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# Public awareness in Science and Technology using ludic learning tools: an application for Nuclear Energy and its role in climate change

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## 1. Introduction

It is widely known by the nuclear community that, among the challenges inherent to the technology itself, one of the biggest difficulties towards the development of new nuclear energy facilities is the public awareness. It becomes even harder in countries where the nuclear industry is strongly dependent on policy recommendations. Even though this problem is intensified in the nuclear industry, not only this industry is impacted by public engagement. In reality, the development of any industry is heavily dependent in the relationship between science, technology and society (STS or CTS, in its Portuguese acronym).

The STS theory aims to bring and discuss these three main and bounded strands that eventually lead to technological and scientific advances and thus create societal and political impacts. The society expresses its concerns regarding the potential impacts the scientific knowledge and the technological development could cause. Therefore, these three strands influence each other mutually, in a way that one always influences the other and so on.

Bringing STS context in the school curriculum would enhance the development of a broader understanding of real-life situations and phenomena in future societies given that it articulates between many knowledge areas such as philosophy, sociology, economy, science, and others. Considering a technological application, the STS-oriented society should know how to distinguish the reasons why that application is being used, what impacts and benefits it brings, who the responsible for the management and operation is, and how it works.

According to Santos e Mortimer (2002), inserting STS-based curriculum in the school environment can be done in different ways and with different goals. Table I below shows some STS teaching categories as well as its quick description.

Table I: STS categories and its brief description [Adapted from Santos e Mortimer (2002). Free translation.]

| Number and Category | Brief description | Number and Category | Brief description |
|---|---|---|---|
| 1. STS as a motivating factor | Traditional science teaching using STS discussions as a tool to make classes more interesting. | 5. Science through STS approach | Syllabus is STS-oriented. Content is multidisciplinary. |
| 2. Eventual STS insertion in the regular program | Traditional science teaching using STS discussions as an appendix in science subjects. | 6. Science with STS content | STS content is the main focus. Content is used to enrich the learning process. |
| 3. Systematic STS insertion in the regular program | Traditional science teaching using STS-integrated discussions in science subjects. | 7. Science incorporated in STS | STS is the main focus of the science curriculum. Science is not taught systematically. |
| 4. Specific course using STS approach | Course syllabus is organized by STS content only. | 8. STS content | Study of an important social or technological issue. Science is only mentioned to indicate the relation with the problem itself. |

Categories are sorted somehow to express the proportionality of STS insertion in the school curriculum. In this work, it is proposed the development of a game as a ludic learning tool that aims to introduce STS discussions in the school atmosphere. The use of this game is then analyzed and classified into the STS categories described previously. The game was mainly focused in aiming at secondary school students, given that some previous science knowledge and also current global challenges regarding climate change.

The efforts for the development of this game were driven by the strongly need of increasing public awareness in terms of nuclear energy, since the current view from the society is among fear and rejection. These feelings are directly related to the way nuclear energy was introduced to the world many years ago and the negative impact of it has been persistent over the years. Given the complexity of this subject and the lack of information both from media and general public, the perception of the impacts caused by nuclear technology has not been changing much. Work towards a long-term solution, NucGame tries to introduce to players many aspects of nuclear technology, especially the ones related to the production of electricity through nuclear power plants (NPPs). The role of nuclear energy in fighting against climate change is the biggest motivating factor for them. In the next session, one may find the specifics of this game, such as the topics covered, the rules and the overall dynamic.

## 2. Methodology

The game begins with a card that presents to all players the Paris Agreement, signed in 2016 by almost 200 countries. This agreement foresees that those countries would join efforts to keep the increase in the average global temperature below 2ºC. The content of this card introduces the issue of electricity production by fossil fuels as being the most contributor to climate impacts and claims that along the game the player would be faced to reasons on why nuclear energy can be a potential way of generating clean and safe electricity without harming people and environment.

The players would be sitting around a game board in which a different color pin is assigned for each of them. The pins represent fictional countries which goal is to construct a NPP and therefore "comply" with the Paris Agreement. The game has two main components: physical and online. These two components communicate with each other by using QRCodes located on the back of each card. Along the table, pins are supposed to walk into the numbered spaces as shown in Figure 1.


Figure 1: NucGame board table. (Text in Portuguese)

In every turn, players would be faced to the effects of each space. The initial phase is composed by the 8 first spaces and since the start until the 8th space, players are about to be tested with their prior knowledge about electricity matrix, capacity factor, mining resources utilization, carbon emissions and the climate impact of electricity industry. The questions are introduced by physical cards which contains a QRCode for players to answer them. Number of spaces to walk with their pin is proportional to the correctness of their answers. If a player does not make up to the 8th space, then the player is eliminated.

The second and biggest phase of the game, from space 9 to space 22, is where the nuclear technology among the nuclear fuel cycle is introduced. In every space, players are requested to scan a QRCode that leads to an online roulette containing the 7 main steps of the nuclear fuel cycle, they are: mining and milling, conversion, enrichment, fabrication, construction and operation, storage, and reprocessing. Depending on the topic the player randomly selects, the player would be pointed to a deck of cards in which every card contains valuable information about the selected nuclear fuel cycle step. Along the information, a makeup scenario is presented, it means that if the scenario randomly picked is a scenario with a technical problem, for example, then the players should keep or step back with their pin or if the scenario presents a good aspect, then the players should advance their pins. A example is found in Figure 2.

In the last phase of the game, players are about to be asked for each path to run at space 22. The longer run finishes at space 28 while the shorter run finishes at 25. The two paths represent the construct and operation of a generation IV (longer) or a generation II reactor (shorter). In this phase, the players are introduced to specifics of each of these generations and some interesting features of the nuclear fuel cycle for each of them.


Figure 2: Example of a card showing the sintering process used during the fabrication of uranium fuel pellets. The makeup scenario is that the sintering furnace is under maintenance and the players needs to step back one space. (Text in Portuguese)

## 3. Results and Conclusions

Considering the elaboration and its potential applications in formal and non-formal contexts of education, the NucGame can be classified as the number 6 of STS application from Table I, where the application of a technological issue is the main focus. In formal education context, teachers could use the game during science classes or as an extracurricular activity, for example during lectures where science subjects tangential to nuclear technology is being introduced.

## 4. Conclusions

In this work, the NucGame was introduced as ludic learning tool for introducing STS in science education. The use of this tool was, unfortunately, impacted by the COVID pandemic and could not be presented as an outcome from the research group at the Science Teaching Laboratory in the Federal Center for Technological Education of Rio de Janeiro campus Nova Iguacu. Research findings from the group are usually presented to the students and the community close to campus during the Teaching, Research and Extension Week that had to be an online edition this time. Since the game is current mostly composed by physical aspects, then it could not be played by the community. Even though, a presentation with the development of this game was performed. As future work, the fully transformation of an online game is the main goal of the group, given that it would proportionate much broader access to the content and increase the range of public to be aimed.

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