European Journal of Agricultural and Rural Education (EJARE)
Available Online at: https://www.scholarzest.com
Vol. 4 No. 8, August 2023
ISSN: 2660-5643

A STRATEGY TO MOTIVATE FRESHMAN AGRONOMY STUDENTS FOR THE USE OF APPLIED COMPUTING TECHNOLOGY

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Article history:
Received: 14th June 2023
Accepted: 11th July 2023
Published: 20th July 2023

Abstract:
This work objective is to propose a class activity that combines technological and agricultural aspects with the purpose of motivating freshmen students of agronomy to think about the use of computing technology applications in the agricultural area. The methodology was based on a 2-hour practical class in a computer lab where the students, most with no previous knowledge, use mathematical processing software to generate a color map of the temperature variation inside a greenhouse. This article shows step by step activity design, which can facilitate its reproduction even by professors without knowledge in this area of computing. Finally, this work proves qualitatively and quantitatively that its results were satisfactory to motivate the students to learn more about applied technology.

Keywords: Mathematical processing, temperature map, Greenhouse, Education

1.INTRODUCTION

This work focuses on the technological education for agricultural students and uses a strategy that introduces technological aspects associated with the solution of a concrete agricultural problem. Thus, one area motivated studies in the other and, in addition, the students were encouraged to motivate others in a collaborative process, which created virtuous processes of learning and involvement that benefit the entire class. The proposal is a 2-hour practical session in a computing laboratory where the students use Matlab, which is a mathematical processing software, or another similar, to generate a color map representing the temperature variation in different points inside a greenhouse, connecting computing technology with an agricultural question.

The Matlab is a programming language focused on mathematical computation with simple commands based on human language statements, allowing the user to define which mathematical operations or processes must be done, without having to worry about complex algorithmic details. Besides, it has a simple and intuitive software integrated development environment (IDE) that combines, in one area, all the basic tools needed for a software project development, such as code writing editor, real-time program interpreter and a special window for commands running and interaction with users. It tends to simplify the design of applied software to solve problems associated with specific fields such as statistics, curve fitting, image processing, simulation, finances, automation and control, data science, matrix operations, data acquisition, graphics, etc. The Matlab is advanced software with professional features, but the license cost may be an access barrier for some groups. However, there are other mathematical processing software that are very similar to the Matlab but which are free, such as Scilab and Octave, thus, this work used the Octave and, from this point, will associate the presented experiments specifically with this specific software, but Matlab and Octave run them well.

A problem associated with this work execution may be the lack of instructional skills about computing systems [1, 2], and another problem may be the definition of an educational strategy to introduce technological concepts in the classroom with an effective and motivational learning [3]. Because of these problems, this work proposes an activity using only by a few Octave commands that are easy to understand, even by instructors and students without previous knowledge, and besides, it proposes a teaching methodology based on a logical sequence.

The agricultural problem selected for this work is the temperature variability, but this work could use other environmental parameters that influence the plant life inside a greenhouse, such as relative humidity, radiation, soil moisture content, among others. Temperature is an attractive phenomenon for educational purposes because it allows an easy measurement, is an intuitive physical concept and can present significant variations inside a greenhouse.

The temperature can vary significantly from a part to another inside a greenhouse, being influenced by on factors such as the external weather, greenhouse location, orientation, cover material, etc among others [4]. In this context, there are practical studies [5, 6, 7] that verified simultaneously the horizontal temperature variation at different points inside greenhouses that presented variations in the range of 3.5 ºC to 7.0 ºC. Although other experiments could present different values under other conditions, these ranges give us a quantitative reference. An optimum temperature range ensures ideal thermal conditions for the plant development [8, 9], which depends on the plant type and its growth stage. For instance, the optimum rice temperature range varies from 20 ºC to 35 ºC [10, 11], while mango trees have a smaller range varying only from 24 ºC to 27 ºC [12]. A temperature variation up to 7 ºC may exert a critical influence on the plants according to their location in the greenhouse, which occurs mainly for plants with a short temperature range. Therefore, the knowledge of the thermal variations inside a greenhouse allows a better planning of its use and a better crop management.

This work presents a methodology based on fundamental concepts to introduce the greenhouse horizontal grid for the temperature measurement and the data processing. In the next section, it analyzes the students' perception about their learning and motivation about the technological concepts presented.

2. METHODS

This work methodology was based on a two-hour practicum aimed at freshmen students of agronomy without previous significant knowledge of computing and greenhouse temperature variation, and it was composed of two parts:

1. The teaching of the greenhouse horizontal grid and temperature measurement.
2. The teaching of Octave software usage for the temperature data processing, followed by a survey to study the students' perception of their own learning process and motivation.

The practicum aim was not to make the students experts on the presented subjects, but to verify the hypotheses that a short time hands-on activity would be sufficient to motivate students to think more concretely about the use of applied technologies in the agricultural area.

2.1 The greenhouse horizontal grid and temperature measurement

Figure 1 shows the first teaching step was to divide the greenhouse surface area as a grid to create measurement zones, called *grid cells*. The cells number defines the system *resolution*, which represents the image details level, and the representation will be more detailed (fine) as the resolution increase. A high resolution is desirable, but when this occurs, the number of cells increases and it might make the measurement harder and therefore, the operator must establish a satisfactory relation between the number of cells and work feasibility.

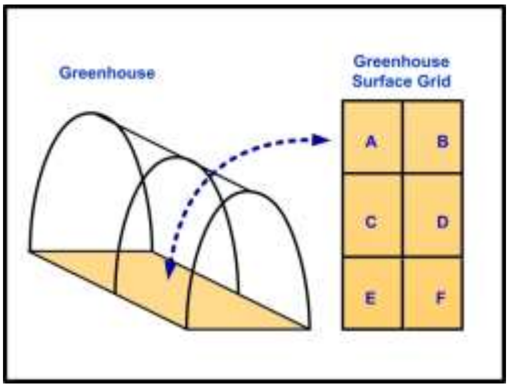

Figure 1. Example of a greenhouse surface division in cells.

For this practicum the students collected data in greenhouse with a length of 5 m and a width of 10 m, which was divided it into a grid with 16 rectangular cells, with 1.25 x 2.5 m each. After each measurement, the student must write the cell temperature value in a form and later input all values in a computer for processing. Figure 2 shows the form model used in this work, which is already filled with real data (blue color). Each greenhouse cell received an exclusive name composed of letters from "A" to "P" to allow their identification, and the operator noted each temperature value above the cell letter name. Besides, the form includes a heading with the operator's name, the greenhouse identification, the measurements date and time, and the measurement height.

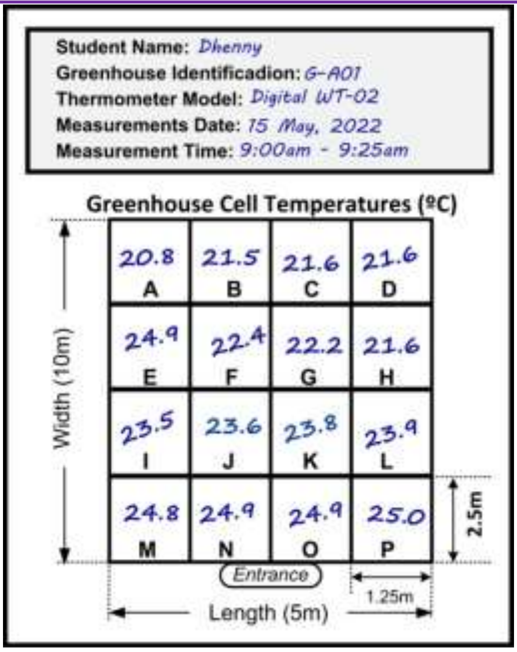

Figure 2. example of form to write-down the measured temperatures.

Since temperature is a dynamic variable, during the day a longer data gathering time may introduces a larger error due to the sun's positioning over the greenhouse. Thus, a higher grid resolution could slow down the data collection, inducing an unrealistic relation among the cell temperatures.

As the temperature is a dynamic variable, a longer data collection time during the day can introduce an inconsistency in the measurements due to the variation of the position of the sun over the greenhouse. Thus, higher grid resolution can generate better analysis, but it can also delay data collection and consequently induce an unrealistic relationship between cell temperatures.

The human operators require a time to move from the center of a cell to another and after they need a time to take effectively the measurement, which influences the total measurement time.

The operator must position the sensor close to the cell center and keep it protected from that solar radiation that influences its operational behavior. Besides, the operator must fix the sensor at a height in a range between 1.2 m and 2.0 m [13, 14, 15] to avoid vertical temperature gradients that represent temperature variations that may occur naturally in the layers closer to the ground, under this range.

The operator's moving and sensor positioning require a period that depends on each operator's experience. However, after the correct sensor positioning, it is necessary to wait for a period called *sensor response time* that determines the minimum period required by the sensor to detect effectively a phenomenon variation [16]. It means that after the positioning, the operator must wait a response time period and then write-down the measured temperature value.

Sensor manufacturers should specify the response time of their thermometer, but it doesn't always occur. For practical approaches, the response time of temperature sensors can vary in a range from milliseconds [17] up to some tens of seconds [18], and therefore, when lacking information, this work suggests the adoption of a relatively long period, such as one minute.

This work used the digital thermometer model "WT-02" whose technical manual didn't specify the response time. However, it informs the instrument uses a traditional temperature sensor type NTC that usually presents a typical maximum response time at about 15 seconds. The WT-02 sensor has a cover metallic protection to allow its insertion in different mediums, but it may influence the repose time. So, this work fixed empirically the response time at one minute to ensure a very large margin of safety, and the data collection took 25 minutes, which is satisfactory for a simple educational experiment, assuming a minimal temperature variation in this period.

An in-depth study on temperature measurement techniques and its physical variation in greenhouses can require many hours of classes, so this work presented these topics in a summarized way in the first part class and at about 30 minutes. The used educational strategy was more informative than formative, but it was enough to allow satisfactory class continuity with the practical activities. We have empirically observed that these topics promote curiosity among the students and thus, depending on the students' expectations, the instructor may schedule another longer later class to teach and analyses details about them. Other teaching goals could be added to the experiment, such as safety standards while working under hot conditions, instrumentation handling or heat exchange basics, according to the learning outcomes for the course in which the activity is embedded.

2.2 The temperature data processing with Octave

Assuming no previous knowledge about the Octave software, the first part of the practicum consists of an exploration of the IDE windows (panels), which are shown in figure 3 [19, 20] and detailed as:

1. The Command Window: it serves for a direct interaction with the user, data entering and commands, and besides visualizing the processing result. At each line beginning in this window appear automatically two "greater than" symbols that serve only as a line position reference in the window.
2. The Work Directory: It shows the current work directory and the students mustn't forget to set it according to their use directory, where they stored their data.
3. The Workspace Window: It shows all the input and output variables created during the software operation and serves as a guide for the users' data verification.

Figure 3. The main Octave windows (panels).

Before the Octave windows presentation, it is important to associate the temperature data with a mathematical matrix because it will be the data structure used in the Octave. Figure 4(a) exemplifies the mathematical representation of a generic matrix called *A* and structured with *m* rows and *n* columns, while figure 4(b) shows a mathematical matrix called *dt* that was filled with the real temperature data from the figure 2.

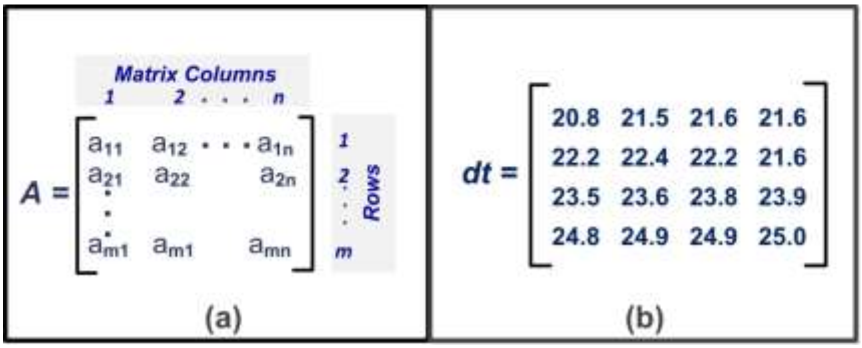

Figure 4. (a) Mathematical matrix structure, and (b) a matrix with the temperature data.

Figure 5 shows how the students can input the figure 60 matrix in the Octave through the Command window. To follow this figure, they must type the matrix name *dt* followed by the "equal" symbol and a "left bracket" to express that it is the beginning of the matrix input. Subsequently, the user must type each data line and at the end of each one to press "Enter". The last line end requires "right bracket" symbol to express the matrix data entry ending.

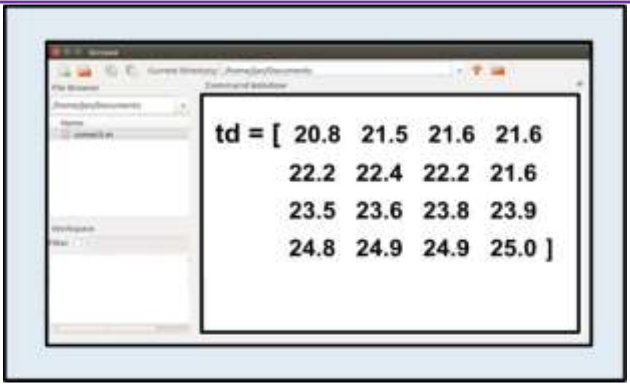

Figure 5. Temperature data input with a matrix structure in the Octave command window.

ASubsequently, the class focuses on the greenhouse temperatures map design, which is a relatively simple process that requires only three Octave commands [19, 21], which are *imagesc, colormap,* and *colorbar*.

After the students have typed the *dt* matrix data, they uses the command *imagesc(dt)* to generate automatically a new special window with a gridded block that displays each *dt* matrix data with a specific color (Figure 6). Sometimes the image window appears in the background and so it is necessary to minimize the Octave screen or others so that the image appears.

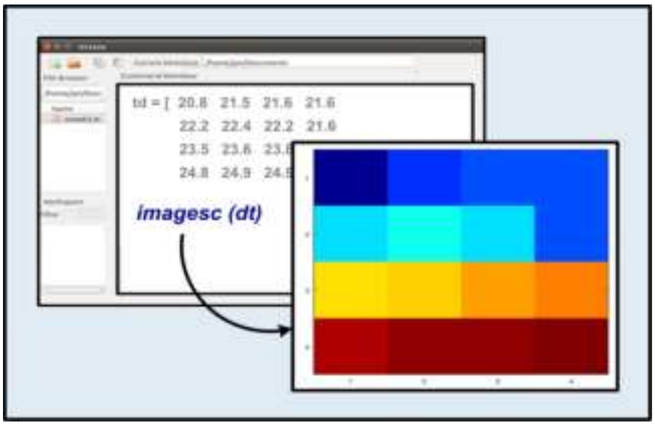

Figure 6. The color temperature map generated with the imagesc command

Figure 7 shows the second command, which is called *colormap* and is used after the *imagesc* command to define a specific color map scheme through the syntax *colormap (sch),* where *sch* is the color scheme name.

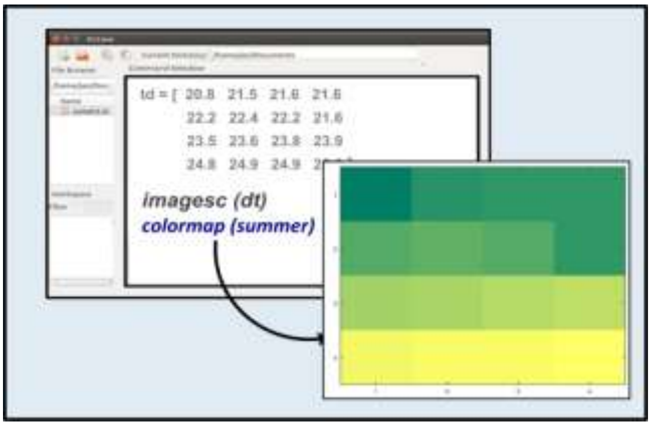

Figure 7. The colormap command to define a specific color scheme.

Figure 6 map was generated with an automatic color scheme, but figure 7 shows the user can change the color scheme with a Octave command called *colormap*, after the *imagesc* command. This command uses the syntax *colormap (sch),* where *sch* is the color scheme name, and figure 7 map composition used a color scheme called *summer*, and therefore the command was *colormap(summer).* Figure 8 show some of the several color schemes, but the Octave documentation shows all.

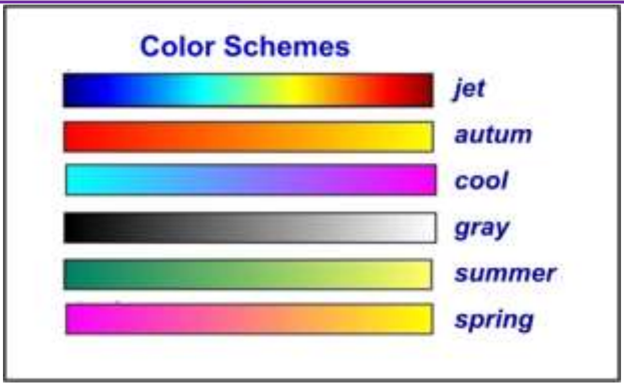

Figure 8. Example of some Octave color schemes

The last step is to place a vertical color bar that allows a direct association between each color and a numerical temperature value, which is done with the command *colorbar*. In this context, the figure 100 summarizes the three presented commands usage and shows the final image result.

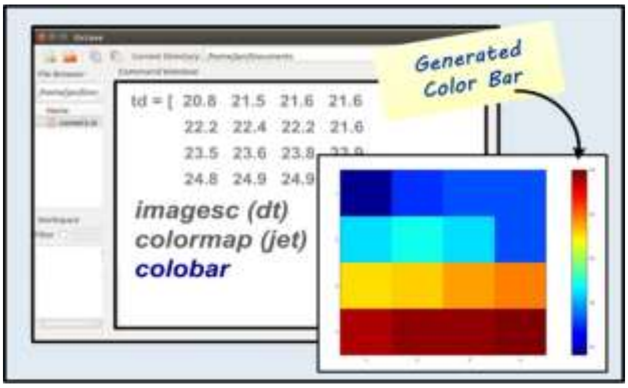

Figure 9. The colorbar command to plot a vertical bar used to associate colors and temperature values.

Note that at the top of the color Image Window will appear an option menu where the user can choose the *File* option and then save the image in your directory as a figure and later import it directly to different other software such as text editors.

2.3 General survey analysis

After the first part of the practicum focused on the greenhouse horizontal grid and temperature measurement, the students should be able to understand the basic ideas about:

1. The greenhouse grid concept
2. The sensor time response
3. The time estimation to take all the temperature measurements inside the greenhouse

After the second practicum part in the computer laboratory to process the temperature data, the students should be able to understand the basic ideas about:

1. The data representation as a matrix
2. The matrix data input in the Octave
3. The color map design with the Octave, using the commands *imagesc, colormap,* and *colorbar*

To verify to what extent this class effectively affected the students' motivation for the use of computing technologies applied in the agricultural area, the students completed a brief survey after the class, which was structured in two main lines that were:

A) The students' learning: The objective was to verify the students' perception in relation to their own knowledge on the topics covered, before and after the class, and also their self-confidence to repeat later the class experiment alone.

B) Students' motivation: The objective was to verify the students' perception about their motivation for future in-depth courses on general technology applied to agriculture and also to take a proactive stance by creating their own questions and seeking answers autonomously about applied technology.

As explained above, the class aim wasn't to make the students experts on technology, but to verify the efficiency of a short time class to motivate agronomy students, whose perception trend was analyzed thought the survey responses that are presented below.

RESULTS AND DISCUSSION

This work asked the 29 students to answer a questionnaire after class, and this section describes below its analysis.

Figure 10 shows the answers distribution when the students were asked about their knowledge about any application software for mathematical processing, whose use doesn't require programming concepts, and 74% reported they had no or little prior knowledge. It shows that 26% of the students state they had a medium or higher level about any mathematical software use, which could include even simple Spreadsheets. Therefore, for a more specific analysis, this work asked who knew something specifically about Matlab or Octave, and the affirmative result reduced to 15% of the students that reported a previous knowledge, but which was limited to only basic or theoretical concepts.

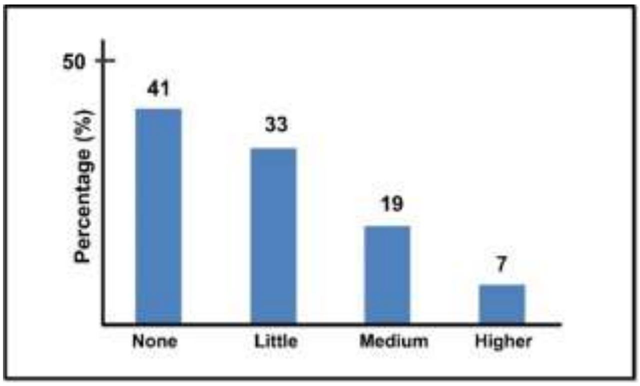

Figure 10. Mathematical software knowledge.

Figure 11 shows that when the students were asked about their previous knowledge about temperature variability in a greenhouse, 52% reported that they had not thought about this issue and were not aware that this occurred, 33% knew that it can occur but had never studied the subject and only 15% had already studied basic concepts about it.

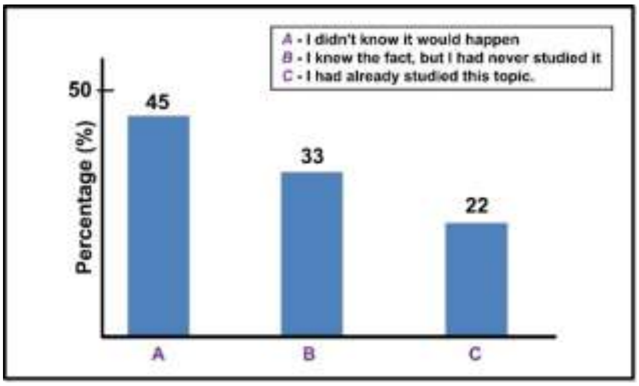

Figure 11. Previous Students' knowledge about temperature variability in a greenhouse

The figures 10 and 11 show the students' knowledge about mathematical processing software and thermal variability in greenhouses was null or minimal, and therefore they represented an ideal group for the educational proposal of this work that was focused on freshman without pervious knowledge.

Figure 12 shows that 85% of the students had not studied the temperature variability in greenhouses before the class, but after the class, in a second complementary question, 96.3% reported considering this subject can be very useful in your future activities as students or professionals. Note that this second question is qualitative because it doesn't verify the learning amount, but it proves that they have gained a good level of awareness of this topic relevance, which was one of this work objectives.

This class made students aware of the proposed theme relevance, but it is necessary to transform awareness into action and therefore this work asked the students about their self-confidence perception to carry out this type of experiment alone. Figure 12 shows the responses distribution where 33% of students reported an excellent level of self-confidence to carry out this type of experiment alone in another greenhouse, and 44% a good level. The other 23% of the students showed a null or low level of self-confidence, which was expected because not all students of the agricultural area have the same facility with the use of technologies. Thus, Figure 13 shows a realistic distribution, which contributes to the data reliability. In the present context, with only a two-hour class, this work considers satisfactory an educational result where 77% of the students assume a satisfactory level of self-confidence, which is a reasonable indicator that it is possible to teach some basic, but fundamental concepts, of the proposed topic in a short class.

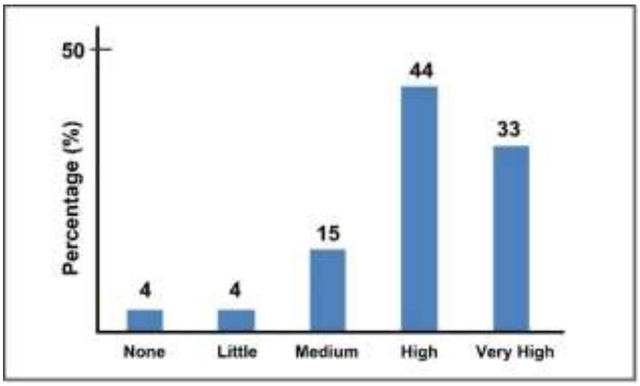

Figure 12. The students' self-confidence perception to carry out this type of experiment alone.

Figure 12 shows a realistic distribution is important in this type of teaching. Assuming that practically all the students presented a very low level of self-confidence, and then it could suggest a teaching process review because the class didn't achieve a minimum level. However, if almost all the students presented a very high level of self-confidence, then the professor should carefully analyze the context, because the students could have a high ability for the learning of technological, which maybe not a usual reality for the agricultural area students. Another possibility could be a student's false sense of knowledge, which is usually developed when the content presentation was supposedly complete, but which in practice was limited to merely superficial aspects, without a more critical teaching.

We have observed empirically that the motivation of many agronomy students for applied technology decreases or even ends when they face more complex technological problems. Therefore, an important part of this educational context is to balance motivation among the students, while making them aware that difficulties for the technological usage frequently occur, even for experts in technology, but they must face the problems with persistence. It means the persistence philosophy becomes a fundamental part of any realistic process of motivation for applied technology usage.

Although most students presented self-confident to carry out this specific experiment alone, it doesn't mean that they are interested in learning more about technology applied in the agricultural area, even because this accomplishment requires an aptitude for the technological area, more studies, time, and additional efforts. Therefore, it is important to complement this analysis, and the students were asked if they would like to take in-depth courses of general technology applied in agriculture. When prompted, 74% of the students responded that they are effectively interested, which reinforces this work achieved its proposal to motivate the students (Figure 13).

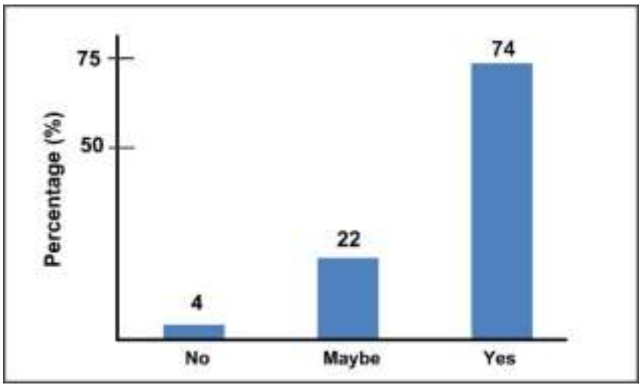

Figure 13. The students' desire to take advanced courses

Besides the students' interest in take in-depth courses of general technology applied in agriculture, this work also asked them about their motivation to think more deeply about technological topics and to take responsibility for their own future learning about this topic by creating their own questions and seeking answers autonomously.
High levels of awareness, motivation, inspiration and intuition are very important parameters to lead to success in any process that involves creativity [22], such as social and educational process. However, even students with these traits may feel a lack of enthusiasm or aptitude to propose new concrete projects to face real challenges autonomously in this area. It is a fundamental factor in transforming conceptual aspects into practices, which Thomas Edison summarized in the phrase "Success is 10 percent inspiration and 90 percent perspiration" [23].

This work analyzes the students' willingness to be not only technology users, but developers of new technological applications. Figure 14 shows that 52% have a great level of predisposition, which composes a group that may deserve special attention during the undergraduate course to be prepared to act in the future as researchers or entrepreneurs of applied technology in agriculture, which may have a beneficial impact on their careers and also on society, with results on social, academic and economic aspects.

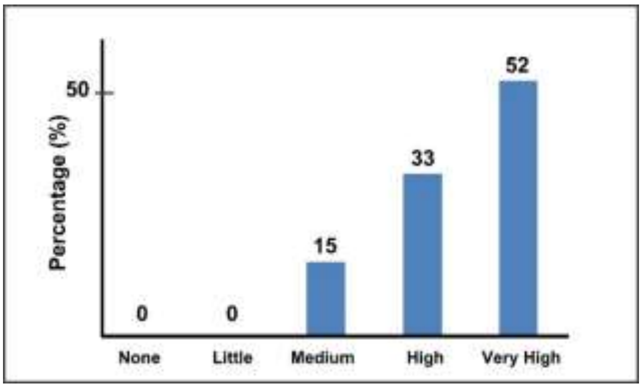

Figure 14. Students' predisposition to act as developers of new technological applications.

Figures 13 and 14 show that many students have interests in improving their knowledge in this area and take responsibility for their own future learning. This prompts a much broader reflection on the teaching of agronomy, in order to verify to what extent undergraduate students are being motivated and effectively trained in using technologies applied in this area. This analysis, when done in a critical and realistic way, involves complex aspects and can be a target of different studies, including curricular structure, pedagogical plans, educational strategies, effective integration of technological aspects, among others. This educational approach creates a context that isn't simple and depends on each local reality, which may be a challenge for schools themselves to define effective ways of teaching and curricular integration.

CONCLUSIONS

This work proved that is possible to promote the basic training of students to use a computer to map the thermal variability in a greenhouse in a 2-hour practical class, even without previous knowledge about both subjects. The educational result analysis showed that 77% of the students reported high level of self-confidence to fully repeat this type of experiment alone, which is a good indicator of the class efficiency. Besides, 74% of the students reported that they were interested in taking in-depth courses of general technology applied in agriculture, which shows the class also created a satisfactory motivational environment. In addition, 52% assumed a great predisposition to face new applied technology challengers, which is important to compose new leaders in terms of agricultural production and research. Besides, the high motivation degree showed by the students can suggest and motivate future works focused on educational theory and practical processes for the insertion of applied technology subjects in the agronomy courses.

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