Teaching Botany for Adults with the Blended Learning Modality

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Abstract. In the area of biological sciences, teaching botany constitutes a fundamental contribution to understand the dynamics of living systems. Traditionally, this process has done in person with the help of field trips, visits to the herbarium and simulations in the classroom. However, little is known about how new information and communications technology would promote digital teaching environment for the development of academic skills. The present study focused on a training course on the introduction to botany of vascular plants present in the tropical dry forest, which used blended learning supported in constructivist activities using digital tools. Overall, the study showed that digital tools are used by participants in the development of autonomous and previous work. However, young adults showed low participation, being mature and older adults are the ones who stood out, regarding the development of activities and work in the blended learning modality. In addition, it was evidenced that older adults are who develop activities that demand a higher level of cognitive complexity. The results showed that there are few students who dropped out during their development. In conclusion, the results provide a basis for promoting digital instruction using blended learning. Furthermore, the study shows the effectiveness of digital tools for teaching botanical science.

Keywords: Botanical education · Digital education · Blended learning · Digital tools

1 Introduction

Universities are increasingly neglect taxonomic education, which means that new generations will not be able to identify plant specimens, even in their locality [1]. In the

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educational field, there are some researchers who argue that " the disinterest of the students is probably due to the teaching way and the lack of didactic resources in the classrooms [2] ". It may be true, for sure, but the environmental variables from the classroom are many and sometimes they are not considered.

Blended learning is of great importance to the training of professionals, given the context of virtual education and learning through interactive online technologies, these tools are necessary for a developing country like Ecuador, since the student shows autonomy and independence to acquire new knowledge [3]. Continuous or permanent learning implies breaking paradigms in the training to professionals in the biological sciences, since these become entrenched in the kinesthetic activities of the student, with experimentation and practice. In this sense, reasoning based on modeling becomes a powerful tool in the development of scientific process skills [4]. The allows us to structure new strategies in continuous learning, making use of innovative plans that adopt learning combined with digital resources to teach students [5]. Therefore, well-designed courses that include synchronous and asynchronous communication can be as effective as traditional classroom courses [6].

Blended learning combines face-to-face and online technology-based instruction [7], widely used in current university teaching [8]. Blended learning has been used with names such as hybrid, blended mode, flexible learning. It is a system that results in a learning environment consisting of a content, communication and constructive component [9]. So, research shows that blended learning is a ubiquitous definition [10]. The activities developed through this educational methodology provide students with various possibilities to do, create, research and experiment in a way that enhances the teaching-learning process for students and professionals in any area of science, technology, engineering and mathematics [11]. These students learn to interact, look for information, select activities, ask questions, and argue in a pertinent way the instructions given by the facilitator [12].

Although programs in the field can improve students' attitudes and knowledge of botanical science [13–15], with the application of adequate teaching methods, favorable results can be obtained in student attention and learning [16]. As well as the implementation of virtual tools that allow to carry out practices, training and evaluations of learning based on theoretical constructs of botanical science [17, 18].

Currently, with the invasion of technologies, classes must be flexible, allowing immediate alternatives in the learning process. Therefore, the activities should provide opportunities for students to acquire skills while building their knowledge [19]. Given that the blended learning environment is different from the traditional one, it is necessary to focus attention on techniques and strategies that meet the needs of the adult [20], in this sense, active learning methodologies based on research that can make students transit towards complex operations of thought [21].

The teaching of botanical science must be fundamental in the training of academics in the area of biological and related sciences, since their understanding allows us to reveal the impacts on biodiversity and mitigate threats to food security [22, 23]. For this, tools must be sought to improve the teaching and learning processes. However, very little is known about how mixed instruction affects the teaching process in adults. Therefore, the objective of this research was to apply the blended learning methodology in the training of professionals in the biological sciences using search and interpretation tools for the identification of plant specimens.

2 Theoretical Framework

2.1 Teaching of Botanical Science

In botanical education students can develop scientific competencies, providing solutions to real-life problems such as the making of herbaria, orchards, drawings, photographic and specimen collections. Seen in another way, people who study flora have an innate passion that transcends by visualizing other ecological relationships in their environment and this strengthens the evidence of role models as internal questions arise in students about the subject and the knowledge they possess. Botany being related to other sciences allows the development of critical thinking from its historical compilation and useful knowledge associated or not with the botanical environment, being a science that has allowed itself to be adapted to different pedagogical scenarios [24]. The typical botanical excursion is of great relevance since it allows to guide and direct actions within a course [25], however, mixed learning allows to carry out an autonomous in-house simulation, the same one that makes possible a subsequent diagnosis of the specimens and the environment where they live. The botanical description of medicinal plants and edible species are a great strategy to encourage and promote the environmental conservation of vulnerable species, since students distinguish their main uses and functions in the ecosystem [26].

2.2 Teaching with Digital Technology

The new way for students to develop basic and complex thinking operations is underpinned by research on learning theories. Several of the theories are: sociocultural theory based on the Vygotsky Proximal Development Zone, constructivist theory, connectivity theory, all these theories based on student-centered learning methodologies, making their role more protagonist in the process to produce and share knowledge and experiences. Technologies offer these students tools that can be used to represent their knowledge through mind facts, conceptual or mental maps, images, infographics, etc.

The successful incorporation of technologies in the teaching process may be subject to the context and needs of the process [27]. However, teaching practice is increasingly influenced by technologies, as society has a closer approach to mobile devices [28], tablets [29] and laptops, which constitute new challenges and opportunities for teachers. Digital technologies provide teachers with greater breadth in the use of different tools to support their educational practice [30] and students a greater approach in the management of data and information [31], which could favor the construction of knowledge.

2.3 Digital Virtual Tools as Means of Disseminating Knowledge

Digital resources have generated new communication environments understood as systems of construction, socialization and evaluation of knowledge within the teaching-learning process, but the innumerable applications of digital tools also open new fields of analysis in the digital literacy skills of teachers

In traditional education, the linear communication model is promoted where students are recipients of instructions and the teacher is the face-to-face transmitter that promotes communication of the activity [32]. Today we find a receiver-user (student) that transforms linear communication into a dynamic form of learning using digital tools. Consolidating in them the opportunities to promote their communication skills and presenting new open and shared knowledge according to their interests, that is, they went from being consumers of passive information to active creators of "prosumer" content [33].

The conjunction of education and digital tools have given way to a type of "participatory architecture" where the recipients-users build information about society and not about technologies [34]. The impulse of this culture of knowledge has been promoted under the perspective of the evolution of the web, ICT (Information and Communication Technologies) and the internet, presenting a new opportunity in online education and training "e-learning".

With the arrival of the internet, the drive from a linear one-way model and without updating (web 1.0) to its first approaches to the social and participatory web (web 2.0), where the virtual community appears, followed by the accessibility of information without a browser, is evident. (web 3.0), being undeniable to highlight the level of intervention and evolution in the linear communication model to circulate where new technologies provide value to these prosumers, facilitating access to content and resources (see Fig. 1).

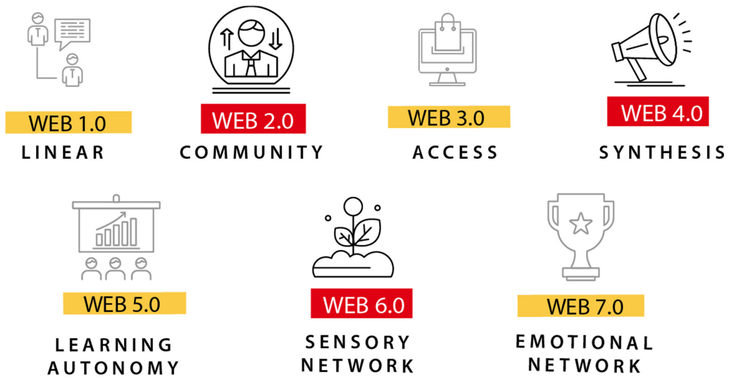

Fig. 1. Evolution of the website and its objectives. Authors' own elaboration.

However, the advantages that 7.0 (sensory network and emotional network) present in the new web updates, points out to a student-user that they have many more tools, but without the ability to be motivated to the learning process at levels of attention, effort and work. This scenario shows the dissociation of the objective in the teaching-learning process and the use of digital tools, where the technological process is adopted first to the pedagogical one, that is, we speak of an ICT teaching and not a process of learning with ICT.

The internet has built a new scenario where hypertextuality establishes connections between the different elements of information, expanding the types of representation of the text and with it, presents new demands in relation to understanding. The diversity of discourse presentation in education is shown in letters, but nowadays it is complemented as a story with multimedia resources (images, videos, audios), giving way to leaps to find what is necessary, ceasing to understand the words, to read alone. What interests us, persuades and attracts.

The challenge in education and the application of digital tools is not only in their implementation, but also in self-regulating new media literacy strategies where the user is a reader capable of issuing and generating information selection criteria using ICT tools, transformed the representation of space, time and society.

2.4 The Dry Forest Network (REBS)

The Dry Forest Network (REBS) is an initiative of the Institutional Program of Protective Forests "La Prosperina" of the Escuela Superior Politécnica del Litoral, in alliance with the Ministry of the Environment, Provincial Directorate of Guayas. It was created on February 18, 2020, with the aim of working together to plan prevention and conservation actions, share information, promote research regarding the biodiversity of dry forests; and execute activities related to the responsible and sustainable management of the natural resources of our forests.

It is made up of representatives of different Dry Forests of the Costa Region, professionals, students and the general public interested in the conservation, protection and research carried out in the coastal ecosystems of Ecuador; Its creation stems from the need to communicate to sensitize society to environmental problems, coordinate and execute joint actions in favor of the biodiversity of dry forests; as well as establishing strategic alliances to obtain external financing and execute research and/or linkage projects.

Among the programmed activities related to the transfer of knowledge, the members of the REBS considered through a cooperative work, the execution of the course of introduction to botany of vascular plants which arises due to the need to strengthen skills and abilities. in the identification of plants located in tropical dry forest areas.

3 Materials and Methods

The module of introduction to the botany of vascular plants present in the tropical dry forest taught by the REBS, incorporated aspects of anatomy, morphology, physiology of the plants, as well as tools for the identification of specimens, ecology and floristic composition. The classes were conducted through the Zoom platform with 27 participants from REBS. These students have previous experience in basic elements of botany, there were a total of 8 undergraduate students in the biological area with ages between 20–25 years and 16 professionals with ages between 26–70 years. The undergraduate students have passed the botany course and some of the professionals have previous experience in flora sampling.

The module was about 20 h divided into 10 h of synchronous communication and 10 h of autonomous practical work. The module was prepared with the application of new methods, with interaction with the participants and previous instructor training [35]. Practical exercises (PE) and comprehension activities (CA) were used. The virtual classes were five, segmented every 48 h. Classes contained, opening with remembrances, orientations, and activities like the game of roulette (https://wheelofnames.com/) to recreate an atmosphere of empathy. Starting from the simple and gradually to the complexity of the topics covered [36]. Then the facilitator gave the lecture, culminating with information on the activities and advice regarding the works that were used as practical and autonomous works, which were developed in classes with the help of the tutor and using technological tools: Cmaptools, Nubedepalabras.es, kvetnidiagram, Easelly, Plantidtools.

The training program prioritized five key themes: plant overview, vascular plant morphology and tools for identifying plant specimens, morphological identification of plant specimens, landscaping, and floristic composition. In each of the topics, two practical works were carried out and two autonomous tasks were sent.

The first topic contained the following activities: field file using elements of the observational technique (PE), conceptual map of plant morphology (PE), reflection of 100 words on the importance of Ecuadorian botany (CA) and search for two publications prioritizing the plant diversity of the tropical dry forest (CA).

Second topic: investigation of leaf shapes (PE), word cloud of the characteristics of the stem (PE), floral diagram and the particular characteristics of the plant family (CA) and, 250-word summary of the flora endemism with introduction, objectives, methodology, results and conclusions (CA).

Third topic: drawing of the morphology of a plant (PE), high-level questions and answers analyzing a scientific article from the BBC (PE), reflection of 80 words that shows the importance of studying this endemic species in the Tumbesian Region of the forest tropical dry (CA) e, identification of a species in digital herbarium (CA).

Fourth topic: advantages and disadvantages of digital herbaria and mobile apps (PE), infographic of the Raunkiær classification (PE), recognizing in five words five plant families highlighting their importance (CA), and botanical description of two plant species, evidencing its agricultural and ecological utility (CA).

Fifth topic: with a field card three describe species of their preferred diet (PE), a reflection of 80 words: What do you think of mycorrhizal networks and the adaptation processes of plant species in the tropical dry forest? (PE), create a species list of three typical Ecuadorian dishes (CA) and make six slides describing the plant species of your favorite dish (CA). The fulfillment of the activities was qualified by assigning categorical data 1 complies and 0 does not comply, to ask about the preference of the selected activity. The activities of the virtual classes and the level of complexity were established without the prior knowledge of the participant. At the end of the training, the students took a multiple-choice test, which was developed on the Quizizz platform to learn about the new learning acquired during the process.

Finally, a questionnaire of perceptions regarding the module was sent to the emails of each student. They were asked to rate on a scale of 1 (minimum) to 5 (maximum) the content, the didactic process, the planning and organization of the introductory module to the basic botany of vascular plants present in the tropical dry forest.

The quantitative data collected from the didactic activities were analyzed using the InfoStat v. Software. 1.2.0 (2017), where the analysis of variance (ANOVA) and the Tukey test were performed with p values <0.05 for the variables studied. In addition, a correspondence analysis was applied on the results of categorical data of the different activities.

4 Results

Of the 27 participants registered prior to the start of the course, 24 of them completed, completing all activities, while three of them withdrew during the course.

To know the participation of the students in the autonomous and previous works, of the five classes under the blended learning modality, the data were distributed according to their level of categorical complexity (low, medium and high) and delivery. The works with the highest participation were: a reflection of 50 words, identification of the shape of the leaf, a drawing, the advantages and disadvantages between herbaria and mobile applications, and creating a list of species of a typical dish in Table 1.

Table 1. Didactic content of the virtual sections of the module.

Autonomous and previous works	Virtual classes	Complexity	Number
1. Observation sheet	1st	L	19
2. Conceptual map	1st	H	8
3. 50 word reflection	1st	L	20*
4. Critical transfer of scientific article	1st	M	10
5. Leaf shape ID	2nd	L	23*
6. Word cloud	2nd	M	13
7. Floral diagram	2nd	H	15
8. Specialized article	2nd	M	11
9. Botanical drawing	3rd	L	19*
10. Prosumer role of questions and answers	3rd	H	8
11. 80 word reflection	3rd	M	14
12. Search for species in digital herbaria	3rd	H	13
13. Advantages and disadvantages of digital herbs VS Apps	4th	M	19*
14. Raunkiær classification infographic	4th	H	9
15. Recognition of main plant families	4th	M	9
16. Botanical description of Agricultural and Ecological species	4th	L	18
17. Field tab	5th	M	10
18. Mycorrhizal networks video	5th	L	17
19. Create species list of the typical dish	5th	H	23*
20. Slides of the species present in the favorite dish	5th	H	5

* Works with more participants, L = Low, M = Medium, H = High, Own elaboration, 2020

To evaluate the activities elaborated by the participants, a statistical analysis of correspondences was made, taking as base of classification the ages according to they are young adults (20–40 years), mature adults (40–60 years) and older (more than 60 years). The data reveal that there is a greater participation of mature and older adults, in the realization of autonomous and practical work (see Fig. 2). In addition, the older adults were the ones who developed the activities that demanded the highest level of cognitive complexity (such as concept map, flower diagram, prosumer role, search for herbarium species, creating species list and slides of the species present in the typical dish). These results can be considered as a product of the academic level of mature and older adults, for being all third and fourth level professionals. In addition, the older adults have experience in sampling flora in different regions of the country. Meanwhile, the young adults are all undergraduate students and despite having a greater approach to technologies, they were not able to integrate these experiences in the presentation of well-prepared papers. While the digital immigrants with the follow-up of the teacher were able to elaborate ingenious tasks, product of their imagination, complemented with the technological tools.

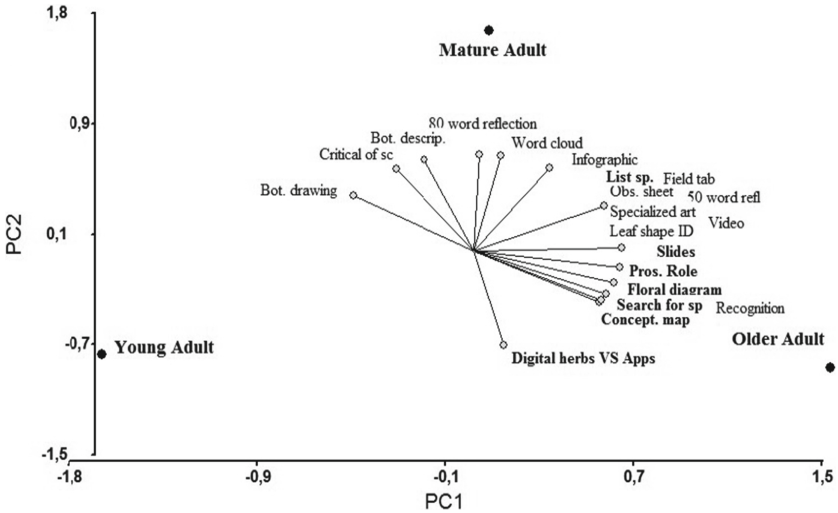

Fig. 2. Statistical analysis of correspondences to determine the degree of participation in the different constructivist activities, considering the ages of the participants and classifying them into young adults (20–40 years), mature adults (40–60 years), adults older than 60 years. Authors' own elaboration.

The evidence collected at the level of complexity has significant differences for low-level activities (see Fig. 3), while medium and high-level activities did not differ. Therefore, the application of the blended learning methodology allows the participants to develop basic operations of thought, thus achieving a conceptual understanding of the basic contents of the botany of vascular plants.

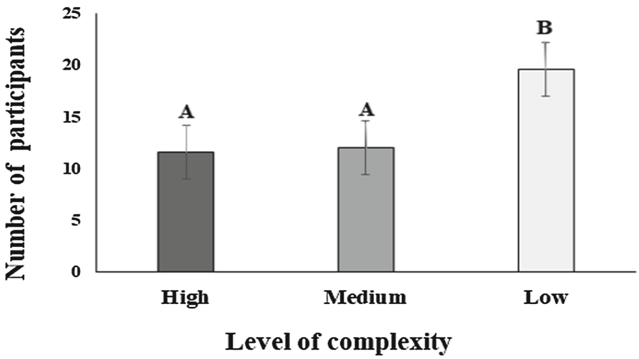

Fig. 3. Acceptance of the participants according to the level of complexity of the performed activities. Different letters on the bars indicate the significant statistical differences according to the Tukey test ($p < 0.05$). Authors' own elaboration.

On the other hand, if we consider that the results are true, we can infer that in the different virtual classes through the application of the blended learning methodology the students presented discrepancies in the development of their activities, showing greater interest in identifying the types and shapes of leaves of plant specimens. (see Fig. 4).

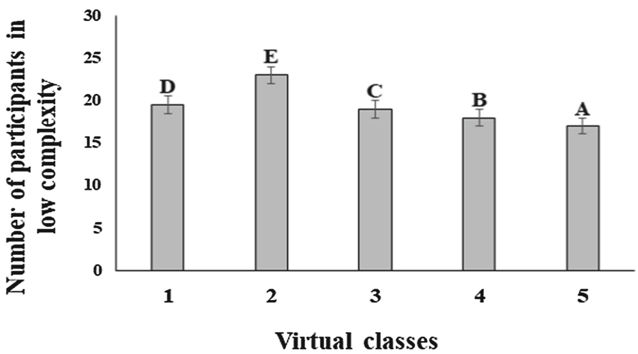

Fig. 4. Low complexity activities of virtual blended learning classes. Different letters on the bars indicate the significant statistical differences according to the Tukey test ($p < 0.05$). Authors' own elaboration.

At a qualitative level, the virtual module met the proposed objectives and allowed professionals to develop new skills, such as the botanical identification of vascular plants. In addition, the participants rated the academic content, activity methodologies and general organization of the virtual module very well. Most of the academic performance was acceptable above 50% of the minimum fulfillment of the activities to achieve a certificate of participation and approval Table 2. Participants who performed more activity received a certificate of honor, since it exceeded expectations of the initial policies of the module.

Table 2. Didactic content of the virtual sections of the module

Participants	Sex	Qualification %
1	M	50
2	M	50
3	F	65
4*	F	100
5	M	55
6	M	60
7	M	50
8*	M	85
9	M	60
10	F	60
11	F	50
12	M	60
13	M	50
14	M	55
15	F	50
16*	F	95
17	F	50
18	M	55
19	F	55
20	F	50
21	M	50
22	M	50
23	F	55
24	M	50

*Participants with the best scores, M = Male, F = Female

Activity Comments: "Slides of the species present in the favorite dish"

"Finally, it is important to understand the origin of our food, some of which are our favorites, to know which family they belong to and their gender. In addition, it is very helpful to know the family of vegetables that we consume daily because in that way we know the nutritional benefits that it brings us and as a result we would have a balanced diet and very beneficial in nutrients."

"Creole crabs in their preparation include 5 families of vegetables, corresponding to 7 genera and 8 species, being from the AMARYLLIDACEAE families with one genus and two species of the APIACEAE family with two genera and the other three families. They have one representative each. The vegetables present in the preparation of Creole crabs are from different types of ecosystems, being these from tropical dry forest of the western coast or region and the Andean highlands or central regions."

"The identification of the characteristics at the family level by reviewing the leaves, the stems, the fruits, I consider to be a very important starting point, which with practice allows developing at the field level the experience to be able to identify plant species."

Students give an important rating to the activity of describing the species present in their favorite typical dish, belonging to their locality. This activity has allowed them to put into practice the learning acquired in the module, and taxonomically identify the vascular plants that belong according to their preferred food.

The participants find it interesting that the nutritional benefits provided by each of the vegetables consumed during their diet are also included within the systematic identifications, which can help them differentiate the nutritional requirements of their diets. Likewise, they consider the diversity of plants that they may have in their typical dish and contrast the specimens with other ecosystems belonging to the different regions of Ecuador.

Regarding the perception's surveys in Fig. 5, a total of 18 multiple-choice questions were asked where the students rated on a scale of 1 (minimum) to 5 (maximum), planning, the teaching process and the facilitator. From the results obtained, it was evident that over 90% consider the development of the training relevant (maximum grade). From the observations presented in the comments to improve, the participants consider that more interaction should be allowed, that means, develop more group or collaborative work.

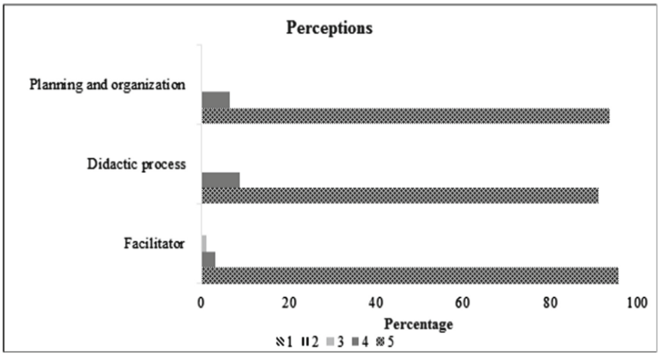

Fig. 5. Evaluation results of perception by participants. Authors' own elaboration.

5 Discussion

In this study, the mixed learning modality was applied to a training module about the introduction of vascular plants of the tropical dry forest. The results shown the active participation of the students in several of the proposed activities. This same type of achievement has been shown in the results of the university students in STEM education, when mixed modality where applied. [37, 38].

In the present study, it was possible to show that the application of technologies in the area of botany can encourage to the students to become interested by doing various activities that will help them to strengthen their skills and build their knowledge. The use of technological resources is increasingly used by students in their learning process [39].

During the development of the module, a low dropout rate was evident, so there is a positive effect of the mixed modality, as described in a previous study, where it is shown that ICT provide to the trainers and students a learning environment that stimulates the teaching process to remain successful until completion [40, 41]. In general, studies using human beings leads to very specific results because many factors may affect human performance. For example, local culture and personal context may affect reasoning, understanding, and feelings. So, the same aspects tested may find different results, for example, in management students, the application of blended learning increased the dropout rate [42].

Due the activities developed by the participants, from the different levels of complexity: low, medium and high, it is possible that they achieve a conceptual understanding of the aspects related to the basic principles of botany. This shows that students can achieve basic and complex thinking operations (recognize, remember, apply, analyze, evaluate and create) of Bloom's taxonomy [43]. For the dynamic and interactive nature that technologies provide could help students reinforce their learning about the general aspects of biological science [44–47].

The scores obtained by the presentation of the different works, evidence that many of the participants could successfully passed the training. The module design has allowed the activities to being innovative, motivating to the students in their development and presentation. Therefore, in order to increase interest in botany, it is necessary to focus on the material that is designed in the training [48], integrating innovative strategies that allow harmonizing the curricular contents [49, 50].

6 Conclusions

Blended learning is an effective learning modality that helps as a complement to the construction of knowledge for academics in the biological sciences, since it enables an appropriate space for people to discuss, learn and provide useful feedback in the professional field of science botany. With the application of the blended learning modality, the participants externalized a perception of complacency and highlighted the high professional level of the facilitator and the coordinators of the virtual module, making this an ideal setting for the future training of validated environmental interpreters in the field of botany by REBS, academic and government institutions. In conclusion, this research provides useful information on the applicability of blended teaching in the area of biological sciences, specifically in systematic botany. However, it is important to continue with studies where these blended learning methodologies are applied in other branches of biology to integrate and complement the results. New studies should include activities such as gamification or serious games, to challenge to the participants in a constructivist learning environment.

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