The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2014

Volume 1, Pages 477-483

ICEMST 2014: International Conference on Education in Mathematics, Science & Technology

POTENTIAL USE OF DIGITAL TECHNOLOGIES IN MATHEMATICAL MODELING THE FIRST STEPS OF RESEARCH

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ABSTRACT: This article presents and analyzes one practice of scientific initiation developed from the use of modeling and digital technologies on basic research projects as a way to stimulate the art of research. The empirical study was conducted in a public agricultural institution in southern Brazil, in which high school students develop research papers at school, during one year. Data were collected through observation of the students activities, field repports, articles and the socialization material. They were analyzed using content analysis of Bardin (1979). Results points that the use of digital technologies enhances the work of mathematical modeling and, both articulated with discussions related to the reality of those involved, promote students: motivation in learning and research; autonomy; reflexion and knowledge to the expression of their own actions and even math itself.

Keywords: Modeling, digital technology, project, scientific initiation.

INTRODUCTION

School research should occupy increasingly larger space in educational institutions, in order to develop skills and abilities that enable students to aim educational goals of different levels, both conceptual, as procedural or behavioral. In mathematics teaching, the subject must extrapolate the instrumental character, posing itself as science research with characteristics of investigation, whose role is to integrate with the other sciences. Thus, in the basic education we seek to develop "strategy of learning to learn, how to think, understand the reality globally, evaluate social and productive processes, discuss and perform quality citizenship and production" (DEMO, 2009, p. 85).

Therefore the teaching of mathematics should prioritize the construction of knowledge; knowledge gained through investigative, constructive and non-instructional processes. A student, much more than mastering techniques and strategies of calculus, needs to develop the initiative and creative sense to learn to adapt it to different contexts, using them appropriately in many situations (BRAZIL, 2008). Because "we are, as bodies that adapt themselves and solve problems, motivated to respond to our environment and achieving goals and objectives." (George, 1973, p. 29).

Learning math and in parallel learning to research with the help of digital technology, software, computers, internet, makes that they acquire natural importance as resources that permit an approach of problems which data require selection and analysis skills. Accordingly, it is necessary to provide students opportunities to develop skills related to representation, understanding, communication and research, as well as the sociocultural context, regardless of the subject or context. The school can help stimulate the student to research, both within the classroom and beyond. As endorses Demo (1996) it may be an opportunity to begin the first steps in the art of research, awakening the student's curiosity, autonomy in seeking information and, finally, the expression of ideas.

In this way, teachers and students can share tasks traversing paths that culminate in the development of skills and learning of scientific concepts, through the development of research projects. As mathematical modeling has an approach related with projects, these have received significant contributions in the last years, of digital

- Selection and peer-review under responsibility of the Organizing Committee of the conference

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technologies as a way of support. Many practical research in this direction have already been made. We mention the research of Araujo (2002), Diniz (2007), Borba and Malheiros (2007), Franchi (2007), Malheiros (2008) and Borba and Villareal (2005), whose research involves modeling and ICT, with the objective of understand and analyze modeling practices and digital technologies in the classroom, in the form of activities or projects developed in different levels of education for the purpose of explore mathematical content, i.e., learn math and do not necessarily develop research-related skills.
Based on recent studies involving modeling and digital technologies, and with the premise that students become more interested in learning by conducting research, the study aims to present and analyze a practice of Undergraduate Research in Secondary Agricultural School looking for potentials on the use of digital technologies in modeling. Therefore, hereafter is a theoretical outline used to contextualize the study, followed by the methodological aspects that are the guidance, the reasoning, data, the manifest and latent knowledge of the study.

THE THEORETICAL CONTRIBUTION OF THE RESEARCH: FROM MODELING TO THE DIGITAL TECHNOLOGIES

Biembengut (2004) sees modeling as a set of procedures to make a model which process may be used in any area of knowledge. For Bassanezi (2006), either as a teaching strategy or scientific method, modeling is a process that involves theory and practice, leading researchers to interact and understand the reality that is inserted in the investigation, and may have as consequence the action on it aiming transformations.

In the context of education, Biembengut (2004) defines modeling as a research method, particularly used in the Sciences. He emphasizes that modeling procedures are essentially the same presented in stages of scientific research; so, defends as a method in education. The purpose is to encourage and engage students to do research, learning math at the same time, which can be used at any stage of education. Therefore, Biembengut (2013) groups into three procedures of modeling:
- First stage: Perception and seizure - at this stage occurs the recognition and delineation of the problem; and familiarity with the subject to be modeled, consisting of a subsequently theoretical framework.
- 2nd stage: Comprehension and explanation - after performing interaction with the subject, the formulation of the problem is made, questions are elaborated and hypothesis are pointed up; subsequently takes place the formulation of the model.
- 3rd stage: Significance and expression – made the resolution of the problem from the model and interpretation of the solution found. Consists of a review of the model looking for verify whether the model is valid or not and the expression of the process and the outcome.

In recent decades, as modeling, digital technologies also came up when the objective is the pursuit of knowledge and interpretation of a phenomenon, with them there are more and better ways to learn. Lévy (1993) points out that computer media creates conditions for qualitative changes in education, quality regarding the one arises from the collective, with the formation of networks and intelligence seen as a process in which various knowledges are included. To Papert (1985, P. 2), to think about the use of computers coupled with the use of projects, just realize that this adds quality learning, if those implementing the project, is in possession of their interests and desires. Ponder that "[...] technology is not the solution, it is only one instrument." Soon, school modeling practices can have it as a tool to enhance research and education, as advocated by Brazil (2008).

For Moran, Masetto and BEhrens (2000), the *internet* facilitates students' motivation, because of the novelty and the endless research possibilities it offers. It helps to develop intuition, mental flexibility and adaptation to different rhythms. In the context of modeling, Blum and Niss (1991) argue that ICTs used in modeling work not only in facilitating problem solving as are necessary to validate the mathematical model. Borba and Penteado (2001 believe that informatics facilitates the visualization of models, enables the emergence of conjectures and may lead to discoveries. They emphasize that computers reorganize the thoughts and contributes to change the traditional teaching practices. Araújo (2002) confirms these information showing that the interaction between students and ICT enables new strands of research, well as the interaction of modeling and technology enables the exploration of problem situations in which it participates actively in the process.

METHODS and PROCEDURES

Regarding the empirical space, the study was conducted at the Federal Institute of Santa Catarina - Campus Rio South, public institution of integrated technician course located in southern Brazil, during the development of 4 research projects in which students have initiated the art of research. Developed at school environment, seven students from 2nd and 3rd grade of Technical Education, with 16 and 17 years old, held their projects integrating the areas of agriculture, mathematics and informatics. These projects have utilized modeling as a search method for studying the phenomena / problems existing in other areas of knowledge related to daily life of their course, with digital technologies a resource for the development of research.

In this context the research is inserted, caracterized with qualitative case study (Yin, 2001). Empirical data were derived from observation, field diaries, articles and socialization material, materials produced during the project development. Unstructured observations occurred for approximately one year (2011-2013) at weekly meetings of 1.5 to 2 hours and were being recorded in a logbook. They were conducted to describe and understand what was happening in certain situations. Also, copies of written materials produced by students in the course of research activity were utilized, such as work files, the final article, *poster* and video. For the data analysis procedures of Content Analysis (Bardin, 1979) were used.

RESULTS and FINDINGS

The collected data allowed the identification of three categories in relation to the potential of digital technologies and modeling at the first steps in the art of basic research in high school. They flow with more or less emphasis according to the characteristics of each group of students in the developed projects. These categories are seen on the speeches of the students, along with material that they have produced. In the text that follows these three categories are implied, which are identified as: the use of technical standards in the writing of research; understanding of what and how to research; cognitive development (descriptive skills, analytical, critical and creative).

About perception and apprehension

Related to agricultural area, the subjects of the research were about growing heifers for dairy purposes, study of egg production of laying hens, chicken and pigs growing and lactating Holstein cow curve. In an initial stage, students have look for realizing and getting a larger number of information about the topic in order to delimit a problem situation for each project. Biembengut (2013) points out that this phase is important, because in order to understand a problem situation, a phenomenon or a theme / topic of interest, one must understand its context and get the greatest number of information and data available in first instance, and thus recognize and become familiar with the topic / subject.

In this step, students have explored the existing knowledge in the literature, with professionals from zootechnical area, as well as part of academic material available on the worldwide web pages, all with reference to the subject. Such information obtained were arranged in the form of files, records of readings, data, videos, magazine articles, and other forms. The internet, computer and software such as *Excel and Grafhmática* resources were further explored by students. This confirms what is described by Borba and Penteado (2001), that students use technology from the beginning of their research. "- When we choose *Google* search, there are thousands of search options for us to know more about the topic. Now we need to filter and see what really matters. It is not only open the first and the search is over. ", Considered the student B.

Stands out beyond the modification of the concept of common research in basic education by students, that in the transition from the 1st to the 2nd phase of modeling, they have already opted for recording data using *Excel*, leaving aside simpler resources like calculators or non digital spreadsheets. Students have already incorporated technology into their studies, confirming the birth of information in the digital age. Biembengut (2013) highlights that the phase of perception and apprehension (recognition and familiarity of the theme) are not disjoint. As some data are perceived, they collect them, and this allows the perception of other data, other information, and so on in a cyclic process, however, increased. This modeling step may be ended with a text compiled and arranged and organized in data tables, such as Table 1.

Table 1. Chicken eggs industrial classification according to its weight (grams)

Identification	Rating

Jumbo	Greater than 66
Extra	60-65
Big	55-60
Average	50-55
Small	45-50
Industrial	Less than 45

Understanding and explanation

In the second stage of modeling, there is a dialogue between the counselor and the student C asked, which developed the project on growth of calves:
- "Does the height and chest girth of the calves have proportional growth? Are they constant? - "What this question can infer in your study?" The teacher asked. - "You mean the two do not grow proportionally, it will have its disproportionate body and this may impair milk production" Student C. Students seek to understand a problem in every part of it, seeking a way to make it explicit. The question from the student demonstrates that they start not to accept reality anyway, questioning it. They do not consider as something perfect, correct.

In the episode above, the student makes use of mental mechanisms to take advantage and upgrade his/her perception on the considerations of the problem. This is the way people expand their cognitive ability. Vygotsky (19 89) calls inner speech the process in which the student enters the symbolic system in his psychological apparatus, with the support of the language. And a research favors this type of development to be active, interactive and constructive individual in an environment conducive to interaction.

Cognitive skills enabled students design a model that would allow not only the resolution of the particular issue, but also serve to make predictions or allow a (re) creation. They used the previous knowledge for a model. Result can translate what, in high school, can be constructed by students.

The algebraic model A (p) = p*0.55 + 32.28 was one of the obtained with the aid of Excel, when investigating the relationship between height and heart girth present in the growth of calves. In this model, like all functional model, are incorporating the particularities of the analysed phenomenon (Bassanezi, 2006). In the case of explicit algebraic model, the "A (p)" is the height (cm) and "p" the heart girth (cm) along the calves growth, obtained through what Levy (1993) calls simulation possibilities. Thus the second stage is effective to understand the data and explicitation of the model. And this requires the modeler student creativity, critical, analytical power, persistence, among others.

Of meaning and expression

The model validation, in all projects, took advantage of the use of Excel and it consists of the resumption of empirical data arising from experiments and / or literature by applying the model. It was noticed at this stage that on studying and solving a problem using the computer, the student describes the problem to be solved, the computer performs a task through software or a programming language, and allows the student to interact with the program, thinking, reflecting and making decisions about the activity. This is the constructionist paradigm defended by Valente (1993).

- "Wow, the graphical display of the model obtained by empirical data and the model designed by the company that provides the animals is very close visually. Now we need to check whether this difference is significant "? Student S on the express graphical model in Figure 1.

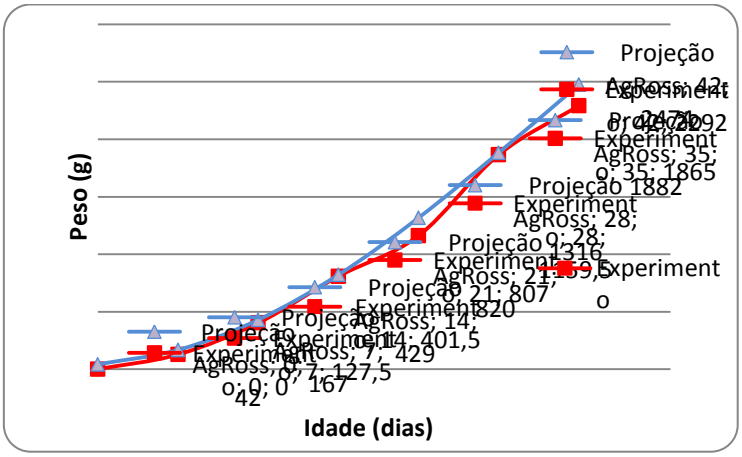

Figure 1. Comparison of representative models of the growth of broiler chickens based on empirical data and engineered for animals.

In this third stage of modeling, Biembengut (2013) discusses that it is the stage of expression and this implies to evaluate and verify the validity of the model, and thus express it. Students perform evaluation of the models taking into account aspects presented in the literature, which data were obtained empirically and projected by the model. "- Damn life, now I'm really seeing what it means to do research, it is quite cool teacher!" Student K illustrates about the phase of modeling and representing what the research means for him/her, when handling the Excel spreadsheet aiming at validating the model.

The communication of the model is one way to test it and complete the modeling process. As a final step of expression, lactation curves Project students developed na projection and control instrument of these curves in an Excel spreadsheet, preparing a video for better explanation of the project and the instrument to the general public (Figure 2). This part went beyond the initial purpose of the project and demonstrates that motivation and interest drive the student to build ways to solve his/her problems. "The ownership of a response to a stimulus or stimulus complex should depend on the motivation (George, 1973, p. 28).

Figure 2. Outline of study instrument developed by students completing the modeling process

All projects were released to the community, both orally and in writing. For that, students have developed na abstract, article and poster, explaining that socialization are crucial when doing research, when it takes the first steps in the art of research. "- It is very good to present what we have done, it gives a pride, especially when there are people who want to hear us. It is rewarding, and our public commitment to take our studies to milk producers and others in the community" student M expressing his views about the research communication. It

was just possible at any level of education "because the student is given the opportunity to study the problem situations through research, developing their interest and sharpening their critical thinking" (Biembengut, 2004, p. 23).

CONCLUSION

All the navigation through this study so far allows some relevant analysis of the practice of scientific research: aim of this study. We emphasize modeling as a research method in which students extend their understanding and build knowledge. Knowledge not only conceptually, but also procedural and behavioral related to mathematical and technological domain, techniques and procedures of the research. It is important to consider the use of technology as a resource to support the modeling, present in all stages of modeling, enabling students to complete inferences about: the research theme and your interaction with it, the model in their tabular representations, graphical and algebraic, significance and the model's expression and communication project for validation.

It is emphasized in the study, three potential use of digital technologies and modeling in the first steps of research of high school students: the first refers to the use of technical indicatives on writing results of the projects of these students to develop their final articles, abstracts and posters. Stand out the tables, charts, quotes, references, among others. These are aspects that are not customarily present in works produced by students at this level of education. Another highlight is to the "new" conception of what is and how to study, since most students conceive research as a copy of what a particular author claims related to a theme, taking it as his/her. Finally, we highlight the cognitive development of students in terms of descriptive, creative, analytical and critical skills. It was noticed in describing the theme, sketch and compare the data, choose strategies for obtaining the model, analyze the feasibility of the model, modify the assumptions for model improvement, communicate their results, worrying about the social commitment to socialize their work, among others.

Digital technology and the modeling provided to students social posture while studying a theme. This occurs not only by studying, but for considering it essential to extrapolate the school boundaries with socialization and dissemination of the instrument to milk producers, broiler breeders and laying, of calves and the school community. This way, contributed to the formation of citizenship, to awaken new views, whether on the situation investigated, or on the political and social reality that surrounded them in the environment that was motivating for them. This presentation and analysis ends here highlighting the statement Papert (1985), expressing that to educate is to create situations for learners to engage in activities that will fuel constructive process to think and learn. A process in which active subjects in the construction of knowledge, authors subjects, dive in art research.

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