species lists and their parameters have to be given, you may ask your students to take pictures of all plant species (or just dominant, or diagnostic ones) in studied communities and upload them in an iNaturalist relevant project within the field courses "Geobotany", "Vegetation Survey" or something similar. Certainly, the students will have to pass filled geobotanical forms (relevés) with links to their observations in iNaturalist to you later.

Depending on the location of your student and its biogeographical peculiarities, the search of different numbers of endemic, alien species as well as, boreal, nemoral, pontic, alpine or subalpine species etc. may be offered to students within the field courses "Plant Geography" or "Biogeography". Also, using the algorithm described above for other disciplines, the observation of some amount of protected and/or rare species of different levels (regional, national, international) may be a task for the field course "Environmental Protection". Moreover, if you do not like that the geographic coordinates of such observations are open for all iNaturalist users, you should ask your students to use the options "Location is obscured" or "Location is private" during their uploading.

The task checking: basically, there will not be another opportunity for the course teacher/s to check the performance of tasks according to uploaded observations of each student in iNaturalist relevant projects by him/herself comparing them with received lists. The right identification of these observations will be mostly checked by iNaturalist users, some of whom are leader experts in specific taxonomic groups or in local flora.

Feedback: The course teacher/s should provide feedback to help improve learning among students, indicating what the student has achieved, what needs to be improved and what to do to improve performance, thereby enabling the student to achieve goals and progress, as well as it is important to ask student feedback about this course and its evaluation process. The recommendations for organizing this process have recently been given by Jurs and Špehte (2021).

Discussion

Though iNaturalist has already been applied in the education process around the world (Echeverria et al., 2021; Hernawati et al., 2020; Panitsa et al., 2021; Unger et al., 2021; Young et al., 2021a), and it is even possible to find common recommendations for taking its advantages during some field courses (Gerhart et al., 2021; Unger et al., 2021), any clear algorithm for work with this platform has not been described yet. Therefore, it is difficult to exploit this useful and comfortable tool within field courses for university lecturers and teachers who have no personal experience. Therefore, their

familiarization with maximum possibilities of iNaturalist platform will give a lot of benefits, especially during distance learning of field courses of the botanical cycle.

Proper equipment and internet connection are an absolutely ordinary request because, according to the latest statistical data, 83.89 % of people have smartphones worldwide today, and it is expected that this level will only increase during the next few years. Moreover, 94 % of people aged 18–29 have this type of phones (Turner, 2022). The numbers vary from developing countries to developed ones; therefore, as a variant for developing countries, students can be divided into small groups (2–3 people) with one smartphone or photo camera for each team. Almost the same situation is with internet access around the world, except for some Central African, South and South-eastern Asian countries (Roser et al., 2015).

It is worth noting separately that this approach takes into account almost all advantages of distance learning which have been mentioned in students' surveys (Al-Mawee et al., 2021; Shim & Lee, 2020), namely: location flexibility, comfortable educational environment and smooth interaction. Moreover, it partially eliminates lack of social contact that has been noted as a negative experience of distance learning.

Despite the many positive sides of the iNaturalist platform in distance learning of botanical cycle disciplines, it is obligatory to understand that this approach can be just an important element of any course. But offered algorithms cannot replace the whole field course which usually contains video excursions, photo exchange, virtual meetings etc. If we talk about the classic botanical field course, we would recommend using the methodology developed at the Swedish University of Agricultural Sciences (Auffret et al., 2022). However, we see more benefits of including the iNaturalist platform in the education process, instead of the mobile app Pl@ntNet as offered there.

Actually, there is almost no limitation for applying the iNaturalist platform in distance learning of botanical cycle disciplines. It means the spectrum of tasks which may be offered for students is very wide. Everything depends on teachers' imagination, i.e. it is possible to find a lot of heuristic and amusing exercises aimed at forming students' professional skills and increasing their knowledge level, except for the examples described by us.

We think that the described protocols may be useful not only in pandemic times, but in some other crisis situations like the current war in Ukraine that started on February 24, 2022 when Russian troops began bombing Ukrainian cities and infrastructure. Under such conditions, the normal education process is impossible in most parts of the country; moreover, it is hard to predict when it is possible to resume it. At present, many students left campuses and homes to save their own lives, and now they are in different regions of Ukraine and Europe. However, those who are safe are already ready to continue their study online. Such events provoke a lot of vital questions that challenge us all to re-evaluate our recent lived experience, to get rid of the habits that have been accumulated in shallow everyday views of life, the world and education, and to continue our search for the deeper scientific foundations necessary for our development (Salīte et al., 2022). Consequently, our algorithms may be in demand for some field courses soon, as well as serve as a partial response to the mentioned questions.

Certainly, our algorithms of the iNaturalist platform may be useful in normal times too, for example, during the implementation of student projects. That is because this approach allows documenting all found species in any area. It will be very helpful not just for keeping species distribution data and checking of the student success, but such use will be a good contribution to the biodiversity information collection globally.

Moreover, using our protocol in the framework of the recently described model of Collaborative Online International Learning (Adefila et al., 2021) could allow supporting even transnational collaboration in digital spaces, particularly, around the enhancement of sustainable environmental attitudes. Namely, stakeholders including university students and staff, researchers, technical experts, business leaders and entrepreneurs, social innovators, policy makers and others can be involved in the solution of the common problem with benefits for all stakeholders. As an abstract example: a researcher from Northern America, who is interested in obtaining modern data about distribution of a taxon of vascular plant in Europe (because this scientist collaborates with a pharmaceutical company which is considering this species as a potential effective medicine), can ask university lecturers and students from the Baltic and Black Sea region countries to help with information collection within their botanical practices; but, first of all, this researcher together with representatives of this pharmaceutical company will make presentations about their research, technologies and perspectives that will motivate students additionally both in their professional development and in quality of data collection.

Conclusion

The authors have presented a future-oriented vision for the solution of biodiversity and sustainability education, which may be useful for crisis times like pandemic, wars and others when the learning process in-person is impossible. The developed protocols as available on the iNaturalist platform may allow carrying out effective distance learning of botanical cycle disciplines and their use will provide a constant process of biodiversity data gathering for plant scientists and nature conservationists that is problematic in complicated epidemic situations. We expect a wide integration of this approach in education and research activity, as well as a discussion, at least, on pages of the Journal of Teacher Education for Sustainability, a forum for the meeting of different views, ideas, and research to promote the further development of studies and practice of teacher education in all areas of formal and non-formal education in relation to sustainability (Salīte et al., 2021).

Acknowledgment

The authors are very grateful to Prof. Dr. Marinus J.A. Werger (Utrecht University, the Netherlands) for critical discussions on our results as well as for language editing.

Declaration of interest statement. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding. This research has been carried out within a scholarship study in the framework of the National Scholarship Programme of the Slovak Republic (ID 35882). It has also been supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences VEGA No. 2/0132/21 and VEGA 2/0098/22.

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