# Archimedes' principle, articulation with steam and storytelling

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**Abstract:**

**Background and objectives:** This paper aims at devising creativity developmental activities based on methodology and the Storytelling tool. The topic selected for the study was Archimedes' principle included in the Industrial Chemical Engineering curriculum in Mexican public university, during the 2021 confinement period

**Methods:** The research was a case study following an inductive and analytical method. For data collection, a self-made rubric was used based on specific creativity criteria. Through structured didactic planning, a series of activities aligned to the STEAM methodology were designed.

**Results:** The creativity categories of the product made by the students were analyzed and described. All information was triangulated when discussing the results.

**Conclusions:** It is concluded that there is empirical evidence that suggests that the development of creativity may be stimulated by the proposed set of activities. In addition, this way of learning results innovating.

**Keywords***:* creativity, university students, educational research.

## 1. Introduction

At the university level, the dogma that it is more effective and important to teach content than to develop higher-order skills has been rooted. Therefore, the authors focus on devising a methodology and a didactic tool to stimulate creativity, without sacrificing the learning of relevant topics for physics and engineering, such as Archimedes' principle. Stimulation for the development of creativity is a pending assignment for teachers at the university level, namely in engineering (Liu, 20014), hence the relevance of having experiences that describe how to innovate the teaching of physics and enhance creativity.

Archimedes' principle is usually a topic difficult to understand in Higher Education. Thus, Melo, Sánchez, and Martínez (2016) suggested analysing physics books' limitations concerning the teaching strategies used. In addition, if we consider teachers' self-efficacy beliefs regarding the didactic knowledge of the content, as reported by Melo, Cardona, and Martínez (2018), then we'll keep stuck in a vicious circle that neither promote learning nor higher-order skills, such as creativity.

Likewise, for chemical engineering students, the relevance of this topic is important, since, in several chemical processes, such as wastewater treatment, which is present in all chemical plants; the principle of flotation, linked to the sedimentation theory; and flocculation, among others.

In chemical engineering, the principle of hydrostatics is quite relevant, for example, the chemical treatment of brine in the production of sodium hydroxide (NaOH), generates residues that can be eventually used as raw materials for other processes. A recent graduate would presumably not make proposals of what to do with these by-products, because, they are not trained to propose solutions (or being innovative), they are instead trained to solve exercises, at least in the Higher School of Chemical Engineering and Extractive Industries (ESIQIE) of the National Polytechnic Institute (IPN) in Mexico. Being innovative is a key competence in the marketplace of the XXI century (UNESCO, 2015).

Therefore, it is conjectured that graduates after being hired at a company are far from being proactive. Most of them are expecting instructions on what to do (as they are usually trained in classrooms), not thinking about how to improve technological processes. The foregoing is evidenced in the study "Talent Shortage 2018", sponsored by Manpower Group (2018), where they suggest that the lack of both technical and professional skills (proactivity) –one of the main factors in the shortage of talent in Mexico– is connected to university education limitations in training and developing initiative. If students are not trained accordingly, they will never dare to innovate and therefore will not provide ideas for improvement.

In this regard, proactivity, creativity, and decision-making are among the most valued qualities by companies (Randstad, 2020). Moreover, a global study carried out by the International Business Machines Corporation (IBM) of more than 1,500 executives in 60 countries and 33 industries indicates that creativity will be the most crucial factor in a volatile and complex business environment (IBM, 2010).

The National Association of Universities and Institutions of Higher Education (ANUIES) indicates that by 2030 Higher Education must be renewed; and, the guiding role of the teacher will be neuralgic since professors must create learning environments that manage the relationship with the world of work and incorporate the intense use of technologies as instruments for strengthening didactic experiences (2018).

Next, the relevance of the selected topic is described; the state of art about the difficulties of studying the principle of Archimedes is discussed and the theoretical frameworks of STEAM and the scope of Storytelling are justified. Likewise, the methodological design of this inquiry is described. The findings are qualitatively analysed from the achievement perspective (rubric for creativity) and finally the conclusions are presented.

### 1.1. Relevance and learning difficulties of the Archimedes' principle

For chemical engineering, physics is a fundamental pillar. The competency-model-based knowing-to-learn dimension profile of the Industrial Chemical Engineer at ESIQIE devotes 63% of the allotted time to topics implicitly and explicitly linked to Physics. However, teachers have become aware of learning difficulties and suggested strategies to solve them. Table 1 describes studies related to difficulties in understanding Archimedes' principle in high school and university.

Table 1. Some research studies on learning difficulties of Archimedes' principle

| Author / Educational level | Methodology | Research aim |
|---|---|---|
| Alurralde & Salinas (n.d) / University | Exploratory | To inquire the organization of students' ideas in explanatory models linked to pushing exercises. |
| Buteler&Colenu (2014) / University | Case study | To clarify two university students of Physics understanding of the concept of pushing. |
| Melo , Sánchez & Martínez (2016) / Junior and Senior High School. | Mixed (qualitative y quantitative) | To explain the process of construction and validation of a test to identify alternative ideas of junior and senior high school students about pushing in the context of floating. |

| | | |
|---|---|---|
| Madrigal, A. y Slisko, J. (2010) / Senior High School. | Qualitative | To inquire about the students' construction on their predictive and explanatory schemes for the floating and sinking phenomena of bodies. |

The afore listed queries show teachers' concern about the cognitive process. However, these studies fail to propose exercises or learning activities that allow the construction of knowledge on the topic nor for the development of creativity. It is for this reason, that the proposal described in this paper has the premise of presenting a useful and stimulating learning experience with the use of STEAM and Storytelling, on the one hand to acquire solid and integrated knowledge, but also contextualized, as recommended by the Organization of the United Nations for Education, Science and Culture (UNESCO, 2015).

### 1.2. STEAM methodology

The unified approach to Science, Technology, Engineering, Art, and Mathematics (STEAM) is a study methodology that promotes a comprehensive approach to science, technology, engineering, arts, and mathematics following the idea that they share a common trunk of thought that prepares the individual for life and urges curiosity, initiative, and challenge. The Organization of Ibero-American States for Education, Science and Culture points out that this way of thinking is methodical and rational, but at the same time creative, problem-solving, and cooperative (OEI, n/d).

Likewise, the authors share Delgado's (2017) opinion that "the training processes must promote not only research skills but also to configure personal criteria to judge new knowledge and to decide what to do with them […]". The above can be achieved by using methodologies such as STEAM.

However, to enhance this methodology, the author suggests its completion with another learning tool or strategy following similar learning objectives. This explains the author's selection of Storytelling. It helps to arise interest in learning, moving from the traditional way, while creating favourable conditions for the development of creativity.

In fact, previous studies involving the use of STEAM and digital narrative have been carried out, but they follow an approach of developing skills for the 21st century, from the perspective of students (do Santos Silva, Sobrino, and Valentim, 2019). Another proposal following the STEAM methodology was accomplished by das Graças (2019) for learning Chemistry, but it focuses on improving students' commitment to self-education. Thus, it is seen that the inquiry continues to be scarce, especially at the university level.

### 1.3. Storytelling

Storytelling is the ability to tell a story, in this case digitally. In this proposal, this didactic tool connects the dimension of art that STEAM implies. That is, the development of creativity is pursued by relating art to the determination of doing things differently, in a disruptive way.

The didactic potential of Storytelling is also seen by Microsoft (2010), since Storytelling is an approach that allows students to learn in an exciting and convincing way, first it involves them in their learning process and inspires them to become continuous learners. According to Microsoft (2010) with Storytelling the following skills are addressed:

1. Creativity and innovation.

2. Communication and collaboration.

3. Fluency in research and information.

4. Critical thinking, problem-solving, and decision making.

5. Digital citizenship.

6. Technological concepts and operations.

Regarding the decision to incorporate this tool, according to studies carried out by Rosales (2016) with Storytelling in virtual format, students make use of higher-order skills, because they analyse the information, select the most recommendable means, and communicate information complex in a way that everyone can understand. Therefore, it is emphasized that for the proposal herein described STEAM is a methodology and Storytelling is the tool that will allow developing creativity.

Thus, Storytelling requires guidelines, but also a procedure. That is why Escobar and Galve (2019) suggest the following steps to guide the students' work:

• Step 1. Documenting. To carry out the research of Archimedes' principle associated variables.

• Step 2. To define the type of Storytelling (novel, short story, fable, etc.).

• Step 3. The rundown, to define the characters or context, specify what they will say and how they will say it.

• Step 4. To discuss, analyse and make sure the information is clear and actually explains Archimedes' principle.

• Step 5. To carry out production and fine-tune details. Also, students were provided with a presentation of the scope of this tool, characteristics, and rubric with the categories and descriptors of the expected product.

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### 1.4. Creativity

The authors consider that creativity is linked to art, therefore, creating a story and telling it is likely to stimulate creativity. The Royal Spanish Academy (Real Academia Española, 2020) defines the concept of art as a “human activity whose purpose is to create cultural works, a set of skills, techniques or principles necessary to carry out a certain activity […]”.

Therefore, according to Medina, Franco, Gallo, and Torres de Cádiz (2019) it is through creativity that

"[...] it is possible to stimulate and develop through the implementation of a system of activities in which fundamental individual traits are taken into consideration, the purpose of carrying out such activities with the students, and the communication links that promote an effective participation of the students".

From the point of view of the development of creativity, a robust proposal is the one offered by Ruiz (2015) who emphasizes and exemplifies the potential of physics for the development of creativity through the resolution of exercises based on maieutic. This contribution is in the same guideline, to contribute to the development of creativity, through physics.

Therefore, this study proposal is carried out on the notion of Archimedes' principle for students of industrial chemical engineering. As mentioned before, the foundation is based on the STEAM theoretical constructs and the Storytelling tool. The foregoing leads us to pose the research question: what is the potential of the STEAM methodology and the Storytelling tool for

stimulating creativity in industrial chemical engineering students who learn Archimedes' principle?

The objective of the research is to design, implement and evaluate a proposal that links the teaching of this physical principle by articulating STEAM and Storytelling.

## 2. Methods and Materials

This is an exploratory inquiry since the tools are designed to create new information (based on guidelines) and to plan the logistics and procedures to follow (students are previously provided with an assessment rubric). Next, the agreements and contracts with the students are established to set the deadline for completing their learning products. (Hamui, 2016).

The design of the inquiry is a case study. Following Martínez (2006) suggested procedures, the authors are planning to analyse and record the students' products (five units in total) to arrive at conclusions about the use of the STEAM methodology (systematic linking procedure) and Storytelling tool (instrument as a cognitive bridge), respectively in a virtual environment.

In correspondence with what STEAM and Storytelling pursue, the objective was mainly focused on the creations of the students, as well as the connection and correct use that they make of a physical principle in their doing their tasks.

The experiment was implemented with a group of university students in a virtual environment using Google Classroom through 2021-1 period –during the COVID-19 confinement–. Our sample was made of 35 university students (industrial chemical engineering), from a Mexican public university, enrolled in the classical machine learning unit, all students took the learning unit for the second time. Out of the total number of students sampled, 48.75% were men and 51.43% were women. The participants' age was about 19-25 years. This experiment was organized in five consecutive phases, as described in table 2.

Table 2. Experiment phases, implications, and allocated time

| Phase | Task | Doer | Time (min) |
|---|---|---|---|
| First | To analyse how to apply STEAM procedures to the learning of Archimedes' principle. | Teacher | 300 |
| Second | a) To review the explanatory videos of exercises related to Archimedes' principle.<br>b) To draw a conceptual map of the hydraulics issue.<br>c) To respond to the readings test about hydrostatics.<br>d) To carry out the assigned exercises related to Archimedes' principle. | Students (individually) | 120 |
| Third | Perform the Storytelling. | Students (in teams) | 120 |
| Fourth | To give Feedback. | Teacher | 300 |
| Fifth | To analyse the outcomes. | Teacher | 300 |

The research follows the STEAM scheme comprehensively. Therefore, the teacher should devise exercises for each dimension of the methodology, as described in table 3.

Table 3. Dimensions and learning tasks

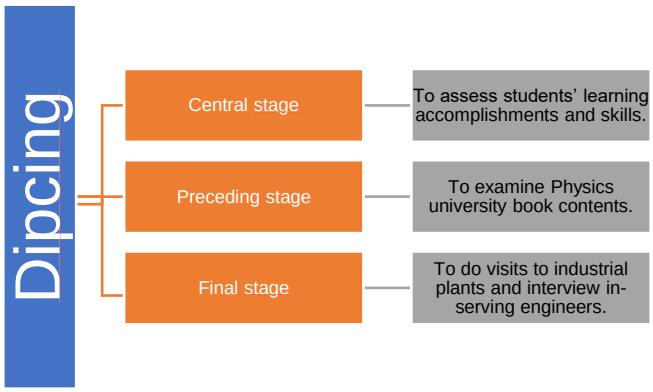
| Dimension | Content | Learning task |
|---|---|---|
| **Science** | Physics | Physics, Archimedes' principle. |
| **Technology** | Physical Genially, Slide story, Wondershare, Filmora. | Using a specialized software for creating something new. |
| **Engineering** | Chemical engineering, clariflocculator analysis. | Outlining solution proposals to process residual sludge, based on a problem contextualized with the Chemical industry. |
| **Art** | Infographics, complex visual diagrams. | Narrative creations made by students, using rubric as a guide. |
| **Mathematics** | Data analysis and modeling through the Free Body Diagram. | Solution proposals through algebraic calculations. |

Taking into consideration the relevance of the engineering dimension for the education of engineers, the students were given a problematic situation. Although this problem-solving task is not fully described here, it is quite important to stress that it follows the methodology either in the instructions given or in the students' expected solutions to promote creativity in a scientific context.

The students should complete a Storytelling as a cognitive task that allows the construction of Archimedes' principle basic concepts before facing the solution of other problem-solving tasks connected to a chemical plant. This will provide new solutions to new problems.

Learning tasks are organized in situ (in a chemical plant), putting physics into practice while analysing a chemical process. This visit to the chemical plant took place before the confinement period as a component of a research project developed from 2017 to 2019. The visit follows Dipcing's methodology, specially designed for engineers' education (Camarena, 2013), and organized in three stages, as described in figure 1.

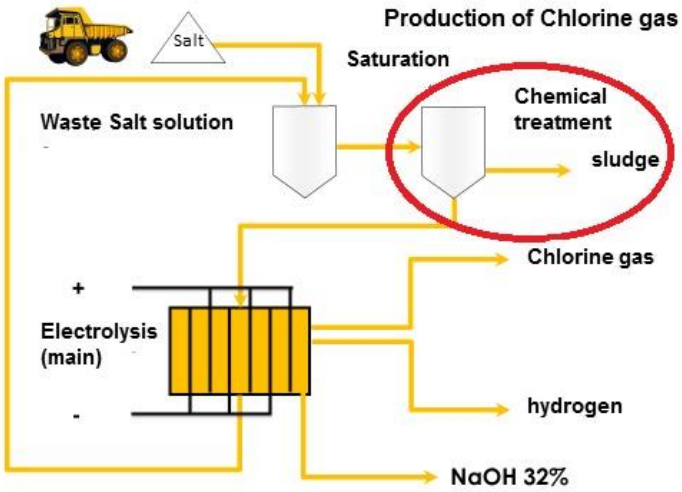
Figure 1. Dipcing's methodology and stages




Next, the problem-solving situation is described and questions are established to guide students to find regularities related to the Archimedes' Principle topic. The company innovation and

improvement council (Chlorine Tec) calls for the presentation of areas for improvement in all the plant processes. As the person in charge of the brine treatment process, which is concentrated at 310 g / L (see figure 2), you realize that after the chemical treatment a large amount of sludge is generated.

Figure 2. Selected brine chemical treatment process




Consider that the brine contains 600 ppm of Ca (calcium) and 70 ppm of Mg (magnesium) and 600 ppm sodium carbonate (Na2CO3) are supplied to remove these impurities, the latter flocculate and form sludge. The product (electrolysis brine) should be left with 20 ppb of Calcium and Magnesium. Suggest a solution for the disposal of the sludge considering the data described.

In this way, it can be observed that all the dimensions proposed by STEAM are fully linked and covered systematically in this proposal; and that through the Storytelling tool, the art dimension is included, thus, it is possible to stimulate the development of creativity. The students' development in this skill area was precisely the focus of this inquiry, consequently, this article shows in detail the construction of the proposal and some results regarding the outcomes of the Storytelling tool.

## 2.1. Instrument and Procedures

The data of this inquiry were obtained from three sessions in the virtual classroom, lasting approximately 120 minutes each, and based on observation, analysis of student learning evidence, and the evaluation rubric. The students' Storytelling and their proposals were registered in the virtual classroom in Google Classroom.

The data curation process was based on the selection of information aimed at analyzing the learning difficulties of the floating principle; the selection criteria were based on the relevance of the inquiry and the results obtained. As well as description and relevance of STEAM and Storytelling for the aim of this proposal.

To analyze this information, the data provided by the rubric were organized and integrated into categories, a cycle of observation of the dialogues in the students' chats, described productions, and Storytelling. Subsequently, a methodological triangulation was carried out, as described by A. Puentes, D. Puentes, E. Puentes, and Chávez (2019); two or more qualitative proximities were included, such as those described above to assess the same phenomenon. The bibliographic and methodological sources and the data were contrasted, the result of comparing them is described in the following section.

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. One of the sampled students reply to the task given, that fulfills the rubric, may be accessed at https://youtu.be/7RW13xBbBGw .

## 3. Results

The scope of the inquiry focuses on analyzing the development of creativity resulting from the use of STEAM and Storytelling.

Regarding creativity, Eisner (cited in Robinson, 2012) points out that: "not every important can be measured, nor everything that can be measured is important" (p.373). Given the complexity of evaluating creativity, we opted for developing a rubric that would assess the creations of the students.

Likewise, linked to STEAM students were encouraged to develop primitive creativity. The outcomes of the rubric used to evaluate the quality of Storytelling exercises were adapted based on Santaella's (2006) criteria for creativity.

Creativity is a subjective concept. This ability is usually associated with professional profiles such as musicians, poets, painters, sculptors, and scientists (Folgarait, 2008). The authors of this article are two chemical engineers and a physics specialist respectively. Physics and Chemistry are disciplines that explain natural phenomena, within the framework of scientific principles. Therefore, to describe the achievement levels, we opted to request the opinion of three professional musicians (pianists, music education graduates, and guitarists), who from their creative perspective strengthened our view on achievement levels. Other inquiries report the construction of rubrics to evaluate creativity by going to experts in the dimension to be assessed (Aguilera and Ortiz-Revilla, 2021).

The previous process is considered necessary since this is an original product, it is a production that implies originality and disruption. There are indeed rubrics for assessing scientific creativity (Ayas and Sak, 2014), however, these metrics do not satisfy the purpose of our inquiry, which is to stimulate creativity for the sake of solving physics problems in the context of chemical engineering. So to reduce subjectivity and attempt to avoid being judged and party. The authors considered it recommendable to request the opinion of professionals linked to artistic activities. This would allow the rubric to be more focused on evaluating creative capacities, instead of technical capacities.

In this order of ideas, the technical aspect is included in the solution proposals of the previously presented contextualized problem. Furthermore, as teachers, we must recognize that we are not specialists in every field, but leaders that are expected to promote multidisciplinary collaboration. Regarding the process of construction of the rubric with the support of the creative experts, the criteria were sent via email, and they were asked to associate between two or three words with each criterion. The level of achievement in the rubric is estimated under a range going from 1 to 5 where 1 means null, 2 stands for elemental level, 3 describes a satisfactory level, 4 a remarkable level, and 5 is the expression of excellent performance. See table 4 and table 5.

Table 4. Rubric for assessing each team Storytelling products

| **Category** | **Level** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **Originality**<br>The product is unpublished and meets all the requested characteristics; it is also | It is plagiarism from another product with slight changes. | It is a product with slight changes in characters or data from other proposals. | It is a product with striking, but irrelevant features, it is not a singular story. | It is a product that incorporates novel aspects, such as the context of the story. The product is not unique. | It is an unpublished product that catches you from the beginning and that you want to see from start to end and see again. |

| | | | | | |
|---|---|---|---|---|---|
| eye-catching. | | | | | |

| **Category** | Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Initiative**<br>Students develop ideas and materialize these through the script, this is reflected in right explanations, laconic and coherent sentences. | They replicate what is on the network. | They fail to follow the script and improvise the product | The script is made based on a story without contemplating all the technical elements requested. | The script is made based on classic stories (Corona and King Herón). It includes all the technical elements requested. | The script has an unprecedented original story and includes all the technical elements requested. |
| **Fluency**<br>The quality and quantity of ideas related to Archimedes' principle are remarkable. | Ideas are not coherent; it is analogous to explaining an exercise. | Ideas are laconic and brief, the activity was done only to fulfill the task. | Ideas are coherent but irrelevant, they do not emphasize the variables associated with Archimedes' principle. | Ideas are coherent but not relevant, they emphasize the variables associated with Archimedes' principle. | Ideas are coherent, precise, and relevant, they emphasize the variables associated with Archimedes' principle. |
| **Elaboration**<br>The delivered product is on time, in addition to presenting the entire planning, development, and materialization process. | They deliver the task 36 hours late. All evidence of achievement is missing. | They deliver the task with 24 hours of delay. Some evidence is missing. | They deliver the product with 12 hours of delay. There is no lack of evidence | They deliver the product with 6 hours of delay. There is no lack of evidence. | They deliver in time and with fine formatting. They deliver all the evidence of realization. |
| **Innovation**<br>The Storytelling presented has innovative elements, uses scientific dialogues within the framework of an unpublished and motivating story. It stands out for the interest it provokes in those who see the product. | They use an exercise from a book and only relate their solution. | History does not include new characters or new dialogues. The story is boring. | The story has original characters, it is coherent and trivial. | The story has new characters, it is coherent and entertaining. | The story has unique characters, it is intriguing and very entertaining. |

Table 5. Students' level of achievement

| | | | | | |
|---|---|---|---|---|---|
| **Originality**<br>The product is unpublished and complies with all the requested characteristics. It is also striking. | | 1/5 | 2/5 | 1/5 | 1/5 |
| **Initiative**<br>Students develop ideas and materialize these through a script, this is reflected in the product, coherent prayers, laconic and correct explanations. | | 1/5 | 2/5 | 1/5 | 1/5 |
| **Fluency**<br>The quality and number of ideas related to the principle of Archimedes is remarkable. | | | 1/5 | 2/5 | 2/5 |
| **Elaboration**<br>The delivered product is carried out in time and fine formatting, presenting the entire planning, development and materialization process. | | | | 2/5 | 3/5 |
| **Innovation**<br>The Storytelling presented is innovating and motivating, including scientific dialogs. It arises readers' interest | | | 2/5 | 2/5 | 1/5 |

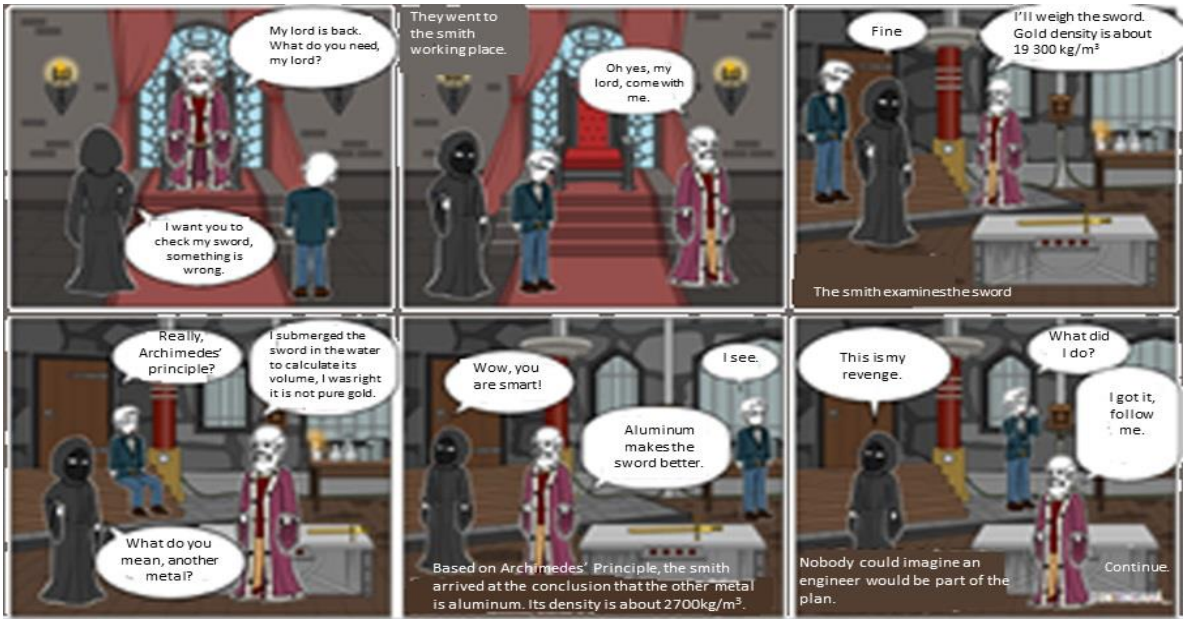
The students were grouped into five teams (three teams of five members and two teams of four). Each team was responsible for one of the five products assessed. Only 66% of the participants completed the assignment, the rest refused to do it. The authors presumed that this lack of interest is partly due to the continuous character of the assessment system, doing such a task takes time and effort; students might believe that failing just one task does not alter grading significantly.

In relation to the students' learning products, every team (100%) presented unpublished Storytelling and other educational products (animated segments, novels, comics, and black humor). But only 60% presented a product on the threshold of satisfactory; but, not exactly relevant. It is also noticeable that only one team (22%) managed to be at the maximum level of achievement of the creativity indicators. A sample of a product that fulfills the rubric may be accessed at https://youtu.be/7RW13xBbBGw .

The above product is a good example of a creative product, congruently expressed and above all useful. It should be highlighted that the explanation has attractive visual elements, it can even be used by basic level teachers to explain the floating principle, due to the type of format it has, it is a cartoon. Thus, it is found that students have the ability to make this type of creation, as long as the guidelines are indicated. A consistent evaluation of the foregoing was essential.

A couple of the products made by the students are shown in figure 3. These products correspond to the school period 2020-2. However, still unpublished, they were all soundly scientifically argued and followed the descriptors described above for assessing creativity, especially regarding fluency, a category that involved technical concepts.

Figure 3. Two Storytelling written by the students.





It is not possible to describe students' enthusiasm, interest, or other psychological response due to the virtual character of the interaction, this is considered as one of the limitations of the study. However, from their work evidence (screenshots from WhatsApp, chats on Skype or Teams), there was discussion, and it appears that they made use of specialized literature –at least 2 of the 5 teams used scientific jargon, such as density, thrust force, volume, displaced liquid, weight and the like–.

One of the teams refers to friction. This illustrates that the students made inferences beyond what was requested by the given task. Team 3, whose Storytelling was based on the contest of geometric shapes of different materials immersed in two different fluids (honey and water) pointed out: "In our scenario, we consider normal conditions, since, if the viscosity is taken into account, it decreases when there is an increase in temperature, so the diamond cube sinks, because the density of the diamond is greater than that of water […]."

Although they did not specify the entity and the parameters that describe the standard reference conditions, it is considered there is an empirical inference that shows inquiry and primitive understanding of the subject.

This fact proves that if the students follow a given script before constructing Storytelling, they are led to write, investigate, and analyze with their classmates if the data collected corresponds to the scientific principle they want to explain.

As the rubric reveals, there was a team that carried out the activity only to fulfill the task, there were no scientific explanations linked to their proposal. Nor did they make any effort to describe a new situation, they took an exercise from a book and produce a Storytelling.

Regarding the use of STEAM, this study proves that it is possible to relate the teaching and learning of physics, and a particular content as the Archimedes' principle, to students' real life. In relation to technology, there was promotion and use of this by teaching initiative by articulating all the activity in a virtual classroom (Google Classroom), likewise, the students were able to use Slidestory, Wondershare, Filmora, etc. Regarding engineering, the problem-solving task, taken from a real situation in a chemical plant, illustrates the potential of relating engineer students' education to their future working environment.

Although students' artistic expression never took the form of a sculpture, a painting, or a prototype, it does as a written unpublished product, that is, Storytelling. The use of mathematics is accomplished as manifested in the calculations made by the students in the scientific explanation's product presentations, they make use of algebra (clearances and dimensional analysis). In one of the products, the students make use of the free-body diagram, therefore, they use the mathematical object, vector.

However, even though the students were always given guidelines and evaluation rubric, and an extended deadline, products were of a low quality, 34% of the students never completed their tasks. A member of this group argues he was unable to reach an agreement with the rest of the team members, others said they were not motivated, and a third-party excuse by saying he is not a creative individual and never dares to do things differently.

## 4. Discussion

### 4.1. Relevance

The findings of this case study are relevant for Higher Education, especially for the training of engineers, for at least three reasons. First, by taking the ideas of STEAM and Storytelling as a starting point a comprehensive approach to learning and professional development is assumed. The future engineer needs to combine knowledge, relate theory to practice, recognize strengths and weaknesses in the production process in which he works and propose solutions to old and new problems. These prepare the would-be engineer to face life and future technological development. Second, the dynamics of Storytelling forces him to get personally involved; he will be able to rely on previous ideas and solutions already published in the bibliography or derived new ideas from the interaction between peers, but he will be forced to present his own solution that will be innovative due to its content and the ways and methods to be used. A third aspect, no less important, is the fact that the development of creativity transforms him from a technician who consumes technologies to a producer of new technologies: An important personal and professional quality for the achievement of the technological sovereignty of the South. Notice that relating theory to professional practice, personal involvement, and creativity (in terms of technological sovereignty described above) lead to the consolidation of intrinsic motives towards training and towards the stimulation of an entrepreneurial character.

### 4.2. Limitations

The conditions of social isolation in which this case study was developed constituted an important limitation for personal and professional development, remember here the ideas about socio-formation expressed by Vygotsky (1979). It is presumable that the interaction between engineering students would eventually stimulate the creation and construction of better

solutions to the problems faced during the execution of the proposed activities and professional performance within chemical plants.

## 5. Conclusions

Traditional education beliefs seem to be uncritically and uncompromisingly rooted in Higher Education. Some teachers continue believing that creativity is not an important skill to be developed. Such an idea will possibly affect the training of students' higher-order skills and, therefore, make them less competitive. It seems recommendable to remember Robinson's (2012) statement concerning the fact that companies complain that education does not produce thoughtful, creative, and self-confident people, who work as a team, speak another language, and master mathematics.

Therefore, this proposal coincides with what Ruiz (2015) pointed out, the improvement of creativity is an essential aspect in the training of students, which may eventually mean a competitive differential at the work level, as revealed by studies carried out by Manpower Group (2020) and Randstand (2018).

With this proposal and with the systematic and articulated use of STEAM in this Mexican university, we are contributing towards the strengthening of Higher Education. As explained above, the academy and the company were linked in the problem-solving task posed to the students, this was done to outline the engineering dimension of STEAM, by extracting a problem from phenomenal reality. Therefore, the objective set out in this research is achieved. The potential that STEAM and Storytelling have in terms of stimulating creativity in industrial chemical engineering students who learn Archimedes' principle is remarkable, as long as the teacher highlights how students should use the methodology, and tool, respectively. Naturally, professors are expected to give feedback on achievements and limitations and to point out the ways of improvement. This was pursued with the use of the assessment rubric designed for the inquiry.

Consequently, the development of creativity is given a foundation. Because, a person who is not trained to produce his own ideas, cannot have initiative and, therefore, will not be able to innovate. It is evidenced that teaching methodologies and tools require not only teacher's will but also articulation and systematization.

The foregoing is in harmony with what Rosales (2016) points out, the process of student involvement in this type of assignment for the development of creativity is achieved with planning by the teacher, never improvising.

In this regard, the authors follow what Medina et al. (2019) have expressed: Creativity promoting activities should be transformed into a methodology, in our case the combination of STEAM and Storytelling, making them a hybrid that allows the eventual development of creativity without sacrificing the professional technical training of an industrial chemical engineer.

It is concluded that this contribution is viable, there is empirical evidence of characteristic features of creativity in students (at least in a team), This is an accomplishment of the synergy of a powerful methodology (STEAM) and an innovative communication tool, such as Storytelling. In addition, 4 out of the 5 teams make a basic and correct argument for the flotation principle. It is inferred that the increasing use of this type of activity will result in further development of creativity, a skill that companies in the century of knowledge are foreseeing (IBM, 2010; UNESCO, 2015).

Four teams (out of 5) delivered the activity, adhering to the requested guidelines. This fact suggests that, due to Storytelling, they had learned notions of the floating principle. However, the attempt to develop creativity was basic because only one team achieved the highest level of

achievement in relation to the initiative and innovation dimensions. The above can be attributed to the fact that the elaboration of the script demands the greatest cognitive effort. As Rosales (2016) points out Storytelling demands the most creativity. If students are reluctant to develop it, teachers should find new strategies to encourage them to dare to do things differently without fear of making mistakes.

Finally, according to the design, methodological consistency, and outcomes, this proposal is considered to be useful for university education, both for face-to-face sessions and for distance education alternatives.

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