International Journal for Innovation Education and Research *Vol:-10 No-07, 2022*
DOI: https://doi.org/10.31686/ijier.vol10.iss7.3816

A Digital Booklet about Natural Disasters with Graphic Animation Focused on Landslides: A Study Case at Amazonas

Diego S. da Cunha[1], Professor Jamile Dehaini[2] and Professor Marcela S. P. Pessoa[3]

[1]Computing Center, Superior School of Technology, University of the State of Amazonas
[2] Department of Meteorology, Superior School of Technology, University of the State of Amazonas
[3] Computing Center, Superior School of Technology, University of the State of Amazonas

Digital booklet available at : https://amazonasemdados.com.br/propostaCartilha

Abstract

The main occurrences of natural disasters in Brazil occur, being in the biggest part constituted by floods and landslides. The use of digital models is very useful to assist in the understanding of those phenomena, mostly geological processes that are developed at subsurface as landslides and are not possible to be seen by humans. This way, a digital booklet about landslides was developed and evaluated with two studies. One, that evaluates the usability through the SUS scale and the other, that evaluates the booklet importance by the perception of Earth Sciences field professors. The results indicate that the booklet brings an important theme and easy utilization, helping to spread to the population how the landslides occur and what to do to avoid them.

Keywords: Earth Science; Landslides; Digital Booklet; Natural Disasters; Geological Processes;

1. Introduction

Nowadays, the scientific information is more accessible than ever to everyone due to the digital ways of spreading information, however, topics related to Earth Sciences are often presented in complex ways, or through a very technical vocabulary. On the other hand, every year natural disasters devastate entire families. Among these disasters, the landslides claim hundreds of victims. In 2022, the population of some Brazilian states suffered with these landslides, like the city of Petrópolis in Rio de Janeiro, that was one of the most affected. Even in non-mountainous regions there is incidence of landslides, for example, only in February 2022, Manaus, in Amazonas, faced a period of intense and lasting rains, where in a single day, fourteen occurrences involving risk of landslides were registered by the competent authorities.

The first signs of the start of a landslide are not clearly seen, since they occur at subsurface. Such signs are even more incomprehensible because are slow processes and not observable on the surface or in the daily life of the population. To understand what is a natural disaster in the form of landslide may contribute

and provide better planning within cities and encourage the practice of citizenship, as well understand how water, from the precipitation, infiltrates from the surface to the ground bringing the possibility of a landslide depending on surface conditions and its occupation by the population.

The educational process on environmental issues has a fundamental role, as it can lead to collective awareness and encourage greater participation of the population in the management of the city. In this context, the purpose of this paper is not only to present an educational digital booklet about geological and environmental processes, but also provide an available source of knowledge to the population, presenting "why and how a landslide occurs" and, this way, discourage inappropriate land occupation and look for safe ways to build. Regarding the popular understanding on the subject, the objective was also to provide knowledge to the population about the physical and geological processes which trigger the landslides regarding the inappropriate land occupation bringing a bigger social development.

This article, in addition to this introductory section, presents, in Section 2, the basis of knowledge acquired researching related works. In Section 3 is presented the Theoretical Reference. The Section 4 presents the research methodology. In Section 5 is presented the main results and discussions and the Section 6 brings the conclusions and future improvement expectations for this digital product. Attempting to obey to the *"double-blind"* review format, the booklet electronic address is omitted for review.

2. Related Works

This article aims to familiarize population with basic concepts about Earth Sciences and expose the problems inherent in inadequate procedures of land occupation and which risks permeate them through a digital booklet.

In that sense, Gusmão et al. (2015), through a digital booklet help to spread knowledge on improving quality life of people over 60 years old. To evaluate the booklet and verify if the users understood its content, the authors made use of some questions regarding the comprehension of the booklet content. The results indicate that some users felt uncomfortable with the size and type of the text font used in the booklet. As opposed to Gusmão et al. (2015), this article's proposed booklet does not have a specific target audience and can be used to assist regarding the understanding for both children and residents of risk areas.

In Santos (2021), the focus is directed to elementary school students, intending to promote the environmental education and the student's awareness, bringing disruptive didactics. Thus, is presented a digital booklet which advises on the correct destination of electronic waste. The results suggest that the use of digital booklets on the basic education contributes to the pedagogical practice. With the same theme, Iop et al. (2018), focused on promoting correct disposal of useless electronic equipment, seek, through spreading digital content, that the population become a wellness promotion agent for both individually and collectively. As well as the booklet proposed in this article, Santos (2021) seeks to help with environmental awareness, however, explores aspects of the correct disposal of electronic waste, with a target audience focused on children and adolescents. In Iop et al. (2018), the focus is on the correct disposal of solid waste regardless of target audience.

Similarly, in da Silva et al. (2021) the digital booklet presents how the authors worked on beneficial concepts and approaches for both man and the environment through the diffusion of knowledge about the

correct destination of electronic waste. Due to the Covid-19 pandemic, the authors make the booklet available by e-mail and received evaluative feedback from their target audience by filling out a form. Of the 70 respondents who evaluated the digital booklet, 100% had approved the tool and informed that they would indicate the booklet for relatives and friends. Although Silva et al. (2021) and the booklet of this article have the same objective, the booklet proposed here has the differential of bringing the theoretical concepts and approaches in a playful way, through the use of graphic animations. Finally, the approach brought by de Melo et al. (2019) aims to raise awareness of children in schools using different didactics in science teaching. Bringing the proposal of digital booklets, the authors intend, in the long term, to work on building ethical sense in children, aiming to construct a mindset concerned with a possible scarcity of natural resources. Its main result, was the production of a didactic material about care for the environment developed by its own target audience, namely, children of the elementary school. Unlike this work proposed in this article, Melo et al. (2019) made use of drawings, engravings, folding and works with paper and ink, and did not make use of digital media or animations.

3. Theoretical Reference

With the purpose of assist in the diffusion of technical knowledge, either by bringing accessibility, either facilitating the understanding of technical terms, is presented in this section the concepts approached in the booklet.

According to Santos et al. (2012), the forms of intervention in the physical-geological environment are considered as a preponderant factor for the population to be inserted in a risk situation. One of the interventions more diffused are the landslides. They are physical processes present in regions where humid climates predominate, constituted by movements of materials (soils, rocks and vegetation) covering the surfaces of the slopes, according to Guidicini and Nieble (1976). The causes of the landslides processes are associated to many factors, as geological characteristics, type of relief, pluviometric index of the region, declivity and shape of the slopes. The indiscriminate urban occupation in unfavorable areas, however, the most accessible to the populations of low income, generally are unprovided of planning and human interference for terrain stabilization, which transform them in areas with eminent risks to disasters and often, with tragic consequences. The concept of landslide is being better described in Section 3.1

3.1 Landslides

The generical term “landslides” encompasses a variety of types of movement from mass of soil, rock or debris generated by the action of gravity, on sloping terrain, having as main triggering factor the infiltration of water, mainly from rains. Figure 1 illustrates slip hazard areas and is part of the digital booklet that is being proposed.

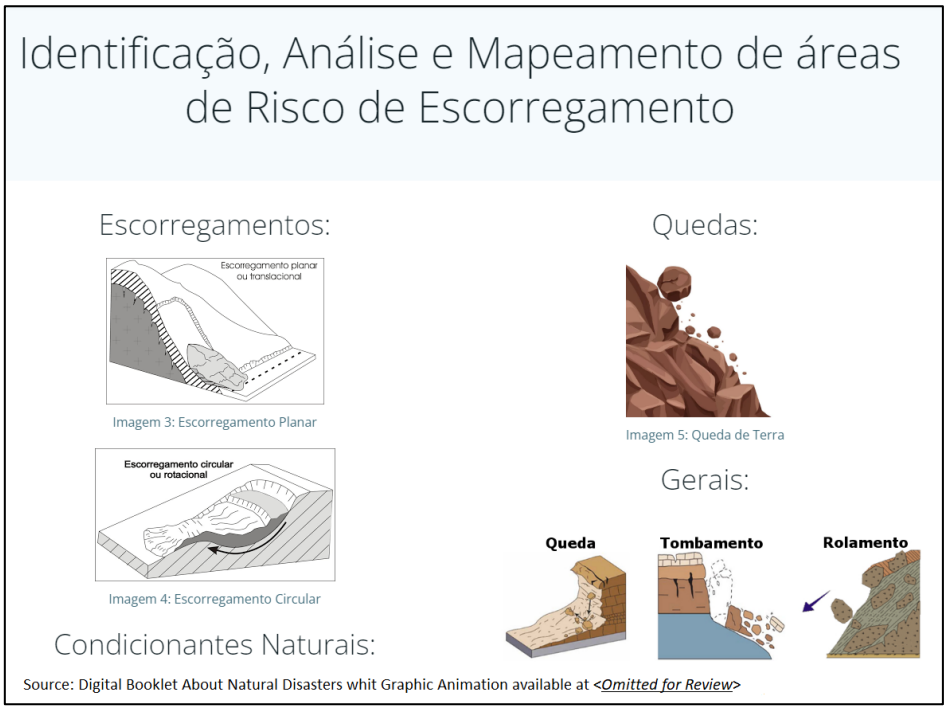


Figure 01: Identification, analysis and mapping of landslide risk areas.

Landslides are rapid movements in the landscape of portions of land (soils and rocks), with defined volumes, moving under the action of gravity, down and out of the slope, as illustrated in Figure 2.

Broadly speaking, a landslide occurs when the relationship between the material's shear strength and the potential surface shear stress of movement decreases until it reaches unity in the moment of the landslide as said by Guidicini and Nieble (1976). In other words, at the moment when the gravitational force overcomes the internal friction of the particles, responsible for stability, the soil mass moves slope down. Normally, the infiltration of water in the soil mass causes the reduction or total loss of friction between the particles. When the soil reaches the state of saturation with total loss of friction between the particles, in a process known as "solifluxion", starts to mobilize downhill, forming the flow movements of racing type.

Considering that the geometry and the nature of the unstable materials, the landslides may be divided in three types: rotational or circular slips, translation or planar slips and wedge slips and can be predicted, in other words, it is possible to know in advance, where, under what conditions occur and what will be its magnitude. For each type of landslides there are non-structural and structural control measures.

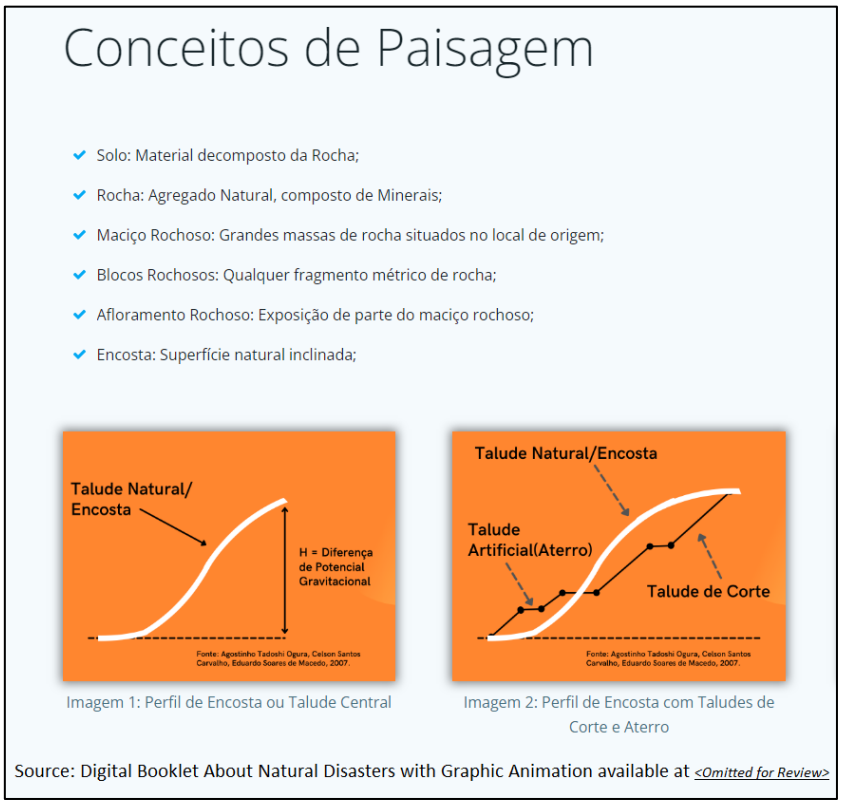


Figure 02: Landscapes concepts: Slope and central slope profile and slope profile with cut and fill slopes.

3.2 Conditioning Factors

The conditioning factors of landslides correspond mainly to the elements of the physical environment and, secondarily, the biotic environment, which contribute to triggering the process. These elements are part of the dynamics of the natural processes, which Guidicini and Nieble (1976) called predisposing agents. However, human actions exert an important influence favoring the occurrence of processes or minimizing their effects. The basic causes of slope instability, including landslides are well known. What is always sought is to achieve, through understanding of the processes involved, answers to questions such as: why landslides occur, when, where and what are their mechanisms, allowing the prediction of susceptibility according to Varnes (1978). The predisposing agents correspond to the set of geological conditions, topographical and environmental aspects of the area where the mass movement develops. They are, therefore, the natural conditions given by the intrinsic characteristics of the materials, without human action. Effective agents, on the other hand, refer to the set of factors directly responsible for triggering mass movements, including human action. They can be effective preparatory agents such as: rainfall, erosion by water or wind, level oscillation of lakes, tides and water table, animal and human actions such as deforestation, among others. They can also be immediate effective agents such as: heavy rain, erosion, earthquakes, waves, wind, human interference, among others as said by Guidicini and Nieble (1976).

Thus, the main factors that contribute to the occurrence of landslides are related to geology, geomorphology, climatic and hydrological aspects, vegetation and human action related to land use and occupation. [Augusto Filho, 1995, Fernandes and Amaral 1996, Tominaga et al. 2009].

4. Study Design

This section describes the used methodology to build the digital booklet about landslides. Initially, this section presents the problem identification and, succinctly, the idealized solution is proposed. Therefore, the project of the booklet is presented regarding the conception of the original idea, construction and development of the tool.

4.1 Problem Identification

<Omitted for Review> is located in the largest hydrographic basin on the planet, and has experienced an intense process of urbanization with a disorderly pattern, cultural characteristic predominant in the country, which causes serious environmental problems for the population. One of these problems is the destructive process related to geological hazards, concentrated in urban areas, corresponding to the stability of cut slopes that can cause loss of life, social impacts and economic damage.

Disseminate knowledge about natural disasters in an educational and stimulating way incurs advantages for the socio-economic-regional development, in addition to disseminate knowledge related to Earth Sciences area in the daily lives of communities. Considering the interactions between atmosphere-lithosphere-biosphere, which is why it is proposed a digital booklet aiming to disseminate knowledge about landslides and to assist communities to learn about actions to avoid tragedies.

4.2 Project and Development of the Digital Booklet

This section presents the references for the development of the digital booklet, the developed prototype and its evaluation.

4.2.1 References for the Development

As inspiration for pagination, structure and layout of the booklet, two websites were used, namely, the booklet "COVID-19: orientações gerais e normas de proteção para musólogos e profissionais de museus" and the website of the State Secretariat for Economic Development, Science, Technology and Innovation of the State of <Omitted for Review>.

As for the reference for the graphic animation's construction, some basic questions served as guidance, focusing on clarifying the most frequently asked questions:

- What and how occurs? (Identifying of the typology of processes)
- Where the problems occur? (Mapping of risk areas)
- When the problems occur? (Correlation with adverse and non-structural hydrometeorological conditions)
- What to do? (Preventive, structural and non-structural measures)

4.2.2 Prototype

The digital booklet had as guidelines to present basic concepts about natural disasters, as well as establish frequently asked questions, answers and basic of prediction and prevention. The current version of the booklet is composed of four quadrants, as shown in Figure 3, they being: (i) Overall, (ii) In <Omitted for Review>, (iii) Summaries e (iv) Animations. The general terms pertaining to landslides, as well as a large part of the literature are encompassed in the "Overall" quadrant. In the quadrant "In <omitted for review> a panorama of the city of <Omitted for Review> is presented, bringing data of registered landslides occurrences and conceptualizing the relief of the region. Subsequently, the "Summaries" quadrant is presented, where condensed concepts are brought in order to allow an easy understanding for people of different study levels.

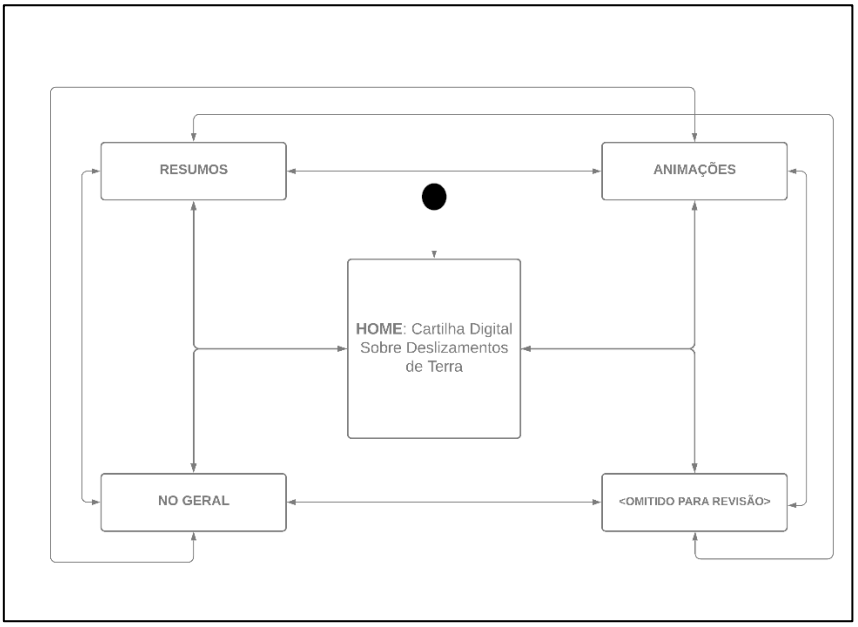
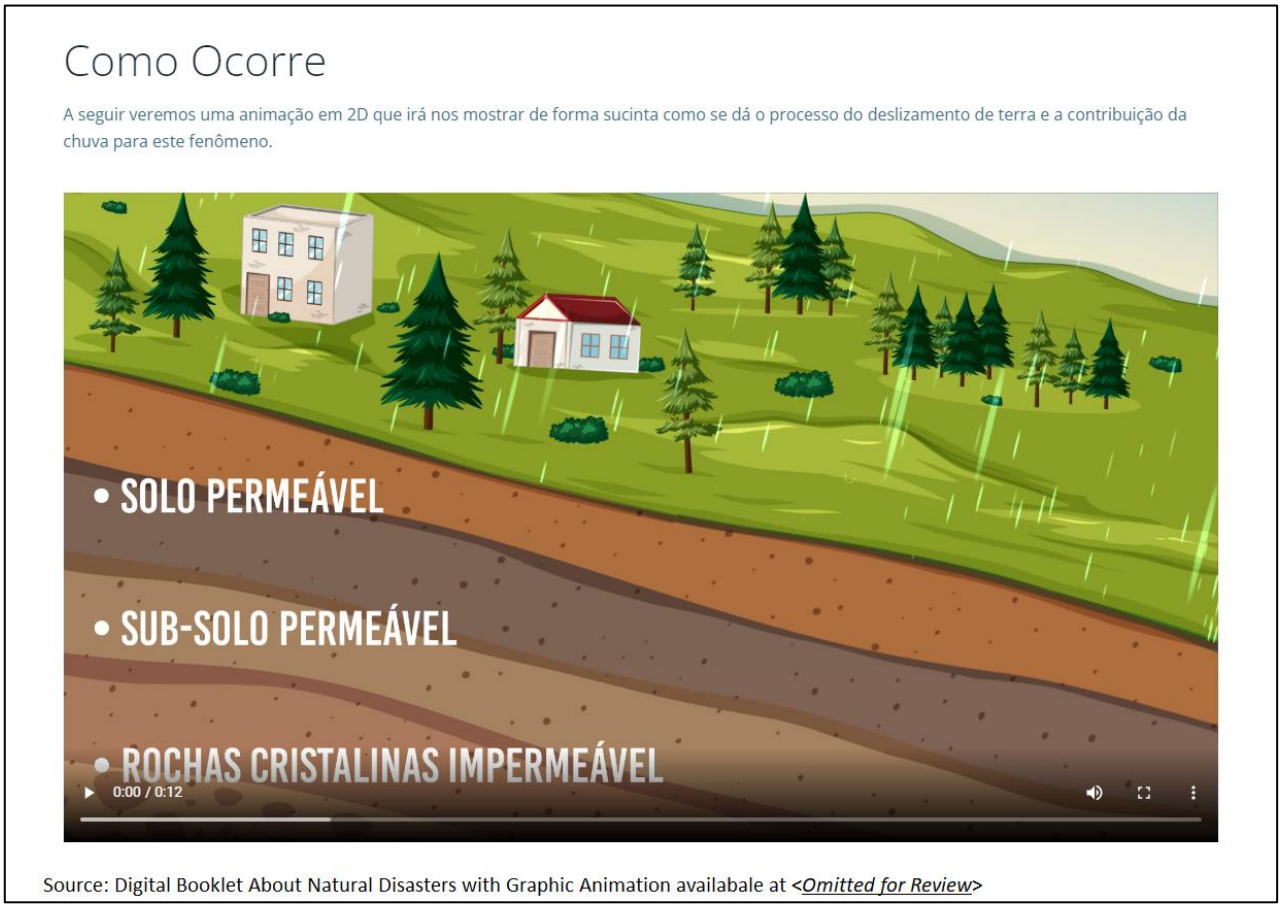


Figure 03: Booklet Navigation Diagram

The booklet presents, through the "Animations" quadrant, the evolutive geological-geotechnical process developed in the surface until the occurrence of the landslide. From a surface with a sharp slope and bare of vegetation or undergrowth with precipitation and infiltration of water from surface to the soil, scenarios were designed for the graphic animations.

The Figure 4 refers to the video which presents how the landslide process occurs. With this 2D animation, the pluviometric action is seen when make contact with the slope surface, from the infiltration and subsurface's slides until the soil ruptures.

The Figure 5 refers to the video which presents what population can do to prevent landslides. With this 2D animation are suggested the main activities to be implemented such as planting grass on slope areas, implementing piped water drainage systems from sinks and bathrooms and to prevent the inherent risk of incorrect garbage disposal.



Source: Digital Booklet About Natural Disasters with Graphic Animation availabale at <*Omitted for Review*>

Figure 05: 2D Graphic Animation presenting the main activities to prevent landslides.

In this booklet, is also brought the identification, analysis and the risk areas mapping; technical criteria of preventive actions deflagration; definition of actions and preventive measures as established by the National Secretariat of Civil Defense. To this end, are covered basic concepts and consolidated from the readings about natural disasters referring to risks and risk areas.

5. Results and Discussions

To evaluate the digital booklet were selected two distinct groups of potential target audiences. The first group is composed by students of the Licentiate course in Computing at University of the State of <Omitted for Review> for having knowledge in develop education and technological solutions as well as pedagogical practices. The second group is composed by Earth Sciences field's professionals, intending to evaluate the idea's importance in the context of natural disasters.

As a method of capturing results, data collected by filling out Google Forms were used, through two distinct forms. One intended to receive answers from professors in the area of Earth Sciences and the other with answers of the students of the Licentiate course in Computing at University of the State of <Omitted for Review>.

Both the surveys were carried out with prior approval and consent by the evaluators of the tool and rely on the protection of their data. Thus, there is no risk of data leakage or security breaches, ensuring reliability and anonymity.

5.1 Study 1: With Students of the Licentiate Course in Computing

This form, directed to students of the Licentiate Course in Computing at University of the State of the <Omitted for Review> seeks to evaluate the usability of the digital booklet, through the SUS usability scale (*System Usability Scale*), that identifies the level of contentment and interactivity with the tools. Because there is no validation for Portuguese from Brazil (pt-BR), the SUS validation in Portuguese from Portugal (pt-PT) [Martins et al. 2015]. The SUS consists of ten objective questions with "yes" and "no" as options for answer, in order to capture the level of satisfaction of the evaluators. Thirteen students participated in this study 1, aged between 18 and 26 years old. Of these, more than 50% claim that they would frequently use the digital booklet. A percentage of 75% say that it is not a complex digital product, and 100% of the respondents consider that the digital booklet is an easy-to-use product. 92,7% of the evaluators claim that the general population would learn to use this digital booklet quickly and 100% of the participants have not experienced complications using this digital product. They also say, unanimously, that was not necessary to dedicate long periods of time to learn to navigate in the tool. The Figure 6 presents the consolidated graph of student's response to the six questions evaluated by the SUS.

5.2 Study 2: With Earth Sciences Field's Professionals

This form, directed to Earth Sciences field's professionals, seeks to evaluate not only the tool's importance but also if the used topics and terms correspond in context and meaning to the reality of the area.

The evaluation questionnaire has ten questions, seven of which are multiple choice and three discursive involving the perception of the importance of the tool. Are examples of questions: "In your opinion, the Digital Handbook about Landslides added some knowledge?", "Do you consider important to work on preventive measures about the theme of natural disasters?", both with "Yes" or "No" answers and questions like "What did you like the most and what did you like the least in this digital product?", allowing the

evaluators to discriminate more about their opinion.

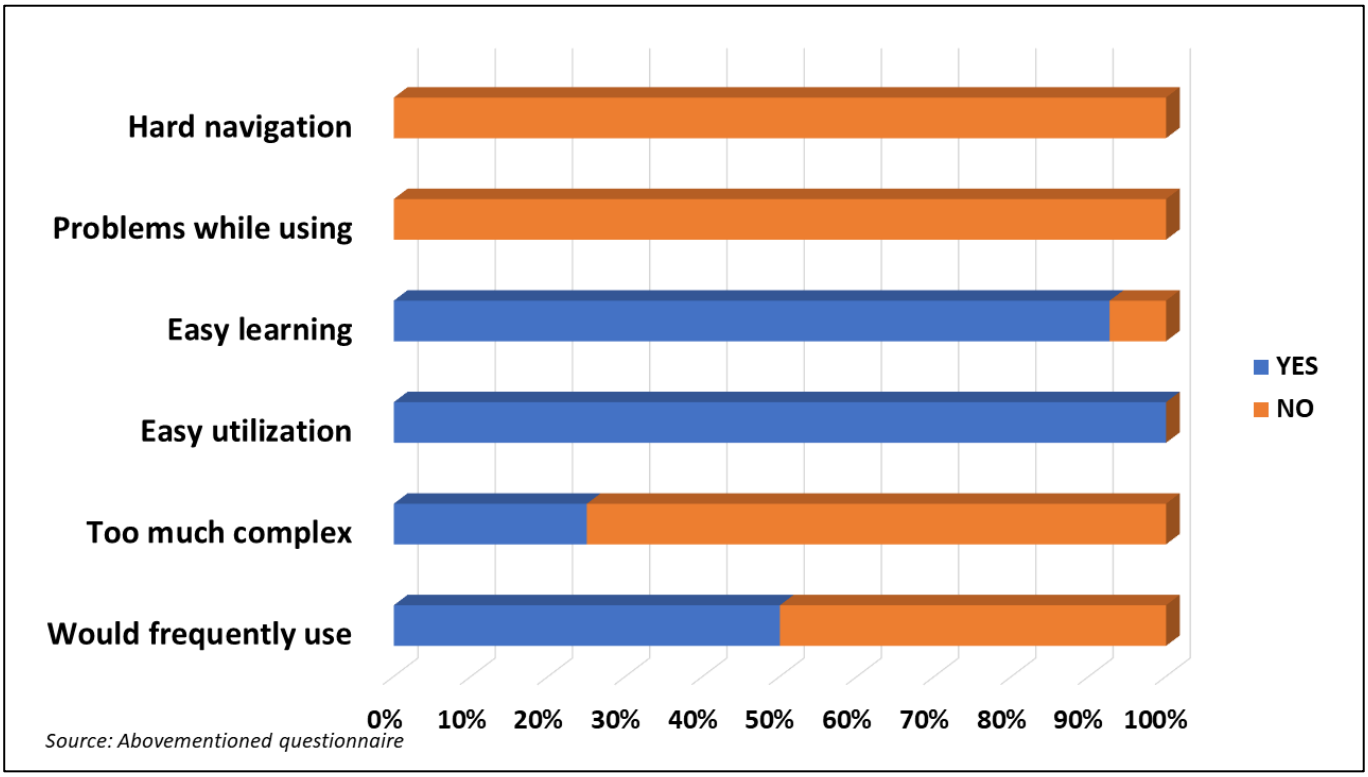


Figure 06: Consolidation of the SUS scale with the answers of the Licentiate Course in Computing students.

Of the respondents, 40% teach for the Geology course, 30% teach for the Meteorology course, 20% teach for the Mining course and 10% teach for the other courses. Unanimously, the evaluators say that the digital booklet adds knowledge and brings relevant information and that it is essential to know about the subject in order to work on preventive measures, aiming to minimize risks of landslide. 100% of the respondents say that the booklet clarifies frequently asked questions. Unanimously, the evaluators also say that the booklet is an excellent way to raise awareness and evaluated it positively, judging to be something necessary. About the design, 10% say that the booklet has a reasonable design, 70% say that has a satisfactory design and 20% had their expectations exceeded. Opening space to describe what they liked the most, it was identified that the respondents liked the 2D animations the most. They also liked the digital format and the simple language. When asked to say about they liked the least, 30% say that there is not something unpleasant in the booklet. In other hand, others suggested that should have a more embracing explanation of some technical topics and, finally, that could have a better layout of the menus in the top of the screen.

Based on the obtained results, it is possible to perceive the feasibility of a better conceptualization of some technical definitions allowing a better understanding of the literature both by those who are from the Earth Sciences area as well as lay people on the subject. Present a harmonic and easy-to-use design increases people's usage time, making the evaluators feel comfortable and correctly directed as seen in this article. Furthermore, it has been seen that pleasant text sizes and fonts increase their satisfaction level. With well-defined values of possible responses from those who are involved, it is possible to work more effectively on improvements, corrections and technical adjustments in the tool, such as better arrangement

of navigation menus, improvements in the 2D animations and even covering more pertinent content. As described in Table 1, it was proposed in this article that society could be tangibly benefited from results validation.

Table 1. Qualitative results achieved with the digital booklet

Qualitative Results	Contribution to Society
Familiarization with basic concepts within the area of Earth and Environmental Sciences area.	Allow the susceptible society with housing in risk areas are aware of how landslides occur.
Knowledge multiplier agents, awareness and consequently, encouraging the citizenship practice.	Demonstrate that is possible to understand complex processes of nature and the impacts caused by anthropogenic influence.
Dissemination and clarification of natural disasters and their consequent conditions of inadequate soil occupation.	Make society aware of the consequences of the inappropriate soil occupation process.
Assimilation of important concepts related to the environmental by students from the elementary and high school being encouraged to seek admission to the Exact Sciences and Earth Sciences courses.	Valuing important areas of knowledge for everyday life in cities.
The physical-geological processes that occur in subsurface visualized in a didactic and accessible way.	Understanding the uniqueness o the planet, the interaction between subsystems and promoting the importance of human, animal and plant life.
Natural resources viewed rationally in a universe of abundant water, in the case of the Amazon region.	The planning of Amazon cities.

6. Conclusions and Future Work

This article aims to disseminate knowledge about landslides through the proposal of a digital booklet. The digital booklet was developed taking as inspiration user-consolidated tools. The main difference of this digital booklet was the adding of 2D graphic animations which illustrate the entire process of a landslide from the beginning until the end and what the population can do to minimize this problem.

To validate the proposal, two studies were carried out with different objectives. The first one aimed to evaluate the usability of the tool using the SUS usability scale. Thirteen undergraduate students participated in the study. As a result, it is possible to verify that 100% of the participants say that it is an easy-to-use digital product, on the other hand, 7,7% of the respondents believe that the booklet is more complex than necessary and that the general community would not be able to comprehend the proper handling of the tool

quickly. It was identified that 84,6% of the respondents of this study feel comfortable while using the proposed digital booklet.

The second study aimed to evaluate, by Earth Sciences professionals point of view, the satisfaction level regarding the booklet. There was dissatisfaction on the part of some evaluators regarding the layout of the manus and pages. Furthermore, it was seen that part of the evaluators stated that there were no dissatisfactions to be registered in note, however, it was observed that the booklet could be better equipped with important concepts. It was noted that part of the respondents did not feel comfortable with the proposed design in the current version of the booklet.

Thus, the results achieved in this article corroborate the scientific literature which suggest that digital booklets help in the promotion of knowledge in several areas. Knowing that these are methods considered not explored, most of respondents consider this digital product disruptive. With the accessibility that online environments bring, this content becomes accessible at any time of the day, allowing people all over the world to access it.

Based on the evaluator's suggestions, it is possible to propose further improvements to this digital booklet. For example, a review of the literature is proposed to bring greater breadth of concepts and clarification of technical terms not understood by society. Furthermore, there is a planning to change the paging scheme to promote greater harmony during navigation through the booklet. Finally, it is understood that animations can be worked on, seeking to evolve then from 2D to 3D animations.

6. Acknowledgement

This article would not be done without the assistance of Jaqueline, Manoel, Stephanie, Nilson, Jamille, Marcela, João Victor, Gustavo, Raphael and many others who, directly or indirectly, contributed to the success of this project.

"For though the fig-tree has no flowers, and there is no fruit on the vine, and work on the olive comes to nothing, and the fields give no food; and the flock is cut off from its resting-place, and there is no herd in the cattle-house: Still, I will be glad in the Lord, my joy will be in the God of my salvation." ***(Habakkuk 3.17-18)***

7. References

Augusto Filho, O. (1995). **Escorregamentos em encostas naturais e ocupadas**: análise e controle. *Curso de Geologia Aplicada ao Meio Ambiente, 1:77-100.*

da Silva Pereira, H. G., da Silva, I., N., Ortoney, S., and Sanavria, C. Z. (2021). **Tecnologias e educação Ambiental**: Uma cartilha interativa digital para aprendizagem sobre lixo eletrônico. *Anais do Computer on the Beach, 12:592-595*.

de Melo, A. C., dos Santos, K. L., and Guimarães, W. N. R. (2019). **Água e Cidadania**: Construção de cartilha digital no ensino de ciências. *Divers@!, 11(2):84-91*.

Fernandes, N. F. and Amaral, C. d. (1996). **Movimentos de massa**: uma abordagem geológico-geomorfológica. Geomorfologia e Meio Ambiente. *Bertrand, Rio de Janeiro*, pages 123-194.

Guidicini, G. and Nieble, C. M., and Pina, C. (1976). *Estabilidade de taludes naturais e de escavação. Editora Blucher*.

Gusmão, C., Júnior, J. M., and Pina, C. (2015). **Experiência de construção de cartilha digital para melhoria da qualidade de vida da população idosa**. *Anais temporários do LACLO 2015, 10(1):168*.

Iop, J., Massia, L. I., and Pellegrini, D. d. C. P. (2018). **Elaboração de cartilha digital educativa**: Cuidando da saúde das pessoas, dos animais e do meio ambiente. *Anais do Salão Internacional de Ensino, Pesquisa e Extensão. 10(3)*.

Martins, A. I., Rosa, A. F., Queirós, A., Silva, A., and Rocha, N. P. (2015). **European Portuguese validation of the system usability scale (sus)**. *Procedia Computer Science, 67:293-300*.

Santos, A. d. (2012). **Enchentes e deslizamentos**: causas e soluções. *Áreas de risco no Brasil. São Paulo: Pini.*

Santos, J. L. S. d. (2021). **Cartilha Digital**: o direcionamento de resíduos eletroeletrônicos através de ações educativas na educação básica. Master's thesis, Universidade Federal de Pernambuco.

Tominaga, L. K., Santoro, J., and Amaral, R. (2009). **Desastres naturais**. *São Paulo: Ed. Instituto Geológico*.

Varnes, D. J. (1978). **Slope movement types and processes**. *Special report, 176:11-33.*