An Online Pattern Recognition-Oriented Workshop to Promote Interest among Undergraduate Students in How Mathematical Principles Could Be Applied within Veterinary Science

Gabriel Molina-Cuasapaz 1, Sofía de Janon 2, Marco Larrea-Álvarez 3,*, Esteban Fernández-Moreira 3,*, Karen Loaiza 4, Miroslava Šefcová 4, David Ayala-Velasteguí 4, Karla Mena 5, Christian Vinueza Burgos 2, and David Ortega-Paredes 2,3,4,*

Abstract: Knowing the importance of mathematics and its relationship with veterinary medicine plays an important role for students. To promote interest in this relationship, we developed the workshop “Math in Nature” that utilizes the surrounding environment for stimulating pattern-recognition and observational skills. It consisted of four sections: A talk by a professional researcher, a question-and-answer session, a mathematical pattern identification session, and a discussion of the ideas proposed by students. The effectiveness of the program to raise interest in mathematics was evaluated using a questionnaire applied before and after the workshop. Following the course, a higher number of students agreed with the fact that biological phenomena can be explained and predicted by applying mathematics, and that it is possible to identify mathematical patterns in living beings. However, the students’ perspectives regarding the importance of mathematics in their careers, as well as their interest in deepening their mathematical knowledge, did not change. Arguably, “Math in Nature” could have exerted a positive effect on the students’ interest in mathematics. We thus recommend the application of similar workshops to improve interests and skills in relevant subjects among undergraduate students.

Keywords: observational skills; interest in mathematics; veterinary medicine students; online workshop

1. Introduction

Observational, technical, and analytical skills are necessary for veterinary physicians [1,2]. For professional praxis, for instance, observation as well as pattern recognition skills within the environment are important for detecting and treating relevant diseases and conditions [3,4]. Moreover, these skills are relevant as the environment, along with demographic factors, influences animal health [5]. Recognizing patterns in nature is crucial for proposing novel hypotheses and applications, including new diagnostic strategies [6–8]. This could be useful for understanding the development of diseases and its relationship between animals, humans, and the environment, which is regarded as the basis of the One Health approach [9].
Patterns, in particular, have been considered as the outward manifestation of an ordered structure resulting from the associations of its constituents [10]. The mathematical understanding of patterns is fundamental in the daily practice of veterinary medicine. For example, mathematics is used in various aspects of veterinary medicine, including drug dosage and epidemiology [11–13]. Furthermore, understanding mathematics helps veterinarians to develop applications such as new epidemiological surveillance models and risk assessments; it also contributes to decision making with regard to epidemic pathologies [5]. Extensive research has produced a compilation of mathematical models [14–16] that could be explored with positive results [10,17]. The use of fractal mathematics, for instance, could be utilized to describe the structure of circulatory and respiratory systems [18,19]. It has also been argued that small disturbances in fractal patterns are related to the initial state of tumor formation [20,21]. Likewise, fractal patterns have been employed to develop low-cost and less-invasive methods for cancer detection and management [22]. Such mathematical advances are not commonly included in Veterinary Medicine programs [23]. Veterinary students might not actively be encouraged to exploit mathematics for explaining and understanding natural phenomena, which could have a negative impact on their interest toward its uses and applications.

Workshops involving hands-on and active strategies have been demonstrated to have a positive effect on students’ knowledge, confidence, interest, and procedural skills regarding STEM (science, technology, engineering, and mathematics) fields [24]. Events focused on science communication, including the aforementioned strategies, are considered useful for enhancing interest in STEM careers among students. Furthermore, these events allow for the development of improved skills for science divulgation, which is fundamental for professionals working in these disciplines [25]. Undoubtedly, the application of these programs can be considered valuable contributions to undergraduate curricula. Previous results have shown that these workshops are indeed useful for improving interest in crucial skills among students [24–26]. Hence, we hypothesized that developing a workshop, where students could strengthen pattern recognition and observational skills, will be more likely to improve interest in mathematics and its applications in veterinary sciences. Therefore, we designed and tested a seminar called “Math in Nature”, which makes use of the surrounding environment for improving mathematical interest among students of Veterinary Medicine.

2. Materials and Methods

2.1. Target Population

The “Math in Nature” workshop was tested among undergraduate students enrolled in the Biology course of the School of Veterinary Medicine at the Central University of Ecuador in Quito, and among those following the logic Reasoning Course of the School of Veterinary Medicine at the Technical University of Cotopaxi in Latacunga, Ecuador. The program was carried out in April and October of 2020. A total of 120 students participated in the program; the workshop was offered as an extra-curricular activity with the aim of complementing the mathematical courses taught during the introductory semester. The workshop bestowed no points or credits to participants to avoid potential conflicts of interest. This was explicitly communicated to them at the beginning of the workshop.

2.2. Evaluation Method

In order to determine the usefulness of the workshop in increasing mathematical interest, an online survey, developed using Google Forms (Figure S1), was employed to assess attitudes towards mathematics in students before and after their participation in the workshop. Individuals were asked to rate separate statements depending on whether they agreed or disagreed with them, ranging from 1 (strongly disagree) to 5 (strongly agree). In general, questions dealt with the biological applications of mathematics as well as the identification of mathematically describable patterns in nature. Moreover, students were asked about their opinions regarding the importance of mathematics in their professional
careers as well as their intentions of expanding mathematical knowledge. Participation was voluntary, anonymous, and ungraded.

2.3. Program Overview

This study was carried out at the School of Veterinary Medicine of the Central University of Ecuador in Quito and at the School of Veterinary Medicine of the Technical University of Cotopaxi in Latacunga, Ecuador. The “Math in Nature” workshop consisted of four sections. First, an introductory talk was dictated by a science, technology, engineering, and mathematics (STEM) professional; this talk discussed topics such as the Fibonacci progression, golden ratio (phi number), hexagons in nature, fractal geometry, and Benford’s law. For each topic, the host placed emphasis on the practical applications in biology and medicine (Supplementary Materials PPT S1). Each topic was discussed for approximately 50 min. Second, a session of questions and answers (Q&A) was held with the intention of discussing particular topics of the aforementioned talk. Third, participants were encouraged to observe their surrounding environment (garden, local park, etc.) in order to identify patterns. Then, such patterns had to be associated with the mathematical models discussed during the workshop. Participants were given one week to complete the task. Next, they were divided into 10 groups and were encouraged to share their findings with others. Finally, each group had to select three observations and discuss them in a five-minute presentation exhibited during the video session.

2.4. Statistical Analysis

Results from the pre- and post-workshop questionnaires were compared using Fisher’s exact test to detect significant differences between sampling points. The level of significance was set at $p = 0.05$. All analyses were carried out using the R [27].

3. Results

One hundred and twenty students took part in the workshop, fifty-nine of whom were enrolled in the Biology course taught at the Central University of Ecuador, while sixty-one belonged to the Logic Reasoning course from the Technical University of Cotopaxi. Students did show interest in mathematics before the workshop. Much of the information that the students possessed regarding the application of mathematics and mathematical patterns in nature came from documentaries and popular tv shows, as was reflected by the questions posed during the Q&A session. Examples included the patterns on zebras, the shape of spiderwebs, and the movement of herds in groups.

The observational exercise, carried out in groups, produced various applications associated with the introductory talk and the patterns identified by participants. For instance, the mathematical patterns in the brain and intestine of guinea pigs were cited. Moreover, the detection of fractal symmetry in video games as well as the identification of unique patterns in the snouts of neighborhood dogs were provided as examples.

The perspectives of participants toward the statements included in the questionnaire are shown in Table 1. Before the workshop, some participants agreed and other disagreed with the statements. However, after taking part in the course, individuals held more positive attitudes regarding the use of mathematics for explaining biological phenomena. Similarly, students were more positive towards the identification of mathematical patterns in living beings. On the other hand, the attitudes towards the remaining two statements did not vary between sampling points. Nevertheless, the data showed that not only were the majority of the surveyed students aware of the importance of mathematics for a veterinarian, but also that they wanted to improve their understanding of mathematics.
### Table 1. Attitudes of veterinary students towards mathematics.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Assessment</th>
<th>Agreement Level (Counts, n = 120)</th>
<th>p-Value a</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Biological phenomena can be explained and predicted by applying mathematics</td>
<td>Pre-workshop</td>
<td>1. Strongly Disagree 5</td>
<td>2. Disagree 10</td>
</tr>
<tr>
<td></td>
<td>Post-workshop</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>2. It is possible to identify mathematical patterns in living beings</td>
<td>Pre-workshop</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Post-workshop</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>3. Mathematics are important for my career as a veterinarian</td>
<td>Pre-workshop</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Post-workshop</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>4. I want to deepen my knowledge in mathematics</td>
<td>Pre-workshop</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Post-workshop</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Post-workshop</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

* a p-values for determining differences between sample points were calculated using Fisher’s test.

### 4. Discussion

A proper understanding of biological phenomena requires the understanding of patterns [10], which entails a basic knowledge of mathematics [28]. Moreover, observational skills are not only considered critical for applying the scientific method, but are also fundamental for a researcher to make in-depth observations when collecting data [1]. The workshop “Math in Nature” sought to integrate these two skills into a course aimed at promoting to Veterinary Medicine freshmen an interest in how mathematical principles could be constructively applied within veterinary science.

Students proved to be interested in mathematics and its relationship with biological phenomena, which was observed not only by the questions posed during the Q&A session, but also by the presentations carried out during the video session. Questions were related to topics that students learned from television, including the mimicry observed in various animals, the black-and-white stripes of zebras, or the development of vaccines. Moreover, they not only showed interest in the use of fractal models to diagnose cancer, but also in their potential application in veterinary sciences. The revealed outcomes indicated that after attending the workshop, participants improved their awareness regarding the link between biology and mathematics. Previous studies have shown that similar workshops exert a positive influence regarding interest in mathematics among students [29–31], thus demonstrating the importance and significance of these seminars.

Understanding mathematics is essential for veterinary researchers [32,33]. However, participants were unable to identify the application of mathematics in veterinary medicine, despite their marked agreement with its importance for research, which was observed even before they took part in the workshop.

Previous research has demonstrated various relationships between knowledge and interest [34–36]. On the one hand, promoting interest has been shown to contribute to a more engaged and motivated learning experience; namely, interest promotes knowledge [34]. On the other hand, it has been proposed that interest is not the cause but the consequence of a process of learning [35]. According to our data, it could be argued that the positive attitudes registered after the workshop might indeed have been associated with the information gained from the workshop, especially regarding the first two statements of the questionnaire that dealt with the application of mathematics for explaining and predicting biological phenomena as well as the identification of mathematical patterns in living beings. This highlights the potential use of these workshops to increase interest about crucial subjects (i.e., mathematics) and their applications in veterinary sciences. No differences were observed regarding the last two statements, which dealt with the importance of mathematics in veterinary medicine. We strongly believe that mathematical courses taught to veterinary students must include information about mathematical principles and their use in animal research. In addition, interdisciplinary work, especially with mathemati-
It has been argued that the interest in science among students could be ameliorated by 'hands-on' activities carried out in nature [39]. Our results are in line with the aforementioned suggestion, as the present workshop provided such an experience to participants. Students were encouraged to gather data from their surroundings and to provide potential relationships to mathematical models; this methodology allowed them to recognize mathematics not only for its importance in describing and predicting biological phenomena, but also for its applications in veterinary sciences. For instance, mathematical models permit to study the dynamics of viruses and bacteria [40–42]. Mathematics also allows to determine the relationship between age and weight, which facilitates the designing of mating and slaughter strategies [43]. Moreover, deep learning algorithms could potentially help veterinarians to detect active tumor regions [44]. Therefore, we strongly recommend “Math in Nature” to be considered in Veterinary Medicine curricula. Furthermore, we suggest that follow-up workshops should be designed to include relevant topics. For example, the application of similar workshops could be utilized to improve the perspectives of students toward genetics, COVID-19, or antibiotic resistance. This arises as an important option as recent research showed that undergraduate students were not necessarily familiar with these subjects [45–48].

This study presents some limitations, which could not be tackled due to time and funding. Firstly, this investigation did not attempt to measure knowledge of mathematics, it focused only on attitudes. Further workshops must consider knowledge and perspectives with the aim of assessing the extent of knowledge, attitudes, and perspectives (KAPs) among participants. Secondly, the methodology used herein must be refined in order to determine if the measured interest was indeed acquired during the workshop, or if it was related to preconceived concepts. Moreover, the use of anonymous responses limited the ability of evaluating the responses by individual, thus data were analyzed at group level. Finally, further workshops must utilize randomized sampling as well as control groups for comparison [29], and also must include larger populations and longer time periods for analysis.

5. Conclusions

In this study, we have proposed a seminar that permits students to improve their interest in how mathematical principles could be applied in veterinary science. Students interacted with a professional researcher, posed questions as well as discussed answers in groups, identified mathematical patterns using their surroundings, and presented videos with ideas of their own. The goal of the workshop was to promote skills that are not commonly discussed in traditional veterinary curricula with the goal of ameliorating their interest in mathematics. The outcomes suggest that the course could have exerted a positive influence on the students’ attitudes as more of them not only adhered to the concept that mathematical principles could help explain and predict biological phenomena, but also to the fact that mathematical patterns could be identified in living beings. Nevertheless, the students’ perspectives with regard to the importance of such principles for their careers, as well as their interest in advancing mathematical knowledge, was not altered. Undoubtedly, more effort is needed to optimize the methodology, so it could be integrated appropriately into educational programs. These findings could serve as a foundation for developing other workshops aimed at improving interest in key aspects of science among the general undergraduate student population.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14116768/s1, Figure S1: questionnaire; PPT S1: lecture.

Funding: This research received no external funding.

Institutional Review Board Statement: The ethics approval has been waived by the Ethics Committee in the Central University of Ecuador, and informed consent has been obtained from all participants.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: The authors want to thank freshmen of 2020 at the Veterinary faculty of the Central University of Ecuador and the School of Agricultural and Natural Resources of the Technical University of Cotopaxi.

Conflicts of Interest: The authors declare no conflict of interest.

References


