LOGO

Use of HQ for the teaching of sustainable materials and processes - an alternative to cultural change of learning in design

Uso de HQ para o ensino de materiais e processos sustentáveis – uma alternativa de mudança cultural de aprendizado em design

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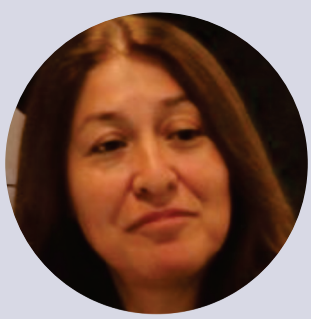

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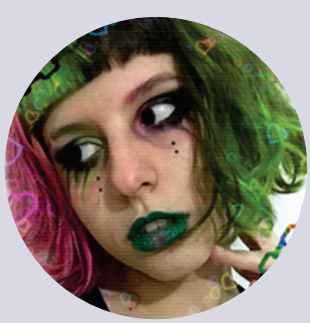

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ABSTRACT

The teaching of materials and processes is directly related to the context of more sustainable design solutions. However, the transmission of knowledge to new generations needs innovative approaches, supported by the cultural changes of recent years and inter- and intra-generational differences. This paper presents the development process of a series of publications for teaching more sustainable materials and processes that meet the demands of a new generation of design students using HQs (Comics) as a tool. To achieve this goal, we searched for references in comics, elaborated theoretical and practical studies in a research method adapted to the pandemic context. The results presented so far show the development of the HQ for the first volume.

KEYWORDS

Materials, Sustainability, Design, Teaching, Comics

RESUMO

O ensino de materiais e processos está diretamente relacionado ao contexto do projeto de soluções mais sustentáveis. Contudo, a transmissão de conhecimento às novas gerações necessita de abordagens inovadoras, sustentadas pelas mudanças culturais dos últimos anos e diferenças inter e intrageracionais. Este artigo apresenta o processo de desenvolvimento de uma série de publicações para ensino de materiais e processos mais sustentáveis que atendam as demandas de uma nova geração de estudantes da área projetual utilizando como ferramenta as Histórias em Quadrinhos (HQs). Para atingir tal objetivo buscou-se por referenciais em HQs, elaborou-se estudos teóricos e práticos em um método de pesquisa adaptado ao contexto de pandemia. Os resultados apresentados até o momento mostram o desenvolvimento do HQ do primeiro volume.

PALAVRAS-CHAVE

Materiais, Sustentabilidade, Design, Ensino, Histórias em quadrinhos

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INTRODUCTION

This paper presents a collection of activities that aim to disseminate the knowledge of materials teaching, with an emphasis on the sustainability, to designers and its clients, through integrated actions involving undergraduate and graduate students from subjective (arts), mixed (design and architecture), and objective (engineering) areas.

The main idea of the project is the transmission of knowledge about sustainable materials selection applied to design through the publication of small books, similar in style and format to comic books (HQs). The publications basically involve the study of sustainable materials in Design, Architecture and Engineering projects.

Recent cultural and technological changes highlight the difference between generations. The teaching-learning process through books and lectures has been changing to the use of didactic materials that combine text and illustrations, without losing the content of the themes.

On the other side, the COVID-19 pandemic has propelled an unprecedented technological advance for humanity. The teaching at the universities, previously done in physical presence, is now done remotely and using virtual integration platforms, digital environments. It was necessary new approaches to the transmission of content in relation to the teaching-learning environment.

Another aspect is associated with more information about sustainability. In the teaching of materials applied to the products and the constructions, in order to ally it with sustainability requirements, an approach that reaches the target audience (students related to the project areas) in a more assertive way. Use a better communication language for of the players and decision-makers has become urgent and necessary. Although the history of communication associated with comics is not recent, the use of this approach with didactic purposes is not yet common, especially when integrated into the virtual environment and the teaching-learning of materials applied to projects..

The correlated activities required for the development of the comic volumes relate to the elements of higher education didactics, by filling

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a gap in the similar activities currently available, whose result supports a broad and quite distinct audience, consisting basically by:

(i) undergraduate students: because of the opportunity to study and reference the content of materials and sustainability in a fun and adapted way for different forms of learning, and also, to actively participate in the construction of the volumes through teaching, research and extension activities. Considering that the subject is not exhausted, i.e., every year new materials, new composites, new alloys, new blends, and so on are launched, the application possibilities for this segment are long-lasting. Here are young people aged between 19 to 26 years, mostly belonging to the so-called Generation Z, which comprises those born after the year 2000, and a smaller part of Generation Y young people, born between the years 1980 to 2000 (FANTINI, SOUZA, 2015)

(ii) graduate students: for the same reasons cited above, plus the opportunity for discussion and greater interdisciplinary involvement, fundamental for advanced graduate studies. This group predominantly involves young people aged 24 to 35 years, called Generation Y (millennials) and more rarely may also involve generation X, people aged over 36 years and under 55 years (FANTINI, SOUZA, 2015).

(iii) high school students: for the opportunity to learn about the design area and its relationship with a very current issue, sustainability, by reading the volumes that will be produced, which may help in their future career choices. This age group corresponds to young people from 14 to 19 years old and basically involves the so-called Generation Z (FANTINI, SOUZA, 2015)

Since the 1990s, with the dissemination of environmental issues, the conception of new products has become the union of technical, aesthetic, economic and environmental factors. Ensuring sustainability in a product design involves the balance between at least three dimensions: economic, social and environmental. Thus, the teaching of materials and manufacturing processes, considering the principles of sustainable development, becomes not only a differential for graduates of design, engineering and architecture courses, but also a requirement.

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The difficulties associated with the teaching of materials and manufacturing processes are many and include the amount of content to support the selection of materials, as well as technological innovation. Currently, it is estimated that there are more than 4000 materials available to designers, which gives rise to an equally large number of manufacturing processes linked to them. The inclusion of sustainability as a wicked problem does not reduce this number of materials or simplify the problem. The analysis of the sustainability of materials requires a ponderation of economic, socio-cultural and environmental factors; where the result will depend of the appropriate use in the context of the situation, considering all the factors of choice. These factors were defined in Librelotto et al (2012).

The traditional method of teaching no longer meets the needs of young designers. The speed of information makes reading technical books less and less attractive, compared to the speed provided by a simple search on websites such as Google, for example. However, committed professionals cannot be held hostage to the luck of finding what they need in reliable sources, since it is common knowledge the significant amount of blogs and independent publications, whose purpose may be much more "commercial" than academic, or professionally reliable and consistent with the actual performance of the solution.

The educational challenge is then to attract the student for the specialized technical readings based on reliable bibliographic sources, which today are limited to books and scientific articles based on a traditional vision of the country's teachers and educators. However, these sources are geared for a linear reading that is being changed by the superficial and fast reading offered by the emergence of the Internet.

Technical material books are usually around 500 pages long, and address, with rare exceptions, only specific parts of the total content. In other words, it is common to find authors specialized in metals, for example, whose works have little or nothing to say about plastics, ceramics or wood. On the contrary, more generalized books, which cover a large volume of materials, are even more extensive, so that the reading load ends up creating an obstacle in the educational

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objectives, intended by the teacher.

The business market changes rapidly, and the speed of change has created the need for a trained professional capable of searching quickly for the necessary information. For this, generalist knowledge of materials and processes is more important than specialized knowledge in some materials and their manufacturing processes. In this sense, some software for material selection, could supply the quick search for materials, but not the introductory knowledge.

Therefore, this article presents an alternative proposal for the teaching-learning of materials and manufacturing processes, having as a starting point for the design course of the UFSC. This proposal happens through the creation of textbooks in the form of comics, approaching the main materials and sustainable manufacturing processes used in projects. The text describes the creation process of the first volume, with the conception of characters and all the other basic elements that will constitute the series.

2 THEORETICAL FRAMEWORK

More and more, "sustainability" is one of the most discussed subjects nowadays. It involves the most diverse areas of knowledge: from applied social sciences to engineering, including humanities, exact sciences, and many others, and, in the professional aspect, being aware and updated on the theme has become increasingly important. In a global perspective, it is expected that each person is able to recognize their own share of responsibility and their potential contribution to the planet, regardless of their professional activity. The term "sustainability" acts in this context as a social link, in which individual actions have an effect that is shared by all.

In academia, industry and marketing, the theme of "sustainability" has been gradually introduced, starting in the 1980s (although insipiently). Over the years, however, the society began to wish, for personal or professional reasons, more information, and currently it has become difficult to find any event (qualification, training, graduate programs, improvement courses, lectures, symposiums, fairs, and so on) that does not include this issue as a focus for discussion.

For Madeira and others (2011) higher education institutions must

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play a leading role in sustainable development and must be models of sustainability themselves. These institutions have as their function the rise of knowledge through teaching, research and extension, aiming at the positive transformation of human beings and society. Thus, their institutional activities should include the task of generating models of sustainable development, as well as inspiring a culture of sustainability for society (CASAREJOS, FROTA, & GUSTAVSON, 2017; LOZANO et al., 2013).

But even with all this increase, the necessary understanding of the theme still comes to face in two aspects: i) the complexity of the factors involved, and, ii) the lack of knowledge of the interconnected variables and conditioning factors. The most direct consequence of this are the risks of interference actions where the players do not necessarily know all the interdisciplinary variants involved, leading to palliative or even amateur actions.

The university, in its conception of integration between teaching, research and extension is the ideal environment for the promotion of interdisciplinary actions related to sustainability. On this point, a contribution focused on teaching is presented in this paper.

The idea of this project is not a new subject. Leite (2020) highlights the use of comics as teaching material in order to facilitate the understanding and, especially, the interest in reading by students. The mentioned author (Leite, 2020) presented a proposal for the use of comics as didactic material with the purpose of helping in the teaching of chemical elements.

As highlighted by the author, although there has been a strong resistance and prejudice towards the insertion and use of comics in teaching, in recent years comics have started to be more valued and encouraged in the field of Education. With a specific use in the educational field, the comics stopped being regarded as something exclusive for children and started being recognized as something capable of favoring communication for several audiences. This achievement of greater space and appreciation in the pedagogical and academic fields is due, in large part, to the inclusion of this type of material in educational documents that have been developed over time.

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A current example of the use of comics as a tool to reach diverse audiences can be found in the work of Harari (2015). The book Sapiens, considered a literary phenomenon, is on the bestseller list in 40 countries, was recently published in comic book form. The figure 1 shows, in the first image the book Sapiens, and in the second image illustrates comics from the inside of the Sapiens comic book edition.

Figure 1. Cover of the book Sapiens and extract of the book Sapiens adapted for comics.

Source: Harari (2015) and Harari et al (2020).

Traditional books are being offered more and more in this modality, and the reception has been positive. The figure 2 illustrates some books recently offered in the comics modality.

Figure 2: Literature in comic book format.

Source: By the authors.

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Carvalho and Martins (2009) cite as a difficulty in working with comics in science classes the possibility of finding stories to work on specific subjects that meet the teacher's interest. Comics, in most cases, discuss scientific issues in the wrong way, according to the scientific community; as well as the lack of knowledge of this type of resource by teachers or even time to develop this type of activity create obstacles to the development of this teaching tool.

Again citing Fantini and Souza (2015), it must be considered that the main target audience of this project consists of individuals of the generation Z, whose general characteristics are to be extremely immediacy, individualism, over-connected, with inability to follow linear standards and difficulty working in teams. Such characteristics reinforce the need for innovative approaches that can reach this profile in a more efficient way.

2.1 History of HQs

With its origins at the end of the 19th century, although there are earlier occurrences in various peoples, comics had their history consolidated really by the profusion of the "superheroes". In the course of time, the history of comics evolved from something that could disturb the development of readers to being perceived as a facilitator of learning.

With the development of the printing press and forms of mass communication, comics had their use in funny, satirical and cartoonish stories in comic strips published in American newspapers. The comics evolved into adventure stories and naturalistic themes until they definitely reached the popular taste (RAMA and VERGUEIRO, 2012).

Even before the famous Japanese attack on Pearl Harbor, a US military base located in Hawaii, in North American comics, superheroes were already fighting against the Axis powers, with the first Captain America comic book, being published in March 1941. One of the facts of this is that many scriptwriters and cartoonists of the time were Jewish, and used art as a form of resistance.

Since the rupestrian art, man has been recording his stories through images, where cave walls were transformed into pages for recording and transmitting information (RAMA and VERGUEIRO, 2012).

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Even with the evolution of writing, images still occupy a privileged space in the formation of the human being, where the drawing is the first graphic representation of childhood.

Rama and Vergueiro (2012) bring a history of the use of comics in the classroom and distinguish applications from 1st to 4th grade (early childhood education), elementary school (at the time from 5th to 8th grade, prior to the inclusion of 9th grade) and in high school, not addressing the issue of the use of comics in higher education.

A counterpoint, however, emerged to label comics as harmful to young people's development and even led to the adoption of codes of ethics to ensure the quality of published material. For example, the Figure 3 shows two images that somewhat illustrate this point. In the first one, Cebolinha, the classic character created in 1960 by Maurício de Souza to integrate the Turma da Mônica (Monica's Gang), often had his reading advised against by parents and educators of the time because of the traditional problem of changing the "r" for "l". Likewise the reading of the stories of Chico Bento, also created by Maurício de Souza one year after Cebolinha, was sometimes "advised against" for supposedly harming the children's learning, since they ended up learning one way at school and "unlearning" it when reading the comic book. This was by no means restricted to Turma da Mônica (Monica's Gang), used here as an example.

Figure 3. Cebolinha and Chico Bento.

Source: google imagens.

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Several other stories, by different creators/editors, presented linguistic problems in the comics, whose characters' peculiar characteristics forced an unconventional type of grammatical writing.

2.2 The didactic use of comics

Neves (2012) reports on the didactic uses of comics in schools. The author brings the statement of Rama and Vergueiro (2012, p.20) who argue that in comics the only limit for a good use is the creativity of the teacher and his ability to use it well to achieve his teaching objectives.

There are several approaches to using comics, from basic teaching of content such as math and physics, to cross-cutting themes. The forms of application involve ready-made stories or even the creation by teachers and students of stories with innovative scripts in order to approach the proposed theme.

Carvalho (2009) cites as reasons to use comics in the classroom the attraction of students for this type of reading, the combination of words and images/shapes as a more efficient way of teaching, the quality of the information, the enrichment of communication through comics, the aid in the development of the reading habit, and the expansion of vocabulary.

In addition to the aforementioned authors, the search terms "comics plus higher education" were searched in the Microsoft Academics database for research associated with the theme. The search returned 4 articles, with one repetition, this being a literature review using the same search strings. Rosso et al. (2015); Macêdo (2021) and Marino and Lindenberg (2014) address the issues of using comics as a teaching tool for higher education. The low return of occurrences still reveals the incipiency of the theme. In the literature review article conducted in Scopus, WoS and Capes journal portal returned 3 publications, namely: Humphrey (2014), Kelly (2009) and Williams et. al. (2014).

3. METHODOLOGY

Systematically, the methodological procedure involved:

1. Documentation of how materials are teaching in design,

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architecture and urbanism and engineering courses (teaching plans for disciplines available online);

2. Process of selection of materials in project and sustainability considerations;

3. Possibility of applying the simulation of professional practice in fictitious situations through the comics;

4. Development of characters, story layouts among others actions to create de story;

5. Development of the scripts, with the context of the story involving characters and the materials to be contemplated in each module.

In the conduct of the research, a literature review was conducted. From a bibliographic review article, found in the exploratory search in the Microsoft Academic database, the search procedures were repeated, in the same bases and with the same search strings as a way to deepen and update the theoretical framework.

In the Capes journal portal with the terms in Portuguese (comics and higher education), were found 57 references in peer-reviewed journals. From the reading of the abstracts of the texts, the following publications stood out:

- experience report by Silva Evangelista (2020): deals with the application of comics in calculus disciplines for engineering in higher education;

- De Oliveria et al. (2013) who researches linguistics associated with technological education.

- Presser and Braviano (2018): this study seeks to identify the contributions of hypermedia in the language of Comics to the reading and learning experience, through a research that uses a Learning Object (OA) containing COMICS with hypermedia elements, aimed at an audience of young people and adults.

- De Assis (2019) investigated the contributions of the making of comics (COMICS) in the learning of geometry of future mathematics teachers.

- De Araújo and Miguel (2018) address the issue of the use of comics in the teaching of young people and adults.

-Silva; Santos and Bispo (2017) aimed to evaluate the use of comics (comics) as an active teaching strategy in the learning of undergraduate

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students in Administration.

In the scopus basis, using the strings: "Comics" OR "Graphic Novel" OR "Comic strip" AND "Higher education" OR "post-secondary education" OR "tertiary education" OR "third level education", on 28/07/2021, a return of 23 documents was found. Of these, they assumed relevance, from the reading of the abstracts:

- Sindhwan et. al. (2020): addressed the behavior of the human eye and cognition from images in higher education courses;

- Kara and Brooks (2020) deal with the positive role of the world's leading staff as a support for the teaching of qualitative research methods in higher education;

- Priego and Farthning (2020) investigated the perceived value of the use of comics as an information resource in the teaching and training of mental health and social care professionals in a higher education context;

- Gomes (2014) reports the use of comics in geography teaching for 10 years;

- Aitken (2020) describes the development of a comic book series as a strategy to increase student involvement in the content of and to improve the achievement of learning outcomes.

The search in the WoS was performed with the same terms, however, using the “parentheses" to indicate the priority of the search. There was the return of 21 results. Of these, applications in the health area and repetitions of occurrences were excluded, leaving only one article:

- Pursitasari, Suhardi and Putikah (2019): the paper reported the use of innovative and fun materials in science teaching.

4. DEVELOPMENT OF THE COMIC

The initial development of this project was based on the disciplines of materials and manufacturing processes of the Product Design course at UFSC (Federal University of Santa Catarina). The data was complemented by means of the UFSC's Sustainable Materioteca (a materials collection), which is part of the VirtuHab Group, of the Architecture and Urbanism course.

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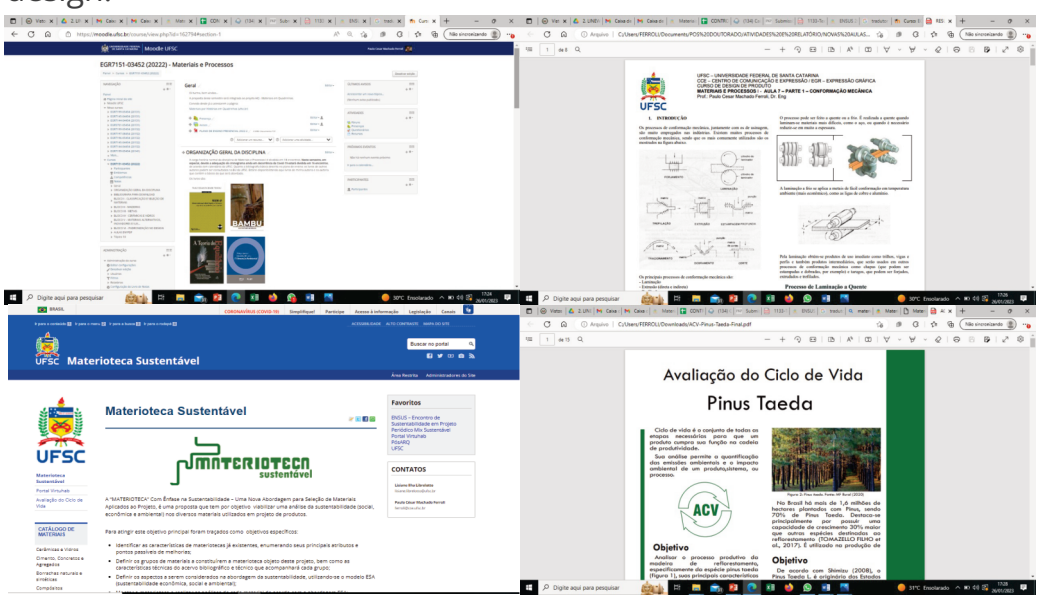
Currently, the teaching of materials and processes in the Design graduation course is basically based on what is available on the Moodle platform and on traditional bibliography, besides guided consultations to the UFSC sustainable materials collection (Materioteca). Table 1 shows the teaching-learning process currently adopted for materials and processes in design.

Table 1: Teaching tools currently used on materials and processes in design.



Source: by the authors

In the first image you can see the textbooks are suggested for the students. The second image shows an example of how all content is available in the form of topics, containing a summary of the most important parts. Each class (weekly meeting) has a summary like the one that shown in the picture, covering the main aspects that will be studied.

The third picture shows the digital part of the sustainable material library (Material collection). This is a web page containing educational material, which complements the physical samples that are available in the laboratory. In practice, the students can find in the virtual part of the material library the complementation of the samples, with the following information about each material: concept, history, specific properties, physical-chemical properties, thermal properties,

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mechanical properties, classification, production processes, manufacturing processes, main uses, disposal, recycling, sustainability analysis and main suppliers.

The last image shows an example of the data sheet, which are all produced with the same graphic style. Figure 4 shows two images that complement the understanding of how the teaching-learning process adopted in materials and manufacturing processes works. Together with the Materioteca (Materials Collection), there is the "construteca" (Construction Materials and Techniques Collection), which is nothing more than prototypes built in teaching and extension activities, providing the students with the opportunity of practical application of the contents studied in the classroom and researched in the laboratory.

Figure 4: Prototypes developed at Construteca UFSC.

Source: by the authors

The activities developed so far are focused on the more traditional teaching of materials and manufacturing processes. In this segment, the present article shows the proposed innovation, aiming to relate teaching, research and extension:

- teaching: primarily, this is an activity that is being applied in undergraduate teaching, initially in Product Design courses. As previously explained, the final goal is the transformation of all didactic materials currently used in the materials and processes discipline of

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the Product Design courses at UFSC into comic formats. The present article shows the pilot project, that is, the first publication of a comic book series. When finished, the comics must contemplate the whole content of the discipline of Materials and Process.

- extension: the interdisciplinarity required for the making of the comics, where there is the need for knowledge of the graphic arts along with knowledge of the technical side that involves materials and processes, all in an environment where sustainability is the guiding axis, promotes as a final result a product that can be used by undergraduate students, graduate students, elementary school students, and practical professionals in the market. The way these diverse actors communicate, with their different visions and expectations composing an extremely heterogeneous and diversified public, promotes continuous extension actions, with dissemination activities and informative actions, such as presentation of papers in congresses, publication of articles in periodicals of the area, lectures, and courses;

- research: the present project involves research activities, being necessary to understand and constantly update both the materials that have been and will be studied, along with their manufacturing processes, and the best dynamics for presenting the comics, which will not necessarily follow, in the following editions, the style adopted in volume I. Although the narrative style is more adequate to transmit the concepts, we opted for the creation of characters, since this way there was a greater acceptance by the users.

4.1 Character Development

The project is being developed in the miro software (https://miro.com/app). Figure 5 shows the initial steps of the project, with the sharing sheets for managing the activities by the whole team.

Figure 6 shows the beginning of the development of the main characters, with primary sketches of their visual characteristics along with their main conceptual information. From the script, the characters are Architecture and Design students, colleagues in a fictional discipline that receives students from all courses.

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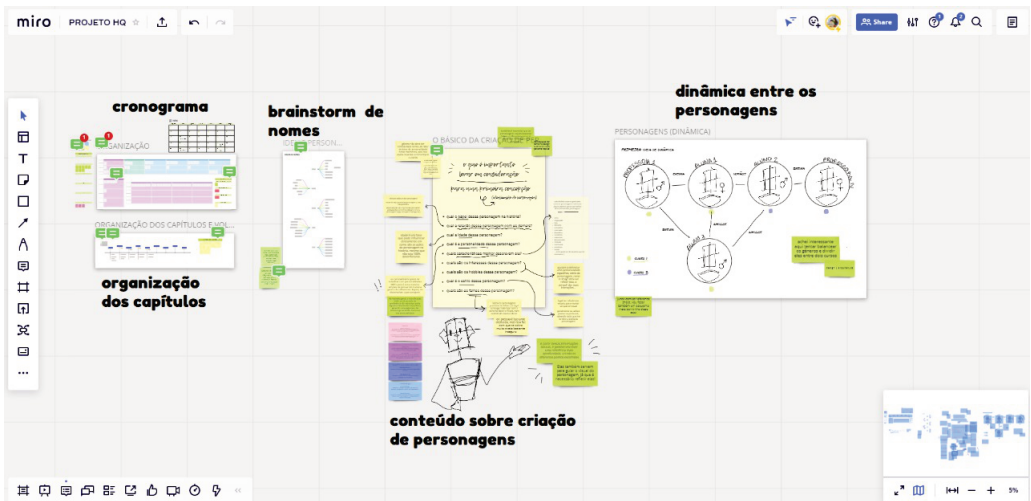
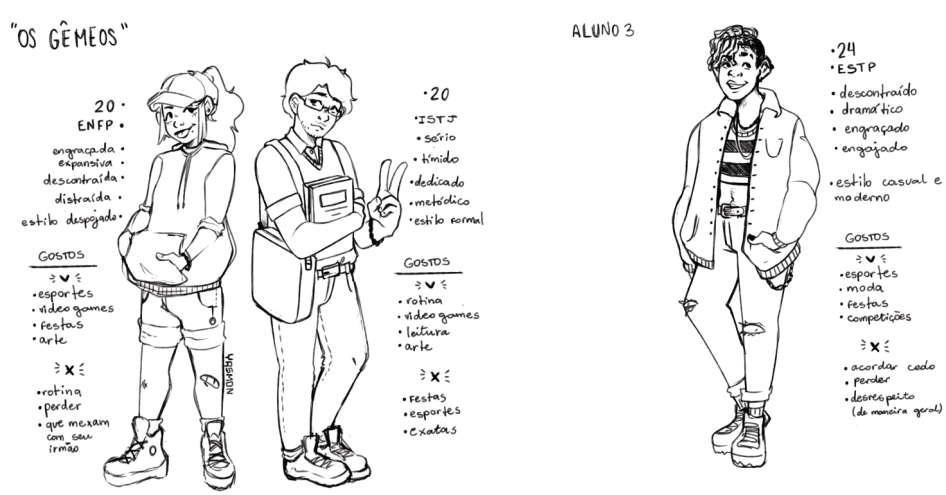
Figure 5: Project development in the miro software.



Source: by the authors

In each chapter, the students are inserted in daily situations or otherwise, which make them need to study/understand certain material for the application in some specific project. In the initial visual development of each character, the students inserted their own characteristics such as age, tastes, preferences, as well as visual information that allowed them to compose the characters personalities, in order to build a solid concept, to be improved in the next stages of construction.

Figure 6. Characters.



Source: by the authors (Yasmin's drawing)

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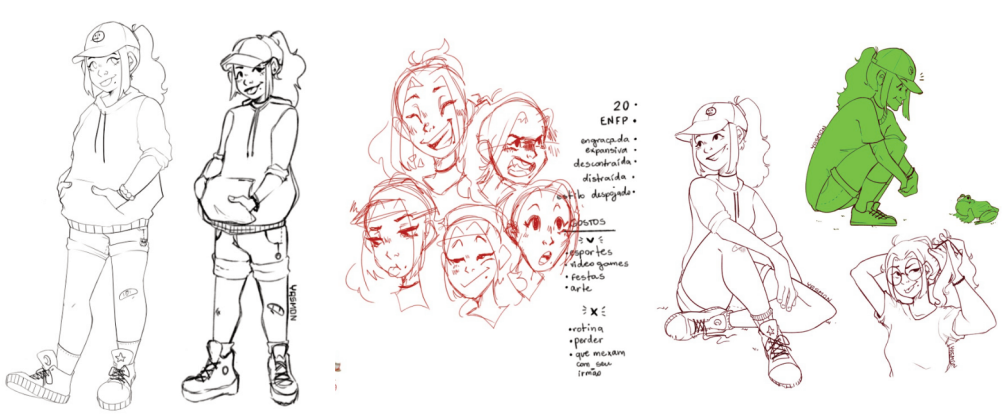
The characters were gradually being refined over time as their personalities were being developed. It is worth mentioning that there were periodic meetings to discuss the relevant aspects of personality. Constructive aspects of personality, personal relationships between characters, etc. were defined. The issues more discussed for definition of the characters, were: the character's relationship with the others, age, characteristics, interests, role in the story, hobbies, and style.

Figures 7 and 8 show evolutionary differences in the anatomy of two of the characters, with a comparison between the primary idealization and the final illustration, present in the reference page - and also construction of poses. This procedure was performed with all the characters.

Figure 7. Evolutionary study of the characters.

Source: by the authors (Yasmin's drawing)

Figure 8. Study of poses and details of the characters.



Source: by the authors (Yasmin's drawing)

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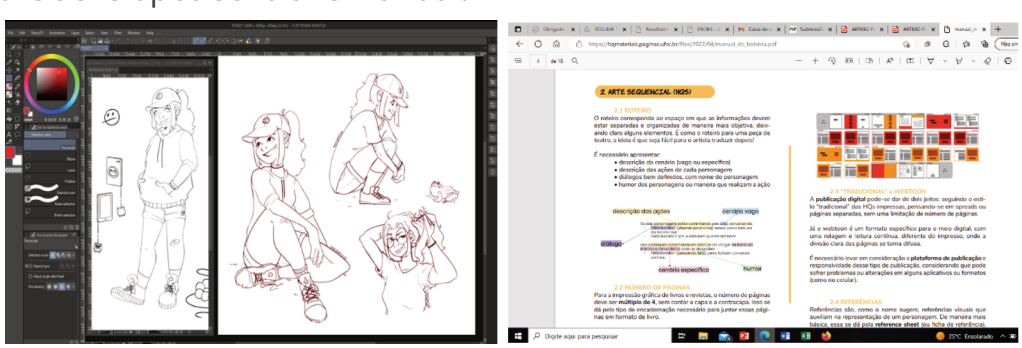
From these and other sketches, four frames were developed that served as a conceptual basis for the visual representation for the characters, already with the final design definition. The development of one of these, made with reference to another, is presented in figure 9, which shows the screen capture procedure of the development of the drawings. Considering this is a long-term project, with possible annual rotation of students, these images come with the objective of serving as a visual reference for all the artists who will work on the development of the comics, serving as a solid base for their translation into comics.

Because of this, a set of guidelines was also developed to ensure that the established standard is maintained throughout the project, even with the rotation of fellows, called the fellows' manual, available at: https://hqmateriais.paginas.ufsc.br/manual-do-bolsista/ and also shown in Figure 9.

Figure 9. Screenshot of the development of the drawings and part of the developed scholar's manual.



Source: by the authors.

The figure 10 shows the reference sheet of the twins (Alana and Henrique). It is a sheet where their main characteristics are listed, also highlighting the main design, along with its details, in order to be easily referenced later in case of possible doubts. Together with this, visual references of expressions were also made, allowing a greater prominence both in the facial details and in their manner of expression, fundamental for a comic book.

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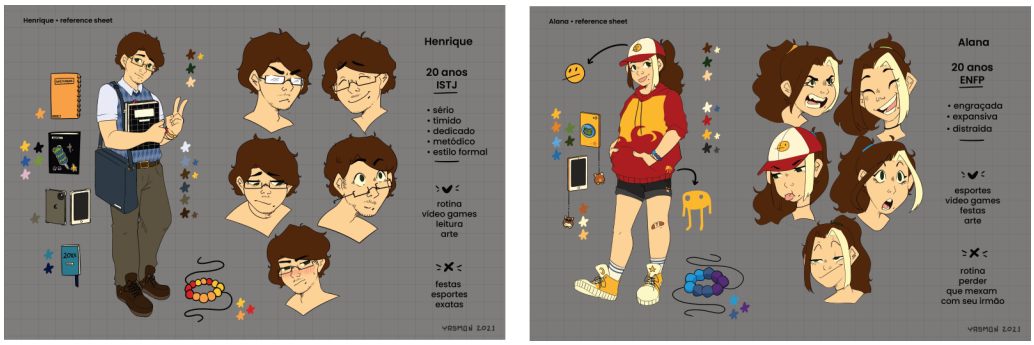
Figure 10. Images of the references produced for a character. Source: by the authors.



Source: by the authors (Yasmin's drawing)

Concomitantly with the visual development, a written reference was also produced for each of the characters, going into more detail about their history, their personality, their qualities and defects, their tastes, their style, general curiosities, and the relationships between each one of the network of protagonists.

4.2 Story Development

In parallel, a script was developed, where a prologue was used to provide the reader the context for the publication. The prologue shows the evolution of the human species and the evolution in the use of materials that accompanied this process, highlighting the beginning of the use of natural materials, the development of ceramics, the first metals, alloys, and finally arriving to modern materials.

The initial part shows that when the human species began to dominate the fires, the increasing heat obtained by the constant innovation of techniques, provided the creation and later the domination of other materials, leading to the appearance of bronze, and later iron, steel, and so on. Figure 11 shows a part of the development of the prologue, where on the left there is the script (narrative) that was used for the development of the prologue and in the sequence the development of the drawings themselves that compose a part of the comic. Each drawing has at least three stages, shown in the figure: (1) sketch, (2) storyboard, (3) linework, and (4) finalization. This whole process is described at:

https://hqmateriais.paginas.ufsc.br/.

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Figure 11. Prologue and progression sequence of each comic.

PRÓLOGO

[Primeiro quadrinho]
Mostrando o desenho de dois "macacos humanos" com pedaços de madeira na mão.
NARRADOR (mensagem escrita acima): Desde os primórdios da humanidade...

[Segundo quadrinho]
Mostrando o desenho de humanos manipulando pedras lascadas.
NARRADOR (mensagem escrita acima): ... os materiais estão presentes no cotidiano dos humanos.

[Terceiro e quarto quadrinho]
Só desenho de humanos primitivos manipulando pedras e ossos...

Em sequência, só o desenho de humanos primitivos manipulando conchas, folhas grandes de palmeiras e galhos.

[Quinto quadrinho] (será maior porque vai ter mais texto).
Aqui cabe um desenho talvez comparativo entre as espécies... mas não pensei bem como poderia ser....
NARRADOR: Existem diversas definições do que é criatividade, e por vezes esquecemos que ser criativo é uma característica intrínseca de nossa espécie. Sabe-se que há pelo menos 300.000 anos o homo sapiens dominava o fogo e produzia armas de caça. Sua capacidade criativa superior foi o grande diferencial em relação ao homo erectus, homo luzonensis e aos próprios neandertais.

Source: by the authors. Drawings by Yasmin and Julia.

The prologue calls attention to the publication's differentiating point, namely, the environmental aspect. In this scenario, designers, architects, and engineers need to find new ways to meet people's growing material needs without exhausting our planet. Traditional materials need to be better understood, and the use of less impactful materials needs to become a reality.

The first volume is finished and the team is currently working on second volume. Resources were obtained from the university (Pró-reitoria de extensão, Centro de Comunicação e Expressão, and SECULT - Secretaria de Cultura) that allowed print the first volume for dissemination. The figure 12 shows parts of the finished volume.

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Figure 12. Parts of the first volume.

Source: by the authors. Drawings by Yasmin, Julia and Pablo.

Thus, the study of natural materials with low environmental impact, in natura or as a base for composites and polymer blends may be an option to ensure sustainability, in other words, meet the current needs without compromising those of future generations.

As already mentioned, this comic has the objective of helping in the formation of new creators, bringing the study of materials in an accessible way and with emphasis on sustainable issues. To this end, each material contemplated is presented with its strengths, limitations, characteristics, properties, and main functions. Also discussing their interaction with economic, social and environmental issues of sustainability, along with what is currently known as the ESA model of sustainability.

5 FINAL CONSIDERATIONS

In a globalized and highly technological world, the transmission of knowledge needs to be adapted to the new needs of a target audience of students and young designers. They will face the challenge of finding ways to materialize their projects in the form of products that meet a

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set of requirements that encompass issues mostly diluted between quantitative and qualitative aspects.

The transmission of knowledge is always under evolution, and obviously procedures and methods adopted for one generation of students do not necessarily work for another. The current generation of students finds technological tools at their disposal that were not even dreamt of by students a few decades ago, in a world without internet, for example.

Given the increasing inadequacy of teaching through traditional tools considering the target audience, this project shows a work of adapting all the content of materials and manufacturing processes into comics, also incorporating the environmental variable of the sustainability.

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