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Mathematics Infographics in STEM Learning for University Students

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Abstract: The aim of the study was to reflect on the role of infographics as a visual medium during the experimental actions of learning achievement with STEM. For this purpose, the qualitative-phenomenological research design was followed, which allowed the hermeneutic understanding of the behavior and reactions of 16 students enrolled in the subject of Euclidean Geometry. Through interviews and a field notebook kept for five weeks, they detected categories such as contextualized scenarios, learning expectations, interdisciplinarity, methodological sequence, resolutions of situations, and evaluation processes, and reached the conclusion. The infographic allowed the visual systematization of the procedures with STEM during the experimentation, in addition, it was an opportunity for the student to show their creativity, imagination, critical judgment, and creative and social skills with interactivity for common objectives, as well as promote multidisciplinary work with common points.

Keywords: infographics, Euclidean Geometry, STEM, creativity, multidisciplinarity.

1. Introduction

The involvement of technology, in recent years, has become more frequently present in social behavior; technological development offers the potential for transformations in various sectors and the unlimited capacity for dissemination [1]. The contemporary educational context demands new professionals with skills and abilities that are different from those of the past decade [2,3]. The discourse of the educational sector is the management of technological resources and means; it is considered a teleological review to rescue education as a right for the citizen; however, the pandemic has demonstrated the existence of a social gap in the access to digital tools, the possession of networked technology and the use of the same; challenges and roles of man in a knowledge society are evident; they highlight the transformation of education for a modern and culturally virtual society [2,3,4,5].

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One of the characteristics of our society is volatility; due to constant changes, the community is subject to a series of social, cultural, economic, and educational changes affected by globalization. Assuming a front to the challenges of change, the foundations of STEM (Science, Technology, Technology, and Mathematics) exposed in Lego-Logo games were laid, representing an integrative work of diverse areas, where the student learns by interacting with technology [6,7].

The detachment from STEM is causing high demand in the generation of jobs. In the US, STEM careers are generating high job impact at 17%, compared to non-STEM careers at only 9.8%. Microsoft's manager has generated 700 jobs with scientific and technical requirements. In England, the Future Morph Science Council has launched an interactive network to support student science education to explore STEM career opportunities [8,9].

The STEM methodology encourages problem-solving based on the concept of science and mathematics incorporating strategies from engineering and technology. According to the World Innovation Index, Switzerland is the most innovative country, followed by Sweden and the USA, while Peru ranks 129th in the index [10].

The acronym STEM is simply the development of science, its procedures distinguish the present century, put into practice it fosters scientific literacy at its best by integrating science, technology, engineering, and mathematics [10]. Its origin dates back to 1990 in the United States, coined by The National Science Foundation, referring to the ways of carrying out events, policies, projects, or programs related to the entities [11]. STEM education was promoted by politicians and entrepreneurs to boost vocations in careers related to science, technology, engineering, or mathematics, in order to improve the productivity and competitiveness of economies [12,13].

This approach accelerated changes in educational structures, leading to reflection and methodological reforms in teaching with active and integral participation in decision-making, understanding natural and technological phenomena in their environment, solving small everyday challenges as a cultural part of the worldview and the way of acting in order to develop competences for life, connecting with the dynamics and challenges of the local and international context [14].

The advent of the 21st century has been marked by the emergence and sophistication of digital tools; for example, physical devices, software, simulators to smartphones, and touch devices that are increasingly lighter, but technologically sophisticated [15]. Students, as members of the scientifically literate system, use scientific knowledge from basic sciences such as Physics, Chemistry, and Biological Sciences, among others, in order to understand the natural world and engage with the scientific need for technologies to respond to new challenges [16].

Science classes in educational institutions are influenced by software applications and simulators available on the web that allow experimental work as part of class sessions with methodologies and didactic approaches supported by so-called "creative technologies" adapted to different ages, contexts, educational levels, and school contexts [17].

STEM teaching and learning has been associated with the development of multiple research; for teachers who adopt them to personal computers or the digital whiteboard, they are an opportunity to transform interactions within the classroom; in this framework, learning science, engineering, and mathematics at school involves actively promoting cognitive, social and discursive activities typical of the academic environment [18,19,20].

The emerging high demand for STEM is due to the interdisciplinary interaction, specifically, of mathematics with the emergence of digital calculators, and simulators such as Wiris1 or MathPapa2 [14]. Interactive mathematical software such as Geogebra is facing a different way of problem-solving and is changing the roles of the student and the teacher in front of these tools that open the possibility of working. Nowadays, it is common to use scientific calculators for problem-solving and algebra exercises, geometric thinking, among others, and the use of spreadsheets enables the use of logical functions, and statistical and financial analysis [21].

As a process and methodological sequence, logical thinking and reasoning respond to everyday situations that develop during our existence with heuristic supports; it was key to the achievement of each of the tasks [22,23] since it awakens the student's interest during all the activities and the thoroughness that involves deductibility for the detachment of cognitive processes, allows the reconstruction of knowledge through different processes of logical and abstract thinking in order to develop capacities for various events. This allows the understanding of abstract concepts as they emerged from concrete reality [24].

From an engineering perspective, it allowed the optimization of resources in terms of the way materials are used, and the insertion of mechanisms within the prototype; mathematical models are evidenced from the concrete processes for the facilitation and understanding of phenomena in specific scenarios. The role of teacher, in these scenarios, plays the role of mediator, facilitator, and guide throughout the process, providing the routes, proposing the sequences of collaborative work, as well as providing sufficient information for each stage of the activity [25]. The facilitator provides techniques, and methodology, creates a suitable psychological climate for learning to be more effective and of high quality, and responds to expectations and needs based on the principles of meaningful learning [26].

The scientific modeling of mathematics requires great imagination, and unlimited creativity, furthermore it stimulates

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inquiry and proposals of new and different routines; didactically, it corresponds to the digital association, together with mathematical and abstract constructs embodied in concrete objects with visibility of animations and movements [14].

Actions with Science are shown in the use of software and applications available on the web with devices designed for experiential learning within the classroom [27]. The use of peripheral sensors, of boards adapted to computers to capture in time the displacement of mobiles, detecting pressure, and speed. These devices, such as badges, are becoming more commercially available and affordable, easily adapted into mobile devices and pocket tablets, into digital cameras easily implemented to experiment and simulate different events in classrooms [28, 29].

2. Methodology

The study was approached from the qualitative paradigm with an interpretative model, from a phenomenological approach that allowed for the objective hermeneutic understanding of the behavior and reactions of the students when interacting with the STEM methodological sequence. The inductive methodological sequence made it possible to detect the categories thanks to the interview processes and the notes in the field notebook during five weeks: situation resolution, contextualization, interdisciplinarity, expectations for learning, methodological sequence, and evaluation processes, in a sample of 16 students enrolled in the Professional School of Education in the specialty of Mathematics who share the subject of Euclidean Geometry.

The methodological sequence of the experience

Objective. To prototype geometric objects using cut-out materials, inserting the STEM procedures visible in computer graphics.

Thematic content. Make operational use of Physics concepts: a moment of force, pressure, fluids, and Pascal's principle during the elaboration of the mobile components of the geometric robot.

Technical induction. Adaptation of the Raspberry Pi board, which made it possible to automate the movements of the robot components from a computer.

Geometric concepts: Metric cutting of regular and irregular polygons, operationalization of the concepts of geometric transformations: translation, symmetry, rotation, homotaxial, geometric congruence.

Mathematical competence. Prototype real-life geometric objects by inserting STEM components from recyclable materials made and cut out with mathematical precision.

STEM competencies. Linking scientific concepts to practical situations with fluidic principles, geometric concepts, and automation of movements by means of plates inserted into computers.

Actions. The experimental activities were developed at the beginning with geometric traces on recyclable cardboard, generating pieces for the assembly of arms, heads, deployable objects, and animal wings, among others, and then associating them by means of rubber bands or small fragile springs allowing flexibility; for this purpose, surgical serum hoses were conditioned with air pressure for the sliding of the mobile pieces. Finally, the insertion of a basic Raspberry Pi board allowed the automation of the movements programmed in a computer.

Product: The products were exhibited demonstratively in two moments. The first was the exhibition of mobile prototypes, including spleens, bird wing movement, rotating doors, and a robot, all of which were made using the sequence described. And as a second moment, the prototypes were presented by means of infographics contemplating three components: the conception of Euclidean geometry and the role of observation, listening, and technological skills. This is followed by a description of the processes during the development of the prototypes, which describe the sequences during the construction up to the automation of the movements. This is followed by a description of the prototyping sequence presented in an infographic that was displayed on social media.

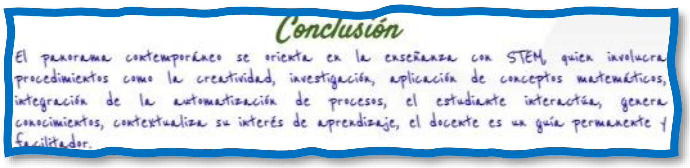
Preview of STEM	**Description.**
	What is shown is the first part of the infographic associated with the arguments of geometry linking the processes of the development of observation skills prior to geometric construction. The second aspect, is the activation of active listening skills, being this the incentive for cooperative

	work during the resolution of geometric situations; finally, the involvement of technology for the simulation and automation of the situations involved.

This second view shows the sequence from the cutting of materials, insertion of the surgical hoses in the mobile and flexible points for the generation of the sliding of the robot parts, the assembly of the interface, and the connection of the plate for the automation of the movements by a computer.

Presentation of the experience and product	**Description.**
	The experience shown is the presentation of a geometric robot, which began with geometric measurements and cut-outs of parts for the assembly of the prototype, sequentially coupled surgical hoses to associate the movements under the principles of Pascal. The points of the logical movements of the robot were detected and a basic board was conditioned

	and adapted to a computer by pressing the programmed keys. Finally, the commands for sliding the arms were issued, the lenses were opened and a buzzing sound was generated. This led to an understanding of the acronym STEM.



Finally, the conclusion of the students' group is shown. The contemporary scenario calls for the adaptation of STEM in the curriculum of the teaching process, as it involves creativity, research, and application of mathematical concepts to concrete situations, which allows the automation of the sliding of object parts.

Figure 2. Sankey diagram of the concepts associated with research.

The diagram shows the flow of concepts related to the research, implying that the components of STEM, as an input in the research process, are condensed in the concepts of Euclidean geometry as a branch of mathematics, while computer graphics, as a means of dissemination, is friction that systematizes the theoretical concepts associated with representative icons that are complemented with the supports of engineering in automation based on plates inserted in the computer and, as an output or systematization of all the

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components described above, we have science as a set of interrelated knowledge.

3. Results

The findings are the result of data collection by means of a field notebook, in which the students' spontaneous reactions during the process of developing their prototypes were recorded. The in-depth interviews allowed us to detect familiarity, conceptual and rigorous responses; with respect to familiarity questions, 30% of the students were found to have made and constructed geometric solids by cutting and pasting; 80% of the students stated that at least one member of their family circle is professional or students of engineering and science; 23% of the students' parents work with technological interaction.

With respect to the conceptual components, all the students presented previous knowledge related to Euclidean geometry, which they may have obtained at school or academies for their entrance to the professional school of Mathematics, as well as physics concepts such as Pascal's principle, fluid density, force, pressure, among others; however, a few students presented knowledge of solid or hybrid plates that could be adapted to order for the automation of movements.

At the end of the in-depth interviews, the rigorous answers led to the detection of codes and traits to identify the categories thanks to the induction, as well as the synthesis of them through the triangulation of the summaries of the 12 answers. The network is systematized by Atlas Ti_22 program is shown below.

The sequence of the semantic network, and the connections resulting from the triangulation, made it possible to identify the categories during the learning of mathematics, specifically in the subject of Euclidean Geometry; the infographic as a didactic sequence and a means of communication allowed the systematization of mathematical information linking the representative icons and also shows the dynamism during the presentation of the theoretical arguments associated with colorful and representative icons that mobilize learning, the understanding of the components of STEM. The findings from the network are described below [30].

Contextualized scenarios. Today, the contextualized approach is based on teaching in the context of the real world, enabling scientific thinking in its environment. The learning of Euclidean geometry is linked in real contexts in an objective way as part of everyday life [31]. The scientific arguments of Geometry as a science, we rescued the methodological sequence of induction, in which, the axioms laid the foundations of the concepts of geometry; for the effect, geometric figures were cut out with measurement and precision, operationalizing the concepts of axial symmetry, similarity, and homotaxial in geometric figures, in addition, space was conserved for the incorporation of inputs: surgical hoses, plates and springs [33,34]. This allowed for the proximate elaboration of a head as an ovoid geometric solid [31]. This category induced the assumption of critical postures of their environment, and creativity as an incentive to generate geometric prototypes and to unleash the imagination during the elaboration of the slogan [35].

Learning expectations. During the process of the elaboration of the prototypes, the students showed expectation, and curiosity, detected at each stage, university students, at this stage of their academic development, showed a high level of creativity, and criticality, and also faced challenging processes to routine forms, taking advantage of these traits, they easily adapted to the integration of STEM areas; from the support of science, they induced the laws of Physics regarding the concepts of pressure [36]. The technology allowed the integration of boards for the automation of movements of the prototype components. From engineering, the components in their integrity fulfill their roles for what they were created for, the designs and the functioning in their integrity; from mathematics, the calculations of areas, volumes, and axial symmetries were the main concepts for the project.

Interdisciplinarity. It allowed the integration of the various STEM disciplines, representing an interrelation of knowledge, relating different areas to achieve significant learning, and applying them to specific cases. To this end, the contents of Euclidean Geometry were interrelated with physics, technology, and science to generate a meaningful product for the student thanks to the skills of the student and the teacher at all stages of development [37,38].

The methodological sequence is a set of sequences and rational procedures that allow planned objectives to be achieved; in this respect, the objective of the project was achieved after planning sequences in three moments, for the effect of creativity and imagination as understood as the inherent reactivation of the student played an important role for the achievement of the slogan and personal satisfaction [39,40].

Situation solving. During the development of the prototypes, students at all stages were confronted with various problem situations [41, 42]. The students in all the activities used their imagination in order to show answers in flowing situations of questions, they got to know how much force is required for the sliding of the moving parts of the prototypes, and the time duration of sliding of the moving parts. In order to respond to their own needs, they did their own research to answer their own questions.

Evaluation processes. They are inherent processes to the didactic sequence with the purpose of procuring achievements the learning; the pursuit to the student was recommended with the purpose of identifying the capacities to absolve the situations in a way that guarantees the development of capacities for the resolution of problems and to achieve the significant learning verified in checklists, the observation cards where they registered deductively what they learned, these actions are predominantly like the qualitative evaluations; in this process, the student's own actions were evidenced during the learning process, considering the initiatives, imagination, inquiry, actions not foreseen within the unplanned processes, interactivity with the members of the group, recovering the reason for the evaluation [43, 44,45].

At the end of the planned activities, the prototypes were evidenced products of the concepts of Euclidean Geometry, the investment of technological components that allowed the movements of moving parts, the inspiration of students during the development with the support of physical sciences, which gave off the high level of motivation, inspiration, inquiry, research and especially the inherent commitment to respond to their own initiatives in each of the planned stages, finally, to absorb the actions, processes, sequences during the work of elaboration, were systematized and represented in the infographics; powerful means of systematized and summarised information accompanied by short data and representative icons were represented, to the effect systematized their most significant achievements and procedures detected during the development of the activities [46].

The idea of the project consisted of the reuse of recyclable materials and with the procedures of the inquiry, the students generate models that generate movements and are attractive, leading to understanding why many objects visible in the market, in agencies, animated presentations, videos, films, cartoons among others recover movements, it was a nice experience of interleading, which could be replicable in other areas in order to promote the criterion of scientificity in students.

4. Discussion

The arguments expressed above show that society demands citizens with high standards of technological and scientific knowledge who are protagonists in facing challenges and being part of the near future; however, students at different educational levels show detachment from scientific knowledge. They think that the fact of being connected to the mobile phone is scientific, leaving aside the understanding of the context and abstract aspects that science demands. Social isolation led to reflective, personal learning, leaving aside social and collective learning; however, the trend of the globalized world, an intercommunicated side, demands interdisciplinarity [47,48].

Collaborative work in fusion with different disciplines is emphasized, engendering holistic results and conclusions. Consequently, the STEM movement stresses the importance of unifying different disciplines for the benefit of the modern citizen [38, 49, 50]. This recent acrostic of STEM presents a paradigm of the insertion of science as part of historical and forthcoming developments. Technology is in line with the developments demanded by society and linked with societal demand. Engineering highlights processes, design, and scientific logistics in prototyping and construction according to circumstances. Mathematics enables the detachment of logical thinking during heuristic and algorithmic problem-solving [51,52,53].

The current trend is oriented toward being part of a globalized society [54]; to be part of it, it is necessary to train and educate with a flexible and multidisciplinary curriculum. The more competence the person shows, the more he/she will respond to the demands of society [55]; STEM is an opportunity for the student to promote meaningful, collaborative, and critical learning, associating the acrostic areas [56]; however, the curricula within professional careers do not allow, since it responds in a particular way only to the nature of the course [57].

Contemporary scenarios demand multifaceted competent citizens with technological interaction and social skills that lead to teamwork; in this respect, current professionals present cognitive skills with scarce procedural levels and much less in the use of technological tools; in the near future, they will be expelled from a society with STEM professionals [2,58,59,60]. The concern of the professional in virtual environments was expressed, and for this purpose, it led to positions and recommendations for adaptation to new work scenarios [11,18,61].

In order to systematize procedures with STEM, comprehensive visualization is necessary, infographics are a powerful medium that associates meaningful elements [30]. Click or click here to write text. The visibility of procedures of the sequences is possible thanks to the organigrams, in front of this position, it systematizes diverse positions related to STEM that admit the integration of areas to be in front of a globalized world with systematized communication within reach of the people; for the effect, the infographic is a visible means, where implicit and explicit data are shown for their respective interpretation [50,19,62].

The results show that creativity, imagination, and collaborative work made it possible to solve the questions and problems detected during the elaboration of prototypes [10], the situations were solved instantaneously, manifested by the high level of systematization of logical thinking and the level of abstraction of mathematical concepts, the socialization of the results detected, awakens the high level of motivation, and of being part of their own learning [15].

During the interviews and fieldwork, categories were detected, with respect to contextualized scenarios, which respond to experiential learning, meaningful according to the conditions of the social environment [32], this aspect was thanks to the thematic sequence of Euclidean Geometry linking STEM during the elaboration of regular and irregular polygons and geometric solids close to a robot head; these skills were potentiated by the interest and objects of study in natural contexts [63].

Learning expectations. University students have a high level of creativity, and criticality, which has made it possible to work with STEM [36], they are also challenging and do not give up easily, these attitudes allowed the detachment of their learning during the process of developing the prototypes. In parallel, the interdisciplinarity, in agreement to respond to the coming and present uncertainties, allowed the student it is multifaceted training to respond to increasingly complex and holistic tasks without leaving the technological aspects allied to a culturally modern man [64].

The methodological sequence was manifested by the sequence and interactions with STEM. It is a set of rational, planned procedures; however, the inherent reaction of the student, who unleashed his creativity and imagination from the indications and learning guides [35,39,59]. Complementing this category, we have the resolutions of situations, translating into the measurements of geometric figures with precision, in addition to the synchronization of the movements of the deployable parts; they are situations of confrontation with situations, awakening creativity, imagination, and novel processes throughout the construction of prototypes [40, 41].

Finally, the evaluation processes are an inherent part of the sequence, prioritizing the evaluation of processes and qualitative [43], the monitoring of the student during the development of the project is comforting in order to identify the capabilities and resolve instant situations, which is urgent to resolve doubts and ponder the formative actions, initiatives, imagination, inquiry, unplanned actions within the unplanned processes, interactivity with the members of the group [45].

5. Conclusion

The infographic allowed the visual systematization of the procedures with STEM during the experimentation in the different learning processes: from the outline of the design for the cutting of geometric figures with pressure and measurement (M), simulations of movements from a computer as part of the technology (T), in addition to the interaction of the geometric components with harmonized simulation in space and time using the concepts of physics as science (S). The components of the prototypes were validated with scientific interaction from engineering supports (I); in terms of displacements, movement flows, coordination with the deployable parts, deployment time, location of the parts appropriately in sufficient spaces, and the integration of electronic boards for control. In addition, it was an opportunity for the student to express creativity, imagination, critical judgment, and creative and social skills with interactivity for common team goals.

Finally, it was an opportunity to demonstrate the possibility of multidisciplinary STEM-oriented work, students easily adapt to experiences that require a sustainable, digitized, and healthy society. They are the ones who ask for new experiences and curriculum changes. Teachers must put aside personal prejudices and seek common ground for collective goals.

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