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Learning By Doing Through Steam Methodology And The Use Of Educational Software

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Abstract

The need to implement practical activities that allow students to boost their learning and solve the tasks posed in the considered theoretical subjects continues to be a challenge in many institutions that think that it is necessary to have great resources and a great technological platform to achieve satisfactory results. In the present study developed at the Polytechnic School of Chimborazo, the results achieved by implementing the elements of the STEAM methodology combined with the use of educational software for the development of skills and abilities in students of the Information Technology Career are externalized. The methodology used was under the quantitative paradigm, the survey technique based on the Likert scale was applied to a total population of thirty-five (35) students within the framework of a field diagnosis, managing to determine the perception of students about the methodology in practical areas and meet the achievement of the objectives of the career study plan. The result was that there is a high degree of satisfaction in students both in the collective and in a particular way to be part of the STEAM method as a teaching scheme that allowed them to consolidate knowledge through practical activities. The conclusions are oriented to the relevance of novel and verifiable tasks in the specialty through the presentation individually or in study groups, allowing for the generation of scientific projects that show their progress in the subject of Oral and Written Communication.

Keywords: STEAM, ICT, software, projects, higher education.

1. Introduction

Higher Education as it is known in Ecuador, today has undergone substantial changes that after arduous studies to understand especially postulates such as meaningful learning, seek to explain how the strategies implemented have an impact on the student, promoting that the knowledge transmitted is consolidated in these. In such a way, the execution of new forms of teaching has resulted in the motivation of students in the development of collective and individual skills that were previously imperceptible. In this sense, conjectures arise regarding the psychology of learning, which according to Soler et. al. (2018) indicates the preferred route that an individual follows when facing an academic demand in the educational field, is mediated by the motivation of the subject who learns and by the strategies used (p.994).

Many statements and propositions have been made in the context of the conception of learning(Luna-Encalada, 2021), and various theories have been written that aim to explain how it happens, for example, cognitivism places emphasis on attention, memory, perception, recognition patterns, and the use of language in the learning process, therefore, it presents a diversity of forms of development, among which learning stands out as information processing, for which, information is encoded, processed and transposed a broad (Orbegoso, 2015). In this regard, Valenzuela (2015) points out that learning is a process whose purpose is to increase knowledge and the acquisition of skills that allow people to potentiate and transform their mental schemes, providing them with the ability to think and understand their environment(Molina-Granja, et. Al, 2022); in this, biological, psychological and social factors converge. Then, it could be said that it arises from the need to know more about life itself, taking advantage of the opportunities that arise to enhance the skills you have. Thus, both the goals of the university professor are about the results not merely quantitative but the effects that the various strategies implemented provide for the achievement of the goals of the students, who in the STEAM method create projects to promote their ideas and consolidate knowledge.

In this sense, says ESPOCH (2022)
A fundamental transformation of education and training is needed to address the new competencies and skills needed to adequately prepare students for life in the future society. To increase the range of innovative products that reflect the needs of society, it is necessary to attract an adequate number of young people to STEAM fields and to link research careers with the changing needs of the labor market. In this context, the ESPOCH through the Faculty of Informatics and Electronics has been carrying out several undergraduate degree projects and postgraduate theses in the subject of Modeling, Animation, and 3D Simulation, without the students or teachers having a specialized laboratory. The projects are usually executed on the student's account and make use of facilities, laboratories, and workshops outside the Faculty where the costs of products are high. (p.7)

The relevance lies in the conception of the curricula and the defined strategies of the teacher, who teaches the subject and the students who are part of the set of learners, who have goals that largely arise from the inquiry of the students and the need to understand practically fundamental aspects of their training, that before were summarized to the mere reception of the concepts taught by the teacher in the classroom. That is why, it is important to remember the fourth objective of the United Nations (UN) in terms of sustainability for the man of the future: "Among the main concerns of Latin American and Caribbean youth are: that the knowledge learned in school – such as reading, writing and arithmetic – is combined with the understanding of the world and its relationships; that education articulates the different knowledge and areas of knowledge, where the various disciplinary contents such as the arts, humanities, language and sciences, dialogue among them" UNESCO (1970).

In Ecuador, there is a growing need to implement and document the new teaching methodologies of the Higher Education subsystem to promote improvements in technical areas, such as engineering, the relevance of existing impact studies of continuous training initiatives does not make it possible to attribute to them exclusively, the progress observed (Chiriboga, 2018). In this context of ideas Carranza and Caldera (2018) refer that there is great meaning in the possibility of promoting learning in students and that in theory there are no limits to it because it is always possible to include new meanings to those already built or establish new and more complex relationships between them. Therefore, learning is not a matter of all or nothing, but of a degree of interest and of

involving the learner in the context of achievable interest, which can be achieved with the application of projects or practical proposals to be solved. Thus, Islas-Torres (2015), states that educational institutions have begun to increase the use of technologies in the classroom, making the combination of virtuality with face-to-face; to understand the impact that these modalities have both on teaching and primarily on learning.

The use of software (SW) in various fields since the fourth industrial revolution evidenced the need to have SW convergence talent capable of solving the requirements of society, in education its use has achieved satisfactory results against control groups that did not apply any software in their classes, the results determine that creative problem solving in students who used SMICE software was higher than those who did not use the software, in addition to a significant increase in problem discovery and analysis, idea generation, persuasion and communication metrics (Kim & Lee, 2022). Therefore, the inclusion of technology in education has allowed us to have tools that simplify teaching processes and accelerate the learning process if combined with an adequate methodology. It has been shown that careers related to STEM skills are constantly increasing worldwide and that from an early age they allow students to reinforce skills thanks to teamwork, communication, and problem-solving (Feijoo-Almonacid & Rodriguez-Garavito, 2022). However, and despite the relevant results achieved with the inclusion of technological tools in educational processes, their massification and importance are evident from the declaration of the Covid-19 pandemic, and the suspension of face-to-face activities and mandatory distancing around the world, which forces all educational institutions to bet on education based on virtual tools becoming the indispensable support for not to paralyze indefinitely the various activities(Lozada-Yánez,2022), but in this case those related to education (Romero-Rodriguez et al., 2020) where among the technological tools that support the didactic activity, are the educational software currently present at all levels of the teaching programs (Pérez, 2021).

In this order, there is the application of projects through one of the most innovative methodologies in engineering areas that are known today(Lozada,2018), such as STEAM, the aforementioned method is an educational model applied in Higher Education that promotes the integration and development of scientific-technical and artistic subjects in a single interdisciplinary framework (Yakman, 2008). The acronym dates from 2008 when Yakman, trying to promote interdisciplinarity, introduces the "A" as the initial of "Arts" in English, which translated into Spanish means "Art", incorporating it into another existing acronym: STEM, which collects the initials in English of the disciplines Science (S), Technology (T), Engineering (E) and Mathematics (M) or, in Spanish, of Science, Technology, Engineering, and Mathematics, respectively (Ruiz, 2017). The reason why the important thing must be more than the medium or the context where the process of educational action occurs, the competition of teaching programs and the consolidation of meaningful learning are opposed to the notion of rote learning (root learning), while the latter consists of storing, in a literal and arbitrary way, large amounts of information; learning meaningfully involves consciously linking new knowledge with previous knowledge in the cognitive structure of the learning subject (Ausubel, 2000; Novak; 2011) and have the ability to apply this learning in the solution of social problems, so educational institutions must encourage the realization of outreach activities to the community and through STEAM-based projects that involve teachers and students in the process but also the educational institution and the community to achieve better results (López, 2019).

According to De Luca (2020), the idea behind STEAM is to combine different areas to put together integrated projects that school students can carry out. In general, these STEAM projects consist of building something. It is necessary to

use mathematics and science, but always with a practical purpose in mind, which brings you closer to engineering. During the process technology is used and, as in all human creation, there is some art and design. In this way, all these areas come together to create a new kind of learning experience. The goals of the STEAM model are for students to develop the following skills:

- Critical thinking,
- imagination
- creativity
- and that they learn to use technology to solve specific problems.

Precisely to develop these skills in students, STEAM requires the implementation of appropriate spaces such as the well-known maker spaces or in turn integrated laboratories, however, it is necessary to have the supervision and surveillance of experts who indicate how to manipulate the different tools, resources, and software that will be used during the sessions due to the increase in dangers on the safety and health of the participants, Therefore, institutions implementing this methodology are recommended to re-examine their safety training policies and practices (Love et al., 2022).

According to Garofalo & Villao (2018), the information society does not seek to create models of people for the development of a job but prioritizes the mastery of skills. It has been necessary to innovate also in teaching, so the instructional schemes have changed, also the evaluation models, the diagnoses made by the teachers, as well as the guidelines of Distance Education. Zamorano et al. (2017) Indicate that the learning process is favored by motivating aspects for those who learn, such as interest, intellectual satisfaction, sense of achievement, curiosity, and wonder, along with the incorporation of learning environments of confidence and play, pleasant, meaningful, fun, attractive and immersive where both the cognitive and affective development of the student is attended, both considered equally important. Considering the above, it is important to mention that the European Union and the US have experimented with traditional teaching methods evidencing the achievement of educational practices, however, what is pursued with methods oriented to learning by discovery is to activate the participant within their instruction scheme. Thus, the STEAM method significantly improves academic results, which adds value above the use of master classes, since it is learned by doing, from the integral pedagogical practice where we work on different curricular contents (Santillán et al., 2020).

This method has been valued and recognized by many international organizations. Among them, one of the most significant is that of UNESCO (1970) it can be said that this approach promotes learning to learn in students and to learn to transform and intervene in reality from the ability that implies connecting, applying, and relating integrally all disciplines of knowledge, as aspects promoted by STEAM education. Its purpose is aimed at improving the skills and abilities of educational actors to solve problems in addition to impacting motivation towards interest in science and technology, adaptable to educational scenarios at any level and type (Santillán et al., 2019). According to D'Souza & Rodrigues (2015), there are records of various investigations in cognitive psychology that have revealed that students achieve a greater degree of information processing through metacognition and active learning, even establishing that this type of learning exceeds in many ways the expository methods. It is even suggested that methods based on active learning increase students' performance, motivation, and retention capacity.

This is how various projects based on the STEAM methodology have emerged, as is the case of the "RubeGoldberg" whose purpose is to size a process to perform a simple task and which has served as the basis for the construction of machines that allow different

tasks to be performed, which the simpler they are executed, the better the end. With the necessary foundations, the students determined what final action their machine would fulfill and began to design the sketches of each of the phases. Each group determined each of the stages of what would become a STEAM-based RubeGoldberg-class machine throughout the semester. In addition, a report describing the process developed was presented. At the end of the semester, there was an open presentation of each RubeGoldbergen machine at the STEAM ThinkingLab. Around this project, the description of the experience developed in the learning project is evident, and the operationalization of the interdisciplinary approach is evident since the project addressed in a comprehensive, holistic, and articulated way the disciplines of the model for the approach of the problem.

Another of the projects launched under the aforementioned methodology is: Building a STEAM-E-WEB (Science, Technology, Engineering, Art, Mathematics – English Web) that involves the design of a web page by integrating knowledge in technology, mathematics, engineering, science, and art in the English language. The students develop the project in groups of five members, gender equity is taken into account, and the slogan that "technology requires responsible users for an effective ethical response" is considered(Paucar-Leon,2022)(Lima, 2021). The purpose of the project is to strengthen communication skills in the English language, the project must be presented in writing and orally in that language. The oral presentation seeks to be made to representatives of the community and parents, as a way to share the knowledge and creativity of students at this level. (MEP, 2016, p.304). In the aforementioned project, according to Saborio and García (2021), interdisciplinary learning activities are developed, given that during the execution of the project the knowledge of other disciplines is contemplated. It addresses real problems related to the context of the student body, in this particular case, with the selection of a technological invention that has changed or influenced the life of the human being and is related to the STEM/STEAM areas, which promotes significant learning. Research skills are developed since one of the stages refers to the investigation of a technological invention that has impacted human lives, this inquiry includes bibliographic consultations, online, or with people knowledgeable about the subject. The solution of the project derives from a specific product that, for this project, consists of the design of the Website integrating a diversity of knowledge around a technological invention, which tries to give an answer or at least promote a reflection on the ethical use of scientific and technological knowledge.

It also highlights the inclusion of online "gamification" mechanisms outside the classroom. What is called “VCLE STEAM-ification”, found that five of the proposed steps are particularly useful to improve the creative thinking and innovation of students, these are research, discovery, connections, creativity, and reflection, in addition, identifies that the 'game mechanics, the 'dynamics of the game' and the 'emotions of the player' are three main components that the gamification process must have. The results of the project indicate that both creativity and innovation (C &I) present an 'excellent' level. In addition, when carried out correctly, innovation and motivation to learn, students who undertook the study with the VCLE STEAM-ification format, achieved higher levels of creativity and innovation than students who studied using the traditional teaching plan (Wannapiroon & Pimdee, 2022).

The literature shows that the development of projects based on the STEAM methodology allows to promote of creativity, through the arts, as a means to express science, for Natalizio et al. (2018), through the design and layout of RubeGoldberg machines, a space of creative and artistic production beneficial for student learning was made possible. Likewise, the design of the learning project gave students the

freedom to decide the type of machine they want to build according to their interests and learning needs, with the only requirement that they should have 10 steps or stages(Molina-Granja,2018). As a result and based on experience, it is demonstrated that students through teamwork in the machine laboratory have jointly and collaboratively, and cooperatively developed integrated solutions for problem-solving, acting according to Stentoft (2017).

In this order, it can be said that the STEAM methodology is focused on structured learning that covers several disciplines but does not enhance any in particular but gives importance to the transfer of content between subjects, and on the other hand, according to the results of this experience, achieving the purposes of the project, being an impactful experience having promoted meaningful and critical learning in students through the search for creative and integral solutions.

Although STEAM shows clear benefits by improving students' skills when carrying out globalized learning projects based on its five areas, in this study it is proposed to be used by combining it with other subjects of Humanities, Arts, and Sciences (HASS) of which although there are not so many studies, it is highlighted that this combination shows an improvement in all the competencies evaluated confirming the benefits of interdisciplinary learning experiences (Fernández-Morante et al., 2022) and therefore, through this article, the perception of students about the STEAM methodology is made known with the realization of class projects and collaborative learning to achieve the objectives of the curriculum of the Information Technology Career in the subject of Oral and Written Communication.

2. Methods

The present study was of a quantitative type framed in the positivist paradigm, it was developed at the Polytechnic School of Chimborazo, located in Riobamba-Ecuador. The population and sample were the students of the Information Technology Career of the subject of Oral and Written Communication, a total of thirty-five (35) students of both genders. Which were surveyed in thirty (30) days during the April-August 2022 semester.

Table 1. Distribution of participating students

Race	Subject	Men	Women
Information Technology	Oral and Written Communication	24	11

Source: The authors

2.1. Variables studied

Students' perception of the STEAM methodology in the development of projects in the subject of Oral and Written Communication of the Information Technology Career.

2.2. Procedure

- Initially, the selection of the student population was made.
- The data collection questionnaire was developed, applying the online format.
- The questionnaire was applied for one working month.
- The responses obtained from data collection were counted.
- The data was processed using spreadsheet software.
- Tables, graphs, and measures of central tendency were generated with the resulting data.
- Relevant conclusions were drawn.

2.3. Data collection instrument used in research

The instrument used was a data collection questionnaire based on a Likert scale, with which it was possible to investigate how students evaluate the use of the STEAM methodology in the subject of Oral and Written Communication. The instrument was designed and recorded using the Forms tool with which the largest number of study participants could be reached. The indications and follow-up were carried out using the institutional Moodle platform and the different educational resources available. The procedure lasted one month.

3. Analysis and Results

After the diagnosis has been made with the implementation of the data collection questionnaire, the results obtained are the following based on the response scale of the Likert questionnaire:

1: Strongly agree,
2: Okay,
3: Neither in agreement nor disagreement,
4: Disagree,
5: Strongly disagree.

1. Do you consider that the implementation of projects in the Information Technology Career improves your ability to independently develop tasks related to the construction of models or the execution of them?

Table 2. Improvement of independent projects through the STEAM model

Answer	Male Frequency	Female Frequencies	% Fr. Male	% Fr. Female
1	8	5	24	15
2	4	2	12	6
3	5	2	15	6
4	6	1	18	3
5	1	1	3	3
	Arithmetic mean		14,4	6,6
	Dev. Standard		7,77	4,93

Source: The authors

2. Is it necessary to continue with the STEAM teaching model in other subjects taken to promote the development of skills and abilities?

Table 3. Perception of the need to implement in other subjects based on the STEAM model

Answer	Male Frequency	Female Frequencies	% Fr. Male	% Fr. Female
1	7	5	21	15
2	6	1	18	3
3	5	3	15	9
4	4	1	12	3
5	2	1	6	3
	Arithmetic mean		14,4	6,6
	Dev. Standard		5,77	5,37

Source: The authors

3. Are the evaluations carried out using the STEAM methodology more reliable than those carried out in the traditional methodology?

Table 4. Reliability of evaluations developed with the STEAM model

Answer	Male Frequency	Female Frequencies	% Fr. Male	% Fr. Female
1	8	2	24	6
2	5	5	15	15
3	4	2	12	6
4	3	1	9	3
5	4	1	12	3
	Arithmetic mean		14,4	6,6
	Dev. Standard		5,77	4,93

Source: The authors

4. Do the projects developed as a team represent strength for your learning?

Table 5. Strength of the STEAM model in individual learning by the collaborative development of projects

Answer	Male Frequency	Female Frequencies	% Fr. Male	% Fr. Female
1	9	5	26	15
2	4	2	12	6
3	4	2	12	6
4	3	1	9	3
5	4	1	12	3
	Arithmetic mean		14,2	6,6
	Dev. Standard		6,72	4,93

Source: The authors

5. Is it understandable to comply with projects based on the teaching scheme under the STEAM methodology and all the elements it promotes: Science(S), Technology(T), Engineering(E), and Mathematics(M) or, in Spanish, Science, Technology, Engineering and Mathematics?

Table 6. Understanding the elements of STEAM projects

Answer	Male Frequency	Female Frequencies	% Fr. Male	% Fr. Female
1	9	5	26	15
2	4	2	12	6
3	4	2	12	6
4	3	1	9	3
5	4	1	12	3
	Arithmetic mean		14,2	6,6

Dev. Standard	6,72	4,93

Source: The authors

6. In your opinion: Does the development of STEAM projects strengthen the progress of intellectual creations in the field of engineering by reducing the possibility of plagiarism?

Table 7. Strengthening intellectual creation through STEAM projects

Answer	Male Frequency	Female Frequencies	% Fr. Male	% Fr. Female
1	10	6	29	18
2	2	2	6	6
3	2	1	6	3
4	3	1	9	3
5	7	1	21	3
	Arithmetic mean		14,2	6,6
	Dev. Standard		10,33	6,50

Source: The authors

According to the results, 39% of respondents say that the development of activities based on the STEAM model represents an improvement to develop projects that generate viable technology area models, which was not possible in the same way with the traditional methodology.

Likewise, according to the processed values, 36% of students say they agree that the STEAM teaching model should be expanded to other subjects of the Information Technology Career, because key elements in learning are promoted, such as cooperation, inquiry, and search for answers, among others.

In other items, it was possible to verify that concerning the criteria used in traditional evaluations, the development of this type of methodologies where the use of advanced models is transposed in the creation of projects, for the consolidation of skills and abilities, is where STEAM becomes a novel and successful scheme in most cases, so 30% of respondents said they agreed on the reliability of evaluating learning after STEAM projects.

On the other hand, 38% of the respondents answered to be very much in agreement, when asked about the understanding of the elements of the STEAM model, because they said that they have clear ideas of how to execute the inquiry, find solutions, make links that enable the solution of problems with the creation and inventiveness of students of practical sciences.

4. Discussion and Conclusions

After carrying out the analysis of the exposed results, it has to be expressed around them that, today everything has had to take a different course in the teaching and learning process, where value is given more to what the student applies, in contrast to the old ideas that the student was a receiver of the knowledge transferred by the teacher and the evidence of learning is mediated to through a summative evaluation, Sánchez, A., and Castro. D, (2013), refer that digital natives are on par with the technological revolution of contemporaneity, artifacts, digital practices, and technological tools. In such a way, it is evident how the present Higher Education has been on the rise in terms of the versatility that educational plans have had to have, because practical sciences, such as engineering, have required changes in instructional processes. Thus, it was evidenced that projects based on the inquiry have a positive impact on the perception and consolidation of skills by students of the

Information Technology Career of the subject of Oral and Written Communication, which has to do with the constructivist pedagogy that provides students with the development of tools, knowledge, and skills, provided by the STEAM teaching method to provide solutions in your daily life.

That is why, it is valid to remember what Yakman (2008) expressed when referring to the STEAM methodology as structured learning that covers several disciplines, but does not enhance any in particular, but gives importance to the transfer of content between subjects, the interdisciplinary nature of STEAM addresses the complexity of a problem for its resolution through the integration in an articulated way of the different areas of knowledge. In this order, learning by doing through the STEAM teaching model represents a means of instruction that has been effective in factual sciences for innovation in teaching.

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