**Sofia Alexandra
Soares Ribeiro**

Ferramenta digital para produção de artefactos físicos: O projeto Gamers4Nature

A digital tool to create physical artifacts: The Gamers4Nature project

Universidade de Aveiro
2021

Sofia Alexandra Soares Ribeiro

Ferramenta digital para produção de artefactos físicos: O projeto Gamers4Nature

A digital tool to create physical artifacts: The Gamers4Nature project

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Comunicação Multimédia, realizada sob a orientação científica do Doutor Pedro Miguel dos Santos Beça Pereira, Professor Auxiliar do Departamento de Comunicação e Arte da Universidade de Aveiro, e sob a coorientação da Doutora Mónica Sofia Lopes Aresta, Investigadora do Departamento de Comunicação e Arte da Universidade de Aveiro.

Dedico este trabalho aos meus pais, pela força, pela inspiração, por compreenderem a dedicação que este percurso exige, e porque sem eles nada disto seria possível; ao Diogo, pela companhia em todos os percursos da vida; ao avô António e à Ana que sei que estariam radiantes por ver o culminar do meu trabalho.

o júri

presidente   Prof. Doutor Pedro Jorge Couto Cardoso
Professor Auxiliar em Regime Laboral da Universidade de Aveiro

Doutora Patrícia Alexandra Pacheco de Sá
Investigadora Doutorada (nível 1) da Universidade de Aveiro

Prof. Doutor Pedro Miguel dos Santos Beça Pereira
Professor Auxiliar da Universidade de Aveiro

agradecimentos

Gostaria de começar por agradecer ao professor Pedro Beça e à Mónica Aresta, a minha equipa de orientação, pelo conhecimento transmitido, pelo tempo investido no meu trabalho e por apoiarem e incentivarem sempre a minha vontade de me lançar a novos desafios.

Além disso, gostaria de agradecer a toda a equipa do projeto Gamers4Nature, pela oportunidade de colaborar como bolseira do projeto, pelo apoio na divulgação da minha investigação, resultando no meu crescimento científico, profissional e pessoal.

Aos meus pais, pelo apoio constante e infindável, pela motivação, pelo amor e, claro... pelas massagens nas costas nos longos serões ao computador. À minha mãe pelas palavras de conforto e incentivo, e por ser um dicionário aberto, infindável e extraordinário. Ao meu pai que me inspira continuamente pela sua vontade intrínseca de aprender. Ao Bloom, o meu gato, que incitou momentos de descontração e corridas pela casa.

Ao Diogo, pelo companheirismo, pelas longas conversas e reflexões, proporcionando momentos únicos de partilha, pelo apoio incondicional e pelos discursos criativos que animaram os meus dias, acreditando sempre no potencial do meu trabalho.

À minha avó Rosa, pelo carinho e por fazer sempre por compreender da melhor forma o que ando a aprender. Ao meu avô António, que já cá não está, mas que me guia neste caminho. Aos meus avós Armando e Madalena, pelos abraços e pela preocupação pela minha felicidade e bem-estar. À minha restante família que sempre me acompanhou, em especial ao meu padrinho e à minha tia Céu.

À Clarinha e à Mari que compreenderam a minha ausência e que estiveram sempre a torcer pelo sucesso de cada passo meu.

Aos professores e aos especialistas de UX que participaram nesta investigação, mostrando-se sempre disponíveis e proporcionando a recolha de dados imprescindíveis à concretização desta investigação.

Por fim, a todos os professores que se cruzaram no meu caminho e que me formaram, providenciando os alicerces para o meu conhecimento florescer.

palavras-chave   Ferramenta para web, Layout Design, Canvas Digital, Design centrado no utilizador, Preservação ambiental.

resumo   Partindo da necessidade urgente de promover a consciencialização ambiental, o projeto Gamers4Nature (G4N) visa encorajar a participação ativa de alunos do ensino secundário e superior na criação de jogos digitais, transmitindo conhecimento sobre o meio ambiente e motivando o envolvimento dos alunos com as temáticas endereçadas.

Tendo em conta a motivação que os alunos têm para criar os seus próprios jogos mas com a preocupação de que nem todos os potenciais criadores estarão familiarizados com o processo de criação de um jogo, a equipa de investigação do projeto G4N desenvolveu uma *Toolkit to Game Design* (um artefacto físico) que engloba um conjunto de recursos para auxiliar o processo de criação de um jogo: um conjunto de cartas sobre os elementos de jogo, múltiplos conjuntos de cartas que abordam temáticas ambientais e um *Rapid Game Design Document*.
Como extensão do formato físico, a equipa do projeto G4N desenvolveu um portal-repositório (artefacto digital) que, além de pretender estabelecer uma ligação entre os dois formatos, tem como objetivo atuar como a presença online do projeto e como repositório para os materiais, resultados e jogos criados no âmbito do projeto.

A plasticidade da G4N Toolkit, nomeadamente das cartas temáticas, promove a criação de novos conjuntos de cartas temáticas sobre questões ambientais associadas a localidades e realidades específicas. Não obstante, no contexto de parcerias com outras entidades (p. ex. entidades relacionadas com o ambiente, escolas), o papel de criar e inserir os conteúdos nas cartas recai sobre as entidades parceiras, que muitas vezes não possuem competências de design. Neste contexto surgem alguns problemas de design, cabendo à equipa do projeto G4N corrigir erros que desrespeitam princípios de design e as diretrizes da marca G4N.

Identificada a necessidade de estabelecer uma estratégia que possibilitasse, simultaneamente, a criação autónoma de cartas temáticas e o respeito pela identidade da marca G4N, esta investigação definiu, concebeu, desenvolveu e avaliou uma ferramenta digital, integrada no portal-repositório.
Concebida para ser intuitiva e desenhada com base nas necessidades de professores e membros de organizações ambientais, a ferramenta pretende reduzir a curva de aprendizagem e a carga cognitiva do utilizador.

keywords

abstract

From the urging need to promote environmental awareness, the Gamers4Nature (G4N) project aims to encourage the active participation of upper-secondary and undergraduate students in the creation of mobile games, as a way to promote behaviour change, fostering knowledge about the environment and enhancing students' engagement with the addressed themes.

Bearing in mind students' motivation to create their own games and that not all potential game developers will be familiar with the process of creating a game, the G4N research team developed a Toolkit to Game Design (a physical artifact) encompassing a set of resources to support the game creation process: a set of cards addressing game elements, multiple sets of cards addressing environmental themes, and a Rapid Game Design Document. As an extension of the physical format, the G4N research team developed a portal-repository (digital artifact) designed to establish a connection between these two formats, aiming to act as the project's online presence and a repository to host its materials, outcomes and games created within the project's scope.

Concerning the G4N Toolkit, its plasticity, namely from the thematic cards, promotes the creation of new resources regarding other environmental location-based themes. In the context of partnerships with other entities (e.g. environment-related entities, schools), the role of creating and inserting the cards' contents lies with the partner entities, which often do not have design skills. As a result, some design problems arise from these circumstances, leaving it to the G4N research team to correct mistakes that disregard design principles and G4N brand guidelines.

Based on this premise, this research defined, designed, developed, and evaluated a digital tool, integrated into the G4N portal-repository, to allow other entities to produce their own physical resources (i.e. thematic cards) for the G4N Toolkit, according to the project's brand and identity. The tool was designed to be intuitive and reduce the user's learning curve and cognitive load, based on the needs of teachers and environmental organisations staff.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

API	Application Programming Interface
AXE	Anticipated Experience Evaluation
BMP	Device Independent Bitmap or Windows Bitmap
CSS	Cascading Style Sheets
DL	Digital Literacy
DOM	Document Object Model
DR	Development Research
EHR	Electronic Health Records
FAQ	Frequently Asked Questions
FCT	(Portuguese) Fundação para a Ciência e a Tecnologia
	(English) Foundation for Science and Technology
FR	Functional Requirements
G4N	Gamers4Nature
GAF	(Portuguese) Grupo Aprender em Festa
GIF	Graphics Interchange Format
GUI	Graphical User Interface
HCD	Human-centred design
HCI	Human-Computer Interaction
HTML	HyperText Markup Language
HIS	Health Information Systems
ICT	Information and Communications Technology
JPEG	Joint Photographics Experts Group
JPG	
JSON	JavaScript Object Notation
LDT	Layout Design Tools
MCTES	(Portuguese) Ministério da Ciência, Tecnologia e Ensino Superior
	(English) Ministry of Science, Technology and Higher Education
MOV	QuickTime File Format
MP4	MPEG-4 Part 14
NFR	Non-Functional Requirements
ODP	Open Document Format
PHP	Hypertext Preprocessor
PNG	Portable Networks Graphics

R&TD	Research and Technology Development
RTF	Rich Text Format
SI	Suggestive interfaces
SQL	Structured Query Language
SUS	System Usability Scale
SVG	Scalable Vector Graphics
TIFF	Tagged Image File Format
UCD	User-centred Design
UI	User Interface
URL	Uniform Resource Locator
UX	User eXperience
UXD	User eXperience Design

INTRODUCTION

With rising pollution levels, global warming, growth numbers of plastics throughout the entire planet and several other environmental problems (Hill, 2020), it becomes imperative to promote and raise environmental awareness and behaviour change in individuals from all age-groups.

Likewise, the creation and development of digital games are referred to by many studies (Falcao et al., 2018; Huizenga et al., 2017; Ke, 2014) as a way to promote students' motivation and engagement to act in more sustainable and environmentally friendly behaviour.

Hence, the Gamers4Nature[1] project, from these two premises, built a set of strategies to involve younger audiences (i.e. upper-secondary and undergraduate students) in the creation of their own digital games, while raising environmental awareness. One of those strategies consisted in the conceptualisation, creation, and validation of a Toolkit to Game Design to support the game creation process. The G4N Toolkit to Game Design encompasses a Game Construction Card Set, a Rapid Game Design Document and multiple sets of cards regarding environmental themes (Figure 1) – all these resources aim to support a structured creation of game narratives.

Figure 1 – Gamers4Nature Toolkit to Game Design and its resources

---

[1] http://www.gamers4nature.pt/index.php?lang=EN, last accessed on June 6, 2021

As a physical artifact and aiming to promote students' or participants' engagement as a team, the G4N Toolkit is suitable for Game Jams, game design and brainstorming sessions, and educational contexts. Moreover, it makes the artifact more accessible to all audiences, allowing the inclusion in schools lacking technological resources, such as computers, internet access or software. The interaction with a physical object enhances the connection not only between the user and the artifact but also between the users themselves and with the cards' thematic, increasing the likelihood to raise awareness.

All contents are also available digitally in the G4N project's portal[2]. By accessing the portal (Figure 2), the Toolkit's contents[3], all the card sets and the box layout itself are available for download.
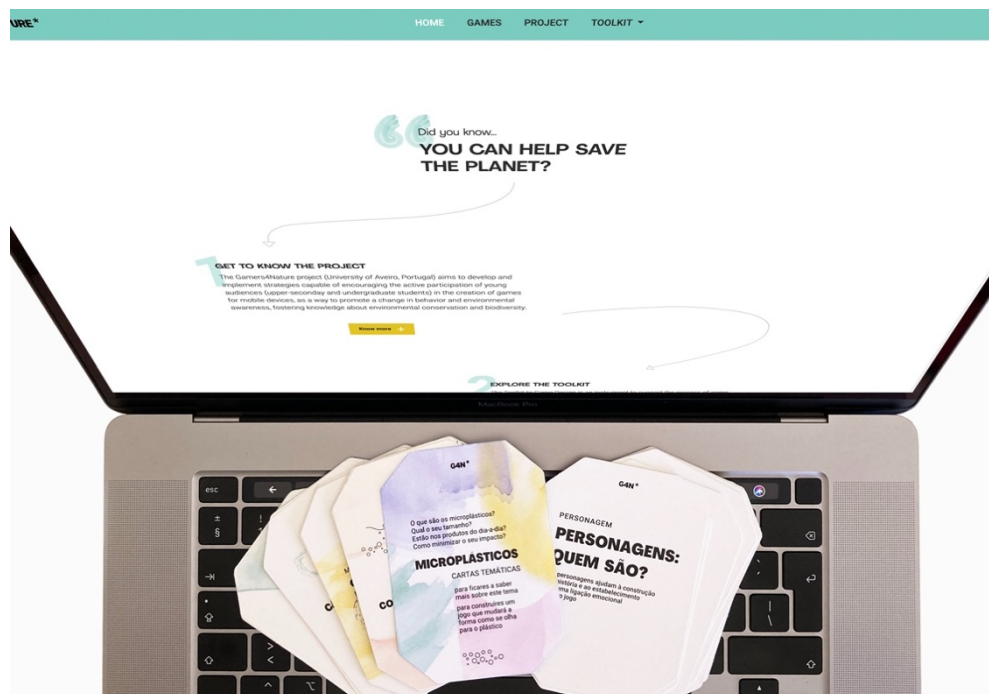
Figure 2 – Toolkit to Game Design Resources and Gamers4Nature portal-repository

The connection between the physical and the digital artifacts (i.e. G4N Toolkit and G4N Portal), was taken into consideration when designing the online portal, so that the G4N's brand and identity could be identified in any of the project's outputs, therefore, emphasizing this connection (Beça, Ribeiro, Santos, et al., 2021).

---

[2] http://www.gamers4nature.pt/index.php?lang=EN, last accessed on June 6, 2021
[3] http://www.gamers4nature.pt/toolkit.php?lang=EN, last accessed on June 6, 2021

The G4N Toolkit contains cards that address environmental issues (e.g. Microplastics, Stag Beetle) developed by the G4N project. Nevertheless, it is also intended that other organizations, entities, schools, among others, can develop their own cards while maintaining graphic consistency and producing a uniform output with all the project's resources. In this regard, this research developed a digital tool, embedded in the G4N's portal-repository, following the same design principles and fulfilling the project's brand and identity guidelines.

As for this research's purpose, it is expected that this digital tool to create physical artifacts will be a resource able to be used by teachers and environmental organisations staff aiming to spread environmental awareness through the creation of digital games in any contexts, whether in classrooms or environment preservation events.

Therefore, this research, supported by the Gamers4Nature project, with the reference POCI-01-0145-FEDER-031047, in the DigiMedia Research Unit (University of Aveiro, Portugal) from the Department of Communication and Art - University of Aveiro, has the two main goals: (i) provide the project with a tool to ease the creation of the thematic cards by other entities (e.g. environmental organisations or teachers); (ii) produce a tool for non-experienced users in the design field.

The Research Problem Statement

Throughout the G4N project several Game Jams sessions were organized, either in educational or non-educational contexts (e.g. Game Jams). Thematic Cards' subjects were explored, written, designed, evaluated and, finally, printed, not always by the G4N's research team. In some scenarios, other entities (e.g. "Grupo Aprender em Festa" (GAF), Private Institution of Social Solidarity) were responsible for the development of the cards' contents due to the need for creating themes describing the biodiversity of the places where the game creation sessions occurred (e.g. Gouveia city, Portugal – Local biodiversity). Nonetheless, the G4N's research team was still responsible for preparing the cards for printing.

During the process of preparing the thematic cards for other entities to fill the cards with their contents, the research team built a PowerPoint presentation with the card's templates, so that other entities could place their contents into the project's layout design. PowerPoint was chosen due to its similarity to other presentation software programs but also because those software programs are, in their majority, compatible with PowerPoint.

However, some issues emerged from this card set creation process: (i) for the most part, the research team had to correct some design mistakes; (ii) the G4N cards contain contextual illustrations according to each card's theme but, in these contexts, these illustrations ceased to exist because these entities did not have designers or illustrators; (iii) at times, the brand and project's identity standards were not met, mainly due to the lack of design and technical skills. In short, and since most entities did not have the necessary skills to do it, these entities could not complete the whole card set creation process.

Given these problems, an extensive literature review on platforms, tools and software that would allow new models and designs to be built was conducted.

The theoretical framework and related work research unveiled that there were no suitable platforms or tools for non-experienced users in the design field and that provide, simultaneously, the compliance of a brand's standards manual.

To conclude, this research aims to create a digital tool to produce thematic cards for the G4N Toolkit (the physical artifact) to be available to users through an embedded section in the G4N's portal-repository (the digital artifact). It is crucial to design an intuitive tool, suitable for teachers and environmental organisations staff without design or digital skills, who aim to design their own thematic cards.

Goals and purposes

This research study aims to define, prototype, develop and evaluate a digital tool to support the production of physical thematic cards for the G4N Toolkit.

From the user's perspective, this tool will provide the mean for teachers and environmental organisations around the world to produce their own resources on environmental issues of their location without the need for any previous design or technical knowledge. Moreover, it will allow teachers to create educational resources to boost their lessons by engaging students on the addressed themes.

From the perspective of the G4N project, the development of this tool will ensure conformance with the brand's graphic standards manual, but it will also assure that the products derived from this tool will dovetail into the G4N Toolkit as a whole.

Finally, this tool aims to withdraw more complex tasks from the users' role – therefore minimizing the cognitive load – by providing design specifications, the necessary information

regarding the layout, the export formats to create its physical format, the printing materials and the adequate dimensions for all design elements (e.g. icons, colours, typography).

Having this in mind, this research's main goals are:

i. To **identify** and **characterise** platforms and/or tools that allow users to create their own contents;

ii. To **prototype** and **develop** a digital tool to create thematic cards for the Gamers4Nature Toolkit to Game Design;

iii. To **evaluate** the tool in an iterative process.

The goals above will impact and will be reflected in this research's methodology.

Expected Results

This dissertation research aims to conceptualise, define, design, develop and evaluate a digital tool to create physical resources to integrate into the G4N Toolkit. This tool should follow the design guidelines of the G4N brand and identity but also be an integrated section of the G4N online portal-repository. Thus, it can be considered as a branch of the G4N Toolkit.

Therefore, it is expected to produce a usable tool for users without specific design skills or with low digital literacy, and to be useful and used by the target audience in the G4N context.

In the first phase, it is intended that schools and environmental organisations (e.g. BioLiving Association[4]) – partners of the project – will be able to develop their contents addressing environmental knowledge and awareness through the creation of thematic cards for the G4N Toolkit.

The creation of this tool as an integrated section of the portal-repository aims to emphasize the connection between the project's physical and digital artifacts. The physical format of these resources plays a major role in promoting students' engagement and motivation, but also its usage is possible regardless of the available technological infrastructure.

---

[4] https://www.bioliving.pt/, last accessed on June 13, 2021

Furthermore, concerning this research's methodology, it is expected to produce a replicable process in other research contexts.

Lastly, it is expected that these strategies, prompted by the creation of thematic cards, will promote environmental awareness and the willingness to spread knowledge with such an important message.

Personal motivations

Throughout my life, I was raised to care for nature and the environment in general. Since I can remember, my family has reused and recycled everything they could, and I inherited that care.

During my Bachelor's degree, I explored the world of games and gamification in senior tourism. Later, at the beginning of my Master's degree, I started my work in the Gamers4Nature project – that joins my care for nature and my knowledge of games – as a User Interface (UI) and User eXperience (UX) designer and programmer research fellow.

This dissertation research provides the opportunity to continue the work I did for over a year and a half and to explore new branches on the project's scope. Furthermore, it allows me to explore new methods of involving users and instigates me to learn and improve programming and design skills.

Dissertation Structure

This dissertation is structured into four chapters that seek to respond to the goals set for this research, as well as point out directions for future work, reflecting on the work developed in the research area and on the findings obtained.

The document initially presents an introduction, stating the research problem, main goals and purposes, and the expected results.

The first chapter encompasses a theoretical framework that approaches eight research-related subjects. Starting by highlighting the relevance and adequacy of Layout Design Tools and Platforms, and followed by a discussion on the features of Familiar Presentation Tools (e.g. Microsoft PowerPoint), depicts features, advantages and disadvantages, and reflects on the gaps that do not fulfil this research's purpose. Furthermore, it addresses Layout Design Tools

components: Suggestive Interfaces, explaining its characteristics and relevance for this research's target audience; and Canvas, debriefing on its concept and characteristics. It also explores adults' digital competencies, current internet usage, online users' ages, the concept of digital literacy and the usage of technology in education and by adults. Finally, approaches User-Centred Design and Interaction Design concepts and unravels the concepts of personalisation and customisation.

The second chapter encompasses the related work analysis which observes design and presentation tools, platforms, and software.

The third chapter elaborates on the methodology adopted for the research, contextualising the choice of methodology within the research scope. Furthermore, it reflects the goals to be achieved in an analysis model and presents and explains the approaches taken regarding the information sources and data collection tools.

The fourth chapter describes the process of contextualising, defining, designing, and developing the tool, as well as details the evaluation stages and its outcomes.

Lastly, a reflection is presented concerning the results achieved and the process undertook, as well as points the directions for future work.

CHAPTER I

THEORETICAL FRAMEWORK

Topics

Layout Design Tools and Platforms
Presentation Tools
Suggestive Interfaces
Canvas
User Experience Design
Interaction Design
User-centred Design
Customisation versus Personalisation

Aiming to provide theoretical support for the research depicted throughout this document, this chapter presents a snowball literature review focused on tools and platforms developed to allow experienced or non-experienced users to create graphical contents. Moreover, it defines a set of pivotal concepts to this research, namely, it highlights Suggestive Interfaces studies, canvas' standard characteristics, and touches upon essential subjects related to designing intuitive and usable interfaces having in consideration user's needs.

I. Layout Design Tools and Platforms

Starting to design a User Interface (UI) or any graphical content from a blank canvas can become a challenging task, particularly for novices (i.e. non-experienced users). As there is no support to users without any experience regarding where and how to start a design. Most of the existing and renowned tools, from more intuitive and simpler (e.g. PowerPoint[5]) to more professional and elaborated (e.g. Adobe Illustrator[6]) systems, do not provide suggestions or models while designing (O'Donovan et al., 2015).

Nonetheless, some researches already approach systems that aim to fill these gaps, such as DesignScape[7] (O'Donovan et al., 2015), Sketchplore[8] (Todi et al., 2016) and others (Jahanian et al., 2013; Kuhna et al., 2012). In these tools, known as Layout Design Tools (LDT), a balance, not only in terms of users' freedom and limitations – in order to respect design principles – but also in the design of these systems – by incorporating professional software features in intuitive ways supporting novice users' experience – must be established.

Regarding the balance between freedom and constrains, DesignSpace (O'Donovan et al., 2015) provides: (i) **smart guides** that snap the object and help align with other objects in the canvas; (ii) allows the user to **lock objects** preventing them from moving; (iii) displays **layout suggestions** based on user's current layout and also brainstorming suggestions, completely independent of the user's layout.

Furthermore, this tool incorporates two modes: (1) Suggestive interface (detailed later in the *Suggestive Interfaces* section) – which presents the user three different suggestions based on the elements' current position, being the first with small suggestions and the last with more severe modifications; (2) Adaptive interface – this mode allows a more fluid interaction since the

---

[5] https://www.microsoft.com/en/microsoft-365/powerpoint, last accessed on June 19, 2021
[6] https://www.adobe.com/products/illustrator.html, last accessed on June 19, 2021
[7] http://www.dgp.toronto.edu/~donovan/design/index.html, last accessed on June 6, 2021
[8] https://www.kashyaptodi.com/sketchplore/, last accessed on June 6, 2021

adjustments happen automatically. The Adaptive mode can become frustrating for users as they do not hold control over the final result. To observe the suggestions, the user can put the mouse over them and then accept the suggestion by clicking on it. Overall, the users favoured the Suggestive interface mode rather than the Adaptive interface mode since it is less limited (O'Donovan et al., 2015).

In relation to integrating professional software's features, some tools (Jahanian et al., 2013; Kuhna et al., 2012; O'Donovan et al., 2015; Todi et al., 2016) incorporate recognized features, such as moving, resizing, adding or removing, font styling, alignment and smart guides.

According to Lee et al. (2010), template-based tools offer advantages for users with or without design experience and produce better results. Moreover, the authors (2010) also mentioned that suggesting similar templates to the user's choices allows an agile and concrete search. The concern to integrate design principles and users' choices produces intuitive tools, suitable for experts and novices (Lee et al., 2010).

Furthermore, the results of the research discussed (Jahanian et al., 2013; Kuhna et al., 2012; O'Donovan et al., 2015; Todi et al., 2016) substantiated that presenting suggestions according to the user's design is a proper interaction method since it allows the designed layouts to comply with design principles without excessively constraining the user's experience. Yet, neither in the theoretical framework (detailed in this section and in the *Suggestive Interfaces* section) nor in the related work research (detailed in the *RELATED WORK* chapter), were found any platforms supporting the compliance of a brand's standards manual.

II. Familiar Presentation Tools

Presentation Tools are well-known and commonly used tools in personal and professional contexts (BBC Bitesize, 2020; Duffy, 2018; Noar, 2018), such as Microsoft PowerPoint[9], Apache OpenOffice Impress[10], Prezi[11], Google Slides[12], Keynote[13], among others. In fact, in Education, nearly all teachers in Europe use "Information and Communications Technology" (ICT) to prepare lessons and to present it to students, in schools (European Union, 2013). From the researcher's empirical experience, in the context of the University of Aveiro, practically all teachers and researchers use Microsoft PowerPoint or Keynote to produce their multimedia presentations.

The widespread use of these tools makes them the first option when the goal is to produce a presentation – with or without multimedia content – or to design, thus recognising their usefulness and good usability. All these tools provide presentation templates which conquers lots of users by the immediate response to their needs. Besides, these tools also allow customisation that gives the user a sense of control (Nielsen, 1998) over the content they produce.

II.1. PowerPoint

From the software abovementioned, PowerPoint has been the leading software since its release concerning the teaching of educational subjects (Hashemi et al., 2012), conveying ideas or pitching new products in any business field (Britannica, 2019).

Initially named Presenter, PowerPoint was designed to ease the creation of visual presentations and to serve as a support to convey information and to communicate (Britannica, 2019; Spencer, 2019). The continuous usage of PowerPoint is due to the fact that its evolution keeps along with the technological development (Syah & Harsono, 2020). Furthermore, the Microsoft monopoly and Office packages available on any computers boosted its widespread usage.

Ever since the software's first appearance and upgrades, there's always been authors who criticise (E. Tufte, 2003) and others that compliment this tool (Gabriel, 2008).

---

[9] https://www.microsoft.com/en/microsoft-365/powerpoint, last accessed on June 6, 2021
[10] https://www.openoffice.org/pt/product/impress.html, last accessed on June 6, 2021
[11] https://prezi.com/, last accessed on June 6, 2021
[12] https://www.google.com/slides/about/, last accessed on June 6, 2021
[13] https://www.apple.com/keynote/, last accessed on June 6, 2021

On the one hand, Gabriel (2008) highlights PowerPoint's greatest advantages, such as the entertaining way of communicating, through which lecturers can express their ideas and messages by applying multimedia resources that stimulate multiple senses. There is no doubt that PowerPoint is still the main software when aiming to design multimedia presentations – with over 1.2 billion users, by 2015 (Wakefield, 2015). The multiplicity of outcomes – that might be due to the software's usability, accessibility, and effectiveness – continues to attract billions of users worldwide. Along with Gabriel (2008), other authors also analyse this software's advantages from different perspectives (Levasseur & Kanan Sawyer, 2006; Sweller et al., 2011).

On the other hand, Tufte (2006) mostly criticises the dominance of form over content and audience, the minimization of content's meaning by using bullet-points and abbreviations and, a relevant topic on this research, even though users value decoration, they usually apply images out of context and overload the audience with superfluous information. Other authors (Craig & Amernic, 2006; Kernbach et al., 2015; Ledbetter & Finn, 2018) also criticise this tool.

Poorly designed presentations can affect, for example, students' engagement with the lectured subject (Spencer, 2019) and PowerPoint does not provide any specific guidelines or limitations concerning design principles. In that matter, Spencer (2019) highlights some design principles that are not respected due to the absence of embedded design guidelines in the software, such as font's legibility, text and colour contrast, alignments, and also cognitive overload with text. Indeed, some authors (Baker et al., 2018) mention the importance of lecturers to consult the Cognitive Theory of Multimedia Learning principles (Mayer & Moreno, 2003), which proposes nine suggestions to reduce cognitive overload by suggesting one or two solutions to each overload scenario.

Aiming to improve the design of presentations, the latest version of PowerPoint already has a feature entitled "Design Ideas"[14], which generates design ideas based on the users' content: from a title, the software suggests a design scheme with colours and images; it detects pictures, charts and tables provides attractive and cohesive layout suggestions; lists, processes and timelines can be transformed into SmartArt graphics; from key terms, the software suggests icons and illustrations. Withal, this feature does not provide suggestions for fixing design mistakes or guides to comply, for example, with the brand's standards manual.

---

[14] https://support.microsoft.com/en-us/office/create-professional-slide-layouts-with-powerpoint-designer-53c77d7b-dc40-45c2-b684-81415eac0617, last accessed on June 6, 2021

II.2.   Prezi

Prezi is, likewise, a software to produce multimedia presentations and contents, which has three modes: (i) Prezi Present; (ii) Prezi Video; (iii) Prezi Design.

First, Prezi Present allows users to organise their presentations by dragging elements without disrupting the layout, create animations to focus the presentation on specific spots in any order – a widely renowned feature –, and integrate users' video transmission into the presentation. Moreover, it displays design templates and pre-designed presentations, and allows to import PowerPoint documents into Prezi (compatibility). This mode also allows the user to upload their company's logotype and the software associates the colour palette.

Second, Prezi Video allows users to integrate their presentations into remote video calls.

Lastly, Prezi Design is an editor to create graphics, maps, infographics, reports, slides, posters, and other contents. This mode supports animated GIF and graphics, cover videos and subtle effects to create professional aesthetics. Furthermore, Prezi Design integrates search of images and resources from *Unsplash*[15] and *Giphy*[16] and allows to apply filters to images.

II.3.   Apache OpenOffice Impress, Google Slides and Keynote

Apache OpenOffice Impress, Google Slides and Keynote software have similar features with PowerPoint as they aim to create dynamic multimedia presentations.

Nonetheless, there are relevant features to highlight: (i) the available export formats (i.e. PowerPoint and Flash (.swf) compatible); (ii) automatic save of the presentations; (iii) objects alignment; collaborative work; (iv) template availability; (v) in Keynote, it is possible to transform Apple Pencil's handwriting into text and to design the presentation in any Apple Device.

II.4.   Final considerations

As can be seen from the research described above, the freedom of creation which characterise these software (of both presentation and design tools) does not match the requirement to comply with the guidelines set by the standards manual of a brand. However, and bearing in mind the aim of this research and the G4N project's context, the mentioned tools and software are too broad since its objectives are to create thematic cards addressing

---

[15] https://unsplash.com/, last accessed on June 6, 2021
[16] https://giphy.com/, last accessed on June 6, 2021

environmental preservation topics, following the G4N's brand and identity – a specific requirement.

Nevertheless, these tools can be suitable for their essential purposes – which is to produce customizable multimedia presentations and designs – as they integrate a set of principles already considered a standard for users, which facilitate a fluid and intuitive interaction.

III. Suggestive Interfaces

Suggestive interfaces (SI) arise as a way to provide the user with some control over its work or design. Most research on SI are focused on 3D sketching/drawing (Igarashi & Hughes, 2007; Tsang et al., 2004), modelling tools (Araújo & Jorge, 2003; Kodama et al., 2018; Yu et al., 2016), gesture-driven interfaces (Cruz & Velho, 2010; Kyan et al., 2015) or layout design tools (O'Donovan et al., 2015).

SI are often applied in contexts where ambiguity is placed in question and the decision-making is placed on the users so they can determine the result they aim to achieve. These interfaces are integrated into any UI (mobile or desktop) and are generally displayed on one side of the interface. According to the abovementioned studies, suggestions are presented on a specific section of the screen and are defined based on the user's current design or model.

Concerning the study of the DesignScape tool (O'Donovan et al., 2015), the "suggestive interface mode" is one of the modes made available (Figure 3). This mode consists of the following: on the left side of the screen, the user can mouse over the suggestion and see a preview and click to accomplish the previewed result. Additionally, DesignScape allows users to lock design elements, fixing its position and scale, also in the suggestions provided.

Figure 3 - Suggestive Interface in DesignScape: On the left side it is displayed the user's current layout, and the right side shows the suggested improvements – aligning the three elements on the left and changing the size of the image.

Suggestions can, indeed, uphold notorious support for novice without constraining their creative process (O'Donovan et al., 2015). However, suggestions must not be invasive, and these tools must consider a broader range since their users can also be expert users, and not only novices. Hence, suggestions must only take on a percentage of the UI, avoiding overloading the users with excessive suggestions. SI may appear when users are first entering the system/tool/app and later be disabled when they are no longer needed. It is imperative to use

suggestions wisely and reasonably, avoiding creating user assistants as Clippit from Microsoft Word – colloquially known as Clippy – that fail at their functionality, design, and humanisation (Kao et al., 2020). In fact, authors (Kao et al., 2020) mentioned that Clippit became frustrating as it would interrupt the user's task, thus driving a distressing experience due to the lack of humanity and personalisation (e.g. learning their name or preferences).

As for this research, suggestions fit as an approach to support teachers or environmental organisations – who can perhaps not be or integrate design experts – in producing high-quality resources for the G4N Toolkit in compliance with the G4N brand standard's manual.

IV. Canvas

The tools presented in this section share a similar feature: all contain canvases to create a design, thus the importance of approaching this topic.

IV.1. Definition of canvas

Canvases derive from the physical world, meant for artists to paint their art pieces, to the technological world through its digitalisation (Thokala, 2011). A canvas is a type of a Graphical User Interface (GUI) that contains graphic elements. A GUI is "a computer program that enables a person to communicate with a computer through the use of symbols, visual metaphors, and pointing devices" (Levy, 2018). In these days, a GUI is simply a computer interface, an integrated component of a software, which provides an efficient performance when stable and reliable (Banerjee, 2017). Even though GUIs are limited to the iconic representation of elements, they stimulate the user's exploration due to that representation (Chang et al., 1995). Despite the mentioned studies are not from nowadays, the concept of GUI prevails.

IV.2. General characteristics of canvases

Some canvases are divided into workspaces dedicated to each design element, others contain individual canvases, typically with smaller workspaces, dedicated to a single artifact (Santos-Gomez, 2000; Swider et al., 2018). Moreover, from some researches and trademarks a set of features can be identified to characterise a canvas, such as: (i) Dedicated workspace with a single or several windows (Swider et al., 2018); (ii) Use of icons to describe the functions available in the workspace (Swider et al., 2018; Yadav et al., 2021); (iii) Drag and drop graphic elements to build the design (Johnsson & Magnusson, 2020; Swider et al., 2018; Yadav et al., 2021); (iv) Multiple models of interaction, such as Scrolling, zooming, scaling (Goldman & Balzer, 1999); (v) Saves the design automatically and previous versions can be recovered (Yadav et al., 2021).

Canvases and LDT have in common interaction models, retrieved from professional design tools (e.g. Adobe Illustrator), such as dragging, zooming, scaling, rotating, moving, among others.

V. Digital skills and competences, and technology usage

Having understood the characteristics of tools linked to the aim of this research, it is imperative to grasp the target audience, particularly their needs and limitations in terms of their interaction with technology.

V.1.   Internet usage

The importance of producing an accessible product arose early in this document, and as internet users continuously increase[17], it becomes more attainable to create a web-based service (i.e. tool). According to Internet World Stats[18], even continents with underdeveloped countries, such as Africa, start to get a significant representation in the Internet World with a penetration rate of 46.7%. Countries, such as Republic of the Congo[19], have been experiencing a fast growing of the online populations – around 126%.
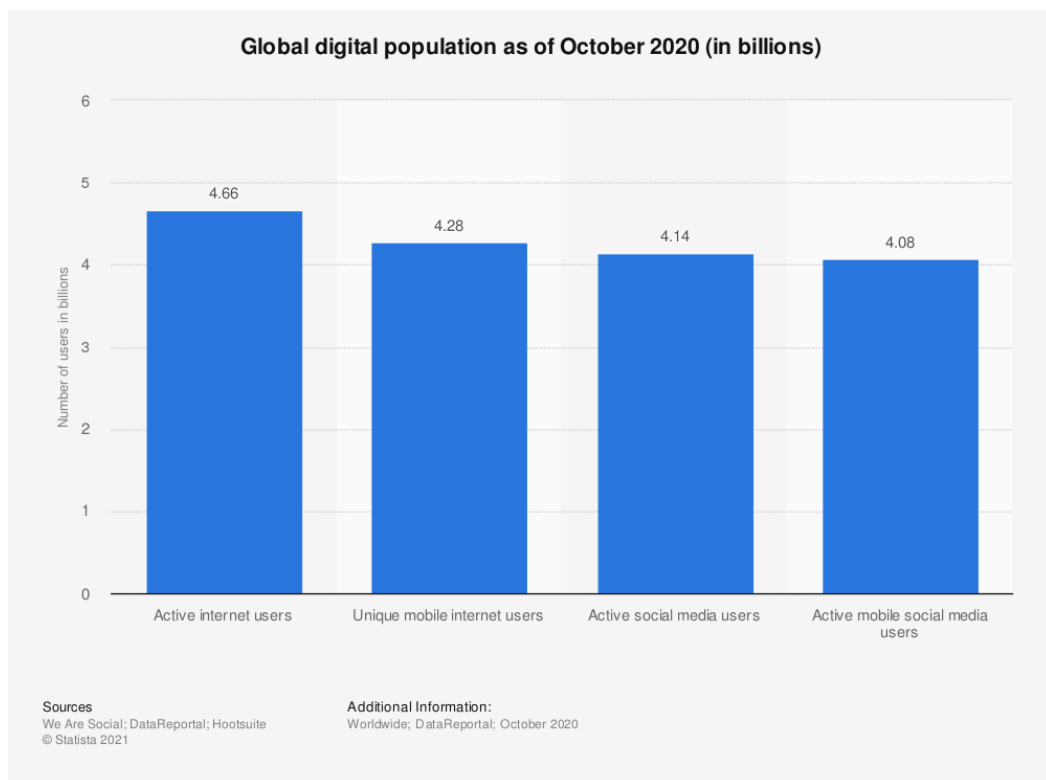
Figure 4 - Global digital population as of October 2020 (retrieved from Statista, 2021)

---

[17] https://www.internetlivestats.com/, last accessed on June 6, 2021
[18] https://www.internetworldstats.com/stats.htm, last accessed on June 6, 2021
[19] https://www.statista.com/statistics/292488/fastest-growing-internet-populations/, last accessed on June 6, 2021

By October 2020, there were almost 4.66 billion active users[20] (Figure 4) on the internet, representing 59% of the global population. Regarding the age distribution of the online population[21] (Figure 5), the biggest group are users between 25 and 34 years old (32%), followed by users aged between 35 and 44 years old (19%).

Distribution of internet users worldwide as of 2019, by age group

- **65+** 7%
- **55-64** 10%
- **18-24** 18%
- **45-54** 14%
- **25-34** 32%
- **35-44** 19%

Source
SEMrush
© Statista 2021

Additional Information:
Worldwide; 2019; 18 years and older
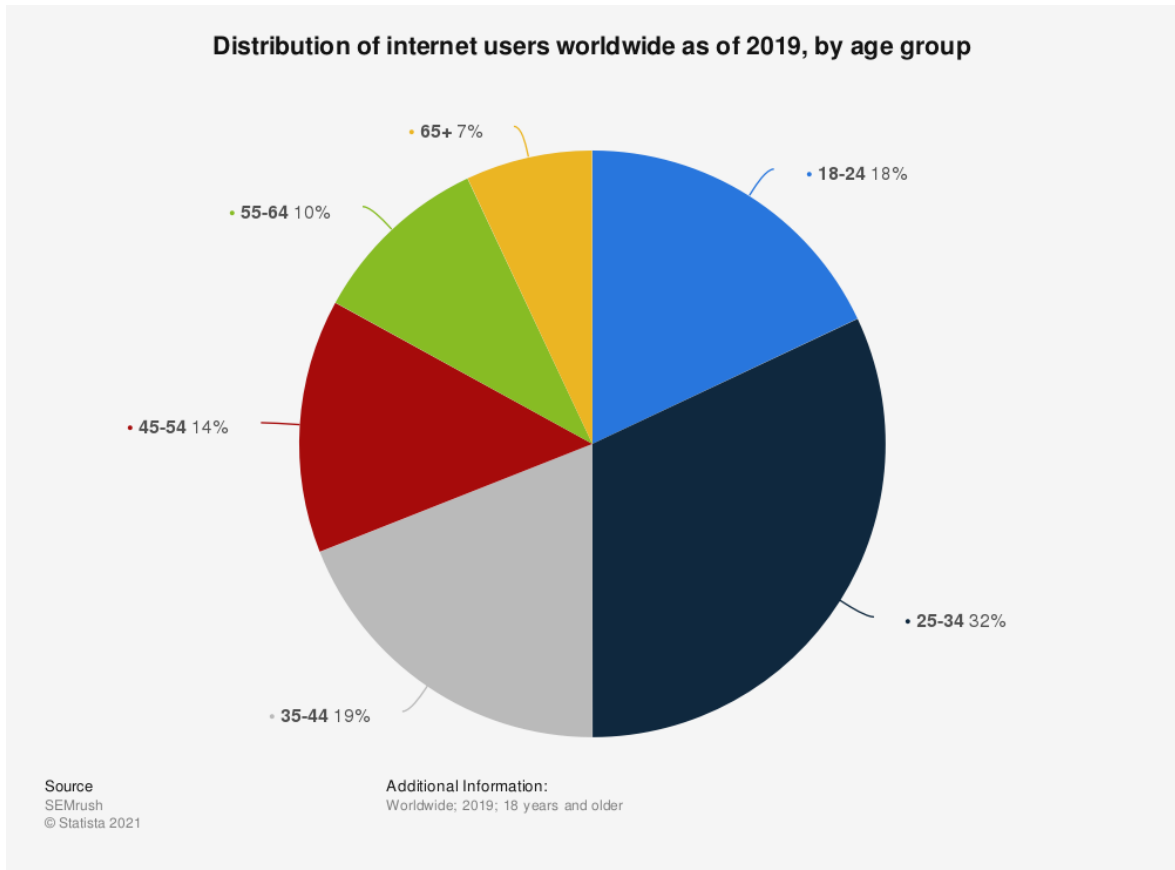
Figure 5 - Distribution of internet users worldwide as of 2019, by age group (retrieved from Statista, 2021)

V.2. Mobile vs Desktop – Users and Requirements

Between January 2009 and January 2021, in the beginning, as mobile usage has risen, desktop usage declined (Figure 6). However, around November 2016, both devices usage converged and has remained so ever since (Figure 6). Yet, mobile devices are still considered the most important channel for internet access (Johnson, 2021).

---

[20] https://www.statista.com/statistics/617136/digital-population-worldwide/, last accessed on June 6, 2021
[21] https://www.statista.com/statistics/272365/age-distribution-of-internet-users-worldwide/, last accessed on June 6, 2021

From observing Figure 6, the tablet does not have such relevance since its usage has remained constant, and low compared to mobile or desktop usage.
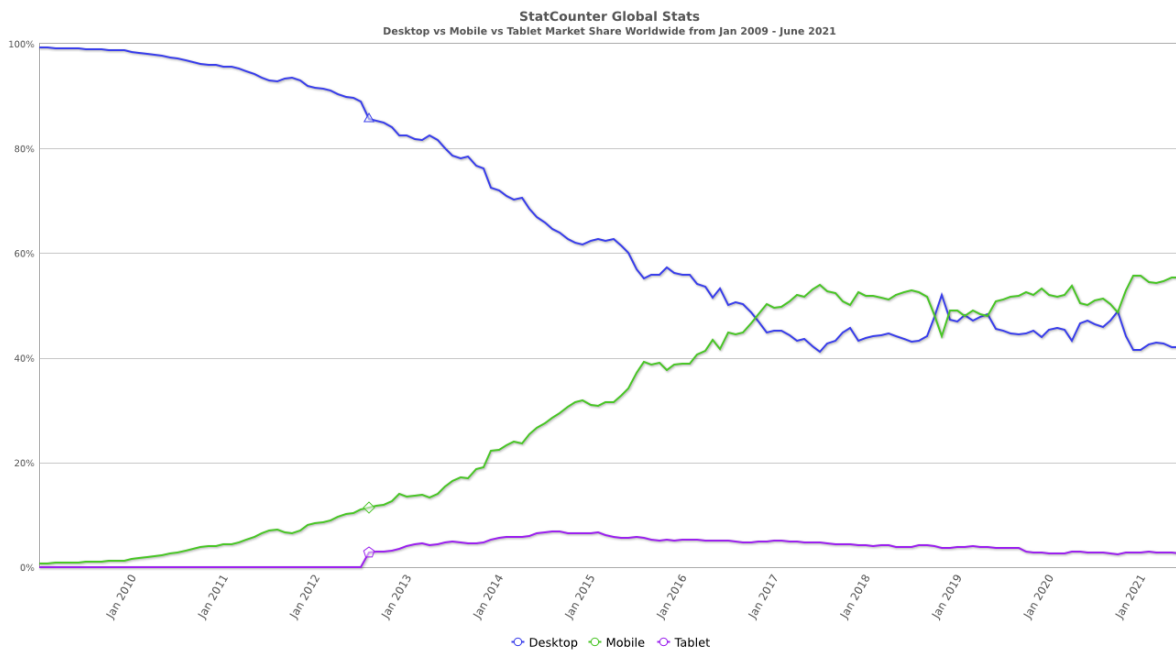
Figure 6 - Desktop, Mobile and Tablet usage worldwide (retrieved from StatCounter, 2021[22])

Considering this, and as technology rapidly progresses, the need for greater storage capacity, faster processors, and higher bandwidth rises (Shneiderman et al., 2018, p. 74). Simultaneously, it becomes necessary to adapt the system's design to mobile devices, with low bandwidth connections and smaller screens than desktops (Shneiderman et al., 2018, p. 74). In this regard, responsive design plays a major role in the contents' adaptability to both bigger and smaller devices. The Cascading Styles Sheets (CSS) allows adjusting design elements to different devices. Therefore, one of the requirements of any system that aims to design a product should be the elaboration of a responsive UI.

V.3. Definition of Digital Literacy

In order to understand users' confidence and knowledge when interacting with technology, it is imperative to fathom the concept of Digital Literacy (DL).

DL has several definitions, yet those have common characteristics, such as the need for technical knowledge and skills, as well as more complex cognitive skills (Kuzmanović et al.,

---

[22] https://gs.statcounter.com/platform-market-share/desktop-mobile-tablet/worldwide/#monthly-200901-202106, last accessed on June 20, 2021

2019, p. 19). However, the most widely accepted definition – called DigComp – was developed by the European Commission (Ferrari, 2013) and revised twice in 2016 (Vuorikari et al., 2016) and 2017.

Between these two framework updates, there were significant changes in the digital world, specifically the adoption of cloud-based storage, information visualization tools for large amounts of information, accessibility and social inclusion, and privacy and legislation (Vuorikari et al., 2016). According to the 2016 report (Vuorikari et al., 2016), these changes imply new requirements regarding digital competencies.

DL has **5 domains** (Vuorikari et al., 2016) comprising **21 competencies**: (1) Information and data literacy; (2) Communication and collaboration; (3) Digital content creation; (4) Safety; and (5) Problem-solving. According to the abovementioned European Union (EU) report (2016), there are competencies related to each domain which are displayed in Table 1.

Table 1 – Domains and competences of Digital Literacy (Vuorikari et al., 2016)

Domains	Competencies
Information and data literacy	• Browsing, searching and filtering data, information and digital content. • Evaluating data, information and digital content. • Managing data, information and digital content.
Communication and collaboration	• Interacting through digital technologies. • Sharing through digital technologies. • Engaging in citizenship through digital technologies. • Collaborating through digital technologies. • Netiquette (i.e. behavioural norms, know-how, communication strategies to each audience, cultural diversity). • Managing digital identity.
Digital content creation	• Developing digital content. • Integrating and re-elaborating digital content. • Copyright and licences. • Programming.
Safety	• Protecting devices. • Protecting personal data and privacy. • Protecting health and well-being. • Protecting the environment.

Problem-solving	- Solving technical problems. - Identifying needs and technological responses. - Creatively using digital technologies. - Identifying digital competence gaps.

Given the aim of this research, it is also essential to understand which skills adults have – considering the age group of members of environmental organisations and teachers.

A study (OECD, 2019, p. 20) that questions adults' readiness to address future skills reveals that there is still a significant percentage of adults (37%) with limited skills regarding digital technology and communication tools (OECD, 2019, p. 22), and 22% only have basic skills, such as reading and/or complete mathematical tasks.

V.4. Technology in Education

The exponential growth of technology, with active internet users rising every day, and the decrease of devices' size, impacts all fields, including Education. In fact, this continuous evolution generates new interaction paradigms and the arising of new products, implying that teachers train to constantly adapt to this evolution (Shneiderman et al., 2018).

Furthermore, research in terms of students' motivation, engagement and better results when applying technology in everyday classroom lessons also thrives (Annetta et al., 2009; Di Serio et al., 2013; Furió et al., 2015; Kaye, 2016). However, the success of a technological approach in classrooms heavily depends on how it is applied – pointing out the importance of the teacher's role in integrating technology (Seufert et al., 2021).

According to Seufert et al. (2021), although teachers value technology, they do not assume its importance in their work. The author (2021) mentions two diverse groups: a group of teachers who believes in the significance of digital skills, actually has advanced skills. Yet, another group of teachers, although also believes in the suitability of digital skills for their work, have little mastery of these skills.

For the so-called "digital natives" (Prensky, 2001), technology is not a problem (Kuzmanović et al., 2019), and so teachers are the ones who must persist in their own training and constant update of the technologies' progress.

V.4.1. Teachers – Technological skills and use

As mentioned in the previous section (*Definition of Digital Literacy* section), nowadays, there are a set of competencies that define who is digital literate or not. The extensive list of competencies imposes challenges to teachers and all Education-related personas. In some European countries, there are specific digital competencies, which vary from country to country (European Commission, 2019b).

According to a study carried by the EU (European Commission, 2019a), 45% of European teachers are "less digitally active, confident and supported", against 33% that are "highly digitally active, confident and supported". However, even if the technological access is limited, teachers have high confidence in their ICT use and focus on their digital development.

A literature review study (Spiteri & Chang Rundgren, 2020) concluded that teachers' confidence and technology usage are detached from their age or numbers of service. Furthermore, teachers' motivation influences their willingness to interact with technology, but also training could contribute to more positive attitudes.

Regarding teachers' skills, primary school teachers lacked "visual literacy and skill to choose the best information provided on the internet" (Spiteri & Chang Rundgren, 2020). Concerning teachers of all levels of education, the authors (2020) mentioned their difficulty to adapt to new digital tools.

V.5. Final considerations

Based on the presented insights in the previous sections, it can be stated that teachers' main difficulties when handling technology and digital products concern visual literacy and information selection. These difficulties endorse the relevance of this research, suggest users' needs (e.g. design guidelines and focused-search), and legitimate the pertinence of designing a usable and intuitive UI for teachers and environmental organisations.

The results analysed in the *Definition of Digital Literacy* section impose a challenge to this research but also justifies the research approach (later detailed in the *METHODOLOGY* chapter) – a user-centred study that aims to better understand users' needs, limitations and requirements (explained in the following section: *User-centred Design*) – by emphasizing the need of defining an approach suitable to minimize the user's cognitive effort.

VI. User-centred Design

Many of the mentioned research in the *Layout Design Tools and Platforms* and *Suggestive Interfaces* section apply Participatory, Co-design or User-centred methods, suitable for either non-experienced or experienced users. This research aims to develop a digital tool to create physical artifacts for teachers and environmental organizations, hence is considered essential the involvement of users in several stages of the process (detailed in *The Research Method* section, in the *METHODOLOGY* chapter).

The effectiveness of Participatory and Co-design methods require longer research periods as these methods are heavily dependent on the participants' availability and feedback. Considering this, a User-centred Design (UCD) approach seems to be the most appropriate to avoid as many constraints (i.e. participants availability and feedback) as possible that might interfere with the final product. Users are considered the centre of this research's approach (detailed in the *METHODOLOGY* chapter), and so their experience impacts the interface of the final product.

VI.1. Definition of User-centred Design

Despite the performed research on adult skills and competencies (detailed in *Definition of Digital Literacy* section) – aiming to aid the understanding of the research's the target audience –, designers must still question the researched data to avoid building a product/service based on incorrect assumptions about particular user groups (Sharp et al., 2019). Designers must focus on meeting users' needs to provide them with paths to achieve their goals within their limits (Saffer, 2010).

Henry (1998, p. 13) defined UCD or usability engineering as an "approach customer-driven organisations are following today to design the user interface". According to the author (Henry, 1998, pp. 12–13), to achieve good usability (a concept later explained in *Usability* and *Interaction Design* section), researchers and designers should apply Human-Computer Interaction (HCI) (a concept later explained in *Interaction Design* section) methods, processes, standards and tools. Furthermore, the author (Henry, 1998, p. 13) mentions four key concepts of UCD: (1) focus early on users and tasks – understand users' behaviour, attitude and cognitive implications, and the context and way users perform tasks; (2) first design the user interface – the first step is to design the interface; (3) involve users – user's participation and design reviews; and (4) insist on iterative prototyping and evaluation – iterative user testing and improvements.

Norman (2013) defines Human-centred design (HCD) or UCD as a process that considers psychology and technology to reflect users' needs, expectations and wishes in any product, from the definition of requirements to its design and development. Understanding people means observing and inquiring and that is why evaluations with users may impact the product throughout all its development stages. According to Norman (2013), iteration and evaluation must be done in this process and, initially, the problem and the approach must be open to modifications. Only in these situations are researchers in fact considering users' needs and expectations.

VI.2. Affordances and Signifiers

Following Norman's line of thought (Norman, 2013, p. 11), affordance plays a pivotal role in UCD. This term represents the parallelism between the object's properties and capabilities and its utility and needs to have social significance (Gibson, 1986). In short, affordances are clues to operations, and they are not always visible.

An affordance may be perceivable or not, but when it is, it often acts as a signifier – a sign of how things should be done (Norman, 2013, p. 19). Signifiers, if not perceivable, fail their function.

VI.3. Feedback

As an essential part of any experience, users must receive feedback. LDT and SI provide feedback to users on where to place the graphic elements and on how they could design something.

Without feedback, users could not comprehend the results of an action and would, perhaps, not understand how to communicate with the system. According to Norman (2013), this term is a "well-known concept from the science of control and information theory" and is required even in simple tasks. Feedback must be immediate, otherwise, users get impatient and unsatisfied with their experience.

VII. Interaction Design

VII.1. Definition of Interaction Design

The limits of multiple disciplines, such as HCI and Interaction Design are still hard to define completely. In Figure 7 - Disciplines surrounding Interaction Design (Saffer, 2010)it can be observed the relation of multiple research areas - all of them are deeply related to User eXperience Design (UXD).
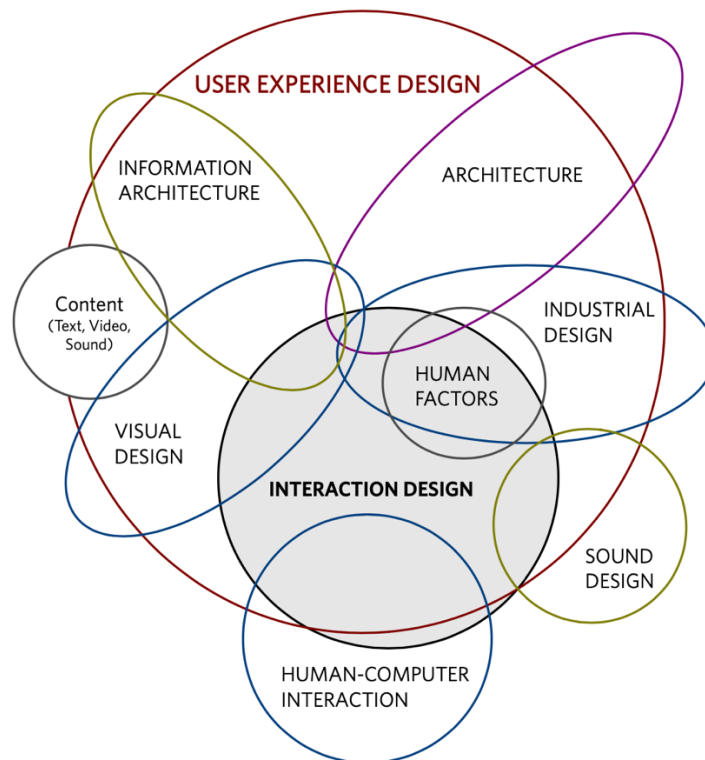
Figure 7 - Disciplines surrounding Interaction Design (Saffer, 2010)

HCI and Interaction Design are two areas closely related, but HCI is a discipline focused on the design and usability of computer systems (Henry, 1998; Saffer, 2010), while Interaction Design is a broader discipline, focus on the theory, research and practice of designing interactive products and UX's, supporting the way people communicate and interact daily (Sharp et al., 2019, pp. 9–10). Interaction Design can be applied to websites, products, systems, software and even robots.

VII.2. Usability

Initially called "user-friendly", Usability is a quality of the UIs defined as if the system is good enough to respond to the users' needs and requirements (Nielsen, 1993, pp. 23–24, 2012a). A usable product must provide easy and pleasant navigation.

Usability has five components to measure its quality (Nielsen, 1993, pp. 25–26, 2012a): (1) easy to learn/learnability; (2) efficient to use/efficiency; (3) easy to remember/memorability; (4) few errors/errors; and (5) subjectively pleasing/satisfaction. Assuring a product/system has good usability implies involving a representative number of users in usability testing.

A system with bad usability (e.g. hard to use, unclear, disorganised) will most certainly make the user leave it (Nielsen, 2012a). Therefore, it is imperative to systematically evaluate and improve a system according to users' needs, requirements, and feedback.

Furthermore, Nielsen gathered a set of Usability Heuristics as ten principles for Interaction Design (Nielsen, 2020): (1) Visibility of system status; (2) Match between system and the real world; (3) User control and freedom; (4) Consistency and standards; (5) Error prevention; (6) Recognition rather than recall; (7) Flexibility and efficiency of use; (8) Aesthetic and minimalist design; (9) Help users recognize, diagnose, and recover from errors; and (10) Help and documentation.

A system's usability can be measured through, for example, Usability Tests. During a Usability Test, participants are asked to fulfil a set of pre-defined tasks (Appendix 5), and the facilitator observes the user's behaviours and registers the given feedback (Moran, 2019). According to the author (2019), usability testing allows to identify problems, discover ways to improve, understand user's behaviour and preferences.

The facilitator administers the tasks (Figure 8) without influencing the user's behaviours and assures high-quality and valid data is gathered (Moran, 2019). The tasks must be realistic activities carefully designed to avoid misinforming the user on the tasks he must fulfil (Moran, 2019).

Figure 8 – Flow of information during a moderated Usability Test (Moran, 2019)

During the evaluation session, the facilitator may ask the user to express his thoughts out loud using the thinking aloud method (Nielsen, 2012b) to understand the participant's behaviour, goals, thoughts, motivations and overall context (Moran, 2019).

Usability testing can either be qualitative or quantitative (Budiu, 2017). In this research stage, both methods would be mixed: qualitative data would allow contextualising tasks' fulfilment according to the participants' behaviour; while quantitative data would enable to measure the time each participant took to execute the task and if the task was fulfilled or not.

Regarding the number of users to be reached, even though main usability problems are likely to be identified with at least five subjects (Nielsen, 2000; Virzi, 1992), since this evaluation would not only be a simple Usability Test but also would integrate a quantitative data collection, the number of recommended subjects rises: for a simple quantitative study, Nielsen (2012c) recommends at least 20 users, while for questionnaires – with task analysis or as follow-up studies – he (Nielsen, 1993, p. 224) recommends at least 30.

VII.3. User eXperience Design

UXD encompasses the entire experience a user has with any product, system or service, from the moment he buys it at a store until he actually interacts with the system/product/service

(Norman, 2016). The first requirement of UX is to meet user's needs, however, it is not the only one since UX is a merge of multiple disciplines, such as engineering, marketing, graphical and industrial design, and interface design (Norman & Nielsen, n.d.).

Users feelings towards a product, the pleasure and satisfaction when using it, and their overall impression comprises the UX (Sharp et al., 2019). Although the UI holds an important part of the UX, the experience itself and the feelings involved in it are also essential.

According to Sharp et al. (2019), UXD (in comparison to UX, with the addition of a D) encourages the quality of the experience, namely the design thinking.

VIII.   Customisation versus Personalisation

Customisation – mentioned early in this document (in *Presentation Tools* section) – is an important term to define the sense of control given to the user regarding the design of presentations.

In theoretical terms, customisation and personalisation are different. The growing need for the user to be able to produce their own contents autonomously simultaneously increased the number of tailored contents on websites (Sundar & Marathe, 2010). Consequently, it was imperative to clarify these two terms: customisation and personalisation.

According to Nielsen (2009), the main difference is in the user's role: in customisation, the user determines what he/she sees on the computer (e.g. choosing a specific car model); while in personalisation, the user's role is passive since it is the computer that modifies the contents according to the user's behaviour and preferences.

VIII.1. Customisation

Customisation, early defined by Nielsen (1998), requires direct user control by providing the "possibility of modifying certain aspects of an online system to increase individual relevance based on their needs" (Zhang & Sundar, 2019, p. 88).

When it comes to customisation, the interface is adapted to the user's preferences (Nielsen, 2009), and the transparency in the sense of control stimulates positive perceptions over the system (Chen & Sundar, 2018, p. 2), enhancing users' experience.

VIII.2. Personalisation

According to Nielsen (1998), "personalization is driven by the computer" and happens when he tries to individualise any page or website to correspond to the user's needs and preferences.

Likewise, Blom (2000, p. 313) defines this term as a process that "changes the functionality, interface, information content, or distinctiveness of a system" in order to increase the relevance of the system for a particular user. The author also states that almost everything a user does when using a computer could be considered personalisation (e.g. entering data).

CHAPTER II

RELATED WORK

Topics

Design Tools
Presentation Tools

Beyond a literature review, it is essential to examine the applications available in the market to understand what exists, the transversal characteristics, and how and where there is innovation potential. Therefore, this chapter focuses on the analysis of design and presentation tools/applications/platforms.

These platforms, applications, tools, and software were found through the snowball literature review and a web-search, using the keywords "tools" or/and "platforms", "online", "graphic" and "design" between December 2020 and January 2021.

Each section comprises a brief description of the tool, mentioning the target audience, its strengths and weaknesses, and highlighting relevant technical, conceptual, and graphical features.

I.   Design Tools

I.1.   Canva

Canva[23] (Figure 9) allows users without previous design experience/knowledge to create professional customised designs from supplied templates of presentations, videos, social media posts, reports, posters, flyers, and other similar contents. This platform is suitable for users of all ages who aim to design digital or physical artifacts without design knowledge and specific digital skills.

---

[23] https://www.canva.com/, last accessed on June 10, 2021
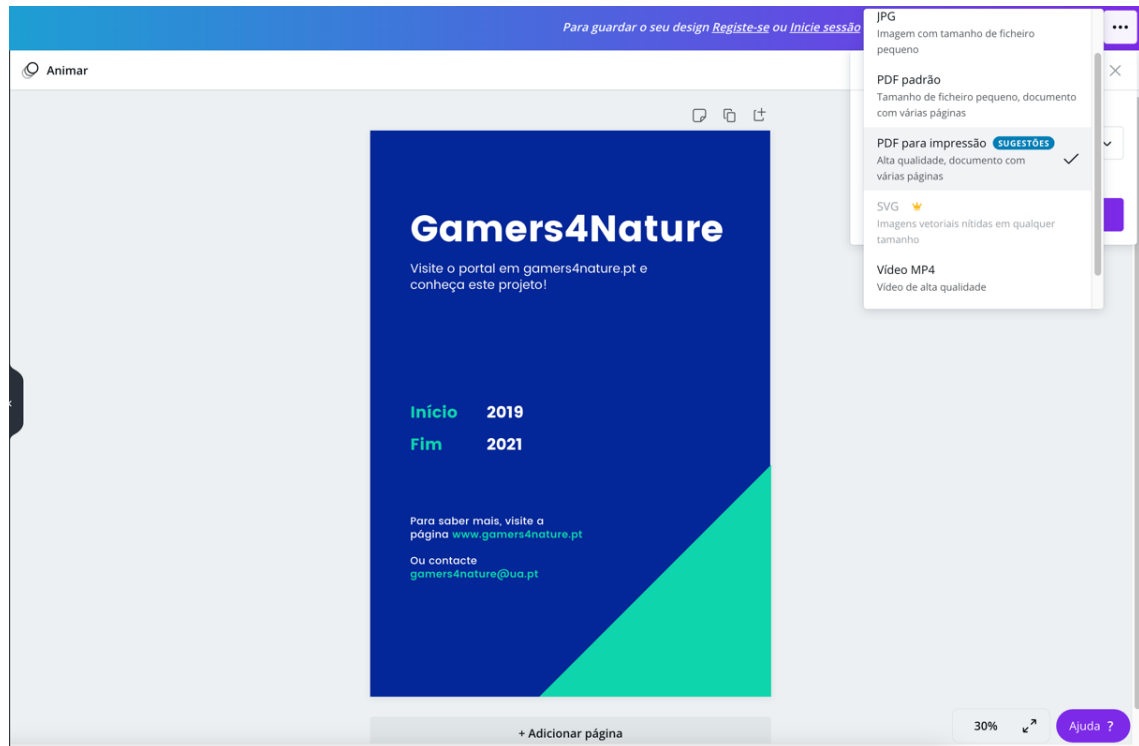
Figure 9 - Canva platform's screen

As for **strengths** stand out the presence of an onboarding, a wide variety of templates to create digital and physical artifacts, an intuitive interface with a wide range of functionalities, the possibility to export in multiple formats (PDF; JPG; SVG; MP4; GIF), including settings to print the designs with trim marks and bleeds, an option to save the design in multiple formats (e.g. Website, PowerPoint, Embedded), smart guides according to the chosen template, and the available tools change according to the selected design element. Moreover, most of the features are available in the free version, a library with icons, images, geometric forms are available, icons, fonts, images, and all design elements are related with keywords to ease their search, and finally, it is possible to import images from outside the platform and to zoom the canvas.

However, there are too many functionalities that can become overwhelming, and also the change of available tools according to the selected design element can be confusing at first.

At a **technical** level, it is highlighted the availability of templates, the integration of features from professional design tools (e.g. smart guides, print marks, export formats, ...), and a canvas to design.

At a **conceptual** level, the platform's suitability for users without previous design knowledge (i.e. previous experience with design guidelines or professional tools), and the possibility to create and export for both physical and digital formats.

An intuitive and sober design, a minimal colour palette, the positioning of template options on the left side and graphic tools on the top, and also the combination of sidebar icons with text are important details to highlight at a **graphical** level.

I.2.   Gravit Designer

Gravit Designer[24] (Figure 10) is an online platform that allows users without previous design experience/knowledge to create professional customised designs from scratch or supplied templates of presentations, videos, social media posts, posters, and other similar contents. The platform is designed for users of all ages who aim to design digital or physical artefacts but requires some level of digital skills.
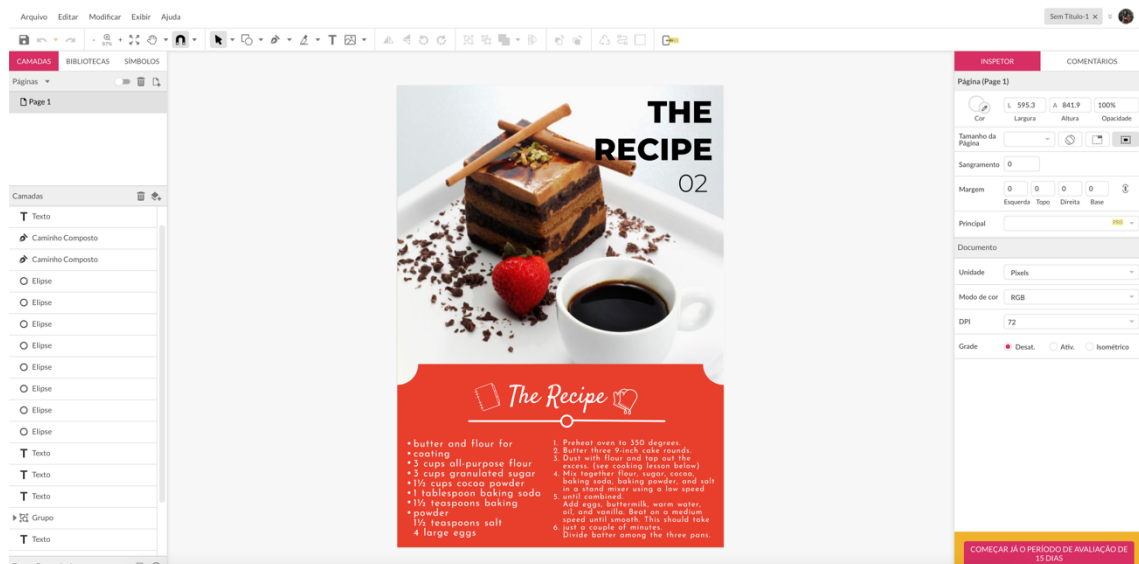
Figure 10 – Gravit Designer platform's screen

As for **strengths**, this platform provides a User Guide and Support Documentation and a wide variety of templates to create digital and physical artifacts, offers an intuitive interface to start the design, multiple export formats (PNG; JPG; SVG; PDF), smart guides, available tools change according to the selected design element, option to design from scratch or based on templates, a library with icons, images, geometric forms, a zoomable canvas, and the possibility to import images from outside the platform.

---

[24] https://designer.gravit.io/, last accessed on June 10, 2021

As for **weaknesses**, the platform presents a complex interface with too many features, making the interaction overwhelming. Furthermore, some useful features are only available on the paid version and the design can only be saved in the platform's format.

At a **technical** level, it is highlighted the availability of templates, the integration of features from professional design tools (e.g. smart guides, X and Y positioning, export formats, layers, colour mode), and a canvas to design.

At a **conceptual** level, the platform's suitability for users without previous design knowledge (i.e. previous experience with design guidelines or professional tools), and the possibility to create and export for both physical and digital formats.

Gravit Designer presents, at a **graphical** level, intuitive icons, a minimal colour palette, layers on the left side, graphic tools on the top, and properties on the right side of the screen.

I.3.   Crello

Crello[25] (Figure 11), similarly to Canva, allows users without previous design experience/knowledge to create professional customised designs from supplied templates of presentations, videos, social media posts, reports, posters, flyers, and other similar contents. This platform is suitable for users of all ages who aim to design digital or physical artifacts without design knowledge, and specific digital skills.
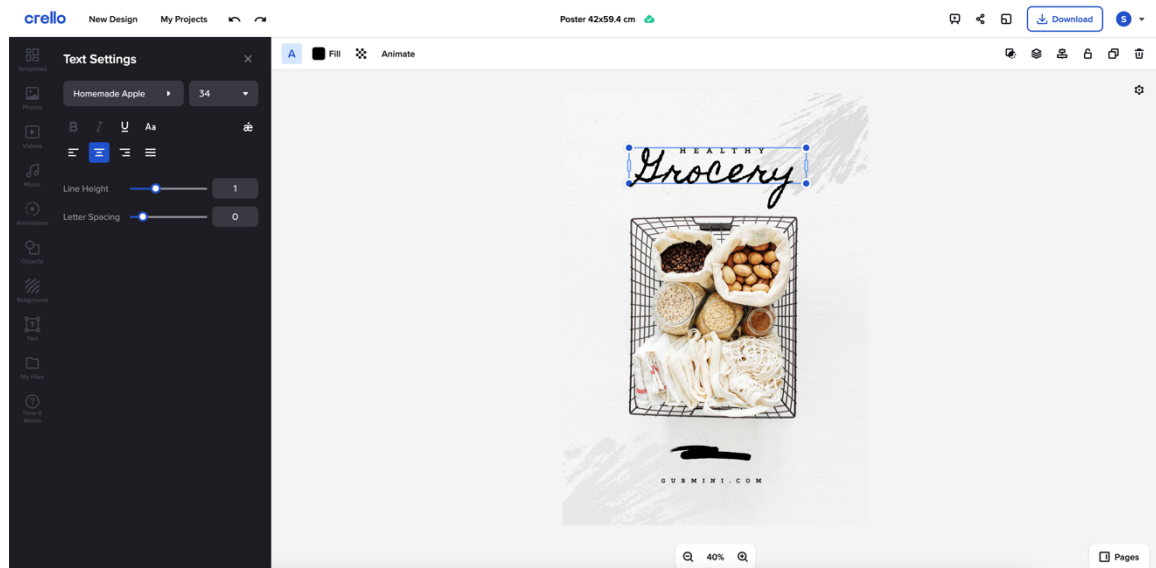
Figure 11 – Crello platform's screen

As for **strengths**, this platform provides an onboarding and tutorial to perform specific tasks, a wide variety of templates to create digital and physical artifacts, an intuitive interface with a wide range of functionalities, and allows the export of multiple formats (PDF; JPG; PNG – with or without transparency – MP4; GIF), including settings to print the designs with crop marks and bleeds. The available tools change according to the selected design element, most of the features are available in the free version, there is a library with icons, images, geometric forms and a zoomable canvas, and it is possible to import images from outside the platform.

As for **weaknesses**, there are too many functionalities that can become overwhelming, the change of available tools according to the selected design element can be confusing at first, the design can only be saved in the platform's format, and it is hard to grab a specific design element.

At a **technical** level, it is highlighted the availability of templates, the integration of features from professional design tools (e.g. print marks, export formats, ...), and a canvas to design.

At a **conceptual** level, the platform's suitability for users without previous design knowledge (i.e. previous experience with design guidelines or professional tools), and the possibility to create and export for both physical and digital formats.

At a **graphical** level, the platform is designed with intuitive icons, a minimal colour palette, with template options on the left side, and graphic tools on the top.

I.4.   Stencil

Stencil[26] (Figure 12), similarly to Canva, allows users without previous design experience/knowledge to create professional customised designs from scratch or supplied templates of presentations, videos, social media posts, reports, posters, flyers, and other similar contents. The platform is suitable for users of all ages who aim to design digital or physical artifacts without design knowledge and specific digital skills.

---

[26] https://getstencil.com/, last accessed on June 10, 2021
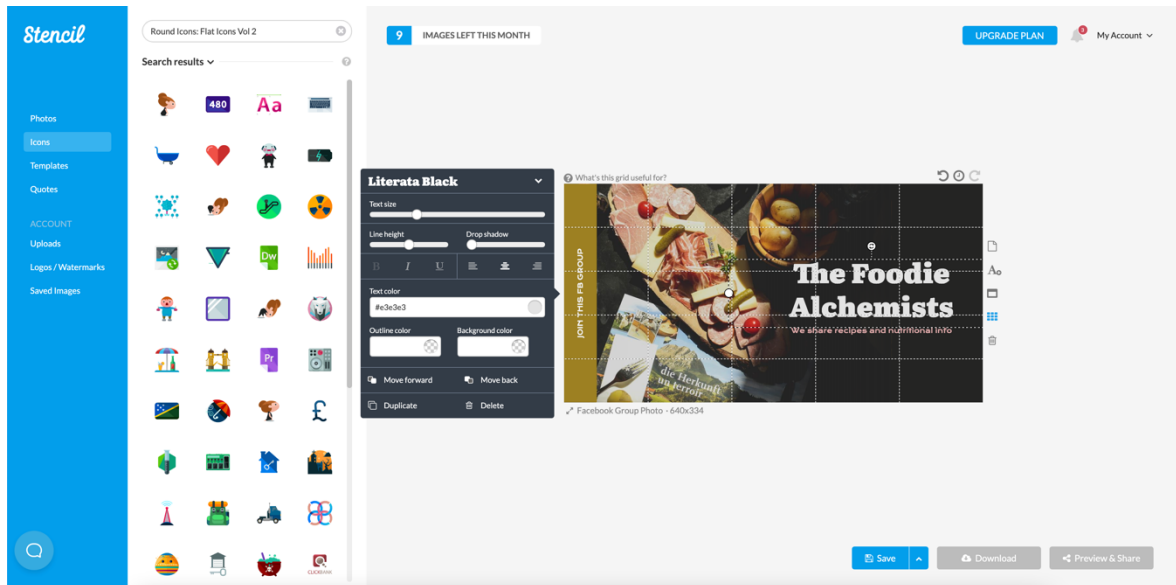
Figure 12 – Stencil platform's screen

As for **strengths**, this platform provides an onboarding with subtle spots in the interface – when clicked, a floating dialogue box opens – and templates to create digital and physical artifacts. Moreover, it has an intuitive interface with a wide range of functionalities and allows to export the design in multiple formats (PDF; JPG; PNG) and choose Dimensions, Media Type and Compression. The floating window of tools changes according to the selected design element, there is also a library with icons, images, geometric forms and others, organised by sets. Stencil has a Focus Mode – only canvas and main tools are visible –, a grid, a zoomable canvas and allows to import images from outside the platform.

As for **weaknesses**, there are too many functionalities that can become overwhelming, the change of available tools according to the selected design element can be confusing at first, the design can only be saved in the platform's format, and it is hard to grab a specific design element. Finally, some useful features are only available on the paid version.

At a **technical** level, it is highlighted the availability of templates, the integration of features from professional design tools (e.g. print marks, export formats) and a canvas to design, and it is possible to toggle to Focus Mode.

At a **conceptual** level, the platform's suitability for users without previous design knowledge (i.e. previous experience with design guidelines or professional tools), and the possibility to create and export for both physical and digital formats.

At a **graphical** level, the platform has a minimal colour palette with template options on the left side, and graphic tools on the top.

I.5.   Piktochart

Piktochart[27] (Figure 13), similarly to Canva, allows users without previous design experience/knowledge to create professional customised designs from scratch or supplied templates of presentations, reports, infographics, flyers, social media graphics, and posters.
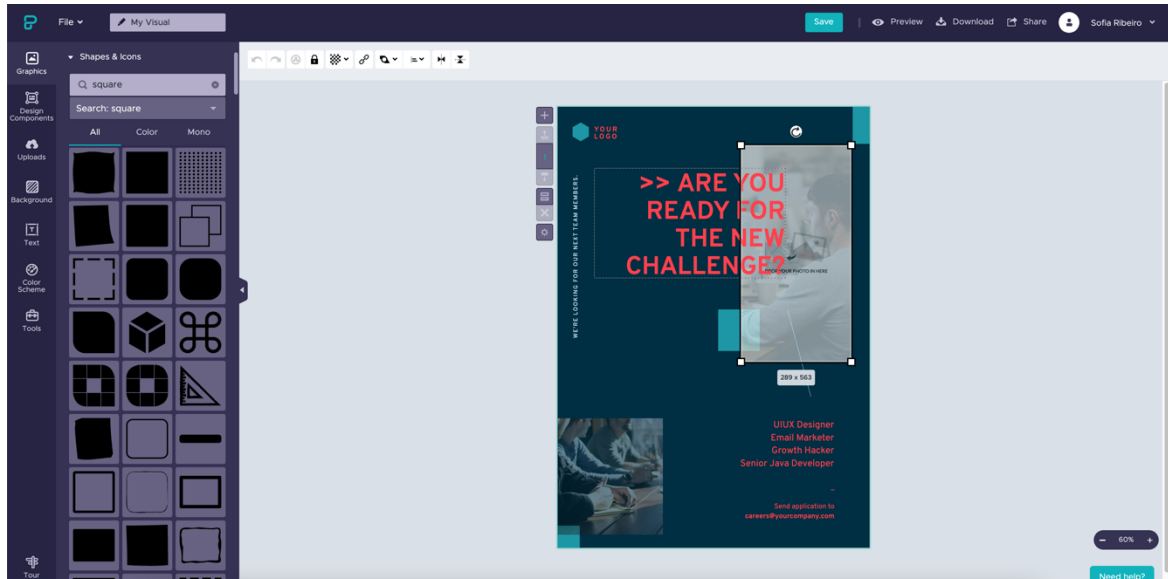
Figure 13 – Piktochart platform's screen

As for **strengths**, the "Need Help" menu with FAQs is always accessible, there is a wide variety of templates to create digital and physical artifacts, it has an intuitive interface with a wide range of functionalities, allows to export in multiple formats (PNG; PDF; PowerPoint) with three different qualities – normal, medium, high – and the option to export as a single page or in blocks and to save the design in multiple formats (e.g. Website, PowerPoint, Embedded, etc). Provides smart guides, the available tools change according to the selected design element, a library with icons, images, geometric forms, and design components – timelines, lists and comparisons –, and icons, fonts, images and all design elements are related with keywords to ease their search. The platform has a preview mode, it is possible to crop images inside the platform and to import images from outside the platform, and it has a zoomable canvas.

As **weaknesses**, there are too many functionalities that can become overwhelming and there are limited features in the free version.

At a **technical** level, it is highlighted the availability of templates, the integration of features from professional design tools (e.g. print marks, export formats, ...), and a canvas to design.

---

[27] https://piktochart.com/, last accessed on June 10, 2021

At a **conceptual** level, the platform's suitability for users without previous design knowledge (i.e. previous experience with design guidelines or professional tools), and the possibility to create and export for both physical and digital formats.

An intuitive and sober design, a minimal colour palette, the positioning of template options on the left side and graphic tools on the top, and the combination of sidebar icons with text are important details to highlight at a **graphical** level.

I.6. Lucidpress

Lucidpress[28] (Figure 14) helps companies bring their brand to life without previous design experience/knowledge. This software allows creating professional customised designs from brand assets. The software is suitable for companies or individuals who aim to design extend their brand into other design formats without design knowledge.
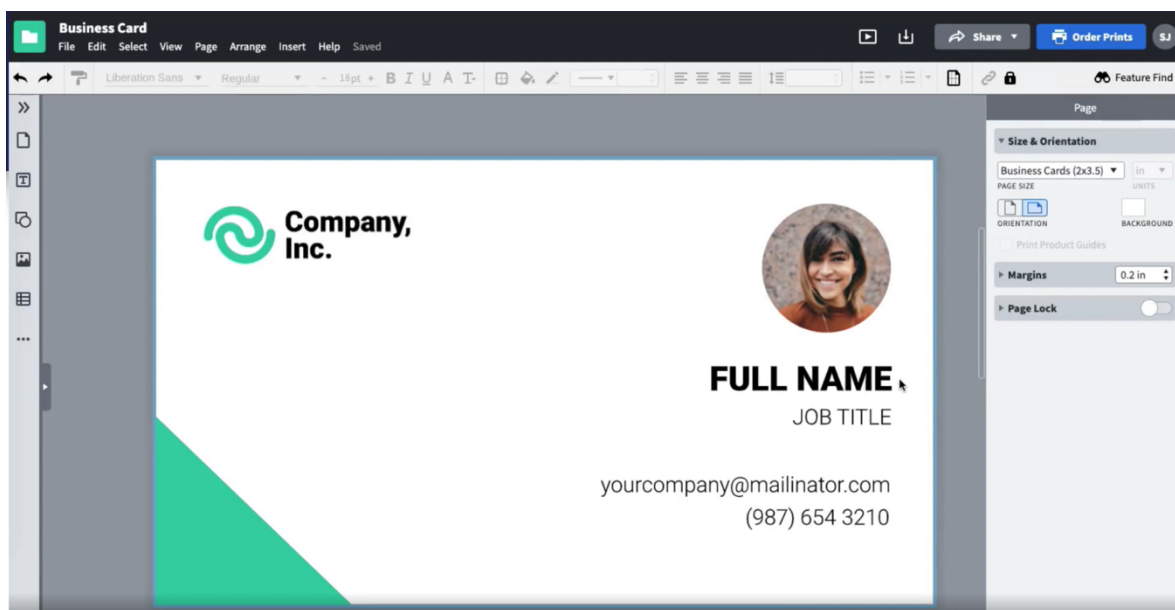
Figure 14 – Lucidpress software's screen

As for **strengths**, it is possible to import documents from Adobe InDesign and to relate fields with their content (e.g. a text box to fill in with the first name), the user can lock the design elements – size and position, style (e.g. font family, font face, …) and content –, can create templates for flyers, business cards or emails from their brand assets, filter by template type (i.e. print content, digital content), and preview full-bleed while designing.

---

[28] https://www.lucidpress.com/pages/, last accessed on June 10, 2021

As for **weaknesses**, the interface is complex, and the software is paid.

At a **technical** level, it is possible to import the brand image, the integration of features from professional design tools (e.g. marks and bleeds, font settings, etc), and canvas to design.

At a **conceptual** level, the software allows the creation of templates according to a specific brand and the creation and export for both physical and digital formats.

At a **graphical** level, the platform has a minimal colour palette with properties on the right side of the screen.

I.7.   Visme

Visme[29] (Figure 15) is a cloud-based content creation and collaboration platform to create customised professional content (e.g. presentations, infographics, printables, reports) without requiring previous design knowledge or experience. The platform is suitable for companies or individuals who aim to design extend their brand into other design formats without design knowledge.
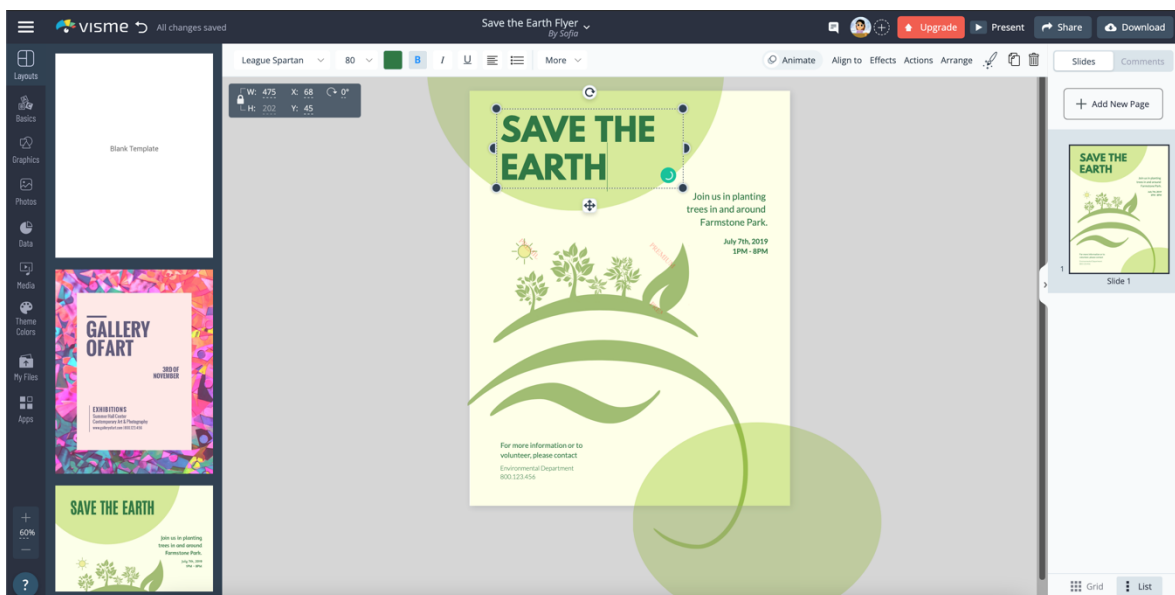
Figure 15 – Visme platform's screen

As for **strengths**, this platform has an onboarding, provides a wide choice from the templates available – full templates, headers and text, stats and figures, graphics and diagrams –, it is possible to create and save customised content blocks, it has smart guides, design tools that

---

change according to selected design element and multiple export formats (JPG or PNG with high resolution; PDF with or without bleed marks; video – MP4 or GIF; PowerPoint; HTML 5). Offers a library of icons, images, illustrations and similar, the possibility to import images from outside the platform, several templates or customised colour palettes, it has a zoomable canvas and makes possible to collaborate with teammates.

As **weaknesses**, there is limited content available in the free version and too many functionalities.

At a **technical** level, it is possible to customise content with brand colours, the integration of features from professional design tools (e.g. export formats, marks and bleeds, font settings, etc), and a canvas to design.

At a **conceptual** level, the platform allows the creation and export of both physical and digital artifacts and is suitable for users with any skill level.

An intuitive and sober design, a minimal colour palette, the positioning of template options on the left side and graphic tools on the top, and the combination of sidebar icons with text are important details to highlight at a **graphical** level.

I.8. DesignBold

DesignBold[30] (Figure 16) is a platform to create customised professional and sophisticated designs (e.g. cards, flyers, magazines, logotypes, etc) without requiring previous design/technical expertise or experience. The platform is suitable for users of all ages who aim to design digital or physical artifacts without design knowledge and specific digital skills.

---

[30] https://www.designbold.com/, last accessed on June 10, 2021
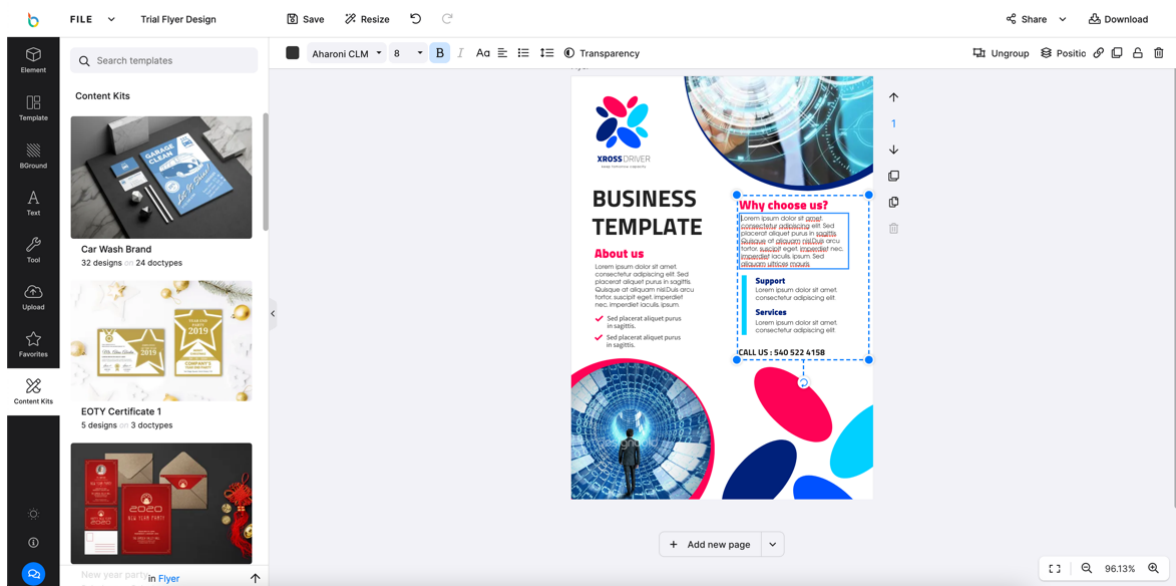
Figure 16 – DesignBold platform's screen

As for **strengths**, DesignBold has drag-and-drop templates, a wide choice from the templates available – full templates, grids, headers, and text –, the possibility to add favourite content blocks, and provides smart guides. The design tools change according to the selected design element, there is multiple export formats available (JPG; PNG with or without transparency; PDF – digital or print) and a library of charts, maps, icons, images, shapes and similar, allows to import images from outside the platform, has customisable colour palettes and default patterns, a zoomable canvas, light and dark mode, the guide is always accessible and is possible to resize the canvas at any time.

As for **weaknesses**, the icons and descriptions are unclear, there is no onboarding and there are limited free features.

At a **technical** level, it is important the integration of features from professional design tools (e.g. export formats, settings, etc), and a canvas to design.

At a **conceptual** level, the platform allows the creation and export of both physical and digital artifacts and is suitable for users with any skill level.

An intuitive and sober design, a minimal colour palette, dark and light mode, the positioning of template options on the left side and graphic tools on the top, and the combination of sidebar icons with text are important details to highlight at a **graphical** level.

I.9. Prezi Design

Prezi Design[31] (Figure 17) is an online tool to create interactive charts, reports, maps, and infographics. The tool is suitable for users of all ages who aim to create visually appealing presentations and designs.

Figure 17 – Prezi Design platform's screen

As for **strengths**, there is the availability of templates – design layouts, layout text templates, icon blocks, diagrams –, basic smart guides, multiple export formats (PNG; JPG; PDF – Print or Vector; MP4) with several levels of quality – 1x (actual size project), 2x, 3x, 4x and Custom –, a library of maps, icons (from Noun Project), images (from Unsplash), stickers and GIF's (from Giphy), video covers (from Storyblocks), basic shapes and countries' flags. The colours are customisable, the canvas is zoomable, there is a Help button, and it is possible to import media (e.g. Prezi Video, youtube, etc) and data (.xls or .csv files, MySQL, etc).

As for **weaknesses**, there are limited functionalities in the free version and too many functionalities, and the smart guides lack contrast with design elements.

At a **technical** level, the integration of features from professional design tools (e.g. export formats, font settings, etc) and canvas to design is highlighted.

At a **conceptual** level, the platform is suitable for users with any skill level, and, at a **graphical** level, the graphic tools are placed on the left.

---

[31] https://prezi.com/design/?element_text=prezi_design, last accessed on June 10, 2021

I.10. Noissue.

Noissue.[32] (Figure 18) is an online tool to create a sustainable paper with brand-customised designs. This tool is designed to users of all ages who aim to create customised sustainable paper.
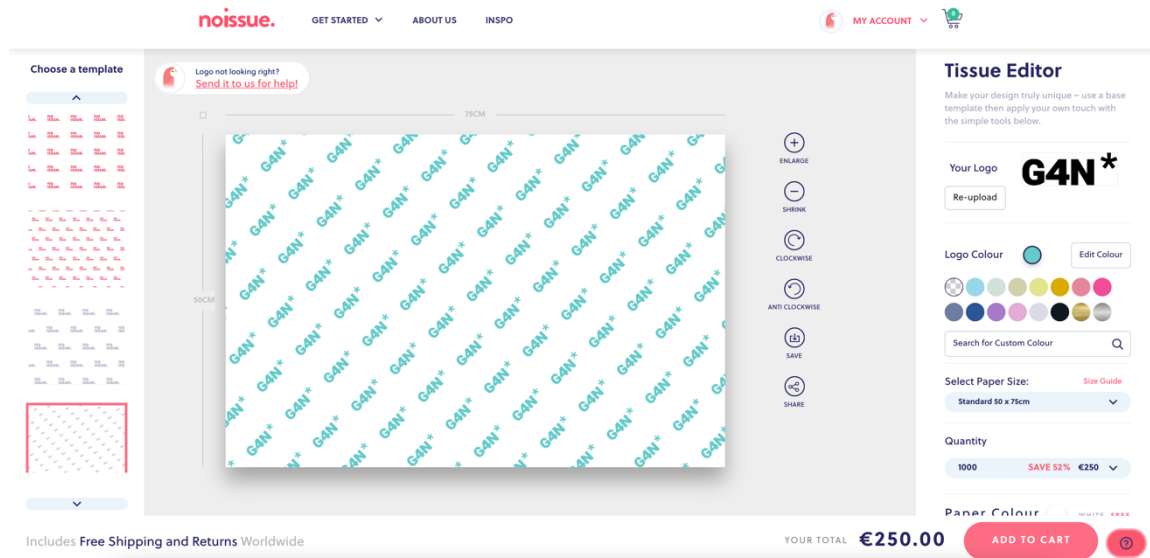
Figure 18 - noissue. platform's screen

As for **strengths**, stand out the presence of a wide variety of layouts templates, flexible templates according to uploaded logotype, the correspondence of hexadecimal colour code to Pantone, several options (enlarge, shrink, clockwise and anti-clockwise), the work can be shared via URL, Facebook, Twitter, Email or Pinterest. Moreover, it is possible to select the paper size and quantity of printable elements, and there is a Help button with FAQs and an input submission.

As for **weaknesses**, it is only possible to save online and, so, there are no export features.

At a **technical** level, the user can search Pantone colours from Hexadecimal colour code and use templates with the uploaded brand.

At a **conceptual** level, the tool is suitable for users with any skill level.

An intuitive and sober design, a minimal colour palette, the positioning of templates options on the left side and editor tools on the top and most frequently used options are fixed next to the canvas are important details to highlight at a **graphical** level.

---

[32] https://www.noissue.co/, last accessed on June 10, 2021

II. Presentation Tools

II.1.   Microsoft PowerPoint

Microsoft PowerPoint[33] (Figure 19) is a tool to create visually appealing presentations by integrating multimedia contents, such as a 3D object, images, videos, or audio. The software is suitable for users of all ages who aim to create visual presentations.
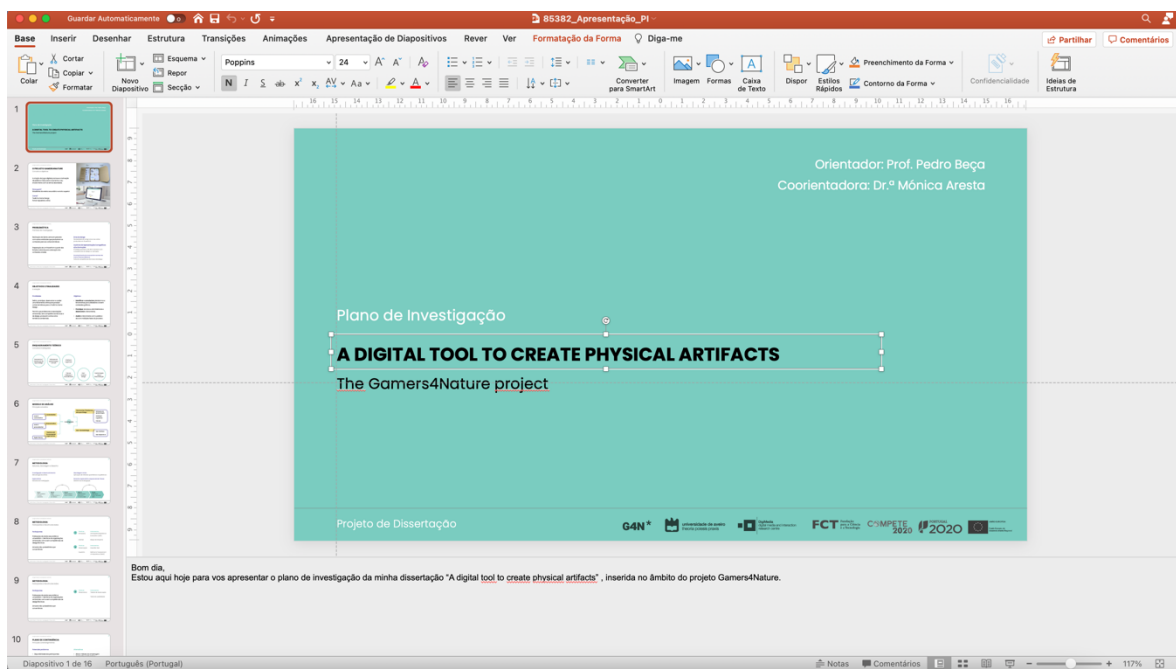
Figure 19 – PowerPoint software's screen

As for **strengths** stand out the presence of a wide variety of templates and the availability of animations between slides or elements. PowerPoint has a feature called Design Ideas that brainstorms design ideas from smartly identifying brand colours or objects, or even from titles. Moreover, provides basic smart guides, multiple tabs with different tools and multiple export formats (PDF; MP4; MOV; JPEG; TIFF; PNG; Animated GIF; BMP; RTF Format; PowerPoint Supplements – .ppam and .ppa), as well as a library of forms, icons, 3D models, SmartArt and charts, import images from outside the platform, customisable colour palettes and default patterns, a zoomable canvas, collaboration with teammates, and integrated features to edit images – remove backgrounds, cut, colour corrections, change transparency.

---

[33] https://www.microsoft.com/en-gb/microsoft-365/powerpoint, last accessed on June 10, 2021

However, it is a paid software with too many functionalities that can become overwhelming.

At a **technical** level, it is highlighted the integration of features from professional design tools (e.g. smart guides, print marks, export formats), and a canvas to design.

At a **conceptual** level, the platform is suitable for users with any skill level.

An intuitive design, a minimal colour palette, the positioning of all edition tools on the top, and the combination of sidebar icons with text are important details to highlight at a **graphical** level.

II.2. Prezi Present

Prezi Present[34] (Figure 20) is an online tool to create dynamic and zoomable presentations, as well as videos with the designed presentations (Prezi Video). The platform is suitable for users of all ages who aim to create visually appealing presentations.
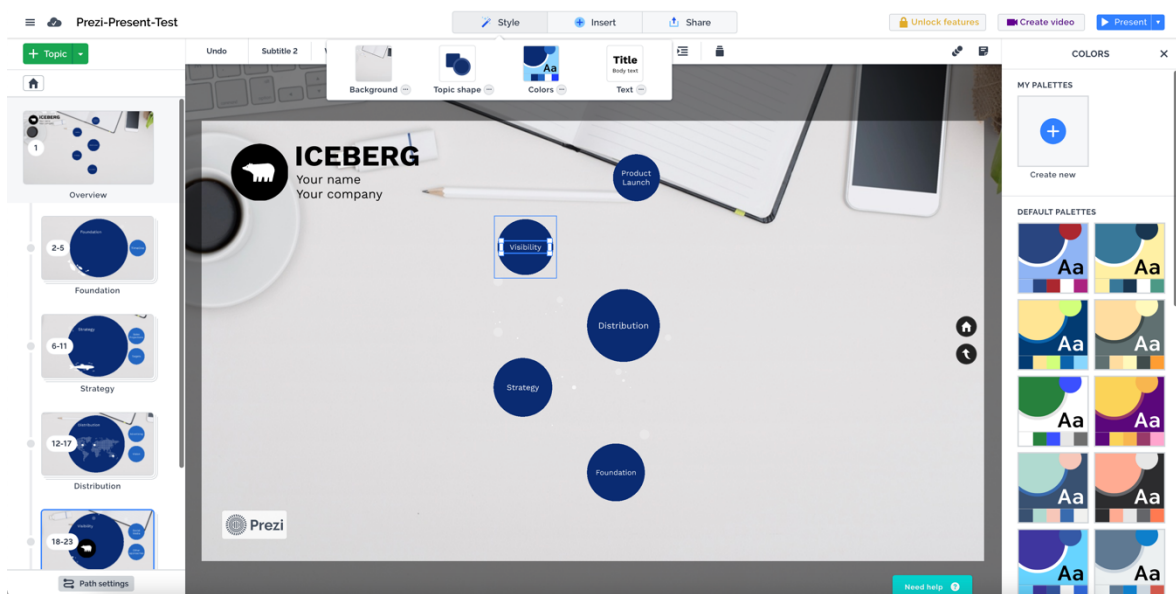
Figure 20 – Prezi Present platform's screen

As for **strengths**, there is an introduction to Prezi, animations between blocks, availability of templates – design layouts, story blocks –, smart guides connecting different slides of the presentation, available tools change according to the selected design element, upload information from a PowerPoint presentation, library of images, icons, animations and shapes,

---

[34] https://prezi.com/product/?element_text=prezi_present, last accessed on June 10, 2021

default and customisable colour palettes, a Help button, and makes possible to collaborate with teammates.

As for **weaknesses**, there are limited functionalities in the free version – PDF export and conversion to PowerPoint only in the premium version –, and some functionalities aren't intuitive to find.

At a **technical** level, it is highlighted the integration of features from professional design tools (e.g. export formats, font settings, etc), and at a **conceptual** level is suitable for users with any skill level.

At a **graphical** level, the user chooses the template before it starts.

II.3.   Google Slides

Google Slides[35] (Figure 21) is a tool to create dynamic and visually appealing presentations. The tool is suitable for users of all ages who aim to create visual presentations.
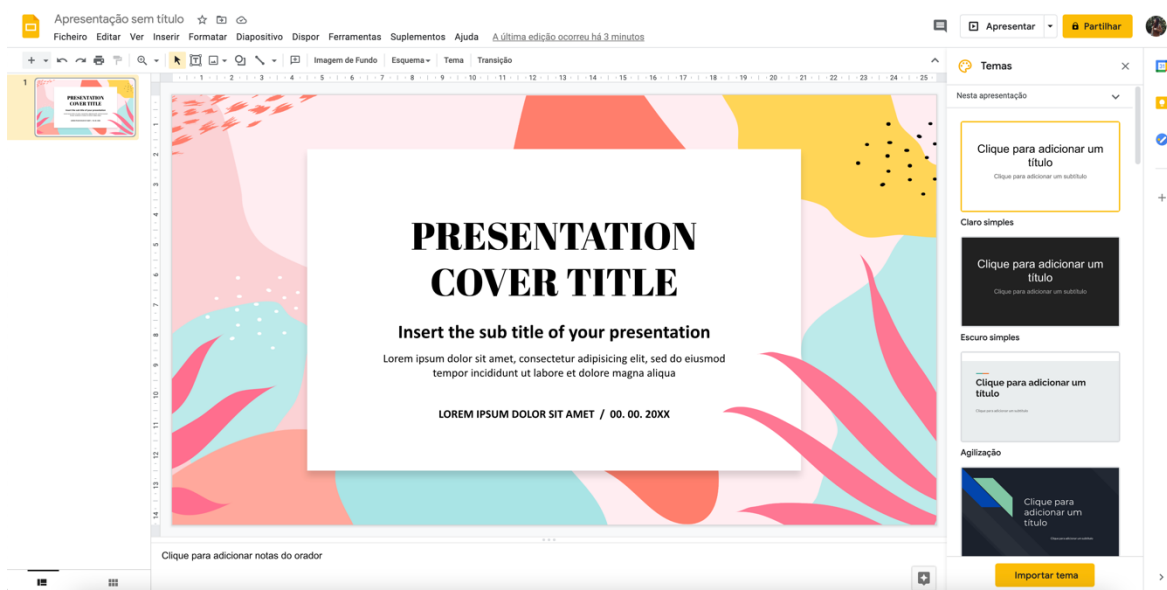
Figure 21 – Google Slides platform's screen

As for **strengths**, there is a wide range of templates available, animations between slides or elements, smart guides, multiple tabs with different tools and multiple export formats (Microsoft PowerPoint, Document ODP or PDF; Simple text; JPG or PNG; Vectorial format - SVG), a library of shapes, charts, diagrams, and images, it is possible to import images from outside the

---

[35] https://www.google.com/intl/en/slides/about/, last accessed on June 10, 2021

platform (Google) and to customise colours. The canvas is zoomable, the tool has an integrated set of features to edit images (remove backgrounds, cut, colour adjustments, change transparency), makes possible to collaborate with teammates, and it is a free platform.

However, in comparison Microsoft PowerPoint, it does not have as many features.

At a **technical** level, it is highlighted the integration of features from professional design tools (e.g. export formats, font settings, etc), and a canvas to design, and at a **conceptual** level, the platform is suitable for users with any skill level.

An intuitive design, the positioning of all edition tools on the top and specific adjustments appear on the left are important details to highlight at a **graphical** level.

II.4.   Keynote

Keynote[36] (Figure 22) is a tool to create dynamic and visually appealing presentations. The tool is suitable for users of all ages who aim to create visual presentations.
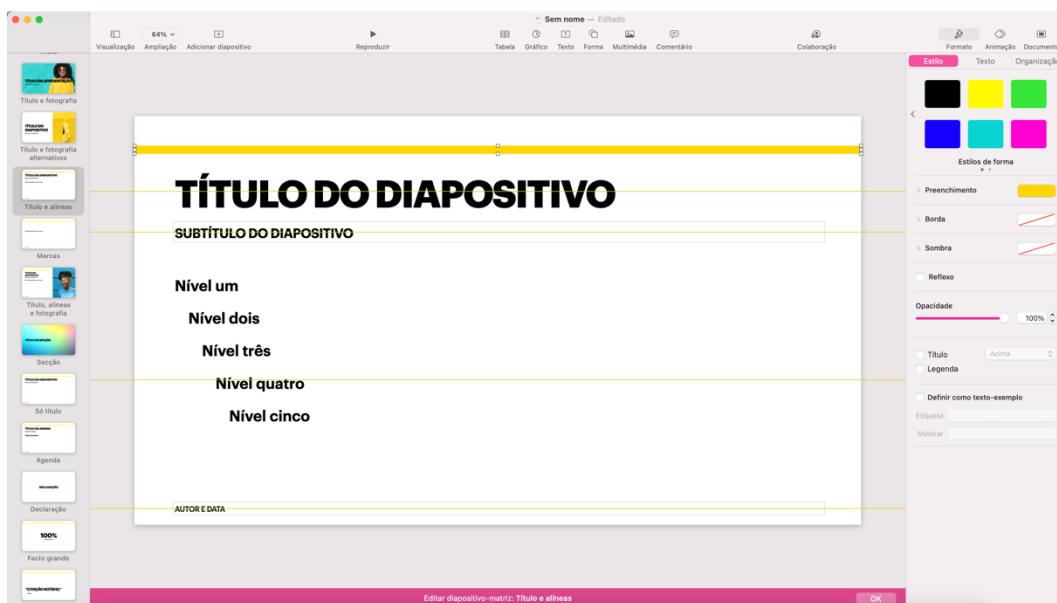
Figure 22 – Keynote software's screen

As for **strengths**, there is a wide range of templates available – design layouts, user can choose what appears in the template (title, body, and slide number) –, animations between slides or elements, smart guides, multiple tabs with different tools and multiple export formats (Microsoft PowerPoint compatibility, PDF, video and image, animated GIF, HTML, and previous

---

[36] https://www.apple.com/keynote/, last accessed on June 10, 2021

versions of Keynote), library of shapes, galleries, math equations, and charts, it is possible to take a photo or scan a document directly into the document and to import images or videos from outside the platform. Furthermore, it can turn handwriting into text, has a zoomable canvas, an integrated feature to edit images – remove backgrounds, cut, colour adjustments, change transparency –, makes possible to collaborate with teammates and is a free software.

As for **weaknesses**, the process is complex when editing the template matrix and there is a low variety of colours.

At a **technical** level, it is highlighted the integration of features from professional design tools (e.g. export formats, font settings, etc), and a canvas to design, and at a conceptual level, the platform is suitable for users with any skill level.

At a **graphical** level, the tool has an intuitive design, with all edition tools placed on the top, and specific adjustments on the left.

II.5. Apache OpenOffice Impress

Apache OpenOffice Impress[37] (Figure 23) is an open-source software to create multimedia presentations. The software is suitable for users of all ages who aim to create multimedia presentations.
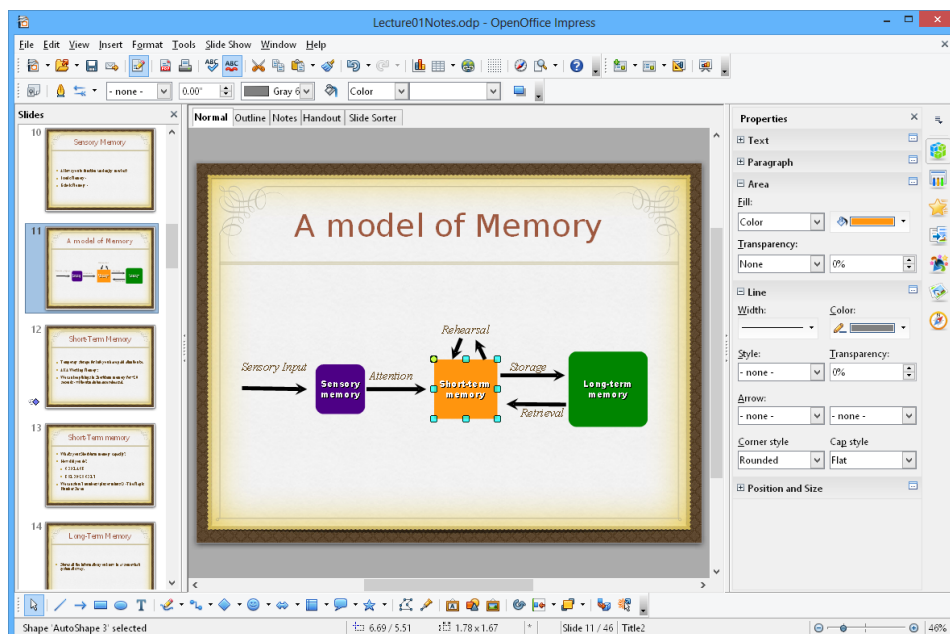
Figure 23 – Apache OpenOffice Impress software's screen

---

[37] https://www.openoffice.org/pt/product/impress.html, last accessed on June 10, 2021

As for **strengths**, there is a wide range of templates available, animations between slides or elements, smart guides, multiple tabs with different tools, Microsoft PowerPoint compatibility, a library of shapes, galleries, 3D objects, and charts, and it is possible to import images or videos from outside the platform. The software as a zoomable canvas, an integrated feature to edit images (remove backgrounds, cut, colour adjustments, change transparency), and it is a free software. **However**, the software is old and a bit complex interface.

At a **technical** level, it is highlighted the integration of features from professional design tools (e.g. export formats, font settings, etc), and a canvas to design, and at a conceptual level, the platform is suitable for users with any skill level.

At a **graphical** level, all edition tools placed on the top.

CHAPTER III

METHODOLOGY

Topics

Analysis Model
The Research Method
Methodology framework

Analysis Model

In order to interpret and understand the research's problem, but also to guide the data collection and analysis, the Analysis Model helps to define the scope of the research analysis (Quivy & Campenhoudt, 1995, pp. 108–109). According to the authors, conceptualisation precludes research from becoming vague, imprecise, and arbitrary. Concepts are unfolded into dimensions and afterwards into indicators, which are measurable and observable traces that, later on, can be compared with collected results.

Table 2 presents the concepts, dimensions, and indicators of this research.

Table 2 – Analysis model

Concepts	Dimensions	Indicators
Layout Design Tools (Britannica, 2019; Jahanian et al., 2013; Levy, 2018; O'Donovan et al., 2015; Swider et al., 2018)	Presentation software	Availability of templates
		Design tips
		Export format
		Required skills (e.g. design, technical, etc)
	Suggestive interfaces	Amount of suggestions
		Suggestions' layout
		Structure of the suggestions
		Method of selection – preview and click
	Canvas	Workspaces
		Interaction models (e.g. zoom, scale, drag and drop)
		Icons to describe available actions
User-centred Design (Henry, 1998; Nielsen, 1993, 2012a; Norman, 2013, 2016; Sharp et al., 2019)	User interface	Affordances
		Signifiers
		Feedback
		Customisation methods
		Personalisation methods
	User Experience	Evaluation methods

		Users' needs
		Users' expectations
		Users' limitations
		Enhance the experience through customisation
		Enhance the experience through personalisation
		Tool's accessibility
Customisation (Nielsen, 1998; Zhang & Sundar, 2019)	Level of customisation	Customisable parameters
		User's sense of control
Personalisation (Blom, 2000; Kao et al., 2020; Nielsen, 1998)	Level of personalisation	Adaptations performed by thes system (e.g. display suggestions, learn user's name)
Teachers and Environmental organisations' staff (Ferrari, 2013; Shneiderman et al., 2018; Spiteri & Chang Rundgren, 2020; Vuorikari et al., 2016)	Digital literacy	Digital skills
		User's limitations
		Technology integration in classrooms

The Research Method

Several studies in multiple fields involve users in their research process since its beginning (Dufendach et al., 2017; Holländer, 2018; Kushniruk & Nøhr, 2016), claiming that user's involvement assures that the final product meets users' needs, considers their limitations, and achieves a higher level of usability. However, different studies involve users in diverse stages of the process. Some research only allow users direct input in redesign stages since most of the design derives from the empirical analysis (Kushniruk & Nøhr, 2016). In other cases, their involvement starts at the beginning of the process, and users contribute to all the stages (Dufendach et al., 2017). Dufendach and his research team (2017), for instance, developed an interactive modular platform to ease the involvement of stakeholders in the design process and reduce users' effort when participating in co-design sessions.

Users' involvement substantially reduces usability errors and proved to be effective in iterative design processes. Moreover, instead of forcing users to change their behaviours according to the UI, the interface is designed to increase its efficiency. In specific contexts where users' safety is at stake is inevitable to involve them (Dufendach et al., 2017; Holländer, 2018).

User-centred approaches in Portugal

As stated above, in Health, interdisciplinary research – with participation of users throughout the process – is essential to ensure the successful development of any health system (e.g. Health Information Systems (HIS) or Electronic Health Records (EHR)). In fact, this participation creates more value to healthcare professionals, even in Portuguese contexts (Grenha Teixeira et al., 2019).

Grenha Teixeira et al. (2019), aiming to develop a HIS, more specifically an EHR, involved users (i.e. healthcare practitioners and patients) in the beginning – to inform the design process – but also in design decisions through participatory workshops. This process ensured the system meets different needs and priorities and fits distinct activities and contexts. As involving less experienced users in design subjects requires a more visual approach, the research team applied Service Design[38] methods of visualising data.

---

[38] "Service design is a process where designers create sustainable solutions and optimal experiences for both customers in unique contexts and any service providers involved. Designers break services into sections and adapt fine-tuned solutions to suit all users' needs in context—based on actors, location and other factors." (Interaction Design Foundation, n.d.)

Besides Health, a particular public with specific needs is the elderly population. Taking this into consideration, two other Portuguese studies (Simão & Bernardino, 2017; Veloso et al., 2020) applied an iterative design process through evaluating a platform with professionals and patients of elderly institutes, and senior citizens. From these evaluations, both research teams were able to locate potential improvements to the platforms' overall experience and interface design, and also to identify users' needs, concerns and expectations.

Likewise, in autonomous systems, user participation holds a lot of value to the end-product. A study of an Autonomous Mobile Robot Vending Machine, called "SnackBot" (Navarro et al., 2016), aiming to understand human and robot interactions, considered not only the technological challenges but also the preferences of potential users. The research team gathered distinct perceptions from users that affected the system's human-robot interaction, and the design, by applying a questionnaire.

The abovementioned studies corroborate the significant value of involving users, regardless of their field.

Methodology framework

A methodology framework is required in any research since it supports the method applied throughout the research process, intending to achieve specific goals – this research's goals are identified in the *Introduction* of this document. The methodology aids a better design of the research process and will enhance the quality and structure of collected and analysed data.

This dissertation has a heavy technological-focused approach towards development. In this sense, the chosen methodology was the Development Research (DR) – also known as Development(al) Research (De Villiers, 2005b; Richey, 1994); Design Research (De Villiers & Harpur, 2013; Kuechler & Vaishnavi, 2008a); Design-based Research/Design Science Research (De Villiers & Harpur, 2013); among other names. In this context, the methodology will be presented as DR – being this the most common designation in the researched literature – and was considered a suitable approach since, for example, Design-based Research is frequently applied in educational research contexts – which is not the case of this dissertation.

The methodological framework adopted for this research was already presented in a scientific peer-reviewed publication (Beça, Ribeiro, Aresta, et al., 2021).

This methodology is a systematic and iterative process of design, development, and evaluation, most commonly related to the development process of a product, to its analysis, description and evaluation (De Villiers, 2005a, 2005b; Richey, 1994). According to Richey (1994) and Kuechler & Vaishnavi (2008b), it requires analysis and description in each research stage and, when applied, new technologies, procedures, patterns and theories tend to emerge.

Van Der Akker and colleagues (2013) highlight a set of six characteristics that define DR methodology and support it as the chosen approach for this dissertation research:

– *Interventionist*, i.e., the present research project seeks to act in real-life contexts and answer a problem by developing a product for the research's target audience. Throughout the design and development process, the users' involvement was valued by promoting their participation in the product's definition.

– *Iterative*, i.e., the present research project research was designed to incorporate a systematic cycle of analysis, design, development, evaluation, and revision, which underlines the relevance of this research approach.

– *Process-oriented*, i.e., progressively improve the research outputs due to the systematic interpretation and intervention process – the purpose when applying this methodology into an iterative research process.

– *Utility oriented*, i.e., the product's functionality must be measured by users in real contexts. This characteristic has its equivalence in this research through performing UX and usability evaluations with both experts and users in the several development stages of the product.

– *Theory oriented*, i.e., to design the final product, both concepts and theoretical assumptions guided the design process.

– *Involvement of practitioners*, i.e., requires users' active participation and collaboration in multiple stages of the process, which took take place when conducting evaluation sessions.

Research's nature and approach

This research project has an exploratory nature since it is based on a literature review and the insights of users to study a phenomenon that is not yet deepened.

As for the research approach, a mixed-method approach was chosen due to the need of applying both quantitative and qualitative methods (Creswell & Creswell, 2018). According to the authors (2018), this approach allows for additional insight into the information collected, and thus, for a deeper understanding than if only one of these approaches were applied individually. On the one hand, the qualitative approach allows the fulfilment of the users' needs and wishes in real contexts by framing the tool's requirements and therefore meet the goals proposed in this research. The interpretative involvement of this approach justifies its need to contextualise and convey meaning to any subject or phenomena in the natural environments in which they occur (Gall et al., 2003, pp. 24–25). The inductive character of this approach allows a focus on the individual and to report the complexity of the studied situations (Creswell & Creswell, 2018).

On the other hand, the appliance of the quantitative approach is explained by the urge to conduct usability evaluations with users in which a set of metrics will be analysed. Quantitative approaches are suitable for this research's context as they allow to establish connections between two or more variables (Creswell & Creswell, 2018).

Furthermore, the combination of these approaches enables to neutralise flaws of each method applied individually and uncover new findings in research results (Hussein, 2009) but also avoids biases.

Stages of the Research Process

Initially, this research was designed in a five-stage process (Figure 24) with iterative stages (represented with the arrows) aiming to achieve the best result in each stage of the process:

Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**
Qualitative data	*Design*	*Qualitative data*	*Development*	*Mixed data collection*
Exploratory Interviews	Low-fi and High-fi protoypes	Evaluating the prototype	Developing the online platform	Evaluating the online platform
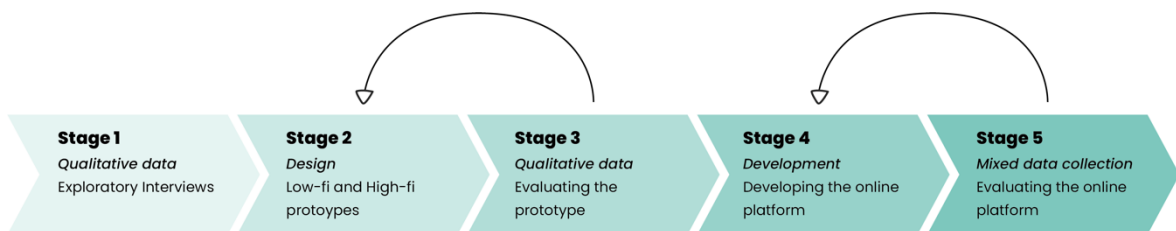
Figure 24 – First design of methodology stages

– **Stage 1**: *Qualitative approach* – **Exploratory interviews** with the target audience to understand their needs and limitations in the scope of this research's context.

– **Stage 2:** *Design* **low and high-fidelity prototypes** based on the exploratory interviews results and literature review.

— **Stage 3:** *Qualitative approach* – **Prototype evaluation** with the target audience resorting to UX methods, followed by the analysis of the collected data and refinements to the prototypes.

— **Stage 4:** First stage of **development** of the digital tool.

— **Stage 5:** *Mixed approach* – **Evaluation** with the target audience of the platforms' first stage of implementation resorting to Usability methods, followed by adjustments identified in the evaluation sessions.

However, due to time constraints derived from the participant's availability during Stage 1 (predicted in the *Contingency Plan* – Appendix 1), the methodology had to be adapted. The adjustments made to the research process are illustrated in Figure 25:
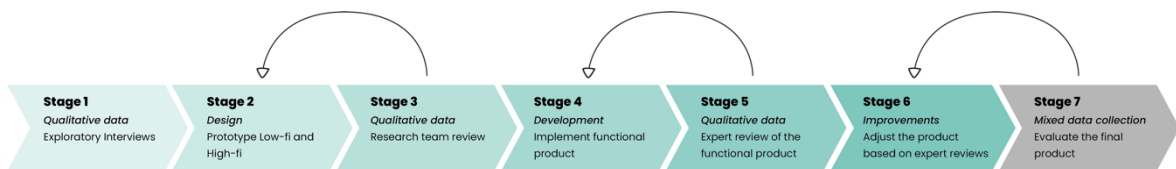
Figure 25 – Adapted methodological approach[39]

The changes made to the methodological process were essentially centred on the unfolding of some validation stages, namely:

— After designing both low and high-fidelity prototypes (Stage 2), a validation of the design proposal was carried out with the project's research team (Stage 3). Following this validation, the required adjustments were made to the prototype and the research process proceeded to the implementation of the functional product.

— Once the functional product was implemented (Stage 4) – the product was validated and in each stage by the research team –, a set of sessions with experts (Stage 5) were held aiming to improve the product and later on validate it with end-users.

— The identified improvements were made to the functional product (Stage 6) and then, ideally, the research would have proceeded to a stage of evaluations with the target audience (Stage 7).

[39] The filled-line arrows represent the iterative stages, while the dotted-line arrows symbolise the probability to return to the design and development stages to perform product refinements – the iterative process.

The data collection tools to conduct the intended final evaluations (Stage 7) with the research's target audience (i.e. teachers and environmental organisations staff) were designed and validated (presented in the *Third stage: Usability Testing* section), even though those sessions were not possible to be carried.

Participants

This research's population are upper-secondary and university teachers, as well as members of organizations related to the environment, with and without design and technical/digital skills.

The participants who intervened in the several stages of product validation were selected through the non-probabilistic convenience method. This was the method chosen for the selection of participants given the short time in which this research took place, which means low statistical precision, thus preventing this study from being generalised to other contexts.

Although not all the evaluations stages were carried (namely Stage 7), altogether in this research, **nine individuals** participated, two being teachers (from the target audience) and seven being UX specialists. From this entire group, two were male, and seven were female. The selection criteria prioritised a diversified selection in terms of experience in the field of UX and gender. Nonetheless, this criterion may not be reflected in the studied sample since some constraints arose from the participants' availability.

Data collection and observation tools

Accordingly with the stages defined in the *Stages of the Research Process* section, exploratory interviews, content analysis and questionnaire were the data collection tools defined. Therefore, the following sections intend to describe each chosen tool and the investigation performed around its choice.

First stage: Anticipated Experience Evaluation

In the **first stage** of the process were carried exploratory semi-structured interviews by applying the method Anticipated Experience Evaluation (AXE) which is adequate to early stages of the design process (Gegner & Runonen, 2012). This evaluation is divided into three stages – Concept briefing, Concept evaluation and Data Analysis – and is suitable for a stage where no prototypes were designed, and only the concept is defined. According to Pernice (2018), user

interviews are appropriate for the same reason above mentioned but also because it aids to inform the definition of requirements and the tool's navigation map and support the identification of users' needs and limitations.

In addition to the interview, direct observation techniques and a characterisation questionnaire were employed. The typology adopted was a semi-structured interview model, with a set of questions previously defined in a script (Appendix 2) that guided the course of the interview. The interview had the following purposes:

- Identify online tools to produce graphic contents (e.g. posters, flyers);

- Understand the user's perception about templates;

- Grasp which customisation features should be available;

- Understand what features were expected in a tool such as the one that is the aim of this research.

In this stage were carried **two interviews** (female = 1; male = 1) with upper-secondary and undergraduate design teachers (with experience in both industry and academy), both with over 10 years of experience. The interviews took place online (due to the lockdown caused by the Covid-19 pandemic), using Zoom to undertake and record the video call conferences (Figure 26), between March 4 and 10, 2021. The sessions' recording allowed a thorough analysis by transcribing the interviewees' quotes (Appendix 3), and then, analysing the collected data.

To carry interviews is recommended to have five users (Nielsen, 1993, p. 224), however, and although seven teachers were reached, only two expressed their availability – perhaps due to the lockdown period Portugal was going through[40].

---

[40] From 15th March 2021 onwards, the school and teaching activities resumed in a presential regime – as regulated in the Council of Ministers Release of March 11, 2021 (https://www.portugal.gov.pt/pt/gc22/governo/comunicado-de-conselho-de-ministros?i=407, last accessed on June 15, 2021).
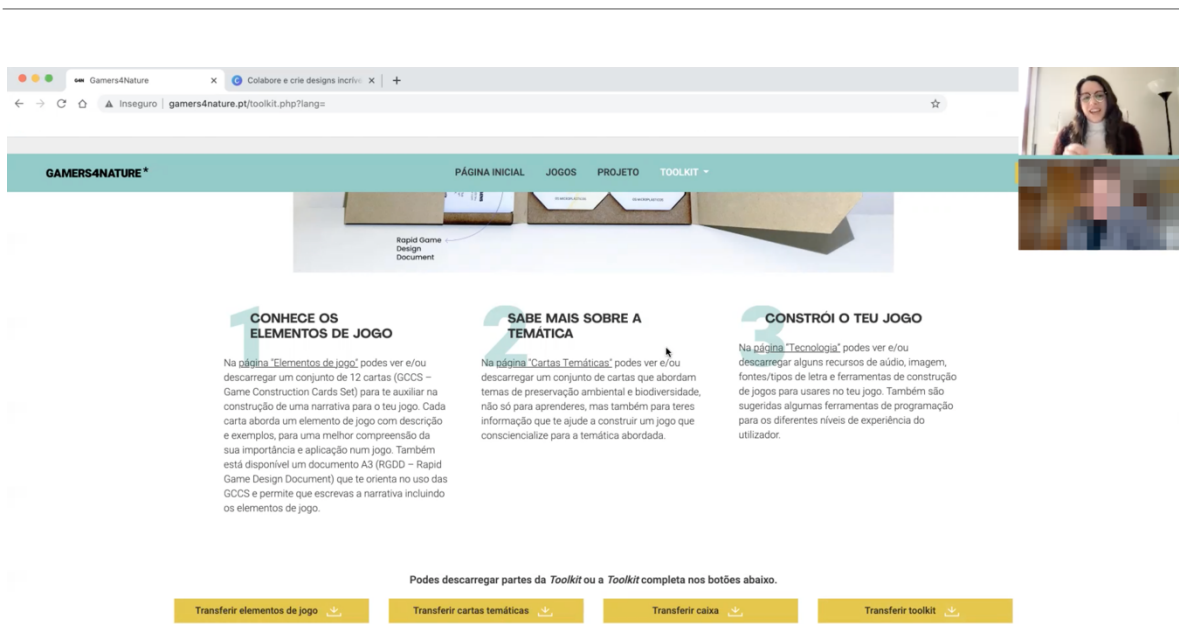
Figure 26 - Remote exploratory interview with a design teacher

Second stage: Expert Review

Expert Reviews are suitable for the final milestones of a project and can be done at any stage of the design cycle (Harley, 2018). Furthermore, this method is more flexible and adaptable to each context since it relies on UX experts' knowledge and not only on a strict set of guidelines, as in the case of a Heuristic Evaluation. Combining this method with the Thinking aloud protocol (Nielsen, 1993, p. 195, 2012b) is useful to pinpoint user's misconceptions and is suitable in iterative design processes (Nielsen, 1993, p. 224).

These evaluations are often reflected on a deliverable, such as a written document, or during a meeting. On the one hand, written documents contain detailed information and suggestions or recommendations but a meeting, on the other hand, provides contextual information and a clear presentation and understanding of the design review. Moreover, there are some components that are essential on any design review, that are: listing usability strengths and issues, severity ratings, recommendations, and examples of best practices (Dumas et al., 1995; Harley, 2018).

The Expert Review sessions do not necessarily require to be longer (i.e. over an hour), instead, the proper amount of time for five evaluators is around an hour, allowing to uncover 85% of usability problems, while over two hours enables to uncover around 95% of usability problems (Dumas et al., 1995). Concurrently, these authors (1995) do not tend to support the idea that is beneficial to have several evaluators performing "mini-evaluations", indeed they consider it has more advantageous to carry one-hour evaluations with three different evaluators than longer evaluations periods – i.e. two or three hours – (in this study, the two approaches

considered differed from 60% of uncovered problems with "mini-evaluations" compared with 70% of uncovered problems with one-hour sessions and three evaluators).

Authors (1995) also represent in a graphic (Figure 27) that one-hour evaluations are sharper and that, after five evaluators, the graphic curve tends to have a softer ascent as more evaluators are involved.
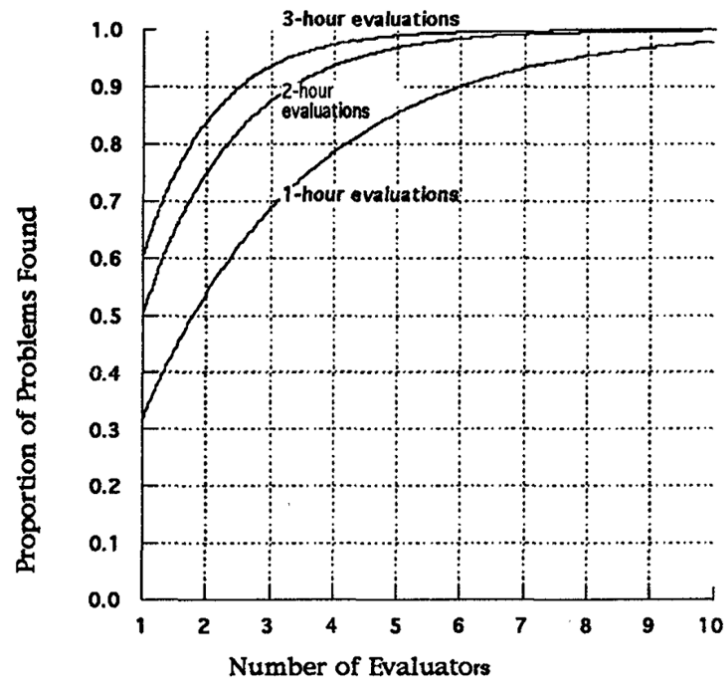
Figure 27 – Proportion of problems found and number of evaluators for different times of evaluation (Dumas et al., 1995)

The **second** stage of evaluation with other research stakeholders was conducted through an Expert Review. Inside the scope of design reviews – a usability-inspection method aiming to identify usability problems – there are: (i) Heuristic Evaluations, which are reviews based on Usability Heuristics and can be carried out by a single individual, such as the researcher; (ii) Standalone design critique, which is usually a group review of an in-progress design, verifying if the current design meets its objectives and provides a good user experience; and finally (iii), Expert Review, which requires a UX expert to inspect a system based on his/her experience and expertise (Harley, 2018).

The Expert Review had the following purposes:

- Identify usability and UX strengths and problems;

- Collect recommendations for improvement based on the expert's expertise and experience.

In the carried sessions, both techniques were combined (i.e. a meeting and a written document) in the evaluation by observing the experts' analysis during the meeting and by providing a structured document to the experts as a deliverable of their review. The deliverable was structured to incorporate the core components of a design review, as it will be explained hereafter. The deliverable was divided into two main sections: experts' characterisation and tool's analysis. Appendix 4 contains the questions regarding the first (Table 13) and second (Table 14) sections of the questionnaire.

The quantitative data (i.e. participants' years of experience and field of work) was organized and assembled using a statistics software analysis, IBM SPSS[41] v16. The qualitative data collected was analysed by undertaking a text-based content analysis setting codes and categories of analysis (revised by the G4N project researchers to avoid biases), using the qualitative analysis software, Nvivo 12[42]. Content analysis is a powerful tool that can be applied to a wide variety of sources, such as text, images, video or audio (Stemler, 2015).

Seven UX experts (female = 6; male = 7) were involved in this stage. Due to Covid-19 pandemic restrictions, the meetings took place online and last around one hour each, using Zoom and Microsoft Teams to carry and record the video call conferences (Figure 28), between May 31 and June 3, 2021. The sessions were recorded to later conduct a deeper analysis on the collected data.
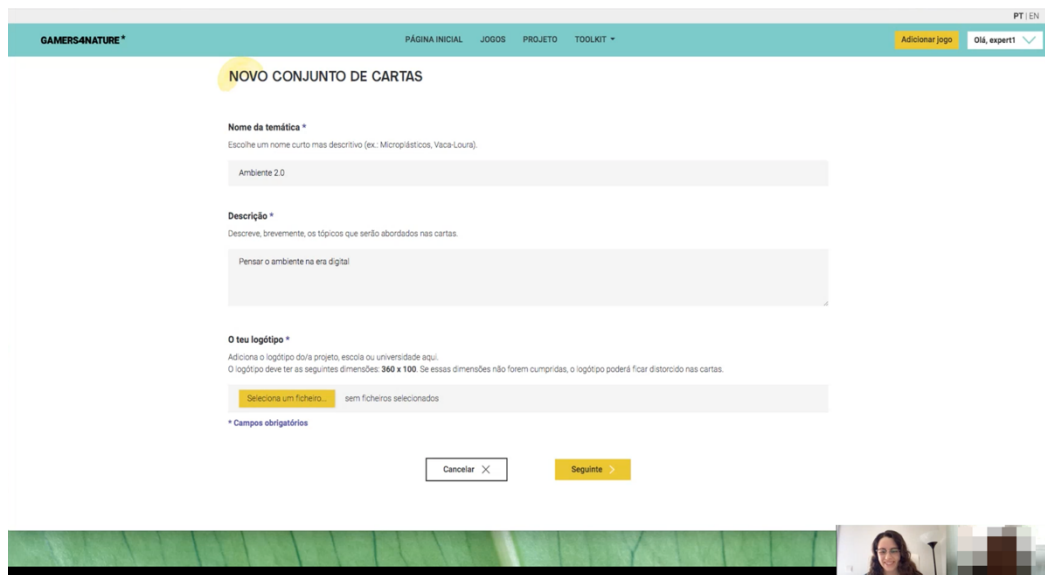
Figure 28 – Remote Expert Review with an UX Expert

---

[41] https://www.ibm.com/analytics/spss-statistics-software, last accessed on June 13, 2021
[42] www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home/, last accessed on June 13, 2021

Third stage: Usability Testing

The **last** stage of evaluation was designed with the aim to gather information regarding Usability concerns of the final product. Even though this stage was not able to be carried, the data collection tools, and the test's planning were designed (Appendix 5 and Appendix 6).

The Usability Testing would have the following purposes:

- Identify opportunities to improve the tool;

- Identify potential interaction issues;

- Understand the user's behaviour whilst using the tool.

As a complement to this test, a questionnaire (Appendix 6) was elaborated to characterise the participants, measuring the tool's usability, identifying the strengths, weaknesses, and suggestions, and obtaining a brief description of their experience with the tool from a more individual and concrete perspective. The questionnaire allows for the identification of subjective user preferences (Nielsen, 1993, pp. 209, 224), and, combined with the sessions, would provide a contextualized analysis and report.

The questionnaire is composed of two sections: I – Characterisation; and II – Reporting the Experience. The second section is comprised of the questions designed for the System Usability Scale (SUS) and questions concerning encountered issues, identified strengths and missing features, and a brief report of the user's experience.

The SUS is a ten-item questionnaire with five response options (from "Strongly agree" to "Strongly Disagree" as in the Likert Scale) and a reliable tool to measure usability created by John Brooke in 1986 (Usability.gov, n.d.). Whilst being complex to interpret the result's score, on the other hand, it is easy to administer to participants, it can be used on small sample sizes and provide reliable results, and it enables to distinguish between usable and unusable systems (Usability.gov, n.d.).

This Usability test would be moderated remotely (Moran, 2019; Whitenton, 2019) due to the Covid-19 situation in Portugal[43] using a video call conference. The questionnaire was designed in both Portuguese and English since the convenience sample reached would include participants with diverse nationalities (i.e. Portuguese, Irish, Hungarian, Spanish). The results collected from this evaluation would support a final revision of the product (i.e. identify issues and improve the UI).

---

[43] At the time, Portugal was still slowly raising restrictive measures to prevent the spread of the pandemic (https://www.portugal.gov.pt/pt/gc22/governo/comunicado-de-conselho-de-ministros?i=426, last accessed on June 15, 2021).

CHAPTER IV

EMPIRICAL RESEARCH

Topics

Conceptualisation and Definition
Development
Evaluation and analysis

I. Conceptualisation and Definition

UX Benchmarking

Based on the related work from the previous sections and alongside with the snowball literature review, a UX benchmarking analysis of the several tools described in section *RELATED WORK* was conducted (Beça, Ribeiro, Aresta, et al., 2021). The benchmarking in Figure 29 presents a comparative study of design and presentations tools, platforms, applications, and software from the *RELATED WORK* chapter. The analysis employs a set of parameters[44] to establish criteria to compare each tool/platform.

From the analysis of the Design Tools described in *RELATED WORK* section, the characteristics from the above part of the table prevail, whereas the presentation tools start to exhibit characteristics from the bottom part of the table.

	Design Tools										Presentation Tools					G4N DIGITAL TOOL
	Canva	Gravit Designer	crello	Stencil	Piktochart	Lucidpress	visme	designbold	Prezi Design	noissue	PowerPoint	Prezi Present	Google Slides			
Onboarding / Tutorial	✓	✓	✓	✓			✓									✓
Templates	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Multiple export formats	✓	✓	✓	✓	✓		✓	✓			✓	✓		✓		✓
Print settings (crop marks and bleeds)	✓		✓		✓	✓	✓									✓
Smart guides	✓	✓			✓			✓	✓		✓	✓		✓	✓	✓
Library of icons, illustrations and shapes	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓
Keyword search for design elements / templates	✓				✓											✓
Zoomable canvas	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓
Help menu / FAQs					✓				✓	✓	✓	✓	✓	✓	✓	✓
Colour customisation							✓	✓	✓	✓	✓	✓	✓			✓
Embedded brand guideline standards										✓						✓
Organisation by layers		✓														✓
Free tool	✓	✓	✓				✓		✓				✓	✓		✓
Automatic save											✓				✓	✓
Font settings						✓	✓		✓		✓	✓	✓	✓	✓	✓
Basic image edition (e.g. crop, colour)					✓						✓	✓	✓	✓	✓	✓
Designated fields						✓										✓
Team collaboration							✓				✓	✓	✓			✓
Light / Dark mode								✓								✓
Brainstorming ideas											✓		✓			✓

Figure 29 – UX Benchmarking

---

[44] The parameters are characteristics and features identified in the analysis reported in the previous sections.

✓ **COMPLETE FUNCIONALITY**   ✓ **PARTIALLY FUNCTIONAL**

Figure 30 – Benchmarking description[45]

Some transversal features identified in Design Tools are: onboardings, tutorials or help menus; a range of templates for the user to choose from and libraries of icons, images, and shapes; export to multiple formats with print settings embedded; smart guides; and finally, zoomable canvases. Notwithstanding, most of the tools are paid or have limited free features.

Presentation Tools, besides providing templates, having smart guides and canvases, also suggest brainstorming ideas, allow team collaboration, font adjustments and basic image edition.

The analysis of these tools will support the definition of this research's digital tool requirements and provide innovative characteristics to integrate into this tool.

The above analysis of the design and presentation tools offers a valuable perception concerning the products currently available on the market, allowing not only to distinguish distinct features of this research but also to identify features already standardised among users or issues to avoid. Furthermore, this analysis will also support the definition of the functional and non-functional requirements of the platform.

This research aims, primarily, to meet the goals of the G4N project and then, to innovate since it will have usability and accessibility concerns while designing the tool. Some features from professional vectorial design tools will integrate this research's tool, such as a canvas to design, image/shape settings (e.g. resizing), and export the design. From the tools analysed, in a technical, conceptual, and graphical level, there are relevant characteristics: show/hide tools according to the selected object/element; library with shapes, icons and illustrations; icons combined with text; screen location of edition tools; intuitive and sober design; and more.

Accessibility and usability concerns, such as the contrast of text and background colours and an appealing, functional, and accessible design for the research's target audience, highlight the importance of involving users throughout the design process.

---

[45] Blue means that the feature/characteristic is available on the correspondent tool; Yellow means that the feature/characteristic is partially represented on the correspondent tool; The blank square means the feature/characteristic is not available on the correspondent tool.

Definition and Design concerns

As mentioned above, the tool derived from this research was developed as an integrated component of the portal-repository already developed in the G4N project. Being the portal-repository the starting point of this research's tool, it is imperative to design the tool's UI with a coherent and consistent approach, namely employing the portal's colour palette and icons, as well as the usage of white space. Therefore, this section highlights the portal's main characteristics that ease the understanding of the tool's graphical approach.

The portal-repository was designed with the concern of establishing a connection between the physical Toolkit (Beca et al., 2020; Beça et al., 2020) and the online resource (i.e. the portal-repository – (Beça, Ribeiro, Santos, et al., 2021)). Whilst designing the portal, it was considered the project's brand and identity (i.e. brand guidelines and colour palette) as well as integrating design elements that emphasized this connection (e.g. minimal and clean UI, using the Toolkit card's format as the website's information cards – Figure 31 –, and integrating watercolour marks present in the Toolkit thematic cards – Figure 32).
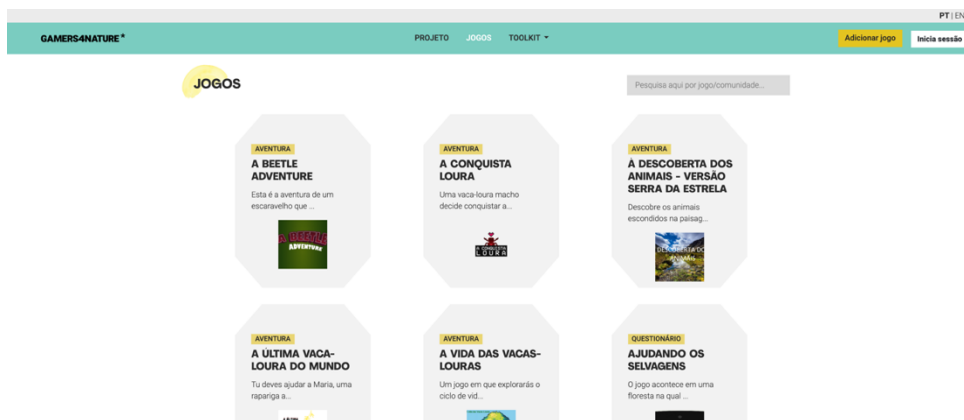
Figure 31 – Screenshot of the Gamers4Nature portal-repository: Games page
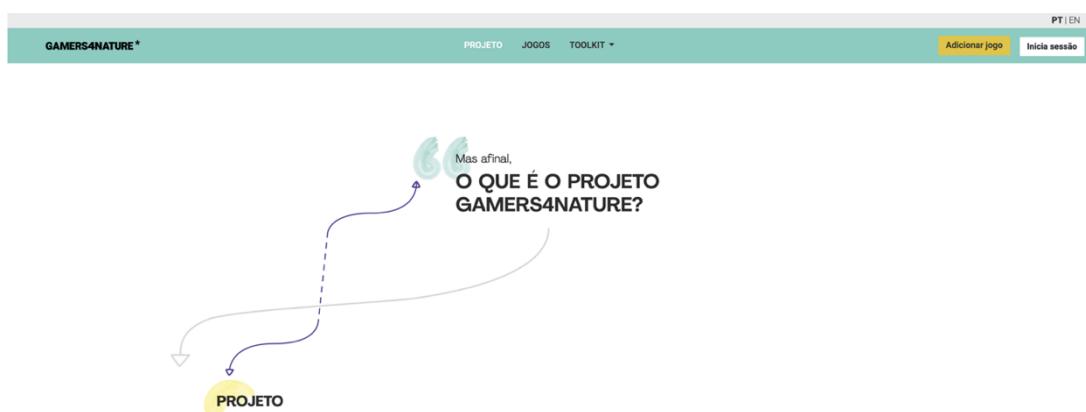
Figure 32 – Screenshot of the Gamers4Nature portal-repository: Watercolour marks – pointed by the purple arrows

Following the same approach, this tool – as it is a component of the G4N portal-repository – should also be presented according to the design line previously defined. Besides the design, the methodological process also adopted a similar approach with the following considerations in mind: involve users, intending to fulfil their needs and expectations; create a usable product that meets their (perhaps) limited skills (cf. *Definition of Digital Literacy* section).

An article comprising the portal-repository's design, development and initial evaluation process (Beça, Ribeiro, Santos, et al., 2021) was published after went through a double-blinded peer-review procedure, and was awarded as the "Best Paper".

Colour palette

There are a set of colours applied to all the project's resources (Figure 33). The meanings conveyed through the colours applied in the Toolkit meant to break the game's paradigm since the G4N project does not necessarily fit in game communities, therefore the need to appeal to a broader audience (Beça et al., 2019; Gomes, 2019). Colours were consistently applied in the portal-repository, with minor changes due to the colour required adaptations from a physical format to a digital format and due to contrast issues (Beça, Ribeiro, Santos, et al., 2021).

#7BCCC0
rgb(123, 204, 192)

#F6B3A8
rgb(246, 179, 168)

#E4C420
rgb(228, 196, 32)

#524C9F
rgb(82, 76, 159)
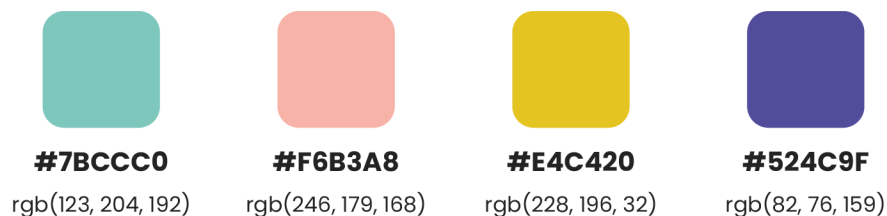
Figure 33 - Gamers4Nature project's main colour palette

The UI main colour is a greenish-blue which combines the blue-related positive feelings (e.g. trust and calm) with the project's nature-context that faces the user when he first enters the portal (Heller, 2013). The colours from the palette are applied in several UI details, such as buttons (detailed later in *UI Design System* section) or warning messages.

It is imperative to communicate clearly with users and assure they do not feel insecure or lost in the navigation, therefore avoiding interactions issues. Colours aid the understanding of actions that are running in the back-end of a system. The principles regarding these concerns are "Visibility of system status" (e.g. feedback about actions and navigation) and "Error prevention", two of ten from Nielsen's Usability Heuristics (Nielsen, 2020).

According to the feedback's severity, pink and yellow are applied in warnings (Beça, Ribeiro, Santos, et al., 2021): pink– a light red hue – is applied when messages concern danger (e.g. error messages) and forbidden actions (Figure 34), and yellow identifies alerts (Figure 35).

Figure 34 – Screenshot of an error message in the Gamers4Nature portal-repository
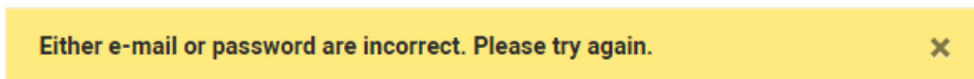
Figure 35 – Screenshot of a warning in the Gamers4Nature portal-repository

UI Design System

This research tool was integrated in the G4N portal-repository after the portal was designed, implemented, and launched. Therefore, it was defined that the tool should follow the portal's UI design system. Below, it will be explained the construction of the portal's design system and how it is followed in this tool's design. The overall portal UI design system and choices are depicted in a published article (Beça, Ribeiro, Santos, et al., 2021).

The design system - represented in Figure 36 - encompasses several button morphologies and states (i.e. normal and disabled) regarding their importance in the UI (i.e. primary, secondary). Moreover, it shows the buttons from the canvas' tool.
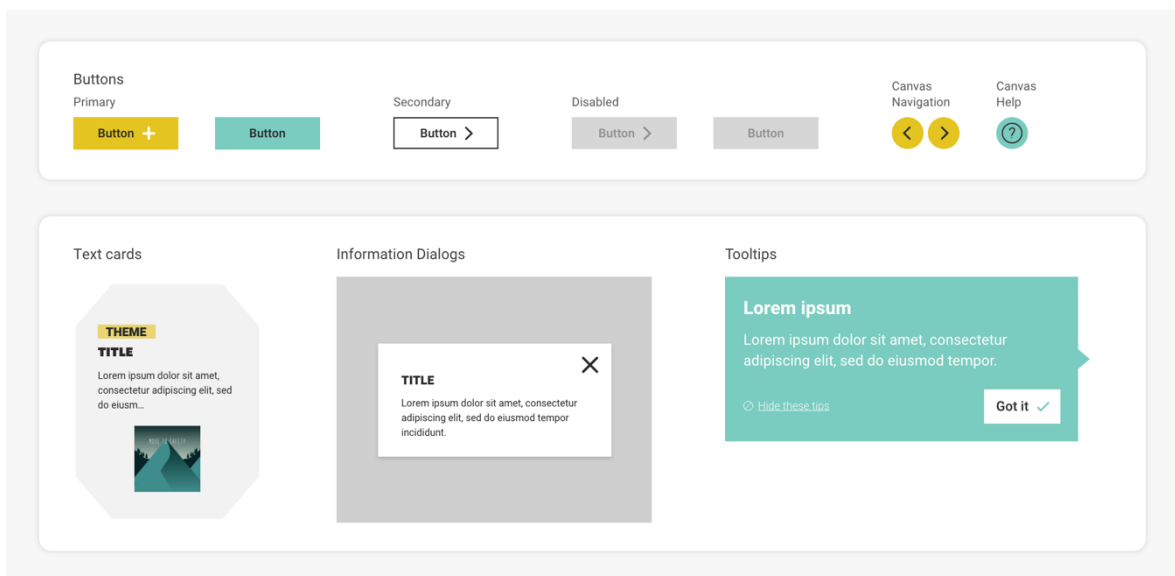
Figure 36 – Gamers4Nature portal-repository design system (i.e. UI kit)

Primary buttons have two different appearances: (1) yellow buttons have both text and an icon and are applied in contexts where there is a reference to a concrete action, such as editing any cards set, add a new game, or download a resource; (2) the greenish-blue buttons only contain text and are often linked to the visualisation of an output, such as visit my game's page or see my cards set.

Secondary buttons are, in the context of the tool, applied in the navigation between steps combined with primary buttons (Figure 37).

Figure 37 – Gamers4Nature portal's tool: Buttons to navigate between steps

However, there is a slight change when the button is applied to return to the previous step. In order to provide fluent navigation and allow a novice user to easily learn how to interact with the system, it is important to place the design elements in such a way that the user interacts with them intuitively and naturally. Considering this, the "Previous step" button has the arrow icon placed on the left side of the text, as it is more natural for the user to establish an association between the icon's orientation – which points backwards, as the back buttons on a browser – and the action of going back.

This requirement tackles the "Match between system and the real world" Heuristic since it applies familiar concepts to the user and follows real-world conventions (i.e. the arrow orientation follows the movement direction – return to the previous page, i.e. back).

The cards' navigation buttons are only composed of icons since the interaction with the canvas is more repetitive and becomes mechanical, wherefore unnecessary to constantly provide text and illustrative icons. Furthermore, the canvas navigation and help buttons are differentiated by colour to distinguish the goal of each button (yellow for actions, such as navigation and adding cards, and greenish-blue to view help tips).

Finally, information dialogues present multiple configurations throughout the UI: (i) to display the user's contents, the hexagonal shape adapted from the G4N Toolkit's cards is used; (ii) prompt modals are white with a grey background and medium opacity, so they don't completely cover the body's contents and allow the user to identify where he is with the navigation; (iii) tooltips, which convey essential information, are highlighted by the greenish-blue background.

Tool's Requirements

The data collected from the snowball literature review, the related work, and the analysis on the UX benchmarking of presentation and design tools enables to identify a set of characteristics, features and potential approaches for this research's tool (Beça, Ribeiro, Aresta, et al., 2021). The UX benchmarking pinpointed a set of features aimed to be integrated into the tool that supported the design of the functional requirements (FR – Table 3).

Table 3 – Gamers4Nature tool: Functional Requirements

	Functional Requirements
FR 1	Register and Login[46]
FR 2	Onboarding when entering the tool for the first time
FR 3	Access to "Help" button
FR 4	Snap objects
FR 5	Use guides
FR 6	Move objects
6.1	Drag-and-drop items
FR 7	Select icons, illustrations, or shapes from a library
FR 8	Search elements by keywords
FR 9	Zoom the canvas
FR 10	See objects in layers
FR 11	Save automatically
FR 12	Show suggestions based on user's current layout
FR 13	Customise colours
FR 14	Export artwork in digital format (JPEG, PNG, ...)
FR 15	Export artwork to print (PDF with marks and bleeds)

[46] The FR 1 is already a functional requirement of the portal-repository itself, nevertheless, it is listed in the table as it is also required and unavoidable for the functioning of the tool.

FR aid to define the scope of a system, its behaviour and what is expected from it, essentially focused on the features it will provide and the user's requirements. On the other hand, non-functional requirements (NFR) are more focused and impact the user's experience, however, there is still not a consensus on its definition (Mairiza et al., 2010).

The depicted FR approached the storage of the designed cards (e.g. FR 11), the identification of the creator (i.e. the logged user – mentioned in FR 1), and the interaction methods to manipulate objects on the canvas, such as move (FR 6 and FR 6.1) –, customise colours (FR 13), and snap objects (FR 4) and use guides (FR 5) – which are features from professional design tools (e.g. Adobe Illustrator) and also from some mentioned LDT (e.g. Canva). Moreover, it intended to integrate a suggestion-based system, perceived as an advantage from the *Suggestive Interfaces* theoretical framework.

Furthermore, to remove more complex tasks from the user's decision layer, avoid the user's cognitive overloading, and as verified in some LDTs, one of the requirements is to have the tool automatically save the created contents (FR 11).

Finally, since providing the user with a printable output is one of the main goals of this research, it is imperative to have export options (FR 14 and FR 15) to provide printable cards set to the user.

Table 3 shows the tool's functional requirements. Nevertheless, as in any research process, and particularly in the DR methodology adopted for this research, findings are unpredictable and affect the decision-making process. On that note, derived from the data collected on the validation stages (which will be approached later in this document), it was identified the need of adapting and even removing some of those requirements.

Sketch and Digital Wireframing

Sketches are methods applied during early stages of the design cycle since it provides a concrete picture of the design approach, an externalisation of the ideas and represents how the defined features fit within the design. Moreover, even rough sketches aid the understanding of the product's goal and allows the prevention of errors that could perhaps only be detected later in the design cycle (Römer et al., 2001).

The first sketch of the UI considered a set of requirements both from the FR list and from Design Tools from *RELATED WORK*: user's onboarding, help menu, libraries of templates, icons, illustrations and other shapes, export artwork, smart guides, and zoomable canvas.

The first design proposal for the tool was sketched on paper (Figure 38), which served to point out the direction to pursue concerning the features to be integrated and the framing into the portal-repository already implemented. In this sketch, the navbar is represented to understand the framing of the tool into the G4N portal.
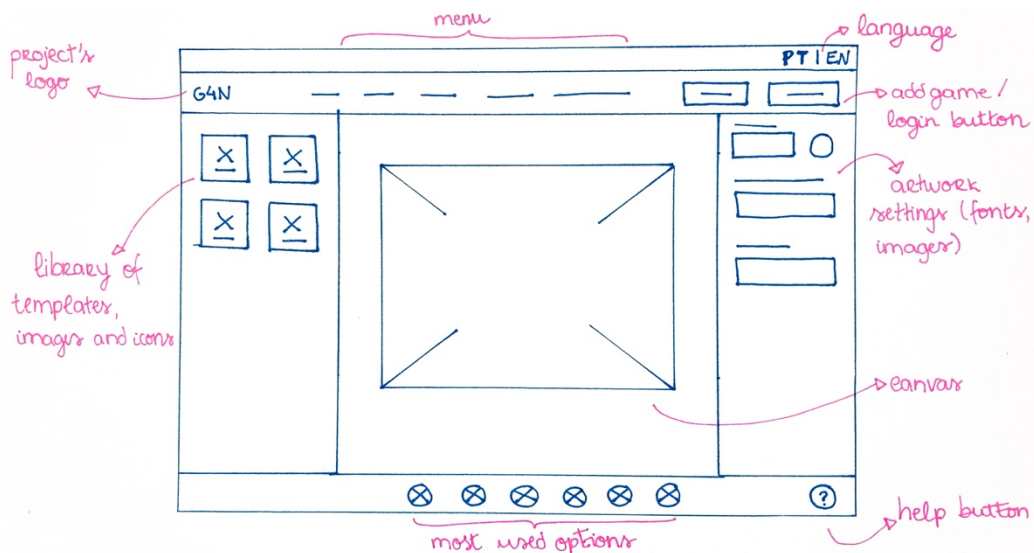
Figure 38 – First sketch of the Gamers4Nature tool

On the left side, the tool would have a library for templates, images, or icons according to what has been selected by the user. On the right side, all the settings available to customise the cards (e.g. font size, element's opacity) would be placed. On the bottom, the most used options, such as "zoom-in", "zoom-out", and "save" would be displayed horizontally on a bar. Finally, the middle section would the place where each card was being created, i.e. the canvas.

The tool will only be available in devices with over 1024px, which is a standard viewport size that comprises most desktops and horizontal tablets, aiming to avoid the eventual frustration and lack of control derived from smaller screens (Beça, Ribeiro, Aresta, et al., 2021; Saffer, 2010, p. 135).

This sketch was digitalised into a digital low-fidelity prototype (Figure 39). In this prototype, the areas which correspond to the portal's elements are already with an accurate representation.
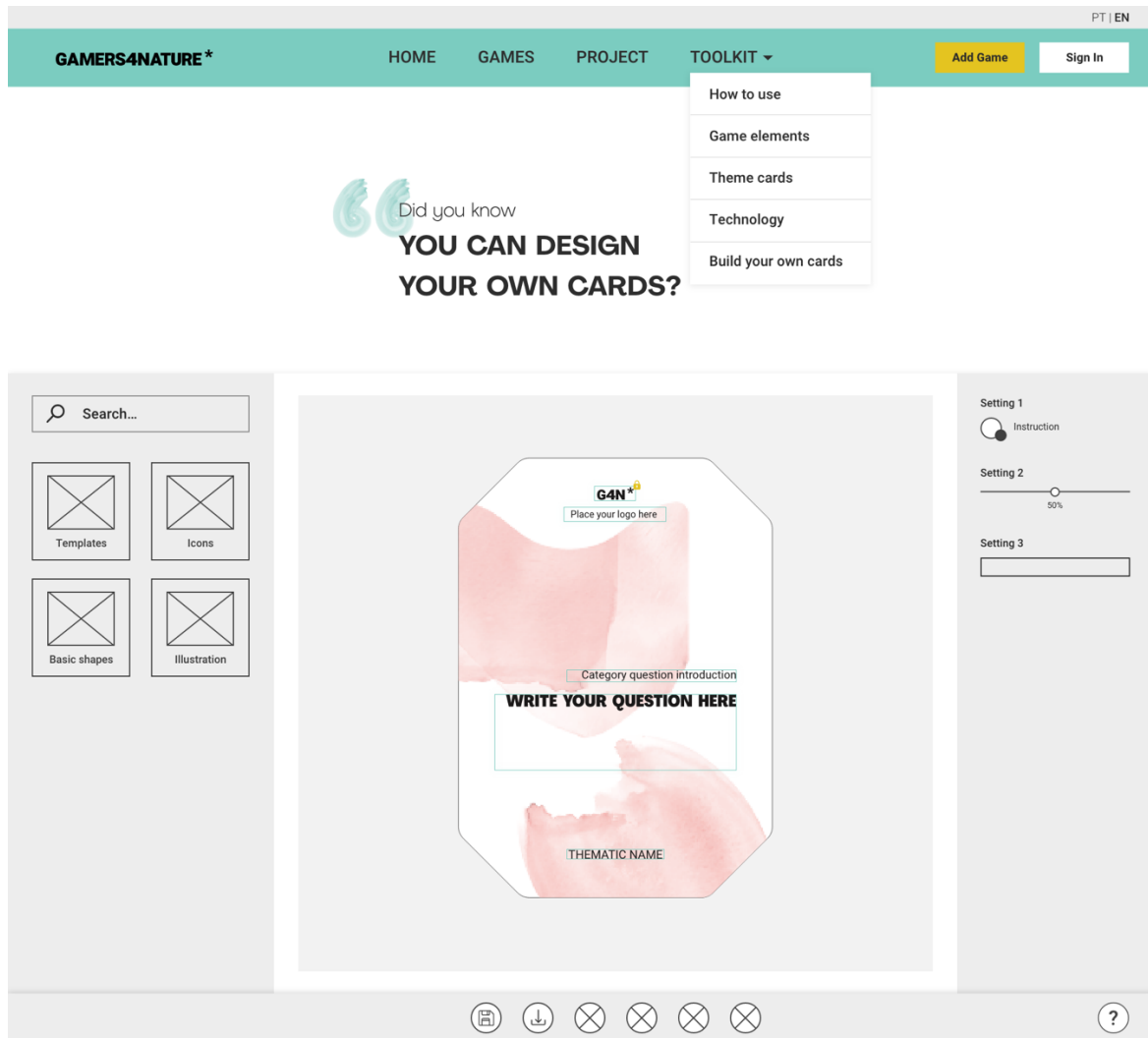
Figure 39 – Gamers4Nature tool: Digital low-fidelity prototype

The Toolkit's dropdown menu is displayed in Figure 39 since the menu link to the tool – named "Build your cards" - was placed there. The copywriting approach for this menu link, while different from the others in the dropdown menu, is similar to the approach taken in the "Add game" navbar since both represent contents that the user can create in the G4N portal.

On the left sidebar of the low-fidelity prototype there is a search bar that filters the templates/illustrations/icons according to the inserted keyword. The right sidebar encompasses multiple features: setting 1 to choose a colour; setting 2 to manipulate opacity; and setting 3 to other feature that, at the time, was yet to define.

The bottom bar has two icons – one to save the card and the other to download the cards set – and the other four spaces were also not defined at that moment. The help button, since having a distinct purpose from the others – it is not an action, but a modal menu to provide support – was placed separately from them.

Within the canvas, specifically where the card is being designed, there are fields that can be edited by the user and fields that are locked for edition. The coloured borders enclose all the fields concerning the current step (i.e. Step 2 – contents), however, the user can only edit the fields that do not have the yellow lock icon over the coloured borders – the locker represents unmovable and non-editable elements, such as the G4N logotype.

It is intended that, throughout all the creation process, the user can have an accurate visual representation of what he/she is editing, so that what the user sees in the canvas will correspond to the final product: the thematic card. Therefore, the font-face and size and the locations of the illustrations and watercolours must be equal or, at least, similar to the final output.

The conducted research until this stage was publish in a book chapter as the extended work of the G4N portal-repository (Beça, Ribeiro, Aresta, et al., 2021).

Anticipated eXperience Evaluation

While designing the first sketch and digital prototype, the researcher started to reach teachers with design experience to get their insights – as teachers and as experienced designers – regarding the proposal designed for this tool. This being an embryo stage of the research, the Anticipated eXperience Evaluation (AXE) was the chosen method as the basis for the semi-structured interviews.

As this research follows a UCD approach, the first key concept, according to Henry (1998, p. 13), is to "focus early on users and tasks" (cf. *Definition of User-centred Design* section). By carrying these interviews at the beginning of the methodological process, users were involved early stages of the development process.

The procedure of the exploratory interviews was settled in the following stages: (i) concept briefing – the concept defined until that moment was explained to the teachers who were free to ask if any doubts arose; (ii) concept evaluations – the moderator (i.e. the researcher) followed the script (Appendix 2) and solicited the teachers to answer questions regarding experience with online design tools, the usage of templates, customisable features and expect features of this particular tool (based on the concept briefing); and (iii) data analysis – the researcher transcribed the collected data and then organised it into four topics, as it will be further explained.

Results

The qualitative data from the two interviews with teachers – one female and one male –, was organised in the following topics: <u>Experience using similar tools</u>; <u>Template usage</u>; <u>Customisation level</u>; and <u>Expected features</u>.

Concerning **Experience using similar tools**, one of the teachers (T1) mentioned that the "Canva" tool allowed the creation of templates for social media posts, which was used to provide templates for a specific client, enabling the client to replace text and images according to their goal. T1 also pinpointed "Canva" as an example of the direction in which things are moving towards, where the designer sets the rules, and the client defines the content. The other teacher (T2) only had experience with professional design tools, namely Adobe Illustrator, and had never used an online design tool, such as Canva or Piktochart. Inclusively, after the session, T2 asked the researcher to explain the workflow with these tools since the teacher considered it a useful work resource to create images for social media.

Regarding **Template usage**, both teachers considered that templates are crucial in the thematic cards' creation process. However, while one of the teachers (T1) only underlined templates as a core element of this process, the other teacher (T2) emphasized that, although templates support users without design training or aesthetic sensitivity, they must be used with caution, allowing the user to convey their personality in the work they create. Templates can spawn in similar outputs, however, since the thematic cards must comply with the G4N brand standards, that is not an issue.

In relation to the **Customisation level**, teachers mentioned that although there must be a customisation level, it is necessary to narrow the work field by providing oriented guidance to create the thematic cards: one of the teachers (T1) mentioned a step-by-step process; the other teacher (T2) mentioned that the typography should be unchangeable because of its distinct character, and that colour could be presented with multiple options of choice. Complementarily, teachers advised avoiding – at all costs – any attempt to scatter from the core purpose (i.e. create card sets following the standard's manual of the G4N brand) since it could lead to a distortion of the message conveyed by the graphical elements. The teachers mentioned that the tool should be designed on the basis that all users are completely inexperienced in the design field but also that the users have some technical and technological limitations.

About the **Expected Features**, teachers mentioned they would expect:

– Colour palette options with multiple pre-defined and -tested combinations of the G4N colour palette;

– Possibilities of layouts and compositions, namely to provide multiple layout options in the template selection stage;

– If there was a font/typography option, to have a limited number of previously tested options to assure they fitted well with the G4N brand and overall design.

Considering the target audience, one teacher (T1) completely supported a step-by-step process, while the other (T2) agreed but adverted that it could perhaps make the experience too restrictive. Moreover, one of the teachers mentioned the importance of constraining the input areas, i.e. limit the number of characters. The considerations of these teachers reinforce the information gathered in the literature review, namely concerning the establishment of constraints for novice users and a structured design to as an approach to facilitate their evolution to expert users (Shneiderman et al., 2018, p. 36).

Unfolding the G4N Thematic Cards

From the analysis of the collected data in the AXE, the researcher started by deconstructing the Toolkit cards' design, which resulted in the following[47] (Figure 40) dimensions:

– Card's shape;
– Layout and Composition according to category;
– Watercolour mark according to category;
– Text:
  o Front: Category name, Motto-question, and Thematic name;
  o Back: Full description;
– Illustrations according to thematic.

[47] The result of this process does not necessarily imply a specific order.

Figure 40 – Deconstruction of the Gamers4Nature Toolkit's Thematic Card

Figure 40 shows the visual deconstruction of the G4N Toolkit's thematic cards, with the top row showing the card's front and the bottom row showing the card's back. As it can be observed, the first row contains the card's shape, the second column displays the graphic composition, the third shows the contents, the fourth adds the watercolours layer, and finally, the last row inserts the illustrations layer.

The cards' deconstruction acted as a starting point to divide the cards' creation process into stages. The cards' creation stages were initially defined as follows:

- Step 1: Select a template from a range of layout options;
- Step 2: Watercolour composition;
- Step 3: Place the contents;
- Step 4: Select and apply illustrations.

Breaking down the card creation process into separate moments focused on specific activities allowed for the reduction of the user's cognitive overload – a requirement identified in the literature review regarding the research's target audience. This initial definition of the stages matured as the high-fidelity prototype of the tool was designed, as it will be explained in the next section.

High-fidelity prototype

Based on the initial sketches, literature review, related work and exploratory interviews' results, a high-fidelity prototype was designed, integrating the insights gathered until the

moment. As Henry (1998) mentions, the second of a UCD process is to design the UI (cf. *Definition of User-centred Design* section).

Before presenting the designed screens from the high-fidelity prototype, it was helpful to understand the user's flow within the tool. Therefore, a user flow (Figure 41) with the high-fidelity prototype screens was created, aiming to provide a clearer representation of the interaction process.
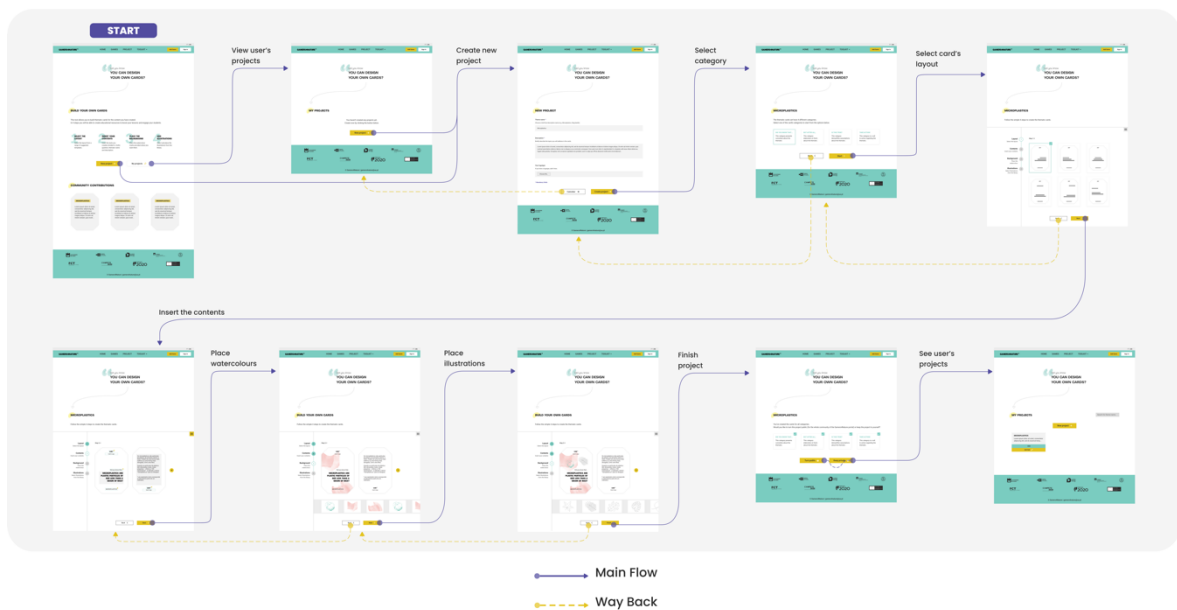
Figure 41 – Gamers4Nature tool's user flow

The flow essentially works as the following: (1) initial page, presenting the tool's purpose and goals; (2) create a new project **or** see user's projects; (3) select thematic card's category – "Did you know that…"; "But after all,"; "Is it true?"; "Take action!"; (4) select a template-layout; (5) insert the developed contents[48]; (6) place watercolour marks; (7) place illustrations; (8) after creating cards for all the categories, finish the project; (9) go back to the user's projects page.

It is important to mention that, in the aim of this research and as an initial proposal, the cards' creation process was designed and developed as a linear process (i.e. the user creates the card sets and after finishing the creation is allowed to edit any of the stages). Further flexibility in this creation process is considered for future work.

---

[48] From the researcher's and the G4N research team's empirical experience when hosting game jam events in partnership with other entities, contents were created before being adapted to the cards' layout.

This user flow contemplates some changes concerning the initial definition of the <u>cards'</u> <u>creation stages</u>. The initially defined as step 2 is now step 3, which means that the contents are placed before the watercolours (Table 4).

Table 4 – Before and after cards' creation stages

Step	**Before** (initial definition)	**After**
1	Select a template from a range of layout options.	Select a template from a range of layout options.
2	Watercolour composition.	Insert contents.
3	Place the contents.	Place watercolour marks.
4	Select and apply illustrations.	Place illustrations.

These changes established two different steps of the creation process, avoiding blending two distinct concerns: contents and aesthetics. Steps 1 and 2 are focused on composition and insertion of contents, while Steps 3 and 4 are related to aesthetic purposes - decorating the cards with watercolours and positioning the illustrations.

First impressions have a deep impact in the user's experience and in the UI design. They are connected to the perception of aesthetics, usability, and credibility (Fessenden, 2017). Therefore, it is essential to provide the tools that allow users to quickly engage with the system, thus preventing them from abandon the system (Shneiderman et al., 2018, p. 288).

Considering that the first impression of this tool is given when the user first accesses the "Build your own cards" menu, on this page – and within first interactions – a brief and clear explanation about that subject is presented (Figure 42), so the user can understand the purpose of the tool. To display the description and start conveying the idea that the card's creation process is carried out in steps, it was applied the same visual composition approach already present in the "Toolkit – How to use" page[49].

After the description, the user can see the thematic cards already developed within the G4N users' community (Figure 42), identified with the thematic name, which is visible on the yellow

---

[49] http://www.gamers4nature.pt/toolkit.php?lang=EN, last accessed on June 17, 2021

label. The design approach to display the thematic cards' projects is similar to the one adopted on the "Games" page[50].
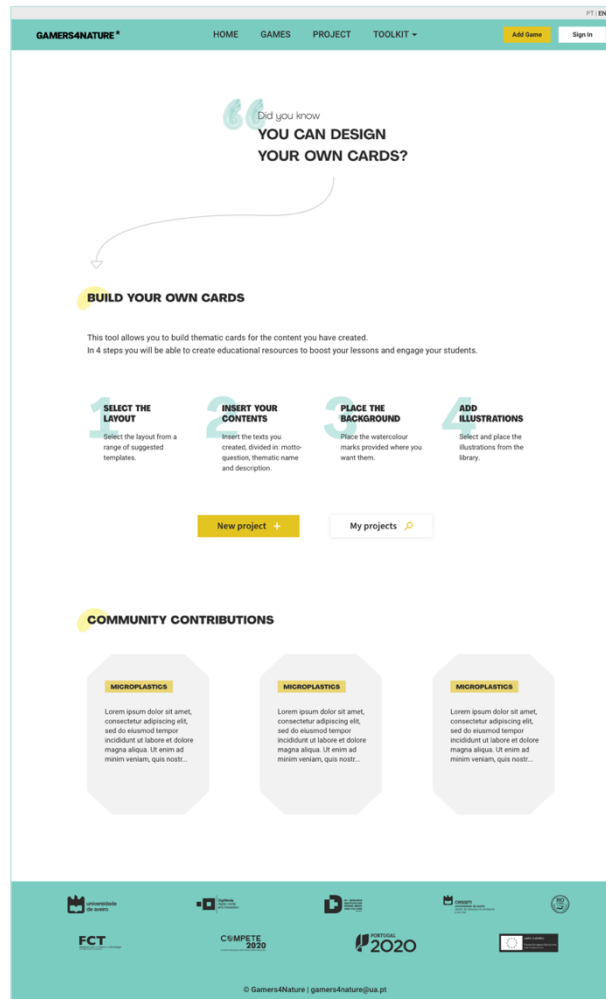
Figure 42 – Gamers4Nature tool: "Build your own cards" page

From this point, the user can either **create a new project** or **view his own projects**. If the users choose to view their projects, they can also, from there, choose to create a new project without needing to return to the previous page. The button to create a new project is always available – after the user has logged in to the account – to make this action accessible, even if the user already created any projects (Figure 43 – (b)).

When the user has not yet created any project, the tool provides a feedback message saying: "**You haven't created any projects yet. Create now by clicking the button below.**" (Figure 43 – (a)). This message not only provides feedback but also encourages the user to start

---

creating. Moreover, and aiming to create a fluid and intuitive navigation, the message points out the direction through which the user should follow – "**clicking**" and "**below".**

(a) User's projects page: The user has not yet created any project.	(b) User's projects page: The user has created one project.
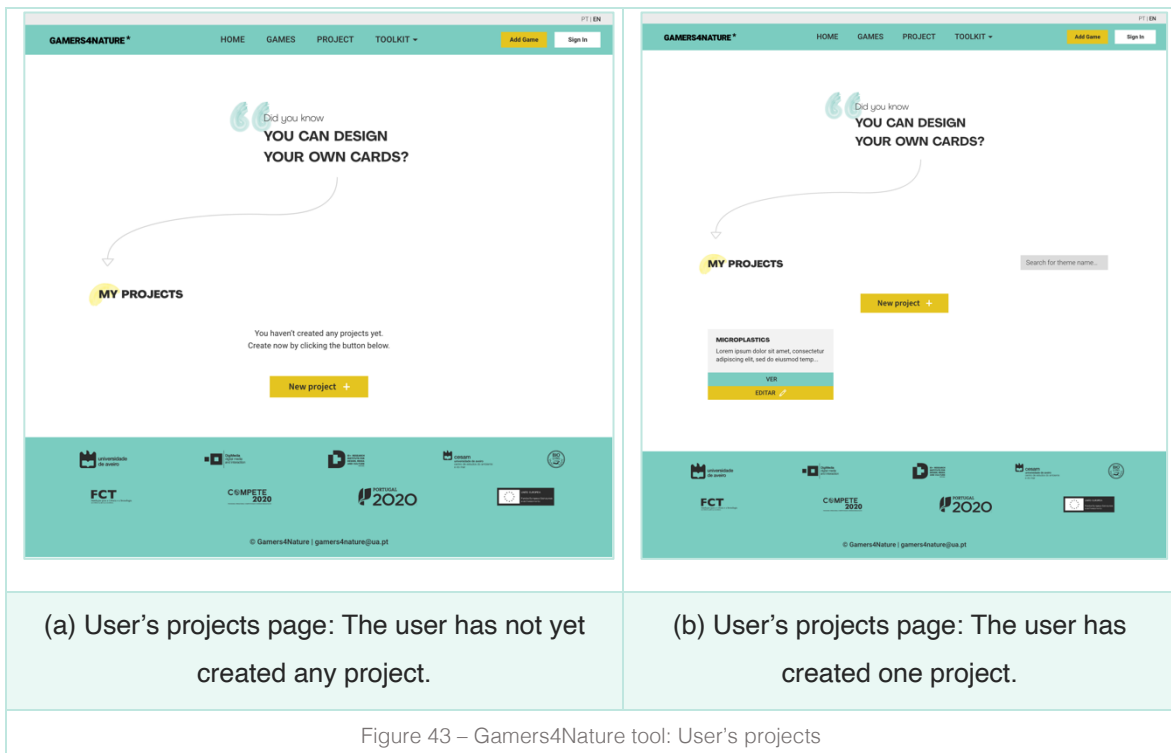
Figure 43 – Gamers4Nature tool: User's projects

Creating the Thematic Cards

When starting to create a new set of cards, the user must fill in the cards theme name, a short description of its content and must add the logotype of its project, school, university or other (Figure 44).

Each input field has a title, a description of what is expected to be written/filled in and a placeholder to assure the user fills the requested information and to address accessibility concerns. Moreover, to provide the users with feedback about their actions, the submit button ("**Create project +**") has two different states: (1) a disabled state (Figure 44 – (a)), where the button has tones of grey, applicable to when the inputs are empty; and (2) an active state (Figure 44 – (b)), where the button has the original colours, to when the user finishes filling the inputs.

In addition, the fields are all marked with an asterisk, which indicates the mandatory fields so the user understands that all inputs must be filled.

(a) Form with empty input fields	(b) Form with filled input fields

Figure 44 – Gamers4Nature tool: Create a new project
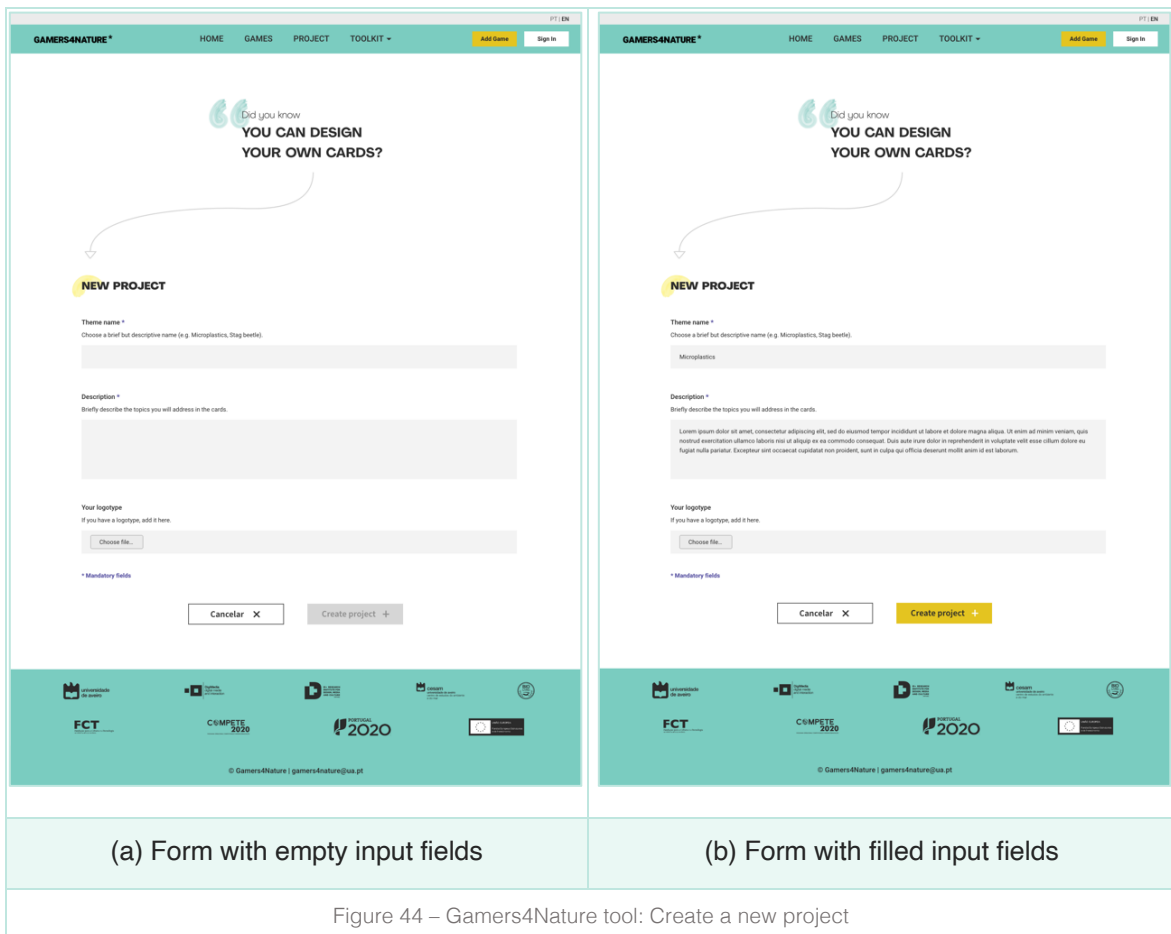
After filling in the information, the user must choose the first category to start creating the cards set. Each category is contained in a white box with an external shadow and displays the category name and description. When the user selects an option, the option box is limited by a coloured outline to identify what was chosen (Figure 45).

When the user finishes creating a set of cards for a particular category, that category is marked by a check icon - identifying it as completed (Figure 46 – (a)). Once all categories are finalised, the user has the option to choose whether to keep their project **public** – for all users to see -– or **private** (the default mode) – to keep it to themselves (Figure 46 – (b)). Between these two screens, not only buttons change – as explained before – but also the copywriting, presenting the actions users can perform next.

In terms of the applied copywriting, particular concern was taken to create concise (Shneiderman et al., 2018, p. 288) and light texts that allow easy understanding and clear communication. Considering that the portal-repository was designed essentially to promote students to share their games, the adopted copywriting was informal – suitable for that audience. Consistently, the same approach was followed for the tool.
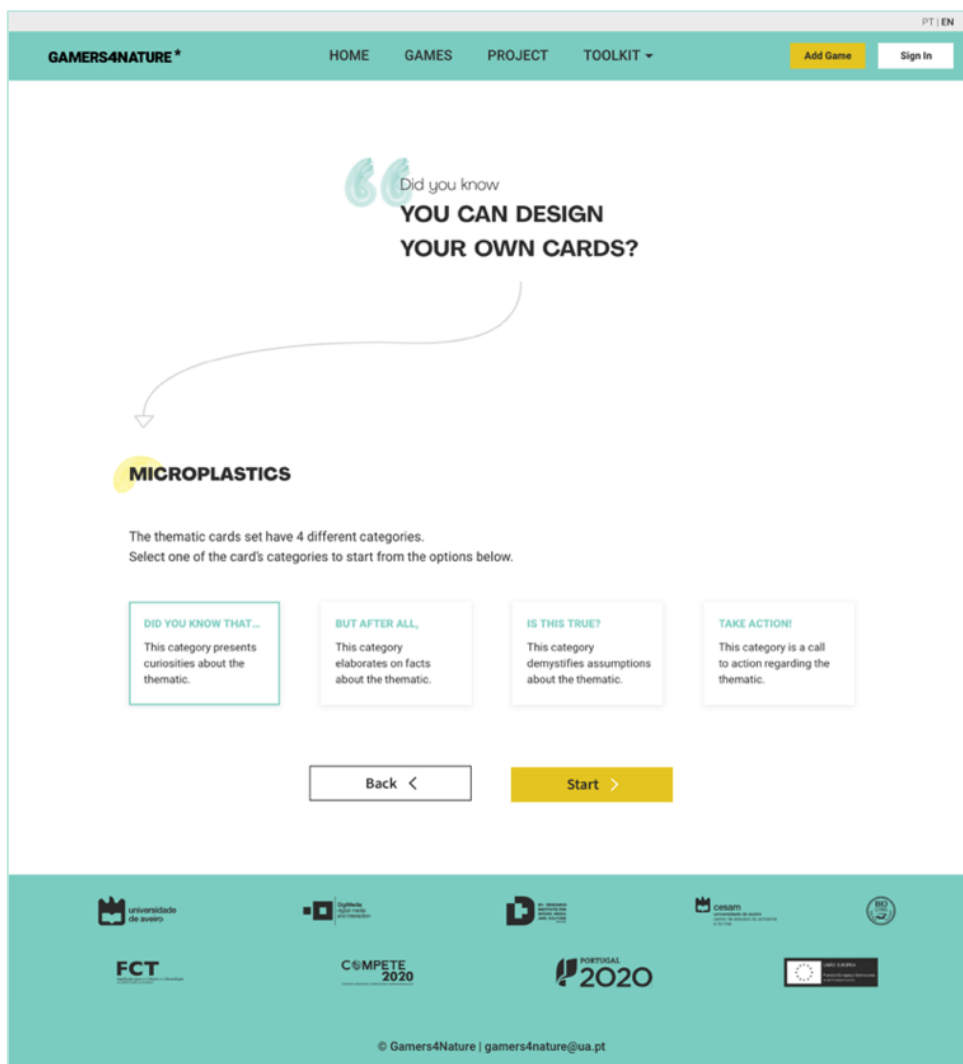
Figure 45 – Gamers4Nature tool: Select category

(a) Representation of the UI with one category finalised	(b) Representation of the UI with all categories completed
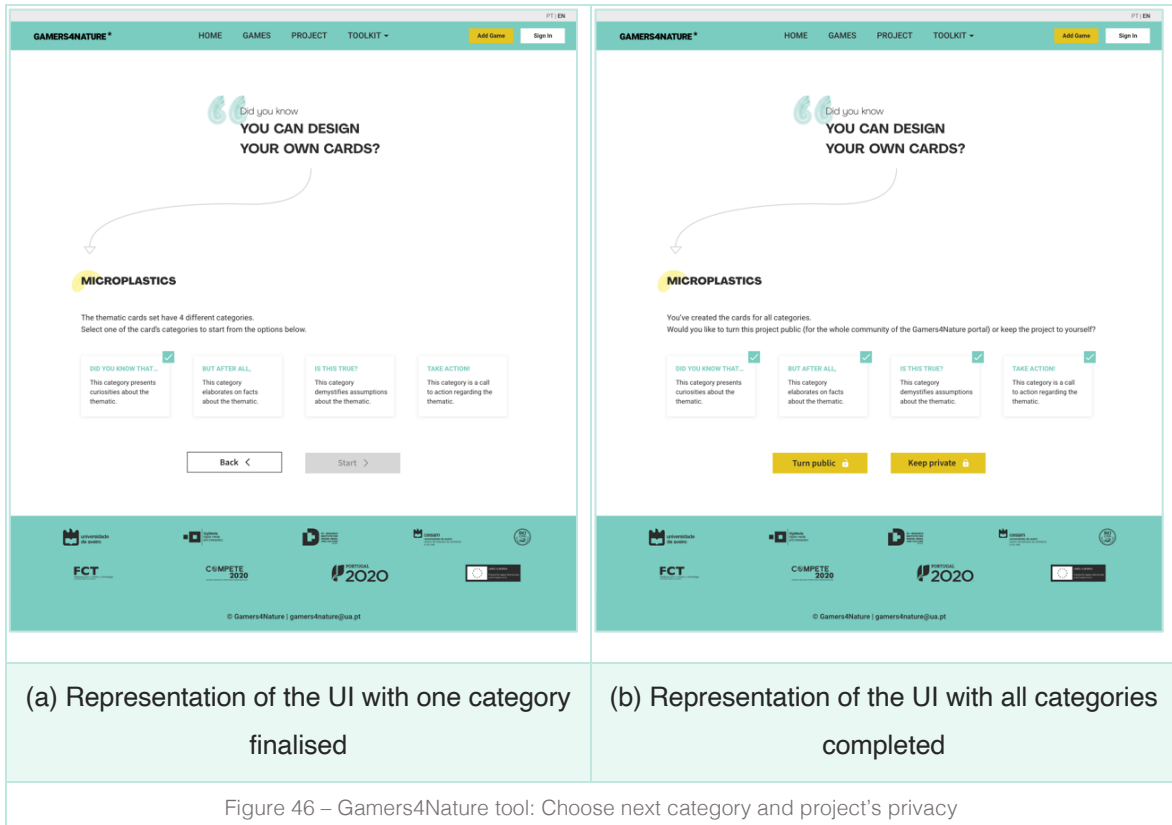
Figure 46 – Gamers4Nature tool: Choose next category and project's privacy

On Step 1 (Figure 47), the visual appearance changes slightly, making it possible to distinguish that the user is now in a new section of the portal and inducing a new interaction paradigm. The tool is embedded in an area outlined by light grey lines to create a workspace, but without designing an overly strict and rigid block that would break the fluidity and minimalism of the portal. This allows the canvas to have, throughout the next steps, a **dedicated workspace** – as acknowledged during the literature review (cf. *General characteristics of canvases* section).

That area is divided into two main columns: (1) the left-side column displays the steps that comprise the cards' creation process; and (2) the right-side column is where the user's decisions will effectively occur, i.e. the place where the user will create their thematic cards.

Each of the steps is identified by number, title, and brief description to provide feedback and situate the user within the navigation. To enhance this feedback mechanism, the numbers of the steps are visually distinct depending on the current user's step: the current step is represented by a coloured border and number on a white background (Figure 47); the next steps are represented in grey, similar to the disabled buttons of the UI, as they will only be available at a subsequent moment (Figure 47); a previous step (Figure 48 – (b)) – finished – is represented with a blue background and the number with the colour used for texts and titles (#2B2B2B).

Additionally, on the right-side column, before the contents, is presented a redundancy indicating and clarifying the user's current step – "**Step 1**/2".

(a) Available layout options	(b) One layout option selected
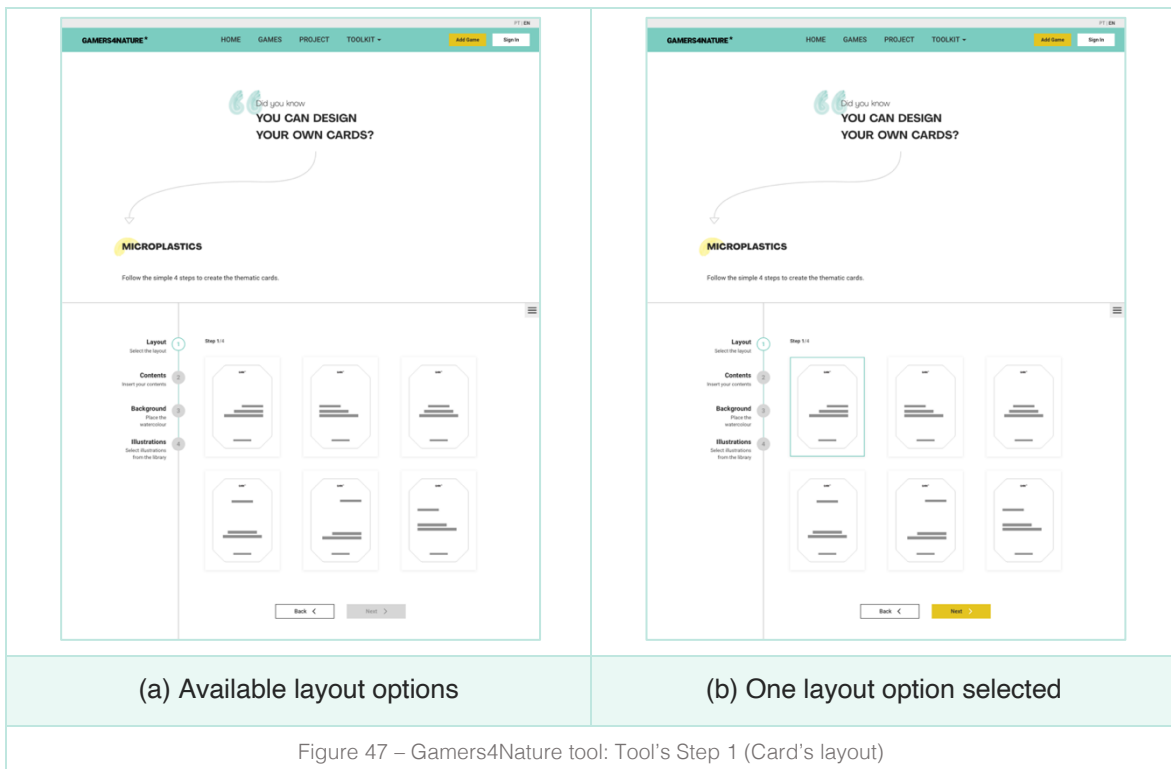
Figure 47 – Gamers4Nature tool: Tool's Step 1 (Card's layout)

Regarding this step, a set of layout options are presented (Figure 47 – (a)), so the user chooses the layout to apply to the cards of the category selected in the previous step - still in the process of creating a new project. The selected option (Figure 47 – (b)) is represented in the UI similarly to when the user selects a category, which provides consistency to the design.

In the literature review and related work, it was observable that several tools featured onboardings, tutorials and help menus. Seeing this as a pattern recognised among users and identifying this as an aid for novice users, the tool integrated contextual hints (i.e. varying according to context – Figure 48 – (a) and (b)) that pop up when the user begins a new step. These hints – which the researcher calls tooltips – were thought through carefully to avoid user cognitively overload, as advised in the literature (cf. *Suggestive Interfaces* section). For this reason, the tooltips pop up in the user's first interaction with the tool and, at any time, can be deactivated. Moreover, in the following steps (Figure 48 – (b)) – where the user can navigate between several cards –, to avoid those tooltips from becoming annoying or insistent and the user impulsively hides them, the tooltips only appear in the first card of the navigation (i.e., when the user creates several cards, the tooltips only appear in the first one).

(a) Tooltip is Step 1 – Layout	(b) Tooltip in Step 2 – Contents

Figure 48 – Gamers4Nature tool: Choose next category and project's privacy
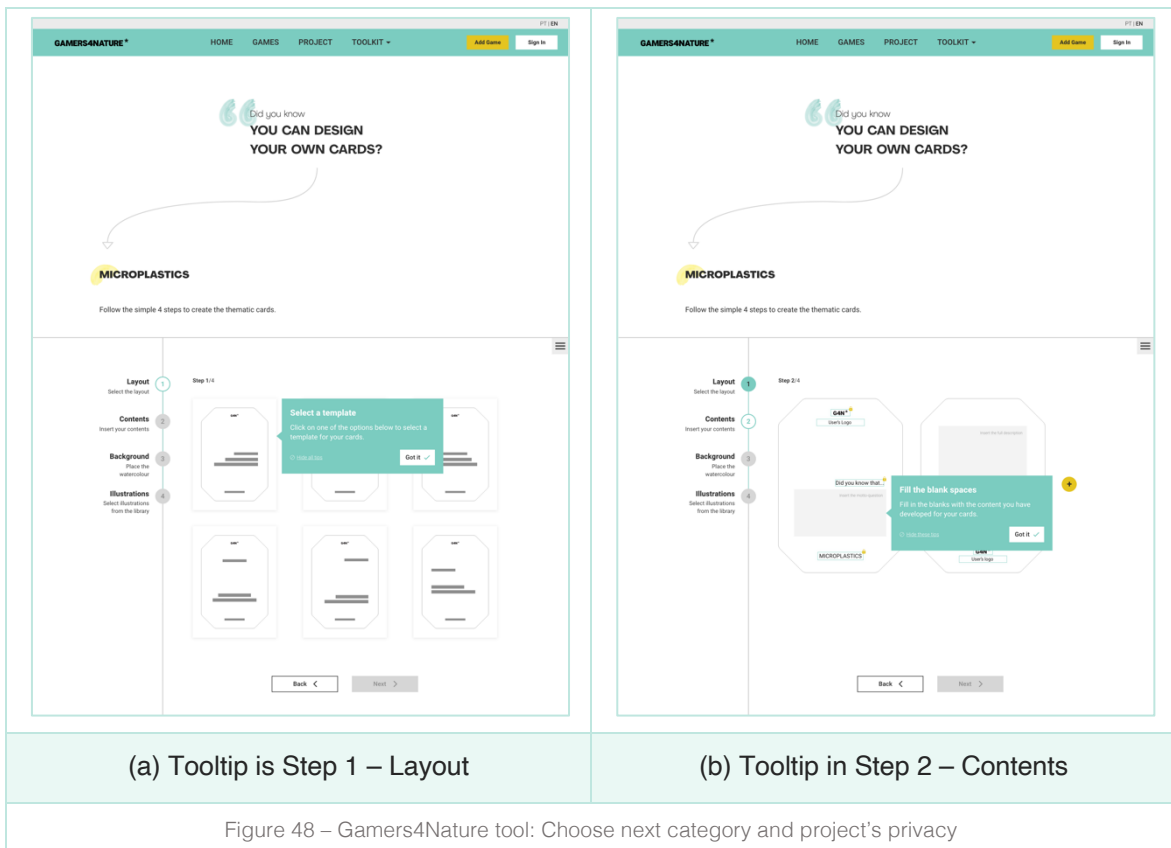
All tooltips have a closing button – "**Got it**" – and have another to permanently hide all the tooltips – "**Hide all tips**". Both buttons are associated with an icon that emphasizes the text's meaning – a check icon and a stop sign icon, respectively.

Moving forward to Step 2, the user is presented with the card's layout (Figure 49). This step clearly allows to distinguish the concepts of personalisation and customisation introduced in the theoretical framework (cf. *Customisation versus Personalisation* section).

On the one hand, personalisation, driven by the computer, allows the user to be presented with a card containing the layout selected in Step 1 and the logotype added while creating a new project – this is a clear representation of a system adapting itself to the user's needs (cf. *Personalisation* section).

On the other hand, customisation is introduced through the modifications that the user may, throughout this process, carry out on the cards, ranging from inserting the contents to adding watercolour shapes and illustrations. This provides the user with a sense of control over the content he produces (cf. *Customisation* section) and allows to convey the user's personality – mentioned as relevant by a teacher during the AXE (see *Results* section).

(a) Simple sidebar – icon only	(b) Extended sidebar – icon and text
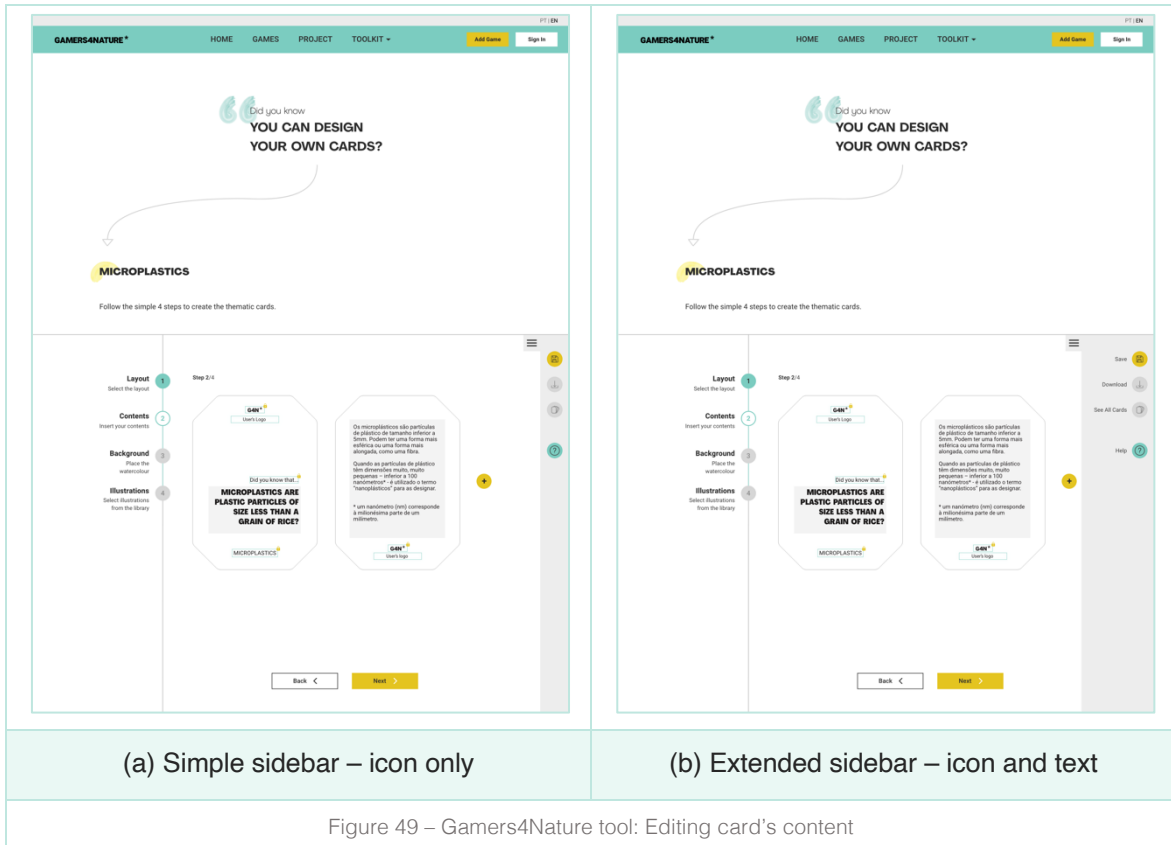
Figure 49 – Gamers4Nature tool: Editing card's content

In Step 2, the user can finally add the contents to the cards. According to the initial sketch and prototype, in Figure 49 can be visualised locked elements, such as the G4N logotype and the theme name, as well as editable areas – represented by the grey blocks and customisable by the user – where the user can insert the contents.

Furthermore, on this screen, there is also a sidebar menu containing four buttons: save the cards set; download the cards set; see all the cards (Figure 50); and help. The buttons for the cards' download and visualisation are unavailable at this time, as these screens represent a scenario in which the user has not yet created at least one card.

To address accessibility concerns and assure the accurate interpretation of the iconography meaning, once the user puts the mouse over one of the sidebar icons (Figure 49 – (a)), the icon description appears (Figure 49 – (b)). The description is placed on the left side of the icons to avoid disrupting the user's interaction.

On this screen, it is possible to view the add card button – a plus **icon** – which is on the right side of the canvas. Every time a card is added, a new canvas loading an empty card is created, containing the G4N and user's logotypes, and the theme name. Moreover, as identified during

the literature review, this tool uses icons on the canvas workspace (cf. *General characteristics of canvases* section).
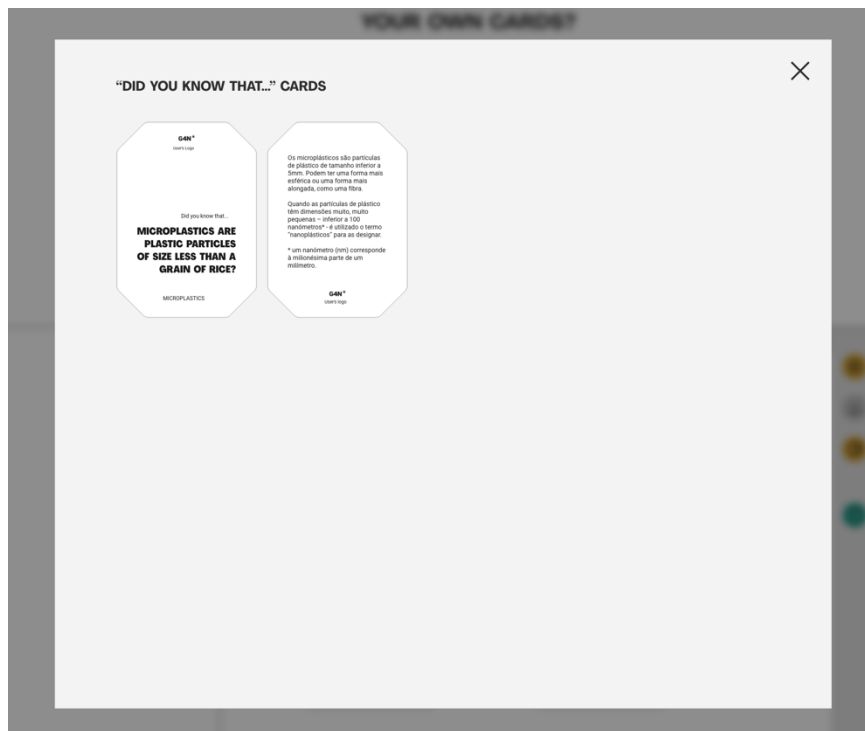
Figure 50 - Gamers4Nature tool: Modal window to visualise the created cards on the current category

When the user clicks to visualise the created cards, a modal window opens (Figure 50) with a slightly transparent and blurred background providing the user's location within the navigation.

In Steps 3 and 4, the canvas no longer contains the editable text areas displayed in Step 2. Instead, the UI displays a horizontally scrollable toolbar from which the user can **drag** watercolours (Figure 51 – (a)) or illustrations (Figure 51 – (b)) and **drop** them onto the canvas. The user can add as many elements as desired and navigate between cards, repeating the decorative process as deemed necessary, by clicking the navigation icon represented by the arrow to the right.

Just as the dedicated workspace and the usage of icons, the "drag and drop" is also a feature from canvases applied to this tool (cf. *General characteristics of canvases* section). The integration of these universal features of the canvas allows for a fluid flow of interaction, as the user may, at some point in their experience with technology, have dealt with these or similar metaphors.

(a) Representation of Step 3 – Watercolours   (b) Representation of Step 3 – Illustrations
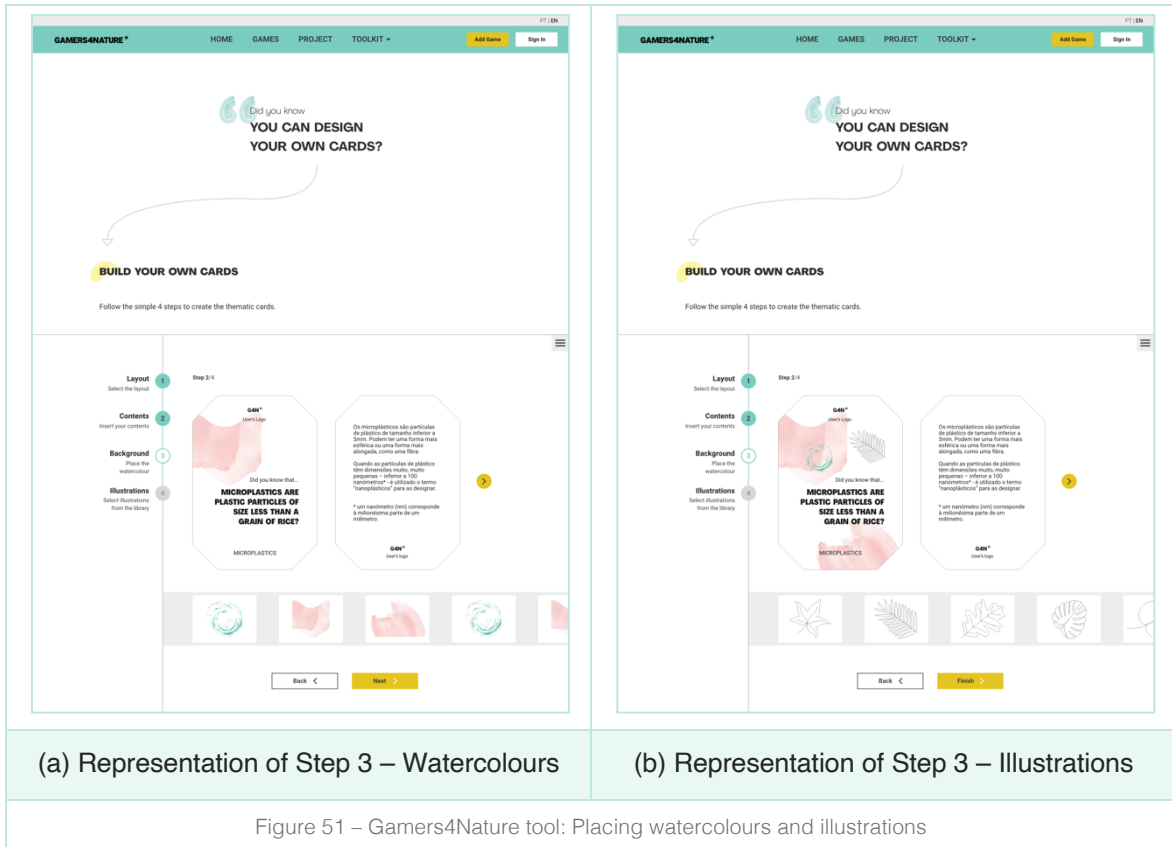
Figure 51 – Gamers4Nature tool: Placing watercolours and illustrations

The toolbar applies the principles of Affordance by creating clues that induce the user to drag the toolbar horizontally (cf. *Affordances and Signifiers* section), namely by slightly cutting one of the slider's elements (Figure 51).

After finishing the card's aesthetics, the user can close this category by clicking the button "**Finish**". The user can also return to previous steps and edit the cards by clicking on the button "**Back**", without losing any of the progress – since it is being automatically saved.

Adjustments to the Functional Requirements

Derived from the high-fidelity prototype design and after understanding the user's flow, some functional requirements (cf. Table 3) were removed, namely "See objects in layers" (FR 10), "Show suggestions based on user's current layout" (FR 12) and "Customise colours" (FR 13).

The option of showing objects by layers was withdrawn because despite layers integrate some LDTs, it adds unnecessary complexity to a process that aims to reduce the user's cognitive overload. However, as it will be seen further, this tool will employ layers, they are just not visible to the user – that complexity relies on the system itself.

In addition, the functionality of displaying layout suggestions based on the user's current layout was overhauled. Having as an essential principle the compliance with the G4N standards manual, leaving the layout entirely open for manipulation by the user, could result in outputs that deviate excessively from the graphical line.

Finally, colour customisation was not applied in the high-fidelity prototype, as it was intended that the user would use the project's colour scheme – considering the same principle mentioned above. Furthermore, the provided watercolour options have the project's colours, and the user is free to combine those colours as desired.

II. Development

This section depicts the tool's development process, starting from a brief analysis of Canvas' technology frameworks, followed by an overview of the first tests with the chosen framework, a contextualisation of the portal's and tool's database, and finally, a description of the development process itself and some limitations found during that process.

Technological approach

After validating the high-fidelity prototype with the G4N project team, the researcher performed a search on JavaScript libraries that integrated the HTML5 Canvas API. On Mozilla's technology documents, the researcher found a set of libraries that integrate the Canvas API[51].

From the available list, the researcher narrowed the analysis to frameworks that fulfilled the principal requirement of integrating a bidimensional canvas able to be manipulated by the user. The analysis settled on comparing each framework to a set of requirements, which are identified in the first column of the table (Figure 52).

	Framework							
	Easel.js	Fabric.js	Konva.js	p5.js	Paper.js	Pts.js	Scrawl-canvas	Zim.js
2D Canvas	✓	✓	✓	✓	✓	✓	✓	✓
Place objects on the canvas	✓	✓	✓	✓	✓	✓	✓	✓
Supports SVG		✓	✓	✓	✓			
Drag-and-drop		✓	✓				✓	
Group and manipulate objects (e.g. move, resize, rotate)		✓	✓					
Export to PDF		✓	✓					
Export canvas in JSON		✓	✓					

Figure 52 – Canvas Framework's Analysis

---

[51] https://developer.mozilla.org/en-US/docs/Web/API/Canvas_API, last accessed on June 18, 2021

The frameworks analysed where: Easel.js[52], Fabric.js[53], Konva.js[54], p5.js[55], Paper.js[56], Pts.js[57], Scrawl-canvas[58], and Zim.js[59].

From this analysis, it was acknowledged that most of these frameworks are essentially focused on creating static scenarios, did not support SVG images or had options to export to PDF and JSON files. Therefore, for fulfilling all the requirements, Fabric.js and Konva.js were the disputed options.

The last analysis parameter was based on the framework's documentation. It was important for the research to work with a well-document framework to aid a fast-learning curve, given the time available to implement the tool. Even though Fabric.js seemed a flexible framework that fulfilled the requirements, when compared to Konva.js, its document was not as clear and intuitive. Furthermore, Konva.js, besides being a well-documented framework, also has a very supportive lead programmer and creator that assists the framework's user-programmers assiduously on the Konva.js website. The final choice was **Konva.js** due to the reasons previously mentioned and since the research has experience working with JavaScript and other frameworks.

Furthermore, it was verified the compatibility of multiple browsers with the CANVAS element to assure it was accessible through multiples device's browsers (e.g. Apple - Safari, Android - Google Chrome). Based on the information provided by the website "Can I use..."[60] (Figure 53), it was acknowledged that CANVAS was supported by all the latest version of web browsers and the majority of older versions, excepted Internet Explorer v6-8.
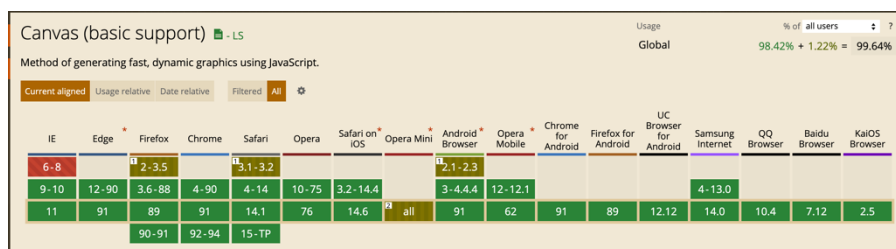
Figure 53 – Canvas basic support by web browsers (retrieved from "Can I use…", 2021)

[52] https://www.createjs.com/easeljs, last accessed on June 18, 2021

[53] http://fabricjs.com/, last accessed on June 18, 2021

[54] https://konvajs.org/, last accessed on June 18, 2021

[55] https://p5js.org/, last accessed on June 18, 2021

[56] http://paperjs.org/, last accessed on June 18, 2021

[57] https://ptsjs.org/, last accessed on June 18, 2021

[58] https://scrawl.rikweb.org.uk/, last accessed on June 18, 2021

[59] https://zimjs.com/, last accessed on June 18, 2021

[60] https://caniuse.com/?search=canvas, last accessed on June 20, 2021

First tests with the framework

After choosing the framework to develop the tool, the research ran a few tests to assure the framework indeed fulfilled all the requirements.

The first test conducted consisted of testing how the framework worked, namely how to create the canvas and how to instantiate elements inside the canvas (Figure 54).
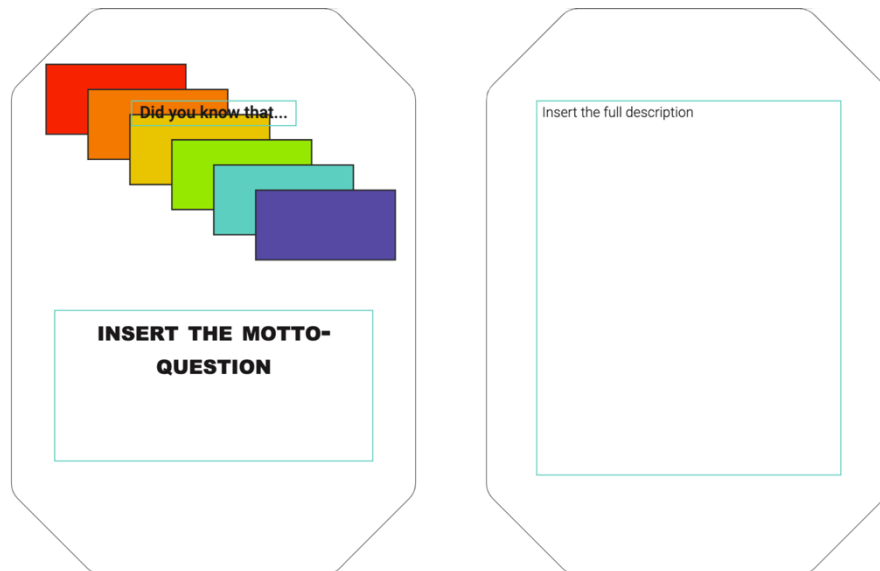
Figure 54 – First test using Konva.js with the Gamers4Nature font and layout

Then, it was tested the compatibility with the fonts used in the G4N project (i.e. *Heebo* and *Agrandir Variable*). Hence, it was perceived that the framework does not support variable fonts, such as *Agrandir*, and for that reason, the motto-question field applied *Heebo Black* to maintain consistency with the other text fields.

In addition, other tests were made, namely to understand the layering method, the canvas generating a JSON code and restoring from that code, and, finally, exporting the canvas to PDF format. Regarding the export, since the purpose of the research is to provide the user with a file to print the physical artefact (i.e. the cards), several export formats and measurements had to be attempted until the real size of the cards in the exported file could be achieved.

Database

To provide a fluid process with dynamic information for the creation of thematic cards, a database was designed to store the required data. Being the tool an integrated section of the

G4N portal-repository, its database is also connected to the portal's database – through the *users* table. Figure 55 presents a scheme of the tool's database and its connection to the portal's database – built in MySQL.
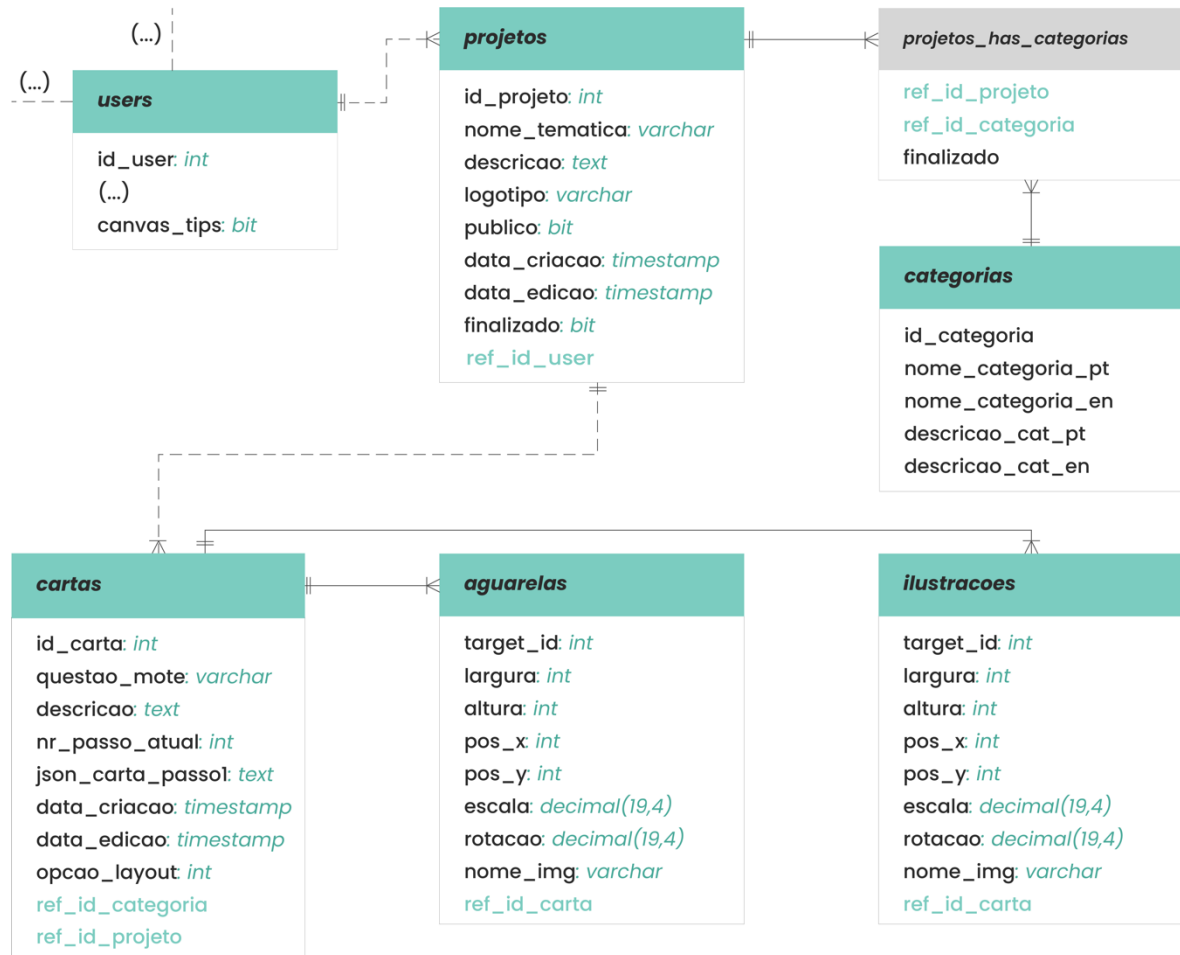
Figure 55 – Gamers4Nature tool database

The *users* table belongs to the portal's database and stores users' data. In the concern of the tool, a column was added, namely the *canvas_tips*, which allows checking if the user wants to be shown the tooltips or has them hidden. The *projetos* table stores all the data regarding the cards' creation process and is connected to all other tables that store other information, such as the cards' text contents (*cartas* table), watercolours (*aguarelas* table) and illustrations (*ilustracoes* table).

The portal-repository is available in two languages – Portuguese and English. The texts of both languages are stored in the header document inside a PHP Associative Array[61].

---

[61] https://www.w3schools.com/php/php_arrays_associative.asp, last accessed on June 20, 2021

Accordingly, the tool also encompasses a bilingual scheme, which is visible in some database tables, such as the *categorias* table that stores the category name and description in both languages. This allows both the portal and the tool to achieve a larger audience.

Development process

The G4N portal-repository is hosted in the University of Aveiro's servers[62], so due to the limitations imposed by the University's IT services, the range of possible technological approaches was narrowed. Therefore, the portal was developed using HTML5, CSS, PHP, and JavaScript (pure and frameworks – jQuery).

Before approaching the development itself, it is important to understand how Konva.js works. The Konva.js basis is a **stage** (Konva.Stage), which is instantiated inside an HTML **canvas** tag[63] (Figure 56). Inside the stage are created **layers** (Konva.Layer) to enclose the **shapes** (Konva.Shape). The shapes, which can be images, text, or transformers, can be grouped (Konva.Group) or instantiated alone. The recommended number of layers is three to five, so it is advised to **group** shapes and layers since the more layers the stage has to render, the more the performance may drop.
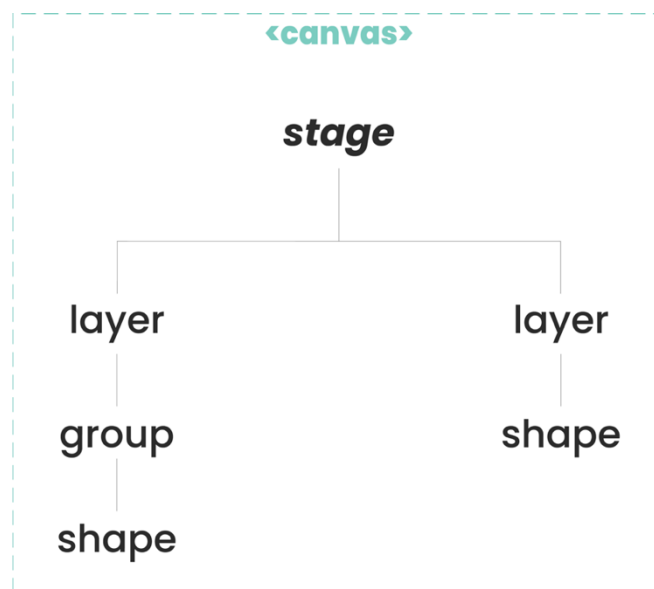
Figure 56 – Konva.js node hierarchy[64]

---

[62] http://www.gamers4nature.pt/index.php?lang=EN, last accessed on June 20, 2021

[63] https://www.w3schools.com/html/html5_canvas.asp, last accessed on June 20, 2021

[64] https://konvajs.org/docs/overview.html, last accessed on June 20, 2021

There are also **transformers** (Konva.Transformer)[65] that allow manipulating canvas' shapes, namely resize, rotate, or scale, through anchors – customizable in shape and amount inside the transformer's attributes. The anchors can be adapted to a shape (nodes: [circle]) or can be customised by the programmer (enabledAnchors: ['top-left', 'top-right']).

All elements enclosed within the canvas have to be added to the stage in order to be displayed (e.g. stage.add(layer)). Moreover, each node can receive attributes (e.g. X and Y position, width, height, font settings) when created (e.g. new Konva.Shape – Figure 57), and a name can be given to identify the shape to perform any action at any moment. As an optimal and neat code principle, all the canvas' elements were given names in English in the CamelCase format, thus facilitating their identification and structuring the whole development logic.

```
var categoryNameTxt = new Konva.Text({
    x: catTextPosX,
    y: catTextPosY,
    name: 'categoryNameTxt',
    width: 150,
    height: 10,
    fontSize: 16,
    text: catText,
    fill: '#1A1818',
    align: textAlignment,
    fontFamily: 'heb-light',
    draggable: false,
});
```

Figure 57 – New Konva.Text with attributes

The attributes also allow to define if the canvas' element is draggable, through a Boolean state – true or false –, and the stage is responsive[66] (i.e. adapts to the window's width).

The tool was developed based on the high-fidelity prototype design (cf. *High-fidelity prototype* section) and functional requirements (cf. *Tool's Requirements* section). Nonetheless, derived from some constraints of the programming languages used, the design had to be adapted in some points.

In Figure 58, the steps are not placed over the vertical grey line, instead, there is a clear division of the informational block – the left – and the creative block – the right. Visual hierarchy is a design principle conveyed by grouping elements by proximity or gathers common regions

---

[65] https://konvajs.org/docs/select_and_transform/Transformer_Styling.html, last accessed on June 20, 2021

[66] https://konvajs.org/docs/sandbox/Responsive_Canvas.html#page-title, last accessed on June 20, 2021

together (Gordon, 2021). Moreover, by experiencing the workflow and exploring the Konva.js documents, the researcher understood that it made more sense to identify the editable areas with the coloured borders and the other areas (i.e. the G4N and the user's logotype, and the category name) marked by the absence of borders or background colours – as it was initially designed. The editable areas are bounded by a Konva transformer to allow editing the contents.
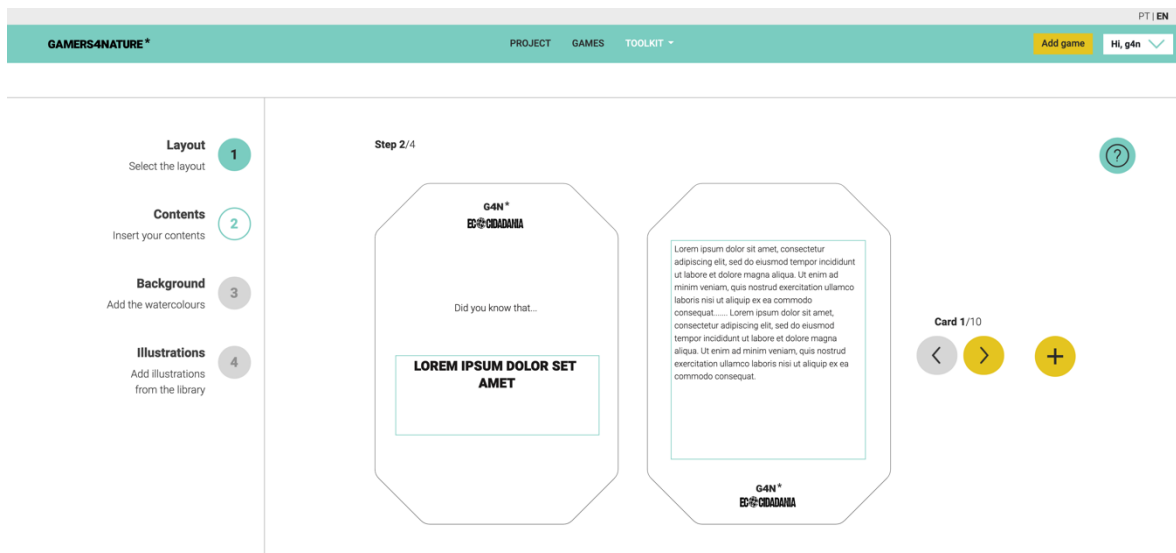
Figure 58 – Gamers4Nature tool: Step 2 – Design Changes

Inserting the user's contents

Based on the review performed with the G4N research team, the card's navigation arrows were added to this Step 2, so that the user was able to move between cards even before proceeding to Step 3; a label over the card's navigation arrows indicating the current card was also added.

Regarding the editable areas, the user must double-click the field to edit the text. When the field still has the placeholder text (i.e. "Insert the motto-question" or "Insert the full description", accordingly – Figure 59 – (a)), when the user double-clicks, the text is removed (Figure 59 – (b)) to avoid creating an unpleasant interaction where the user has to delete the placeholder text before pasting or writing its own.

The editable fields also have a limited number of characters. Once the user has reached that limit, it is no longer allowed to write any more characters.

The overall design adopts a minimalistic design, characterised by empty white spaces that allow the design elements to "breathe", fulfilling the "Aesthetic and minimalist design" Heuristic. The empty spaces also allow grouping similar contents and separate distinct subjects in the UI.

(a) Placeholder text before double-click	(b) Empty field after double-click

Figure 59 – Gamers4Nature tool: Card's editable fields
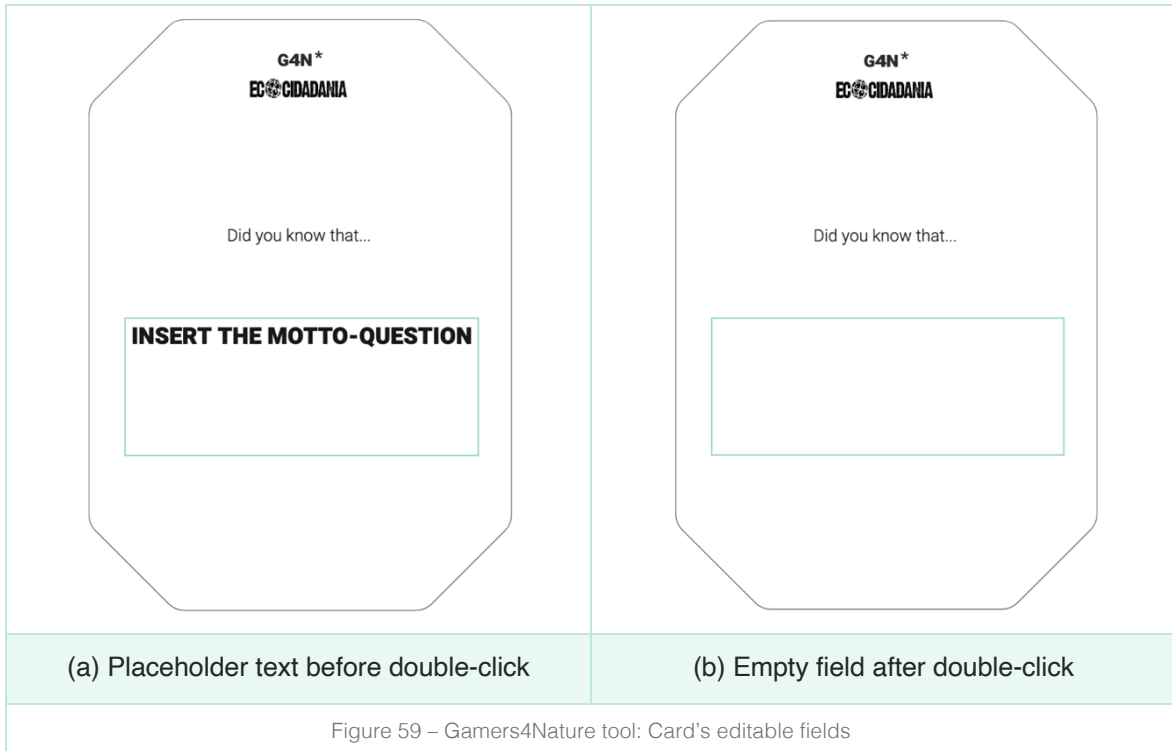
The framework has a few limitations that constrained development. Among them, to present a seamless text field that was visually similar to the output, the framework replaces the visible field (i.e. the coloured border) with an HTML <textarea> enabling the user to write the content (Figure 60). To provide this seamless interface, some amendments had to be made and tested to adjust the font size making it equal, or at least close, to the visual output.
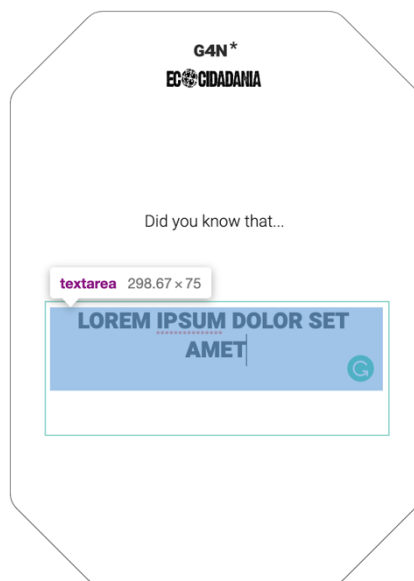
Figure 60 – Gamers4Nature tool: Text field replaced with textarea

The G4N logotype is placed into the canvas as an SVG path, as well as the card's shape. The logotype uploaded by the user is retrieved from the database where is stored the file name – derived from a function that generates random strings –, and placed within the canvas as a static image (PNG, JPEG, JPEG or static GIF).

Therefore, the stage is organised in the following layers: a layer that encompasses the category text, the motto-question, and the description; a layer that includes all the logotypes; and another that comprises the cards' shape.

The contents placed by the user in the transformers are uploaded to the database as String so that, when the user is navigating through the cards in Step 2, the latest modifications can be dynamically visualised. In Step 2, the contents are uploaded when the user either clicks to proceed to the next step, clicks on one of the navigation buttons, or adds a new card. To store the card, each layer is converted to JSON (e.g. categoryLayer.toJSON()) separately, and then, the layers are stored as a JavaScript array. The array is then uploaded to the database as a string. If the user tries to upload a card with empty fields, a warning is displayed (Figure 61).
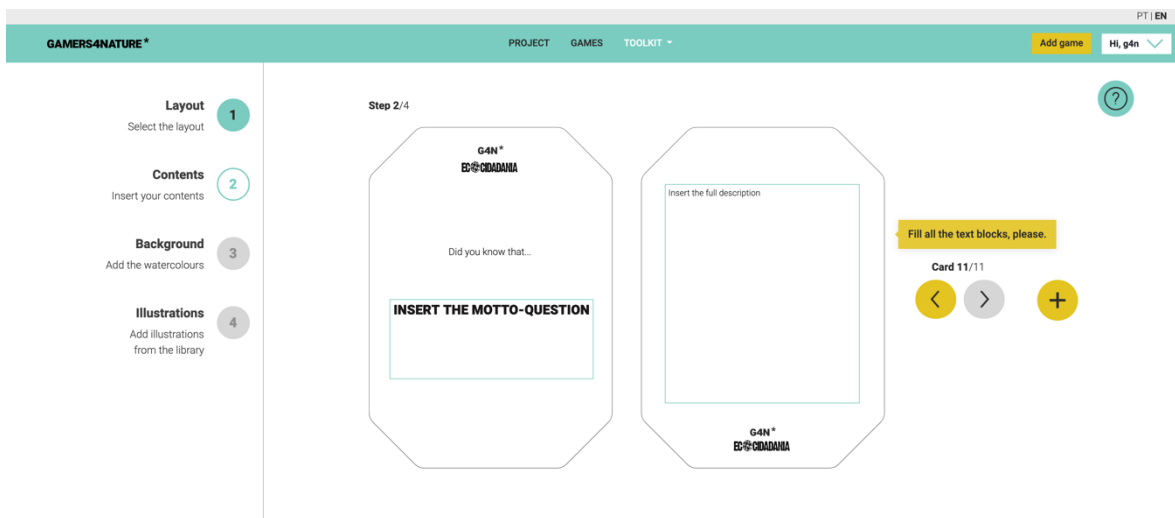
Figure 61 – Gamers4Nature tool: Empty fields warning

Working with pure JavaScript has some drawbacks. While pure JavaScript manipulates the real DOM[67], which means that to render different contents, the page must be refreshed, some JavaScript frameworks (i.e. React) use a virtual DOM – which replicates the real DOM – to perform changes without needing to refresh a page. Therefore, whereby the G4N portal uses pure JavaScript, the browser page must refresh to navigate between cards.

---

[67] https://www.w3schools.com/js/js_htmldom.asp, last accessed on June 20, 2021

To proceed between steps, the user is prompted with a modal asking to verify if all the changes were made to the cards (Figure 62). The dialogue modal adopts the scheme OK-Cancel, having the "Cancel" button on the right side, as most operative systems (Nielsen, 2008). Also, to distinguish between the "Ok, proceed" and the "Cancel" button, different colours are applied to ease that distinction.
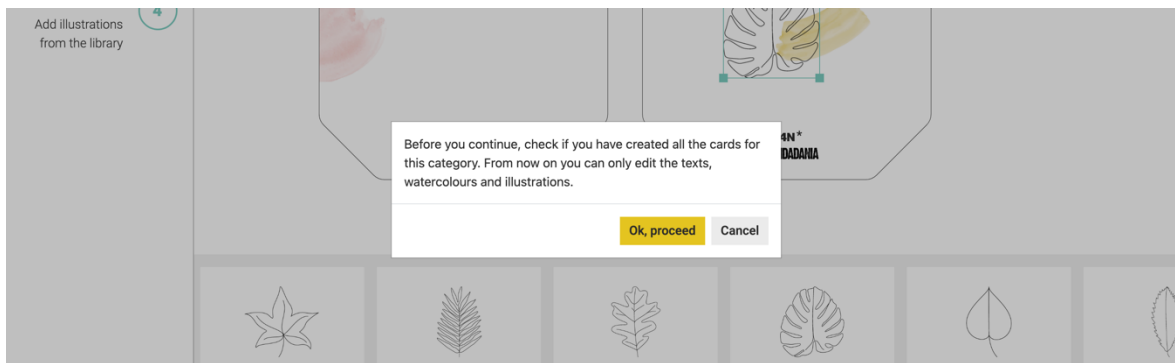
Figure 62 – Gamers4Nature tool: Modal before proceeding to next step

This establishes a "Match between system and the real world" – the second Nielsen's Usability Heuristic (Nielsen, 2020) – by replicating an interaction paradigm commonly applied in some operative systems that users use, and allows the user to recognise the interaction paradigm instead of learning a new way of interacting with the system – "Recognition rather than recall". The dialogue modal also recalls the "Error prevention" Heuristic since it checks, before the interface changes, that the user performed the desired actions.

Adding watercolours and illusttrations

Moving to Step 3, the user can place watercolour marks onto the canvas. The card's navigation arrows are in the same location and allow the user to move between cards to add watercolours to all the card enclosed in the cards set.

In Step 3, the card is retrieved from the database as an array, and the stage is loaded with JSON nodes of each array position by running a *for loop* to go through all array positions. The layers are added in the correct order: below are the cards' shape, followed by the G4N logotypes and, on top, the texts. The user's logotypes must be loaded separately since the JSON stage does not export images.

Furthermore, due to some technical limitations, the watercolours' layer must be placed over the texts (Figure 63). Sine Konva.js works with layers, the user can only drag and manipulate the top layer. If the text layer was on top, in the case of any watercolour was placed behind the text, the user could not manipulate it anymore because the user would not be able to reach it.
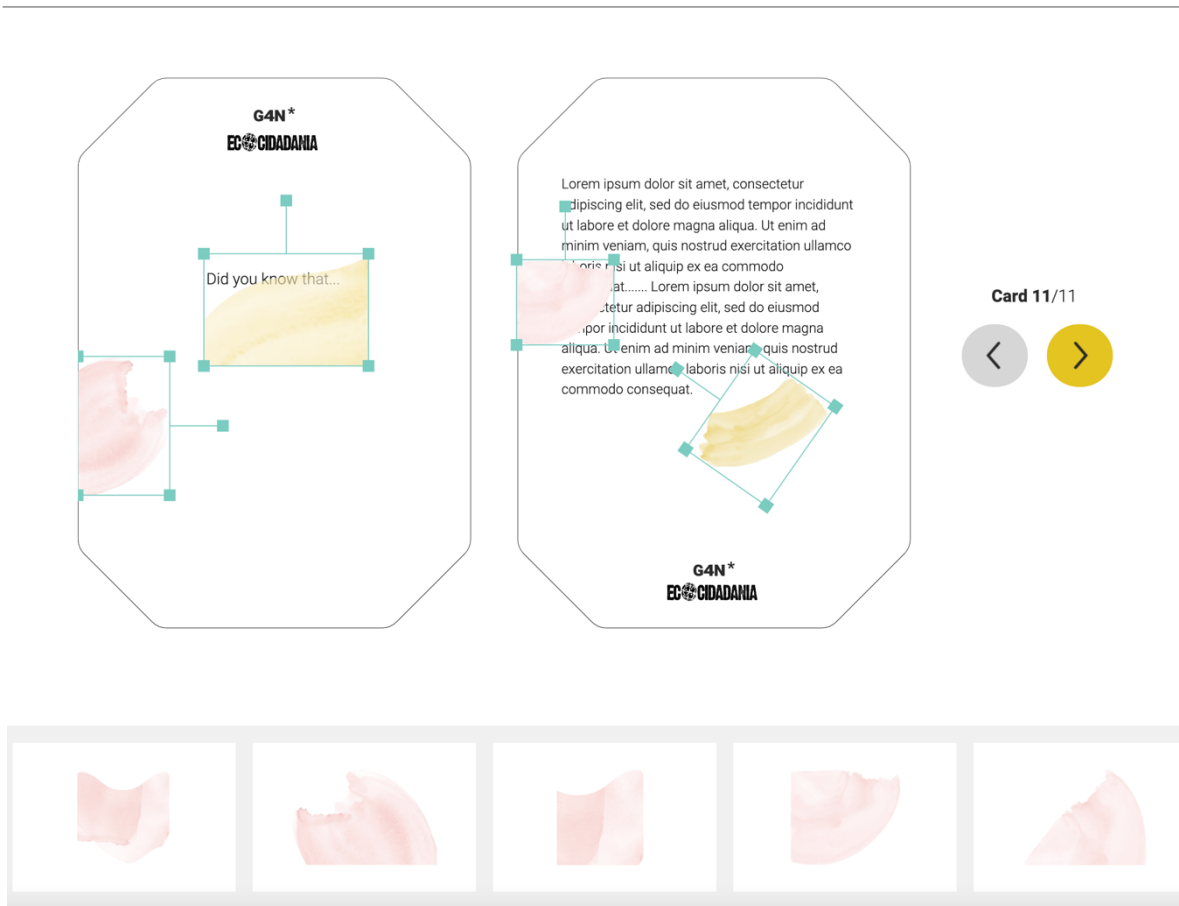
Figure 63 – Gamers4Nature tool: Step 3 – Watercolours

The solution found was that, in the next step, Step 4, the watercolours layer is switched to below the texts. Thus, the user is alerted, through a tooltip, that the watercolours are on a layer above only in this step, and that, afterwards, they will be switched to the layer below. The user is informed about this through the tooltip presented in Figure 64.

Figure 64 – Gamers4Nature tool: Tooltip about layers' organisation

Concerning the drag-and-drop designed in the high-fidelity prototype, when developing this feature, the researcher was faced with another limitation. The elements inside the canvas can be manipulated with drag-and-drop only if the draggable elements are inside the canvas. For this to happen, the watercolour toolbar would have to be inside of the HTML canvas element, which would imply that when exporting the canvas in the final step, the printable document would come with the toolbar. To avoid this situation, the lateral scroll toolbar has been included outside the canvas, and to select a watercolour, the user must click on the desired watercolour. After the click, the watercolour is placed on the canvas (always in the same coordinate: X – 20, Y – 120) the page scrolls smoothly to the canvas area and displays a feedback message to the user (Figure 65) – "The selected watercolour was added to the canvas". The message provides feedback and embodies the action performed in the back-end of the system – fulfilling the "Visibility of system status" Heuristic.

Figure 65 – Gamers4Nature tool: Feedback after the user adds a new watercolour to the canvas

Furthermore, by smoothly scroll the page back to the canvas framing, the system anticipates a user's need, which is to scroll up back to the canvas to manipulate the watercolour – "Anticipation" is one of the principles of Interaction Design (Tognazzini, 2014).

The interaction with the tool is based on direct manipulation – one of the canvas' characteristics. The user can directly manipulate the watercolour marks on the anchors from the coloured bounding boxes (Figure 65). The corner anchors allow to resize the image between 80px (minimum width to be perceivable) and 300px (maximum width matching with the card's width), the top-anchor allows to rotate, click and drag the object allows moving inside the canvas, and double-click over the element to delete it. The rotation has eight snap position in each 45

degrees angles to aid the user in the alignment. Moreover, when the user drags the elements, guides in relation to the cards appear so that the user can align the drawings (Figure 66). When the user moves the element closer to the guide's location, the guide appears and snaps the element.
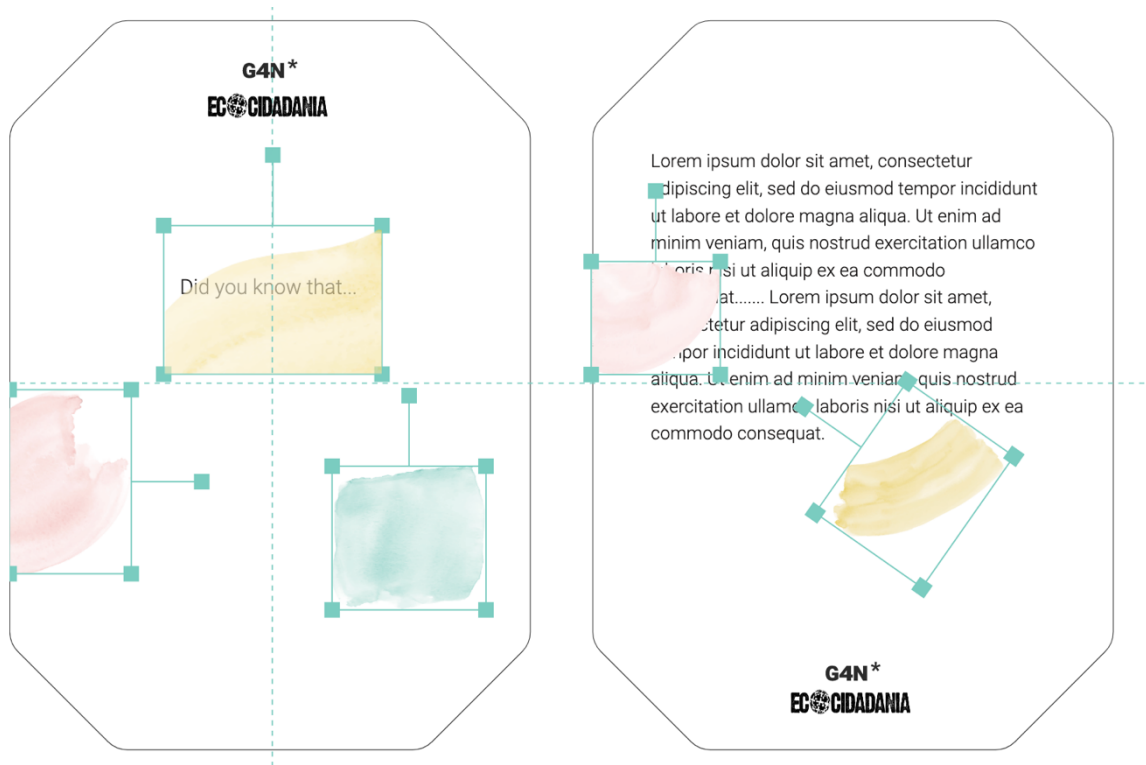
Figure 66 – Gamers4Nature tool: Guides

To reduce the user's cognitive overload and simplify the interface, the tool **automatically saves** all the progress (Shneiderman et al., 2018, p. 288). In the case of Steps 3 and 4, the position, rotation and scale are updated in the database, in the *aguarelas* or *ilustracoes* table, respectively, when the user goes over the element with the mouse cursor. To delete the watercolours or illustrations, the user must double-click over the element and the target entry is immediately removed from the database. Since this may not be a natural interaction to the user – the user would probably try to click on the backspace key –, one of the tooltips informs the user regarding this subject.

The tooltips displayed along the cards' creation process offer the user some autonomy to navigate on the UI, by providing the tools and necessary information to interact with the tool – being Autonomy another Interaction Design principle (Tognazzini, 2014). Besides giving autonomy, it also allows the user to feel control of its experience. The tooltips are displayed in the first card of each card set if the variable *canvas_tips* from the database is with the value 1.

Once the user finishes the cards set, before finalising and moving towards another category, the user is presented with all the cards designed (Figure 67). The user can, at this point, export the cards into a PDF format and proceed to a next category or finish the creation. The verification is made through the database variable *finalizado* in the table *projetos_has_categorias* – if all the categories have the variable *finalizado* (meaning the finished) with the value 1, then the UI displays the button "**Finish**"; if one to three categories have *finalizado* with value 1 and the other or others the value 0, the button "**Next category**" is displayed.
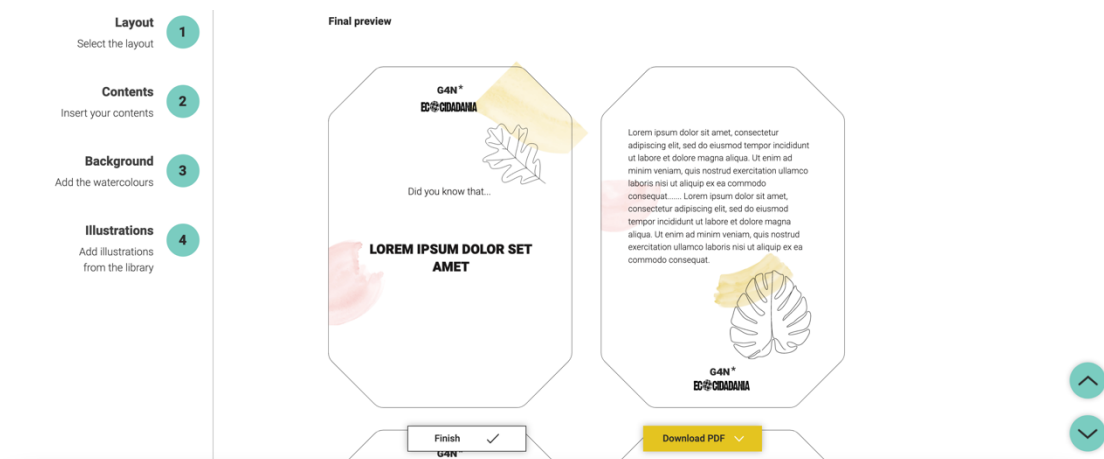
Figure 67 – Gamers4Nature tool: See all the cards to export a PDF

The bottom and up arrows on the right-bottom side allow the user to easily scroll the page up and down, which is useful in particular when a lot of cards are created.

To split the cards across different pages of the pdf, individual canvases were created for each pair of cards – front and back –, hidden from the user. These canvases are created with the stage dimensions and converted to the 2D context (canvasPDF.getContext('2d')). Next, a for loop is executed to create each individual 2D canvas. Each 2D canvas is added as an image (pdf.addImage) to the pdf, and the dimensions and coordinates are entered. Finally, it is verified that the card's canvas number is an even number and if it is not the last canvas, and if these conditions are fulfilled, a new page is added to the PDF and the initial coordinates are restored.

Figure 68 shows the code created to perform this logic. The dimensions had to be tested several times since the pdf millimetres viewed in the code do not correspond the real-life measurements. The several tests were printed in a domestic printer – which could be the resource teachers and environmental organisations can have, a simple printer – to verify the card's dimensions: 7cm x 10cm.

```javascript
document.getElementById('botaoSegProj').addEventListener('click', function() {
    var position = 30;

    var pdf = new jsPDF({
        unit: "mm",
        disableAutoFetch: true,
        disableStream: true,
        pagesplit: true
    });

    pdf.setProperties({
        title: 'Thematic Cards Set',
        subject: 'This thematic cards set was created using the Gamers4Nature Cards Set Canvas.',
        author: 'Gamers4Nature',
        keywords: 'generated, gamers4nature, toolkit to game design',
        creator: 'Gamers4Nature'
    });

    for (var f = 0; f < contaCanvas.length; f++) {
        let canvasPDF = document.createElement('canvas');
        canvasPDF.id = 'canvasPDF' + f;
        canvasPDF.className = 'canvasPDFClass';
        canvasPDF.width = stage.width();
        canvasPDF.height = stage.height() + 50;
        document.getElementById('canvas').appendChild(canvasPDF);
        var context = canvasPDF.getContext('2d');

        for (var t = 0; t < document.getElementById('canvas' + f).children[0].childNodes.length; t++) {
            context.drawImage(document.getElementById('canvas' + f).children[0].childNodes[t], 0, 0, stageWidth, stageHeight);
        }

        pdf.addImage(
            canvasPDF.toDataURL({
                pixelRatio: 5,
                width: stage.width(),
                height: stage.height()
            }),
            30,
            position,
            165,
            109
        );

        position = position + 115;

        if (contaCanvas[f] % 2 == 0 && contaCanvas[f] != contaCanvas.length) {
            pdf.addPage();
            position = 30;
        }
    }


    pdf.save('cartas-tematicas-g4n.pdf');
});
```

Figure 68 – JavaScript code to export cards into a PDF file

At this point, the user can review each card and edit the contents from Steps 2, 3 and 4. The user must click on the number on the left block to open a new window to edit – a new window is open due to a limitation[68] (Figure 69). The user must edit the card on the other page and then return to this page (Figure 67) and refresh it to see those modifications. This information is conveyed through a dialogue modal that opens after clicking the desired step.

---

[68] The limitation is derived from not wanting to "lose" the navigation location where the user is at that moment.
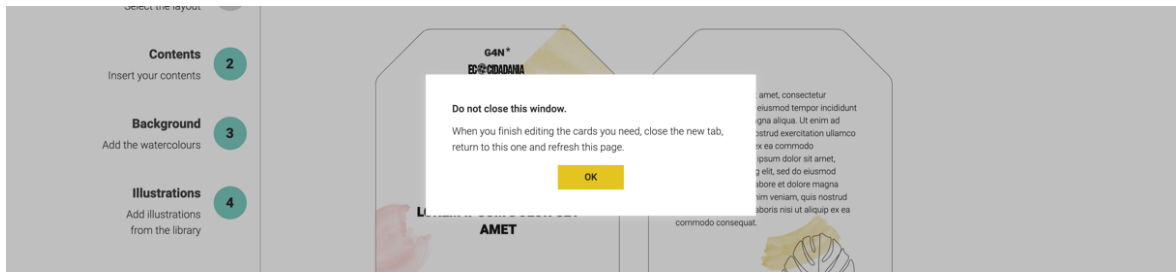
Figure 69 – Gamers4Nature tool: Dialogue modal before editing cards during the creation process

Once the project is finished, the user can always access the projects on the "Create your own cards" page.

The finished cards can still be edited. When the user wants to edit, he/she will aim to edit a specific step at first, even if the overall goal is to edit multiple steps, the user is given a chance to point out the direction by choosing the step before starting to edit (Figure 70).
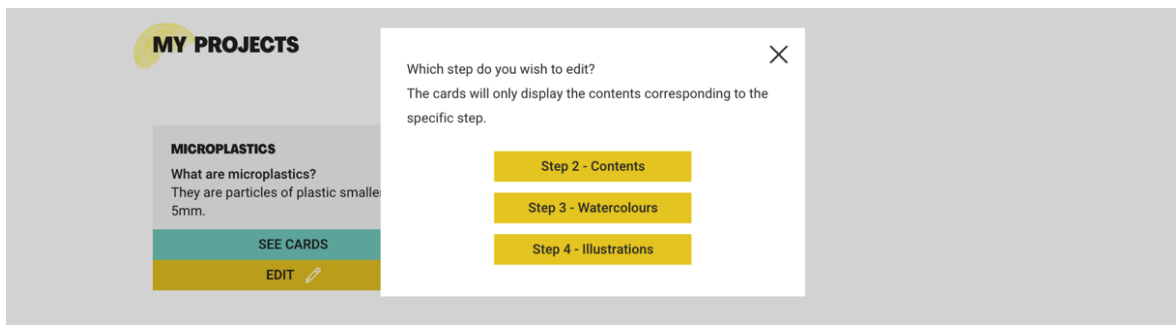
Figure 70 – Gamers4Nature tool: Dialogue modal before editing cards on user's projects page

While editing, the user can either navigate between steps on the step's information left block or on the button "**Next step**" (Figure 71). The user can then go back to the project's by clicking the "**Finish edition**" button. From here, to export the project, the user can click on "**See cards**" and download the PDF file.
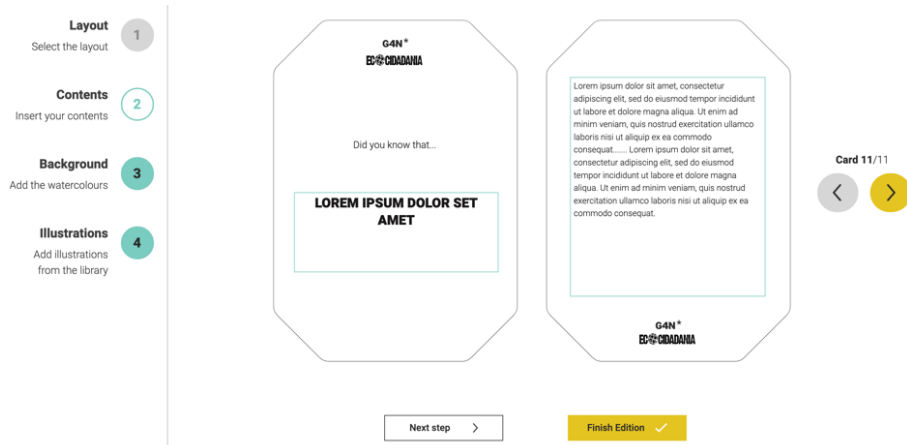
Figure 71 – Gamers4Nature tool: Editing Step 2

In the edition steps, contents are loaded from the database and stored similarly to the cards' creation process. This was described with more detail early in this document, in the *Database* section.

III. Evaluation and analysis

Expert Review

After developing the main features of the tool, integrated it into the G4N portal, and have reviewed the tool with the G4N research team, an Expert Review was carried with the aim of identifying possible usability issues.

Participants

Seven UX experts were invited to this Expert Review, and all of those accepted the invitation, which six were female (n = 6) and one male (n = 1). Regarding evaluators experience, as shown in Figure 72, the sample consisted of 57,14% (n = 4) of experts with over 10 years of experience, 28,57% (n = 2) with 1 to 5 years of experience, and 14,29% (n = 1) with 5 to 10 years of experience in the field. As this study selected a convenience sample, the results cannot be generalised to other contexts.

Years of Experience in UX/Usability/HCI

Legend:
- 1 – 5 years
- 5 – 10 years
- > 10 years

28,57%
14,29%
57,14%
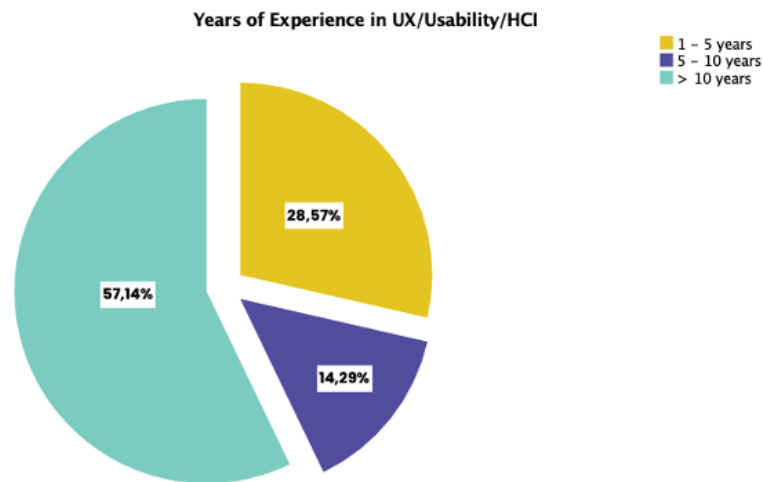
Figure 72 – Experts' years of experience in UX

Data analysis – Analysis of the expert's deliverable

Strengths

The experts' answers were transcribed into a document that was imported into the qualitative analysis software, Nvivo 12. From this document, a word frequency analysis was performed.

From the results of the query criteria[69], meaningless words (e.g. "no", "to", " the") and all those that were not adjectives were excluded.

The first question of the second section of the experts' deliverable was related to the tool's strengths. In this question, the experts were requested to write down what they considered to be the tool's strengths.

The most frequent words (Figure 73) referred more than once were: (i) consistency; (ii) minimalist; (iii) clean; (iv) ease.
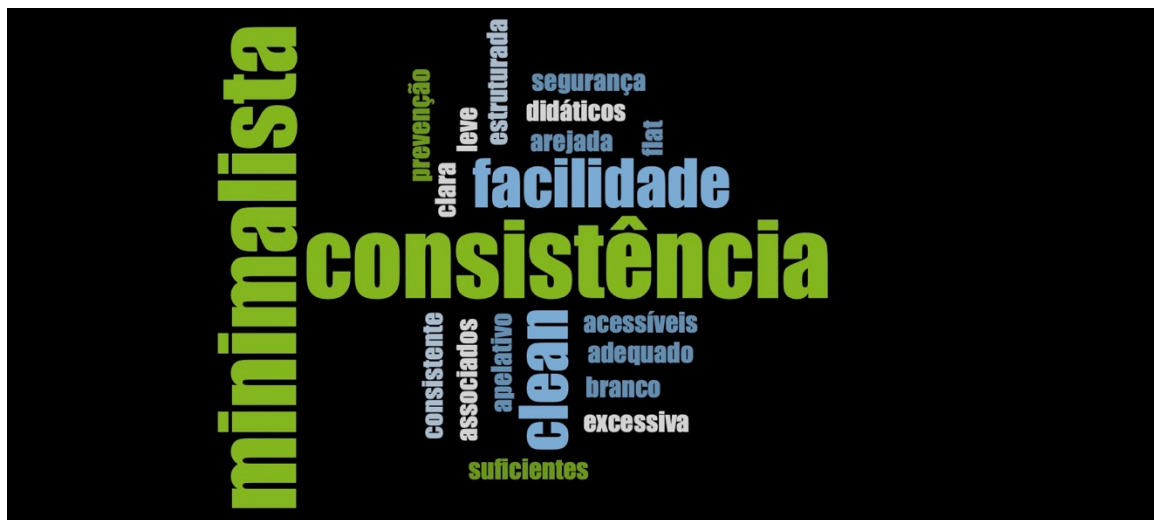
Figure 73 – Nvivo output of the word frequency concerning UX experts' strengths (in Portuguese, original language)

Table 5 shows some examples of the contexts in which each word was applied.

Table 5 - Most frequent words' context

Word	Context	Expert ID
Consistency	"Consistency of overall functioning."	E3
	"Ease of learning through consistency between steps."	E5
Minimalist	"Minimalist design and aesthetic."	E6
	"The design is minimalist and consistent."	E4
Clean	"Clean and flat design was a good choice."	E5
	"The interface is clean, not overflowing with excessive information (…)."	E1, E7

---

[69] Query criteria: the ten most frequent words, including stemmed words, with at least five characters.

Ease	"Ease of learning (…)."	E5
	"Easy distinction between editable area (…)"	E5

In addition, all the strengths were analysed and coded. The six categories arising from this analysis are presented in Table 6, along with examples of the experts' statements. The coding created was reviewed by researchers from the G4N project, in order to try to avoid biases.

Table 6 – Example of coded experts' statements regarding the tool's strengths

Category	Examples	Expert ID
Content	"Hierarchy of information seems correct."	E7
	"(…) game rules and storytelling can make the content more appealing (…)"	E1
Copywriting	"Clear and brief communication."	E2
Feedback	"Visual feedback on the status and which step / card I am in."	E5
	"Error prevention (contains messages confirming the action)."	E6
	"Metaphors in accordance with existing and commonly used."	E3
Help	"Small tips informing the user of functions that require further learning."	E7
Interaction	"The user is guided through the task of building the cards and is mentally liberated for each step of the process."	E4
Interface	"Easy distinction between editable area and other elements, such as the navigation system."	E5
	"(…) 'bits' that aid reading (with good empty spaces)."	E2

Overall, the experts considered that the tool has a good hierarchy of information, is structured in a way that makes the content appealing, provides feedback to users, helps through tips, minimises the user's cognitive effort by allowing them to concentrate on one task at a time, and adopts a clear and brief communication.

Problems

The list of problems mentioned by the experts (Appendix 8) was normalised by grouping references to the same problems and counting the number of occurrences. Aiming to establish an association between the analysis of strengths and the identified problems, each generic problem was framed into the categories defined previously.

Table 7 summarizes the spotted issues and how many times they were mentioned by different experts.

Table 7 – Normalised list of problems mentioned by the experts

Category	Problem	References (no. of occurrences [Expert ID])	Experts' Rating (Severity Scale)
Copywriting	Copywriting inconsistencies.	3 [E2, E6, E7]	3 – rated by all
Feedback	Lack of feedback (e.g. information about the user not being able to edit the card's layout – Step 1).	5 [E2, (x2) E3, (x2) E6]	1 – rated once 2, 3 – rated twice
Interaction	Lack of option to reactive tips.	1 [E7]	4 – rated once
	Tips should have central prominence.	1 [E1]	3 – rated once
	Canvas' navigation (i.e. cards and steps navigation buttons).	3 [E1, (x2) E2]	1, 2, 3 – rated once
	Button to "return" to previous pages.	1 [E2]	3 – rated once
	Remove redundancy before editing the cards.	1 [E5]	3 – rated once

	Switch order of illustrations step with background step.	1 [E1]	2 – rated once
	Interactive guides and contextual help.	1 [E6]	2 – rated twice
Interface	Button "My projects" is misplaced and misleading (e.g. should be on the user's profile, the appearance is similar to a text input).	5 [E2, E3, E4, E6, E7]	2, 4 – rated twice 1 – rated once
	Placeholders and content cards with grey background have lack of contrast.	2 [E6, E7]	3, 4 – rated once
	Inconsistency and misplacing of some buttons.	5 [E3, E4, E5, (x2) E6]	2 – rated three times 3 – rated twice
	Hard to recognise different levels of information on the available layout.	2 [E5, E6]	3 – rated twice
	"The user	1 [E7]	2 – rated once

The aspect mentioned most frequently (n = 5) was that there was lacking information mentioning the inability to edit Step 1. Also, another aspect which was often depicted (n = 5) was the "My projects" button, not only concerning its graphical appearance – some experts (E6) warned that it could be mistaken as a search input – but also its location on the page. This button, being of a more personal dimension – referring to the possessive pronoun "my" – should therefore be associated with the user's personal area. One of the experts (E7) indeed mentioned that this button placed in the middle of the page "Build your cards" could even become confusing and meaningless for the user.

Subsequently, experts mentioned (n = 3) some copywriting inconsistencies (cf. Table 19) and suggested changes in the cards' navigation area, namely the creation of a floating section to place the buttons related with the previous and next steps and gather help button and cards' navigation buttons on a less peripheral area of the screen. Although other considerations are displayed in the table provided above, they were discussed but less frequently.

Suggestions

Similarly to the other topics, all the suggestions were framed into the codes defined in Nvivo and grouped according to their content. All suggestions are described in Table 8 and pertained to copywriting, interaction, and interface categories.

Table 8 – List of suggestions mentioned by the experts

Category	Suggestion	References (no. of occurrences [Expert ID])
Copywriting	Simplify and adjust the copywriting.	3 [E2, E5, E7]
	Review copywriting pertaining to the targeted audience - students vs. teachers.	2 [E6, E7]
Interaction	Add a button to see all the entire cards set when finishing a category set.	1 [E2]
	When editing the cards, step 1 should not be clickable and should have a warning concerning this limitation.	2 [E3, E4]
	Add "My projects" to the user's profile.	3 [E3, E4, E7]
	Enable the user to insert diagrams in the cards in addition to the text.	1 [E6]
	Add "Hide tips" only when more than one tip exists on the same page.	1 [E7]
	The user must be able to "undo" when they accidentally select to hide all tips.	1 [E7]

	When the user selects the edit button, they should be redirected directly to the canvas.	1 [E7]
Interface	Change location and/or appearance of the help button.	1 [E3]
	Slightly reduce empty spaces.	1 [E5]
	For issues associated with contrast do a colour check or A/B test.	1 [E7]
	The instruction next to the task number in the canvas could be moved closer to the cards so that the function and content could be nearer.	1 [E7]

Some experts framed their analysis within specific Usability Heuristics, while others were more meticulous in topics regarding accessibility and copywriting.

UI Improvements

The Expert Review pointed out issues and suggestions that guided the modifications made to improve the UI and, consequently, the UX. The focus of the improvements prioritised the issues rated with the highest value on the Severity Rating for Usability Problems (Nielsen, 1994). Nevertheless, it is relevant to mention that the modifications made were deliberated and discussed by the researcher and the G4N project research team aiming to create efficient solutions based on the identified issues.

According to the experts, the button "**My projects**" seemed lost in the middle of the "**Create your own cards**" page, since it blended buttons of different scopes – user's projects are more of a personal scope, while the rest of the page information is overall information regarding the tool (cf. Figure 42). Hence, this button is now displayed on the user's profile (Figure 74), which is the user's personal space and relates to the possessive pronoun used – **my** – along with other personal information, such as user's games, favourite games, and profile data.
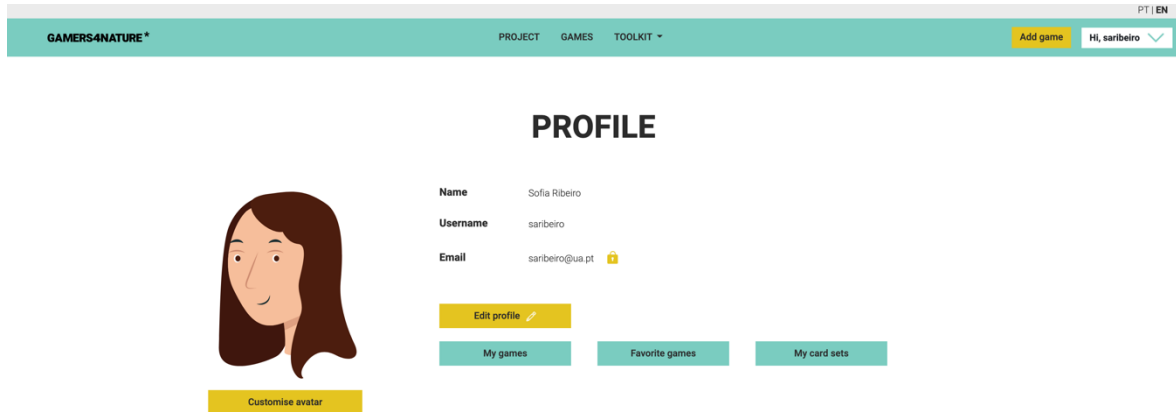
Figure 74 – Gamers4Nature tool: User's profile – "My card sets" button

Additionally, the organisation of the UI in each step was modified. Having as a principle the division of the left area (i.e. which locates the user within the navigation) from the right area (i.e. where the creation takes place), also the information relative to the current step and card were embedded according to this division (Figure 75). The text "**Step X/4**" is now on the left side, while the text "**Card y/Y**" is where the step information was previously placed (cf. Figure 58).

In the portal's navbar, the "**Home**" button was removed (Figure 75) since it is already a convention that the navbar's logotype drives the user to the initial page.

Furthermore, the cards' navigation buttons were placed next to the cards, on the left and on the right, according to the side to which they correspond in the navigation (Figure 75), i.e. if the user wants to go back to the previous card, the button is positioned before the current cards, if the user wants to navigate forward, the button is after the current cards. This provides more fluid and intuitive navigation.
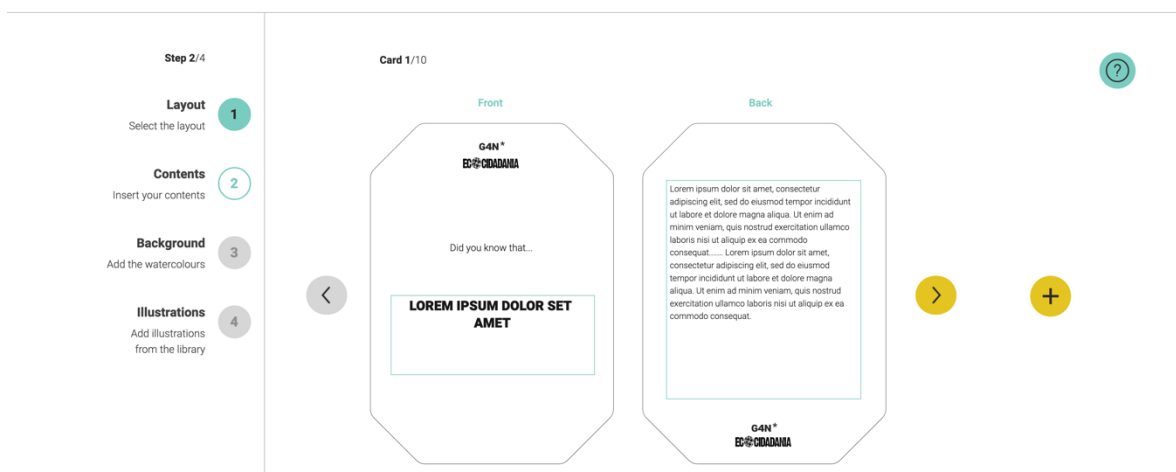
Figure 75 – Gamers4Nature tool: Cards' navigation arrows and information

In case some users struggle to identify perspectives, a description of the displayed side of the card – i.e. Front and Back – has been added to the UI (Figure 75).

In addition, it was mentioned that the help button was lightweight (Figure 76 – (a) and Figure 75) compared to the other buttons, thus the thickness of the lines was improved (Figure 76 – (b)).

(a) Before	(b) After
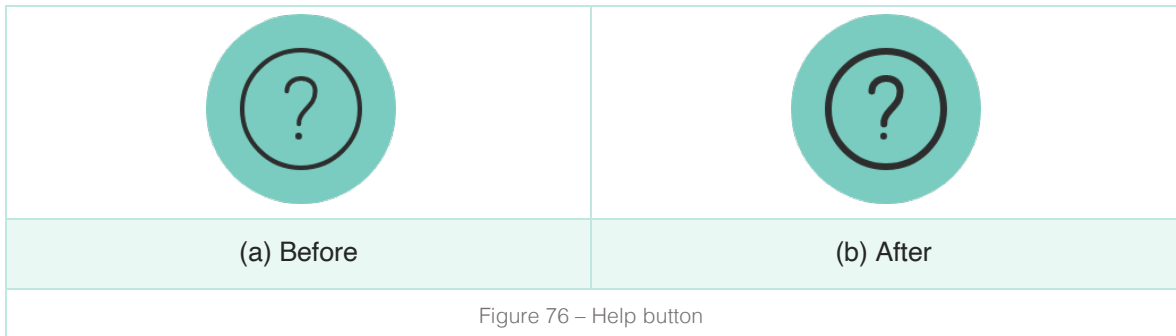
Figure 76 – Help button

As mentioned early in this document, due to the constraints that arose from smaller devices, the tool is only available in devices with over 1024 pixels (i.e. a standard viewport size). Thus, to provide feedback in case the user tries to interact with the tool from the unsupported devices, a warning was designed to warn the user regarding this restriction (Figure 77).
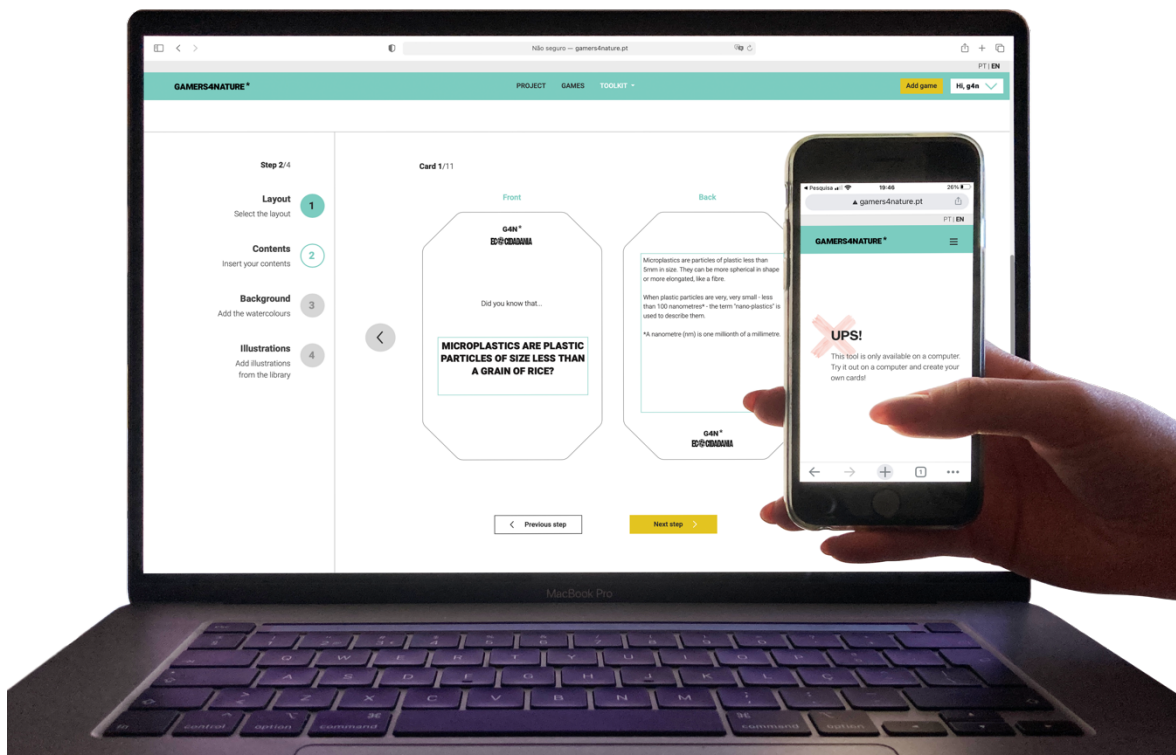
Figure 77 – Gamers4Nature tool: Mobile versus Desktop

To provide the "User control and freedom" – Usability Heuristic (Nielsen, 2020) – it was added a button to reactive the tips (Figure 78). Previously, the user did not have the possibility to reactive the tooltips after hiding them. It is a good UX principle to allow the user to revert any performed action, for example through *Undo* and *Redo*.
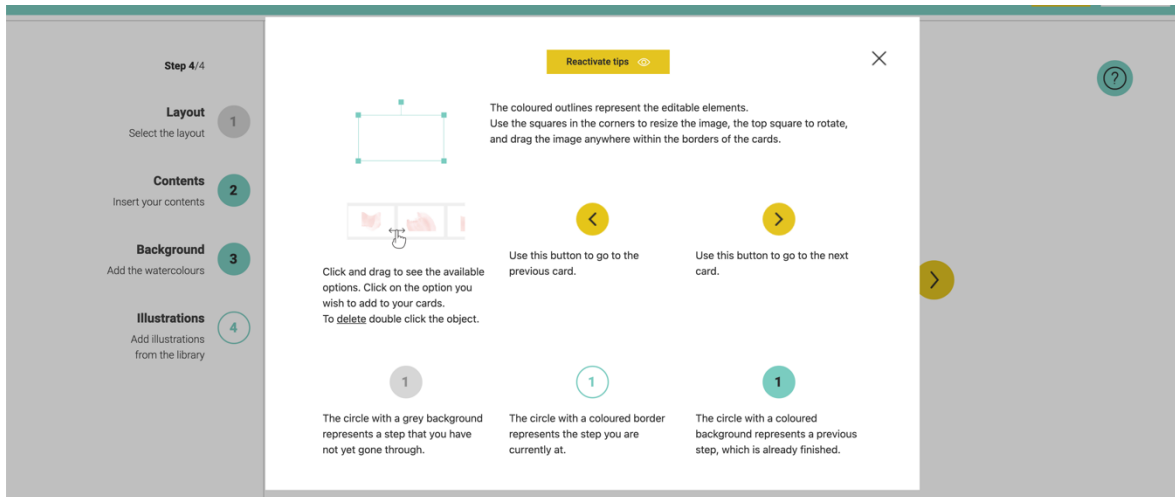
Figure 78 – Gamers4Nature tool: Help dialogue modal

The "**Reactivate tips**" button was placed inside the help dialogue modal since it is not a recurrent action, so it does not need to be accessible at all times.

Moreover, behind the help dialogue modal, it is visible the button from Step 1. Since Step 1 is not editable after the creation process, it is displayed as disabled on the edition windows, indicating its unavailability.

Layout — Select the layout	Contents — Insert your contents	Illustrations — Add illustrations from the library
(a) Step 1 is not available	(b) Step 2 is the current step	(c) Steps other than the current step or Step 1

Figure 79 – Mouse cursor over different step's states

The mouse cursors work as **signifiers** to the step's state and are customised through CSS (Cascading Style Sheets[70]). In the case of Step 1, which is not available in the edition mode, the cursor displayed is the *not-allowed* (Figure 79 – (a)). When the mouse goes over the current

---

step (in Figure 79 – (b) the current step is Step 2), the cursor is the default, while when it goes over other steps rather than the current, the cursor is the *pointer* (Figure 79 – (c)).
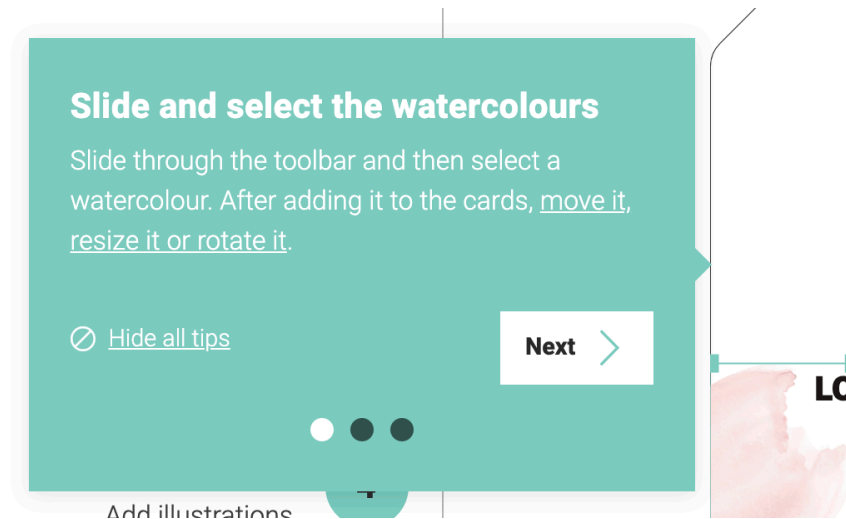
Figure 80 – Multiple tooltips

Regarding the tooltips, the experts mentioned that when several tooltips pop, even being one at a time, it was not clear to the user how many they were. In order to provide that feedback, when several tooltips are displayed, the tooltips have circles (Figure 80) that represent the navigable items and point to how many tooltips will pop. The white circle represents the current displayed tooltip, while the dark grey circles represent the other tooltips.

Moreover, the modal that popped before starting the edition of the cards, for the user to choose the step to edit, has been removed since it represents an additional and unnecessary step (cf. Figure 69). Whereas as soon as entering the edition, the user can navigate using the buttons on the left side (Figure 78).

Finally, concerning copywriting, all mentions to specific colours (e.g. blue, yellow, grey) were replaced, e.g: before – "The circle with a **blue** border represents the step you are currently at."; after – "The circle with a **coloured** border represents the step you are currently at.". This modification is related to the principles of universal design[71], avoiding the exclusion of, for example, colour-blind people and ensuring the visibility of the information.

---

[71] https://www.washington.edu/doit/what-universal-design-0, last accessed on June 22, 2020

Discussion

Although final evaluations were not carried with the target audience, the tool's design has taken into consideration the initial context provided by the teachers involved in the exploratory interviews. Besides, the evaluations with UX experts also intent to identify issues, suggestions and strengths that aim to fulfil the target audience's user needs.

Furthermore, despite the fact that there is always room for improvement, considerations regarding usability (e.g. applying Usability Heuristics), UX, and universal design were taken, intending to create a functional product with a high level of usability that aids a short learning curve to use the tool. The strategies and methods applied throughout the tool aim to encourage the user to rely on the system and intuitively interact with it.

Throughout the process description, some limitations of the framework were listed that conditioned the final product. Revisiting the tool's functional requirements (cf. *Tool's Requirements* section), some requirements were abandoned, adapted, or marked to future work. Specifically, "FR 2 – Onboarding when entering the tool for the first time" was adapted to tooltips available at the beginning, that can be hidden at any time, but are available whenever the user desires them to be. Furthermore, the "FR 6.1 – Drag-and-drop items" was abandoned as explained earlier – due to Konva.js limitations – and "FR 9 – Zoom the canvas" too – it represented an unnecessary feature since the canvas is displayed with a readable size and all the elements (i.e. watercolours, texts and illustrations) were previously tested to see the minimum dimensions to assure readability. "FR 8 – Search elements by keywords" and "FR 14 – Export artwork in digital format (JPEG, PNG, ...)" were marked as future work since this research – due to the limited time it had to be conducted – had to prioritise the creation of a functional product that embodied the realistic cards' creation process.

CONCLUSIONS

Having other partner entities inserting their contents into the G4N layout design revealed design issues and non-compliance with brand standards that lead to this research. In this regard, the G4N project lacked a tool to provide partner entities (e.g. schools, environmental organisations) to autonomously create their own thematic cards by complying with a set of guidelines defined in the G4N brand standard's manual; delivering a document in a printable format, with the dimensions suitable to their integration onto the G4N Toolkit, allowing to prepare the cards towards their dynamization in classes or environmental actions.

In that line of thought, the research defined the followings topics as research goals: (i) to **identify** and characterise platforms and/or tools that allow users to create their own contents; (ii) to **prototype** and **develop** a digital tool to create thematic cards for the Gamers4Nature Toolkit to Game Design; (iii) to **evaluate** the tool in an iterative process. Likewise, the employed methodology – developmental research – intended to aid the fulfilment of these goals by designing an iterative process to continuously improve the final product, focused on its development.

Seeking to grasp the features that a tool complying with these principles should possess, a theoretical framework and an analysis of related work were carried out, which acted as a premise for the exploratory approach of this research. The theoretical framework and the related work provided knowledge regarding the research topics and current market that congregated into this research: (i) the Layout Design and Presentation Tools, Canvas and Suggestive Interfaces have a set of conventionalised features that, being integrated into this tool, reduce the user's learning curve with the system, thus minimising their cognitive overload; (ii) the teachers and adults' digital skills and technology usage imply a set of challenges that requires a system to provide fluid navigation and stepwise interaction; (iii) User-Centred Design and Interaction Design principles supported the tool's design; (iv) Customisation and Personalisation allow to distinguish these two concepts and integrate it through user- or machine-driven contextual adjustments.

Crossing the data from the several stages on the research process, aided the achievement of a digital tool that meets the research goals and purposes. The abovementioned goals were met through the **definition** of a set of functional requirements, the prototypes' design, the development of a functional product, and several evaluation stages. The final product is a digital tool, settled on the G4N portal-repository, that allows users – with or without any design background – to create their own cards within the G4N project's layout design. The tool **splits** the process into four different **steps**, each one concerning a **specific stage** of the card's design

process. Thus, the digital tool **reduces** the **user's cognitive load** since it lays all the complex or focus-breaking processes on the system (i.e. the machine): the design is **automatically saved** through every step; the **layers** assemble without the need of the user's intervention; and **contextual suggestions** are displayed to aid the user's interaction.

Moreover, based on the initial insights provided by two teachers, the tool integrates a set of features that enable the user to guide the creation and have control over the designed card. Namely, in terms of **customisation**, the user has a range of layout options to choose from, can insert his/hers contents, and can add and manipulate (i.e. resize, rotate or move) as many watercolours and illustrations desired. On the other hand, in terms of **personalisation**, the system also adapts to the user by presenting the chosen layout. Then, it loads the logotype uploaded at the beginning of the cards' creation process.

Nonetheless, having **design principles** and the G4N brand **guidelines** to be fulfilled, the templates – that encompass the layout, the font-face and size, and line-height –, the set up library (offering a range of options designed by the researcher), and the dimension restrictions regarding watercolours and illustrations, allows to meet these requirements. However, these constraints were employed in a way that would not limit the user's creativity, hence **balancing** the user's **freedom** and the G4N brand-derived **restrictions**.

From the expert's reviews, it was perceived the suitability of the tool in terms of interface, interaction, and experience design, to proceed to validations with end-users. Overall, the tool complied with UI design principles and usability heuristics, by conveying a minimalistic interface design without overloading users with unnecessary or excessive information, providing feedback of their actions, designing the interface with a consistent design system, and aiding an easy learning interaction.

Finally, this tool provides the user with a printable document, which **transforms the digital artifact** (i.e. the cards drawn in the tool) **into a physical** and tangible **product** (i.e. a printed set of cards).

Concerning this research's purpose, as expected, the final output provides the G4N project with a tool to deliver and allowing availability to its partners that aim to autonomously create thematic cards within the project's context, thus integrating the cards into the G4N Toolkit. Furthermore, the goals initially established were met and fulfilled, providing findings and data to proceed with work in this field and deepen this research topic.

On a personal level, the researcher considers this research was an immensely rewarding and enlightening experience, as it motivated the continuous overcoming of challenges posed along the research process, leading to the development of an exploratory work in a field in which there was no previous research.

Research limitations

As in any investigational context, this research has some limitations that must be considered.

During the research process, the researcher was faced with some challenges, namely, in the first instance, the topic being investigated. As it was found and referred in the theoretical framework, there is little or no research in this field. Thus, this research is an exploratory and innovated approach to the problem statement – i.e. create a tool that allows users to design contents by obeying design principles and brand standards, removing the complexity layers from the user's decisions.

Whilst first predicted in the contingency plan, constraints derived from the participant's availability delayed the process and the methodology had to adapt. Despite seeking to develop a process within a UCD methodology, centred on the needs of the target users, due to the limited time in which the research took place, it was not feasible to conduct final evaluations with the target audience (although they were planned). Therefore, it reflects in the results' generalisability, which cannot be done, as it was not possible to involve users in a final stage, and since the users involved in the initial stage consisted of a small sample –two teachers only.

Furthermore, given the applied sampling method (i.e. convenience sample), the findings cannot be applied or generalised to other contexts. Nonetheless, they can support future research in the field or follow-up studies.

Since the development of the tool relies on a specific technology, it is limited to its potential. As has been described throughout the document, Konva.js constraints required to find alternative paths that perhaps may not be the ideal. Specifically the case of deleting the watercolours and illustrations by double-clicking may not be the most appropriate solution, as it is not a natural interaction method. However, this could only be assessed with end-user evaluations.

Future work directions

As for future work, in the first instance, the researcher would develop the functional requirements that were not implemented, namely enable to search illustrations based on keywords, filter watercolours by colour, and export the cards in other formats, such as JPEG or PNG. Moreover, it would be beneficial to design more watercolour shapes and illustrations dedicated to other environmental themes to provide the user with a wider optional range.

Other feature that was initially thought but not implemented, was to allow the user to visualise the cards designed, during the creation process. Additionally, it would be interesting to allow a non-linear navigation between the cards and steps.

Finally, since drag-and-drop is currently being used in many applications, it would be useful to find a solution to integrate this feature in several tool's sections: when creating the project, allowing to drop files into the file input; when creating and editing the cards, allowing to drag and drop the watercolours and illustrations.

Lastly, this research, due to its potential to scope a broader context, seeks to provide knowledge, to motivate similar studies in other contexts, and to encourage more research in this field.

This page is intentionally left blank

ACKNOWLEDGEMENTS

REFERENCES

Akker, J. van den, Bannan, B., Kelly, A. E., Nieveen, N., & Plomp, T. (2013). Educational Design Research Educational Design Research. *Educational Design Research*, 1–206. http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ815766

Annetta, L. A., Minogue, J., Holmes, S. Y., & Cheng, M. T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers and Education*, *53*(1), 74–85. https://doi.org/10.1016/j.compedu.2008.12.020

Araújo, B., & Jorge, J. (2003). BlobMaker: Free-Form Modelling with Variational Implicit Surfaces. In *Proceedings of The IEEE - PIEEE*.

Baker, J. P., Goodboy, A. K., Bowman, N. D., & Wright, A. A. (2018). Does teaching with PowerPoint increase students' learning? A meta-analysis. *Computers & Education*, *126*, 376–387. https://doi.org/10.1016/j.compedu.2018.08.003

Banerjee, I. (2017). Advances in Model-Based Testing of GUI-Based Software. In *Advances in Computers* (Vol. 105, pp. 45–78). Academic Press Inc. https://doi.org/10.1016/bs.adcom.2016.12.003

BBC Bitesize. (2020, November 14). *Presentation software and web design*. https://www.bbc.co.uk/bitesize/guides/z7c82hv/revision/1

Beca, P., Aresta, M., Ortet, C., Santos, R., Veloso, A. I., & Ribeiro, S. (2020). Promoting student engagement in the design of digital games: The creation of games using a Toolkit to Game Design. *Proceedings - IEEE 20th International Conference on Advanced Learning Technologies, ICALT 2020*, 98–102. https://doi.org/10.1109/ICALT49669.2020.00037

Beça, P., Aresta, M., Santos, R., Veloso, A. I., Gomes, G., & Pereira, M. (2019). *Supporting the Game Construction Process: Development of Artefacts in the Context of a Toolkit to Game Design* (pp. 99–110). Springer, Cham. https://doi.org/10.1007/978-3-030-37983-4_8

Beça, P., Aresta, M., Veloso, A. I., Santos, R., Ferreira, E., Jervis, S., Gomes, G., Ortet, C., Pereira, M., Ribeiro, S., & Ferreira, E. (2020). Developing a Toolkit to Game Design: The Gamers4Nature Project: from Concept to Artefact. *FDG '20: International Conference on the Foundations of Digital Games*, 1–8. https://doi.org/10.1145/3402942.3402983

Beça, P., Ribeiro, S., Aresta, M., Santos, R., & Veloso, A. I. (2021). Definition of a Digital Tool to Create Physical Artifacts: The Case of the Gamers4Nature Project. In *Perspectives on*

Design and Digital Communication II. Springer Series in Design and Innovation, vol 14 (pp. 113–131). Springer, Cham. https://doi.org/10.1007/978-3-030-75867-7_8

Beça, P., Ribeiro, S., Santos, R., Aresta, M., Veloso, A. I., & Ortet, C. (2021). Design and Initial Evaluation of an Online Portal-Repository: The Case of Gamers4Nature Project. In N. Martins & D. Brandão (Eds.), *Advances in Design and Digital Communication. Digicom 2020. Springer Series in Design and Innovation* (pp. 137–147). Springer, Cham. https://doi.org/10.1007/978-3-030-61671-7_13

Blom, J. (2000). Personalization - A Taxonomy. *CHI '00 Extended Abstracts on Human Factors in Computing Systems - CHI '00*, April, 313. https://doi.org/10.1145/633292.633483

Britannica, T. E. of E. (2019, March 29). *Microsoft PowerPoint*. Encyclopaedia Britannica. https://www.britannica.com/technology/Microsoft-PowerPoint

Budiu, R. (2017, October 1). *Quantitative vs. Qualitative Usability Testing*. Nielsen Norman Group. https://www.nngroup.com/articles/quant-vs-qual/

Chang, S.-K., Costagliola, G., Pacini, G., Tucci, G., Tortora, G., Bing Yu, & Jing-Sheng Yu. (1995). Visual-language system for user interfaces. *IEEE Software*, *12*(2), 33–44. https://doi.org/10.1109/52.368262

Chen, T.-W., & Sundar, S. S. (2018). This App Would Like to Use Your Current Location to Better Serve You. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, *2018-April*, 1–13. https://doi.org/10.1145/3173574.3174111

Craig, R. J., & Amernic, J. H. (2006). PowerPoint Presentation Technology and the Dynamics of Teaching. *Innovative Higher Education*, *31*(3), 147–160. https://doi.org/10.1007/s10755-006-9017-5

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications, Inc.

Cruz, L. M. V., & Velho, L. (2010). A Sketch on Sketch-Based Interfaces and Modeling. *2010 23RD SIBGRAPI - Conference on Graphics, Patterns and Images Tutorials*, 22–33. https://doi.org/10.1109/SIBGRAPI-T.2010.8

De Villiers, M. R. (2005a). Interpretive Research Models for Informatics: Action Research, Grounded Theory, and the Family of Design- and Development Research. *Alternation*, *12*(2), 10–52. http://hdl.handle.net/10500/13196

De Villiers, M. R. (2005b). Three approaches as pillars for interpretive Information Systems research: development research, action research and grounded theory. *South African Institute of Computer Scientists and Information Technologists*, 111–120.

De Villiers, M. R., & Harpur, P. . (2013). *Design-based research - the educational technology variant of design research*. 252. https://doi.org/10.1145/2513456.2513471

Di Serio, Á., Ibáñez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers and Education*, *68*, 586–596. https://doi.org/10.1016/j.compedu.2012.03.002

Dufendach, K. R., Koch, S., Unertl, K. M., & Lehmann, C. U. (2017). A randomized trial comparing classical participatory design to VandAID, an interactive crowdsourcing platform to facilitate user-centered design. *Methods of Information in Medicine*, *56*(5), 344–349. https://doi.org/10.3414/ME16-01-0098

Duffy, J. (2018, January 25). *The Best Presentation Software*. PC Mag. https://www.pcmag.com/picks/the-best-presentation-software

Dumas, J., Sorce, J., & Virzi, R. (1995). Expert Reviews: How Many Experts is Enough? *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *39*(4), 228–232. https://doi.org/10.1177/154193129503900402

European Commission. (2019a). *2nd Survey of schools: ICT in education - Objective 1: Benchmarking progress in ICT in schools*. https://doi.org/10.2759/23401

European Commission. (2019b). *A Educação Digital nas Escolas da Europa* (Direção-Geral de Estatísticas da Educação e Ciência (ed.)). https://doi.org/10.2797/393325

European Union. (2013). *Survey of schools: ICT in education. Benchmarking access, use and attitudes to technology in Europe's schools*. https://ec.europa.eu/

Falcao, T. P., Peres, F. M. de A. e, Morais, D. C. S. de, & A, G. da S. O. (2018). Participatory methodologies to promote student engagement in the development of educational digital games. *Computers and Education*, *116*, 161–175. https://doi.org/10.1016/j.compedu.2017.09.006

Ferrari, A. (2013). *DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe* (Y. Punie & B. N. Brečko (eds.)). https://doi.org/10.2788/52966

Fessenden, T. (2017, October 1). *First Impressions Matter: How Designers Can Support Automatic Cognitive Processing*. Nielsen Norman Group. https://www.nngroup.com/articles/first-impressions-human-automaticity/

Furió, D., Juan, M. C., Seguí, I., & Vivó, R. (2015). Mobile learning vs. traditional classroom lessons: A comparative study. *Journal of Computer Assisted Learning*, *31*(3), 189–201. https://doi.org/10.1111/jcal.12071

Gabriel, Y. (2008). Against the Tyranny of PowerPoint: Technology-in-Use and Technology Abuse. *Organization Studies*, *29*(2), 255–276. https://doi.org/10.1177/0170840607079536

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). *Educational Research: An Introduction* (A. E. Burvikovs (ed.)). Pearson Education, Inc.

Gegner, L., & Runonen, M. (2012). For what it is worth Anticipated eXperience Evaluation. *8th International Conference on Design and Emotion: Out of Control - Proceedings*.

Gibson, J. J. (1986). *The Ecological approach to Visual Perception*. Psychology Press, Tayler & Francis Group.

Goldman, N. M., & Balzer, R. M. (1999). ISI visual design editor generator. *Proceedings 1999 IEEE Symposium on Visual Languages*, 20–27. https://doi.org/10.1109/vl.1999.795871

Gomes, M. (2019). *Designing a brand for younger audiences: The Gamers4Nature project* [University of Aveiro]. https://doi.org/http://hdl.handle.net/10773/28261

Gordon, K. (2021, January 17). *Visual Hierarchy in UX: Definition*. Nielsen Norman Group. https://www.nngroup.com/articles/visual-hierarchy-ux-definition/

Grenha Teixeira, J., Pinho, N. F. de, & Patrício, L. (2019). Bringing service design to the development of health information systems: The case of the Portuguese national electronic health record. *International Journal of Medical Informatics*, *132*. https://doi.org/10.1016/j.ijmedinf.2019.08.002

Harley, A. (2018, February 25). *UX Expert Reviews*. https://www.nngroup.com/articles/ux-expert-reviews/

Hashemi, M., Azizinezhad, M., & Farokhi, M. (2012). Power Point as an innovative tool for teaching and learning in modern classes. *Procedia - Social and Behavioral Sciences*, *31*, 559–563. https://doi.org/10.1016/j.sbspro.2011.12.103

Heller, E. (2013). *A psicologia das cores: Como as cores afetam a emoção e a razão* (Editorial Gustavo Gili (ed.)).

Henry, P. (1998). *User-Centered Information Design for Improved Software Usability*. Artech House, Inc.

Hill, M. K. (2020). *Understanding Environmental Pollution* (4th ed.). Cambridge University Press.

Holländer, K. (2018). Applying the User-Centered Design Process to External Car Displays. In R. Dachselt & G. Weber (Eds.), *Mensch und Computer 2018 - Workshopband* (Issue September 2018). Gesellschaft für Informatik e.V. https://doi.org/10.18420/muc2018-ws15-0454

Huizenga, J. C., Ten Dam, G. T. M., Voogt, J. M., & Admiraal, W. F. (2017). Teacher perceptions of the value of game-based learning in secondary education. *Computers and Education*, *110*, 105–115. https://doi.org/10.1016/j.compedu.2017.03.008

Hussein, A. (2009). The use of Triangulation in Social Sciences Research: Can qualitative and quantitative methods be combined? *Journal of Comparative Social Work*, *4*(1), 106–117. https://doi.org/10.31265/jcsw.v4i1.48

Igarashi, T., & Hughes, J. F. (2007). A suggestive interface for 3D drawing. *ACM SIGGRAPH 2007 Courses on - SIGGRAPH '07*, *Figure 1*, 20. https://doi.org/10.1145/1281500.1281531

Interaction Design Foundation. (n.d.). *Service Design*. Retrieved January 28, 2021, from https://www.interaction-design.org/literature/topics/service-design

Jahanian, A., Liu, J., Lin, Q., Tretter, D. R., O'Brien-Strain, E., Lee, S., Lyons, N., & Allebach, J. P. (2013). Recommendation system for automatic design of magazine covers. *Proceedings of the 2013 International Conference on Intelligent User Interfaces (IUI '13)*, 95–106. https://doi.org/10.1145/2449396.2449411

Johnson, J. (2021, January 27). *Global digital population as of October 2020*. Statista. https://www.statista.com/statistics/617136/digital-population-worldwide/

Johnsson, B. A., & Magnusson, B. (2020). Towards end-user development of graphical user interfaces for internet of things. *Future Generation Computer Systems*, *107*, 670–680. https://doi.org/10.1016/j.future.2017.09.068

Kao, G., Hong, J., Perusse, M., & Sheng, W. (2020). Turning Silicon into Gold. In *Turning Silicon into Gold*. Apress. https://doi.org/10.1007/978-1-4842-5629-9

Kaye, L. (2016). *Young Children in a Digital Age: Supporting learning and development with technology in early years*. Routledge. https://books.google.pt/books?hl=pt-PT&lr=&id=Z3R9DAAAQBAJ&oi=fnd&pg=PP1&ots=KIt5BIFWZW&sig=9YGq6i5FaZFETeLwJ HIPKvS7_38&redir_esc=y#v=onepage&q&f=false

Ke, F. (2014). An implementation of design-based learning through creating educational computer games: A case study on mathematics learning during design and computing. *Computers and Education*, *73*, 26–39. https://doi.org/10.1016/j.compedu.2013.12.010

Kernbach, S., Bresciani, S., & Eppler, M. J. (2015). Slip-Sliding-Away. *Business and Professional Communication Quarterly*, *78*(3), 292–313. https://doi.org/10.1177/2329490615595499

Kodama, S., Poulin, P., Moriya, T., & Takahashi, T. (2018). Creativity enhancement of painterly rendering using a suggestive interface. *Computers & Graphics*, *71*, 42–54. https://doi.org/10.1016/j.cag.2017.11.001

Kuechler, W., & Vaishnavi, V. (2008a). On theory development in design science research: Anatomy of a research project. *Proceedings of the 3rd International Conference on Design Science Research in Information Systems and Technology, DESRIST 2008, May 2014*, 1–15. https://doi.org/10.1201/b18448-8

Kuechler, W., & Vaishnavi, V. (2008b). The emergence of design research in information systems in North America. *Journal of Design Research*, *7*(1), 1–16. https://doi.org/10.1504/JDR.2008.019897

Kuhna, M., Kivelä, I. M., & Oittinen, P. (2012). Semi-automated magazine layout using content-based image features. *Proceedings of the 20th ACM International Conference on Multimedia (MM '12)*, 379–388. https://doi.org/10.1145/2393347.2393403

Kushniruk, A., & Nøhr, C. (2016). Participatory Design, User Involvement and Health IT Evaluation. In E. Ammenwerth & M. Rigby (Eds.), *Evidence-Based Health Informatics: Promoting Safety and Efficiency through Scientific Methods and Ethical Policy* (Vol. 222, pp. 139–151). IOS Press. https://doi.org/10.3233/978-1-61499-635-4-139

Kuzmanović, D., Zlatarović, V., Anđelković, N., & Žunić-Cicvarić, J. (2019). *Children in a Digital Age: A Guide for Safe and Constructive Use of Digital Technologies* (P. D. D. P. Breneselović (ed.)). Užice Child Rights Centre.

Kyan, M., Sun, G., Muneesawang, P., Dong, N., Elder, B., Guan, L., Sun, G., Li, H., Zhong, L., Li, H., Dong, N., Elder, B., & Guan, L. (2015). An Approach to Ballet Dance Training through MS Kinect and Visualization in a CAVE Virtual Reality Environment. *ACM Transactions on Intelligent Systems and Technology*, *6*(2), 37. https://doi.org/10.1145/2735951

Ledbetter, A. M., & Finn, A. N. (2018). Perceived teacher credibility and students' affect as a function of instructors' use of PowerPoint and email. *Communication Education*, *67*(1), 31–51. https://doi.org/10.1080/03634523.2017.1385821

Lee, B., Srivastava, S., Kumar, R., Brafman, R., & Klemmer, S. R. (2010). Designing with interactive example galleries. *CHI '10: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2257–2266. https://doi.org/10.1145/1753326.1753667

Levasseur, D. G., & Kanan Sawyer, J. (2006). Pedagogy Meets PowerPoint: A Research Review of the Effects of Computer-Generated Slides in the Classroom. *Review of Communication*, *6*(1–2), 101–123. https://doi.org/10.1080/15358590600763383

Levy, S. (2018, March 29). *Graphical user interface*. Encyclopædia Britannica. https://www.britannica.com/technology/graphical-user-interface

Mairiza, D., Zowghi, D., & Nurmuliani, N. (2010). An investigation into the notion of non-functional requirements. *Proceedings of the 2010 ACM Symposium on Applied Computing (SAC '10)*, 311–317. https://doi.org/10.1145/1774088.1774153

Mayer, R. E., & Moreno, R. (2003). Nine Ways to Reduce Cognitive Load in Multimedia Learning. *Educational Psychologist*, *38*(1), 43–52. https://doi.org/10.1207/S15326985EP3801_6

Moran, K. (2019, December 1). *Usability Testing 101*. https://www.nngroup.com/articles/usability-testing-101/

Navarro, A. S. P. H., Cardeira, C. B., & Monteiro, C. M. F. (2016). User Centered Design of an Autonomous Mobile Robot Vending Machine Concept. *2016 International Conference on Autonomous Robot Systems and Competitions (ICARSC)*, 259–264. https://doi.org/10.1109/ICARSC.2016.67

Nielsen, J. (1993). *Usability Engineering*. Academic Press Limited.

Nielsen, J. (1994, November 1). *Severity Ratings for Usability Problems*. https://www.nngroup.com/articles/how-to-rate-the-severity-of-usability-problems/

Nielsen, J. (1998, October 3). *Personalization is Over-Rated*. https://www.nngroup.com/articles/personalization-is-over-rated/

Nielsen, J. (2000, March 18). *Why You Only Need to Test with 5 Users*. Nielsen Norman Group. https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/

Nielsen, J. (2008, May 26). *OK-Cancel or Cancel-OK? The Trouble With Buttons*. Nielsen Norman Group. https://www.nngroup.com/articles/ok-cancel-or-cancel-ok/

Nielsen, J. (2009, August 16). *Customization of UIs and Products*. https://www.nngroup.com/articles/customization-of-uis-and-products/

Nielsen, J. (2012a, January 3). *Usability 101: Introduction to Usability*. https://www.nngroup.com/articles/usability-101-introduction-to-usability/

Nielsen, J. (2012b, January 15). *Thinking Aloud: The #1 Usability Tool*. https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/

Nielsen, J. (2012c, June 3). *How Many Test Users in a Usability Study?* Nielsen Norman Group. https://www.nngroup.com/articles/how-many-test-users/

Nielsen, J. (2020, November 15). *10 Usability Heuristics for User Interface Design*. https://www.nngroup.com/articles/ten-usability-heuristics/

Noar, A. (2018, May 2). *New Survey Results on Presentations … #2 Will Shock You!* Presentation Panda. https://presentationpanda.com/blog/new-presentation-statistics/

Norman, D. (2013). *The Design of Everyday Things* (Revised an). Basic Books, A Member of the Perseus Books Group.

Norman, D. (2016, July 2). *Don Norman on the term "UX."* https://www.nngroup.com/videos/don-norman-term-ux/

Norman, D., & Nielsen, J. (n.d.). *The Definition of User Experience (UX)*. Nielsen Norman Group. Retrieved December 22, 2019, from https://www.nngroup.com/articles/definition-user-experience/

O'Donovan, P., Agarwala, A., & Hertzmann, A. (2015). Design scape: Design with interactive layout suggestions. *Conference on Human Factors in Computing Systems - Proceedings*, 1221–1224. https://doi.org/10.1145/2702123.2702149

OECD. (2019). Getting Skills Right: Future-Ready Adult Learning Systems. In *OECD Publishing* (Getting Skills Right). OECD Publishing. https://doi.org/10.1787/9789264311756-en

Pernice, K. (2018, October 7). *User Interviews: How, When, and Why to Conduct Them*. https://www.nngroup.com/articles/user-interviews/

Prensky, M. (2001). *Digital Natives, Digital Immigrants*. MCB University Press.

Quivy, R., & Campenhoudt, L. (1995). *Manual de Investigação em Ciências Sociais* (2th ed.). Dunod. https://tecnologiamidiaeinteracao.files.wordpress.com/2018/09/quivy-manual-investigacao-novo.pdf

Richey, R. C. (1994). Developmental Research: The Definition and Scope. In *National Convention of the Association for Educational Comunications and Technology*. http://files.eric.ed.gov/fulltext/ED373753.pdf

Römer, A., Pache, M., Weißhahn, G., Lindemann, U., & Hacker, W. (2001). Effort-saving product representations in design - Results of a questionnaire survey. *Design Studies*, *22*(6), 473–491. https://doi.org/10.1016/S0142-694X(01)00003-5

Saffer, D. (2010). *Designing for Interaction: Creating Innovative Applications and Devices* (2nd ed.). New Riders Publishing.

Santos-Gomez, L. (2000). *Integration of procedural and object-oriented user interfaces* (Patent No. US6104393A). https://patents.google.com/patent/US6104393A/en

Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre- and in-service teachers: The current situation and emerging trends. *Computers in Human Behavior*, *115*. https://doi.org/10.1016/j.chb.2020.106552

Sharp, H., Preece, J., & Rogers, Y. (2019). *Interaction Design: Beyond Human-Computer Interaction* (5th ed.). John Wiley & Sons, Inc. http://publications.lib.chalmers.se/records/fulltext/245180/245180.pdf%0Ahttps://hdl.handle.net /20.500.12380/245180%0Ahttp://dx.doi.org/10.1016/j.jsames.2011.03.003%0Ahttps://doi.org/1 0.1016/j.gr.2017.08.001%0Ahttp://dx.doi.org/10.1016/j.precamres.2014.12

Shneiderman, B., Plaisant, C., Diakopoulos, N., Jacobs, S., Elmqvist, N., & Cohen, M. (2018). *Designing the User Interface: Strategies for Effective Human-Computer Interaction* (6th ed.). Pearson Education Limited.

Simão, H., & Bernardino, A. (2017). User Centered Design of an Augmented Reality Gaming Platform for Active Aging in Elderly Institutions. *Proceedings of the 5th International Congress on Sport Sciences Research and Technology Support*, 151–162. https://doi.org/10.5220/0006606601510162

Spencer, M. (2019). Instructional Message Design with PowerPoint. In M. Ramlatchan (Ed.), *Instructional Message Design: Theory, Research, and Practice (Vol. 1).* Kindle Direct Publishing. https://digitalcommons.odu.edu/instructional_message_design/6

Spiteri, M., & Chang Rundgren, S.-N. (2020). Literature Review on the Factors Affecting Primary Teachers' Use of Digital Technology. *Technology, Knowledge and Learning*, *25*(1), 115–128. https://doi.org/10.1007/s10758-018-9376-x

Stemler, S. E. (2015). Content Analysis. In *Emerging Trends in the Social and Behavioral Sciences* (pp. 1–14). Wiley. https://doi.org/10.1002/9781118900772.etrds0053

Sundar, S. S., & Marathe, S. S. (2010). Personalization versus Customization: The Importance of Agency, Privacy, and Power Usage. *Human Communication Research*, *36*(3), 298–322. https://doi.org/10.1111/j.1468-2958.2010.01377.x

Sweller, J., Ayres, P., & Kalyuga, S. (2011). Cognitive Load Theory. In J. M. Spector (Ed.), *Explorations in the Learning Sciences, Instructional Systems and Performance Technologies*. Springer New York. https://doi.org/10.1007/978-1-4419-8126-4

Swider, N. R., Hammond, E. J., Kayastha, C., & Naylor, D. J. (2018). *Technology for generating product designs using multiple canvases* (Patent No. US10726592B2). https://patents.google.com/patent/US10726592B2/en

Syah, M. F. J., & Harsono, E. R. L. (2020). The development of motion-graphic media in learning: An advanced use of powerpoint in schools for baby Boomer, X and Y generation teachers. *International Journal of Innovation, Creativity and Change*, *12*(2), 322–337.

Thokala, K. (2011). *Haptic Enabled Multidimensional Canvas* [University of Akron]. http://e-journal.usd.ac.id/index.php/LLT%0Ahttp://jurnal.untan.ac.id/index.php/jpdpb/article/viewFile/11345/10753%0Ahttp://dx.doi.org/10.1016/j.sbspro.2015.04.758%0Awww.iosrjournals.org

Todi, K., Weir, D., & Oulasvirta, A. (2016). Sketchplore: Sketch and Explore with a Layout Optimiser. *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16)*, 543–555. https://doi.org/10.1145/2901790.2901817

Tognazzini, B. (2014, March 5). *First Principles of Interaction Design (Revised & Expanded)*. AskTOG. https://asktog.com/atc/principles-of-interaction-design/

Tsang, S., Balakrishnan, R., Singh, K., & Ranjan, A. (2004). A suggestive interface for image guided 3D sketching. *Proceedings of the 2004 Conference on Human Factors in Computing Systems - CHI '04*, *6*(1), 591–598. https://doi.org/10.1145/985692.985767

Tufte, E. (2003). PowerPoint is evil. *Wired Magazine*, *11.09*. http://www.wired.com/wired/archive/11.09/ppt2.html

Tufte, E. R. (2006). *The Cognitive Style of PowerPoint: Pitching Out Corrupts Within* (Vol. 2). Graphics Press LLC. https://www.edwardtufte.com/tufte/powerpoint

Usability.gov. (n.d.). *System Usability Scale (SUS)*. Retrieved June 15, 2021, from https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

Veloso, A. I., Carvalho, D., Sampaio, J., Ribeiro, S., & Vale Costa, L. (2020). Footour: Designing and Developing a Location-Based Game for Senior Tourism in the miOne Community. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12208 LNCS* (pp. 673–687). Springer. https://doi.org/10.1007/978-3-030-50249-2_48

Virzi, R. A. (1992). Refining the Test Phase of Usability Evaluation: How Many Subjects Is Enough? *Human Factors: The Journal of the Human Factors and Ergonomics Society, 34*(4), 457–468. https://doi.org/10.1177/001872089203400407

Vuorikari, R., Punie, Y., Carretero, S., & Van Den Brande, L. (2016). *Model DigComp 2.0: The Digital Competence Framework for Citizens | Update Phase 1: The Conceptual Reference*. https://doi.org/10.2791/11517

Wakefield, J. (2015, December 18). *How to avoid "death by PowerPoint" - BBC News*. BBC News. https://www.bbc.com/news/technology-35038429

Whitenton, K. (2019, October 27). *Unmoderated User Tests: How and Why to Do Them*. Nielsen Norman Group. https://www.nngroup.com/articles/unmoderated-usability-testing/

Yadav, S., Chakraborty, P., & Mittal, P. (2021). User Interface of a Drawing App for Children: Design and Effectiveness. In D. Gupta, A. Khanna, S. Bhattacharyya, A. E. Hassanien, S. Anand, & A. Jaiswal (Eds.), *Advances in Intelligent Systems and Computing* (pp. 53–61). Springer Singapore. https://doi.org/10.1007/978-981-15-5113-0_4

Yu, L.-F., Yeung, S.-K., & Terzopoulos, D. (2016). The Clutterpalette: An Interactive Tool for Detailing Indoor Scenes. *IEEE Transactions on Visualization and Computer Graphics*, *22*(2), 1138–1148. https://doi.org/10.1109/TVCG.2015.2417575

Zhang, B., & Sundar, S. S. (2019). Proactive vs. reactive personalization: Can customization of privacy enhance user experience? *International Journal of Human-Computer Studies*, *128*(December 2018), 86–99. https://doi.org/10.1016/j.ijhcs.2019.03.002

APPENDIXES

Appendix 1 – Contingency Plan

During the research process, issues, difficulties, or unexpected situations may occur. The following contingency plan (Table 9) was designed to provide alternatives and procedures in case some unforeseen events happened. Besides, as this research occurred during a global pandemic scenario (Covid-19), the contingency plan has even more relevance.

Table 9 – Contingency Plan

	Potential issues	Alternatives	Procedures
Exploratory interviews	Availability of participants that fit in the sampling proposed in this research plan.	Extend the schedule initially planned in the chronogram.	Schedule as many interviews as possible with the available participants and provide more time for them to respond to invitations.
		Change the sampling method.	Change the sampling method from a convenience sample to a snowball sample.
Low-fi and High-fi prototypes	Time constraints that affect the design of a low-fidelity and high-fidelity prototype.	Design only the high-fidelity prototype having in consideration the literature review and defined requirements.	Perform a literature review on specific matters concerning the prototype and define functional and non-functional requirements.
Evaluating the prototype	Not being able to evaluate the high-fidelity prototype due to participants constrains.	Recruit another group of participants.	Justify the need for recruiting other participants by mentioning faced problems.
	Time constraints that reflect in the evaluation of the prototype.	Evaluate only the main features of the prototype.	Prototype only the platform's main features.

Developing the online platform	Constrains that affect the tool's development.	Try to implement the main features in order to develop a functional product.	Search for technical solutions and alternatives in order to implement a minimal viable product.
		Refine the high-fidelity prototype.	Refine the high-fidelity prototype by including all the tool's features and requirements.
Evaluating the online platform	Not being able to evaluate the online platform due to participants constrains.	Recruit another group of participants.	Justify the need for recruiting other participants by mentioning faced problems.
	Time constraints that affect the evaluation of the online platform.	Evaluate the refined high-fidelity prototype with a different group of participants, being them experts or potential users.	Refine the high-fidelity prototype.
			Contact another group of participants.
			Perform a deeper evaluation by applying Usability/UX detailed evaluation methods.
			Justify this alternative and explain the problems that have arisen.

Appendix 2 – Exploratory interviews' script

Main goal: Understand teachers' perception about specific features identified in the literature review, namely identify similar tools, templates usage, customisation and expected features.

Interview dates: Between March 4 and 10, 2021.

Interviewees' characterisation:

– Teacher 1 [T1]: Communication Design and Design teacher with a background in Communication Design and professionalisation in Visual Arts. Over ten years of experience in academia and industry, having both employed and self-employed work.

– Teacher 2 [T2]: Communication Design, Photography and Design teacher, with initial training in Communication Design, specialised in Multimedia Arts and, later on, in Artistic Education. Over ten years of experience in academia and industry, working both in an employed and self-employed capacity.

Table 10 – Characterisation questionnaire for the exploratory interviews

Number	Question (in Portuguese – original)
1	Ocupação profissional atual.
2	Há quantos anos trabalha na sua ocupação profissional atual? Escolha apenas uma opção. Opções de resposta: < 1 ano; 1 – 5 anos; 5-10 anos; > 10 anos.
3	Descreva, sucintamente, a sua experiência relacionada com Design.

Table 11 – Script for the exploratory interviews

Number	Question (in Portuguese – original script)	Goal
1	Conhece ou já utilizou alguma ferramenta online (e.g. Canva, Picktochart, ...) para criar algum conteúdo de design (e.g. cartaz, post para redes sociais, flyer, ...)? Resposta: **"SIM"**.	- Contextualisation into this research's scope.

	a. Qual o nome dessa(s) ferramenta(s)? b. Qual foi o objetivo dessa utilização? c. Qual a opinião sobre a ferramenta que utilizou?	- Identify the online design tools most used by teachers. - Identify the features integrated into those tools.
2	Considera que a disponibilização de *templates* poderá facilitar o processo de criação de cartas temáticas para a *Toolkit to Game Design*?	- Understand teachers' perceptions concerning the use of templates in online design tools.
3	Num cenário em que os utilizadores poderão não possuir competências gráficas/ de *design*, quais os aspetos que considera relevante permitir a customização do produto final?	- To understand the expert's perspective on customisable features in a product that aims to ensure compliance with a brand's graphic standards.
4	Quais as funcionalidades que esperaria ter disponíveis numa ferramenta para criação de cartas temáticas para a *Toolkit to Game Design* que garanta o cumprimento de normas gráficas? a. Imagine que está a utilizar esta ferramenta para criar um conjunto de cartas, quais seriam os passos que daria para as criar? b. *(Caso as respostas anteriores não respondam ao pretendido)* Dos softwares ou plataformas de design que conhece ou utiliza, que funcionalidades consideraria interessantes incluir nesta ferramenta (e.g. fazer zoom, cortar, adicionar imagens)?	- Identify the expected features based in the contextualisation made on this dissertation research.
5	Considera viável existir uma ferramenta que garanta o cumprimento de princípios de design e das normas gráficas de uma marca? Se não, porquê?	- Understand this research's expected output viability.

6	Gostaria de acrescentar algum aspeto que não tenha sido abordado?	- Understand if interviewees want to mention anything outside the interview's script.

Appendix 3 – Exploratory interviews' transcription

Main goal: Understand teachers' perception about specific features identified in the literature review, namely identify similar tools, templates usage, customisation and expected features.

Interview dates: Between March 4 and 10, 2021.

Interviewees' characterisation: cf. Appendix 2.

Table 12 – Interviewees' answers during the exploratory interviews

Number	Question (in Portuguese – original script)	Answers (in Portuguese – original script)
1	Conhece ou já utilizou alguma ferramenta online (e.g. Canva, Picktochart, ...) para criar algum conteúdo de design (e.g. cartaz, post para redes sociais, flyer, ...)?	- [T1] Sim. - [T2] Não, só faz esses conteúdos em programas profissionais.
	Resposta: **"SIM"**. a. Qual o nome dessa(s) ferramenta(s)?	- [T1] Canva.
	b. Qual foi o objetivo dessa utilização?	- [T1] "Disponibilizar a um cliente uma plataforma para ele criar os seus conteúdos para as redes sociais, ou seja, fazia um template e com base no template ele editava o conteúdo, o texto ou a imagem estava tudo estruturado"
	c. Qual a opinião sobre a ferramenta que utilizou?	- [T1] "Acho que o canva é um bom exemplo de como as coisas estão a evoluir no sentido em que o designer acaba por definir um bocadinho as regras – os templates – e depois os conteúdos cada vez mais feitos pelo cliente"
2	Considera que a disponibilização de *templates*	- [T1] "Completamente. Até acho essencial. Obrigatório."

	poderá facilitar o processo de criação de cartas temáticas para a *Toolkit to Game Design*?	- [T2] "Sim, principalmente porque (...), no sentido lato do ensino secundário e superior, muitas vezes as pessoas não têm conhecimento nem sensibilidade – ex. a tipografia – (...) as pessoas não têm de saber o que é um rio, (...) como se justifica um texto, tem de ser hifenizado"
3	Num cenário em que os utilizadores poderão não possuir competências gráficas/ de *design*, quais os aspetos que considera relevante permitir a customização do produto final?	- [T1] "Os temas de wordpress têm as suas próprias definições, que cada designer se adapta e depois temos os templates"; "(...) uma coisa é criarmos para outros designers, que têm essas competências, outra coisa é criarmos para um público que não tem qualquer tipo de formação em design e que muitas vezes têm carências do ponto de vista da tecnologia. (...) Às vezes achamos que os jovens nascem com a tecnologia, os computadores, e sabem tudo, mas não é bem assim. Notamos (como professores) muitas dificuldades em coisas que parecem completamente óbvias"; "partir do princípio que o utilizador não sabe rigorosamente nada"; "inscrição num site, usas os passos, passo 1, passo 2 (...) para ir direcionada e não dispersar (...) paralelismo para o vosso trabalho, quanto mais fizeram desta forma, tanto melhor"; "tu como designer crias os templates (...), mas depois dá-se às pessoas 4/5 temas e depois escolhe. (...) balizar cada uma das partes, ter a garantia que o trabalho sai com o mínimo de equilíbrio, etc". **Sugestão: construção da carta por passos.** - [T2] "é importante deixar alguma parte de 'customizar', por exemplo a paleta cromática, (...) mesmo que não saibam tanto sobre a cor"; "a tipografia é fulcral que não se dê permissão,

		porque desvirtua o sentido do grafismo que se quer comunicar (...). a tipografia tem um caráter muito próprio (...) pode haver várias tipografias que já tenham sido testadas e que (...) funcionam bem"; "a cor por ser mais bonita, sendo que a tendência é para as primárias e complementares, isso é o natural para quem não tem a formação (...) é mais fácil deixar livre"; "dar muito espaço é destruir o trabalho"; "no meu trabalho apenas apresento uma opção, podemos fazer as alterações que o cliente quiser".
	Quais as funcionalidades que esperaria ter disponíveis numa ferramenta para criação de cartas temáticas para a *Toolkit to Game Design* que garanta o cumprimento de normas gráficas?	- [T1] "fonte não faz sentido"; "uma caixa com limite de caracteres."; "passo a passo, o trabalho criativo esteve do teu lado"; "3 pontos muito importantes: ser muito claro o que é o projeto, tens a ideia e a ferramenta (...) – reduzir quantidade de texto do site (...); ver exemplos de templates já feitos (...) como se fosse um portfólio; reduzir ao máximo o número de passos (...) é preferível abdicar de algumas opções/funcionalidades para ter menos passos"; "Termos a não usar junto do teu público: fonte, normas gráficas". - [T2] "tipografia, cores, composição"; "o passo a passo acaba por ajudar, (...) mas pode ser redutor"; "mas tendo as ferramentas – tipo de letra, cor – e limito os vários tipos de letra, deixar a criatividade ao serviço disso"; "utilizadores têm de conseguir personalizar a sua identidade".
4	c. Imagine que está a utilizar esta ferramenta para criar um conjunto de cartas, quais seriam	- [T1] Respondido anteriormente. - [T2] "escolha tipográfica, paleta cromática, composição (texto e imagem)"; "tendo

	os passos que daria para as criar? *(Caso as respostas anteriores não respondam ao pretendido)* Dos softwares ou plataformas de design que conhece ou utiliza, que funcionalidades consideraria interessantes incluir nesta ferramenta (e.g. fazer zoom, cortar, adicionar imagens)?	templates predefinidos com várias possibilidades de alinhamento".
5	Considera viável existir uma ferramenta que garanta o cumprimento de princípios de design e das normas gráficas de uma marca? Se não, porquê?	- [T1] "Sim. A ferramenta em si já deve ter essa limitação que garanta o cumprimento de normas." - [T2] "Sim. Não totalmente rígidas porque pode ser limitador."
6	Gostaria de acrescentar algum aspeto que não tenha sido abordado?	- [Interviewer] Ao utilizar o Canva, o cliente sentiu-se limitado? - [T1] "Ao explicar muito bem a vantagem da ferramenta, que não precisava de mim, que só tinha de se preocupar em trocar uma imagem e texto (...) ser muito focado no objetivo (...) ele (cliente) entende"; "reduzir ao máximo o campo de ação do cliente para que sejas tu a controlar a identidade". - [T2] "templates são bons, mas de repente fica tudo igual".

Appendix 4 – Expert Review: Analysis questionnaire

Main goal: Have UX experts performing an inspection on the functional product of this dissertation research.

Expert Review's dates: Between May 31 and June 3, 2021.

Table 13 – Characterisation questions enclosed in the first section of the deliverable

Number	Question (in Portuguese – original)	Question type
1	Indique a sua ocupação profissional atual.	Short open-ended question.
2	Há quantos anos trabalha e/ou investiga na área de UX/Usabilidade/HCI.	Multiple-answer question: **< 1 year; 1 – 5 years; 5 – 10 years; > 10 years.**
3	Descreva, resumidamente, a sua experiência relacionada com a avaliação de *User eXperience*.	Open-ended question.

Table 14 – Analysis questions from the second section of the deliverable

Number	Question (in Portuguese – original)	Question type
Introduction	Pede-se que, decorrente da validação que realizou e da revisão que poderá fazer, detalhe as suas respostas referindo heurísticas, princípios e *guidelines* das áreas de Usabilidade, UX e HCI, com base na sua perícia e experiência.	----
1	Indique pontos positivos identificados na ferramenta, justificando.	Open-ended question.
2	Indique na tabela abaixo os problemas identificados na ferramenta revista, explicitando o problema (na coluna do lado esquerdo) e classificando-o (na coluna do lado direito)	Table with two columns: one to describe the problem, and another to rate according to Nielsen's

	segundo a escala apresentada. Adicione linhas à tabela consoante for necessário. Escala: 0 – Não concordo que este seja um problema de usabilidade; 1 – Problema somente estético: apenas deve ser corrigido ser houver tempo disponível; 2 – Problema mínimo de usabilidade: a sua resolução deve ser de baixa prioridade; 3 – Problema de usabilidade considerável: importante corrigir, pelo que deve ter alta prioridade; 4 – Catástrofe de usabilidade: imperativo corrigir antes do lançamento do produto.	Severity Rating Scale (Nielsen, 1994).
3	Na tabela abaixo pode mencionar sugestões, caso as tenha. Adicione linhas à tabela consoante for necessário.	Table with two columns: one to write the recommendation, and another to paste the page link to which concerns the recommendation.

Appendix 5 – Usability Testing: Participant's Tasks

Main goal: Identify problems in the product, uncover aspects to improve, and observe user's behaviour and preferences (Moran, 2019). This evaluation would have been the final review of the achieved product.

After participants being presented to the G4N project and the aim for this evaluation, they would receive, through the video call conference software, the tasks they would have to complete – one by one, according with their interaction flow. Table 15 presents the pre-designed tasks.

Table 15 – Usability Testing: Participant's Tasks

Number	Task (in Portuguese – original)	Goal
1	Entra no portal Gamers4Nature com o objetivo de criar um conjunto de cartas temáticas. Onde se deve dirigir para o fazer?	Understand if the user identifies he must log in to his account to start creating his own cards set.
2	Agora que criou uma conta no portal já pode começar a criar as suas cartas. Contudo, antes disso gostaria de ver alguns exemplos de outros conjuntos de cartas criados por outros utilizadores.	Understand whether the user was able to identify the designated place to view other users' projects.
3	Após ver outros conjuntos de cartas, está no momento de criar o seu. Ao criar as cartas deverá tentar reproduzir o que está no documento que partilhei, contudo, esse documento é apenas uma referência, pode explorar outras vertentes.	During this task, the researcher would try to understand if the user understood which zones were editable and non-editable, if the user identifies the step in which he was currently in and which ones he had already completed or had not yet arrived, if he identified the cards and steps navigation zone, and finally, where he could find help if needed.

4	Imagine que adicionou uma aguarela/ilustração acidentalmente. Como a pode eliminar?	Identify if the user was able to delete a watercolour mark or an illustration.
5	Agora que terminou de criar as cartas, como as pode descarregar para o seu computador?	Perceive if the user understood how to download his creation.
6	Agora quer criar as cartas numa nova categoria, como deverá proceder?	Understand if the user identifies which category was already finished and the categories which still had no cards associated.
7	Está, então, a criar cartas para uma outra categoria. Como já conhece o funcionamento da ferramenta, não quer mais dicas, como as pode fechar definitivamente? E agora que as desativou, como as pode reativar?	Perceive if the user understood where to click deactivate and reactivate the tool's tips.
8	Decide que não quer criar mais cartas para este conjunto, como visita o conjunto de cartas que criou?	Identify if the user can visit his own creations.
9	Lembra-se agora que detetou um erro numa carta. Como faz para o corrigir?	Understand if the user can edit previously created cards set and navigate through different edition steps.

Appendix 6 – Usability Testing: Experience questionnaire

Main goal: Identify problems in the product, uncover aspects to improve, and observe user's behaviour and preferences (Moran, 2019). This evaluation would have been the final review of the achieved product.

After the Usability Testing session, participants would be asked to answer a questionnaire about their experience (Table 16 and

Table 17). The questionnaire was divided into two sections: I – Characterisation; and II – Reporting the Experience (divided in the System Usability Scale and some other questions).

Table 16 – Experience evaluation questionnaire (in English)

Section	Task (in English)	Question type
I.1	What subject do you teach nowadays?	Short open-ended question.
I.2	For how many years have you been teaching? Choose only one option.	Multiple-answer question: **< 1 year; 1 – 5 years; 5 – 10 years; > 10 years.**
I.3	Have you taught any other subjects throughout your career?	Short open-ended question.
I.4	Do you resort to any kind of technology or software to teach? If your answer is yes, name the technology or software used.	Open-ended question.
II.1.1	I think that I would like to use this system frequently.	Likert scale: **1 – Strongly disagree; 2 – Disagree; 3 – Neither agree or disagree; 4 – Agree; 5 – Strongly agree.**
II.1.2	I found the system unnecessarily complex.	
II.1.3	I thought the system was easy to use.	
II.1.4	I think that I would need the support of a technical person to be able to use this system.	
II.1.5	I found the various functions in this system were well integrated.	
II.1.6	I think there was too much inconsistency in the system.	

II.1.7	I would imagine that most people would learn to use this system very quickly.	
II.1.8	I found the system very cumbersome to use.	
II.1.9	I felt very confident using the system.	
II.1.10	I needed to learn a lot of things before I could get going with this system.	
II.2	While using the tool, did you encounter any problems or struggled with any feature?	
II.3	What are the strengths of the experience?	Open-ended question.
II.4	During the experiment, did you felt that any functionality was missing?	
II.5	Briefly report on your experience.	

Table 17 – Experience evaluation questionnaire (in Portuguese)

Section	Task (in Portuguese)	Question type
I.1	Qual a disciplina que leciona atualmente?	Short open-ended question.
I.2	Sublinhe a opção correspondente ao número de anos que leciona.	Multiple-answer question: **< 1 year; 1 – 5 years; 5 – 10 years; > 10 years.**
I.3	Ensinou outras disciplinas ao longo da sua carreira? Se sim, quais?	Short open-ended question.
I.4	Recorre a alguma tecnologia ou programa para lecionar as suas aulas? Se sim, quais?	Open-ended question.
II.1.1	Acho que gostaria de utilizar este produto com frequência.	Likert scale: **1 – Discordo totalmente;**
II.1.2	Considerei o produto mais complexo do que necessário.	**2 – Discordo;** **3 – Não concordo, nem**
II.1.3	Achei o produto fácil de utilizar.	**discordo;**

II.1.4	Acho que necessitaria de ajuda de um técnico para conseguir utilizar este produto.	**4 – Concordo;** **5 – Concordo totalmente.**
II.1.5	Considerei que as várias funcionalidades deste produto estavam bem integradas.	
II.1.6	Achei que este produto tinha muitas inconsistências.	
II.1.7	Suponho que a maioria das pessoas aprenderia a utilizar rapidamente este produto.	
II.1.8	Considerei o produto muito complicado de utilizar.	
II.1.9	Senti-me muito confiante a utilizar este produto.	
II.1.10	Tive que aprender muito antes de conseguir lidar com este produto.	
II.2	Ao utilizar a ferramenta, encontrou algum problema ou sentiu alguma dificuldade? Se sim, descreva-o(s).	Open-ended question.
II.3	Quais foram os pontos fortes da experiência?	
II.4	Durante a experiência, sentiu que faltava alguma funcionalidade?	
II.5	Descreva brevemente a sua experiência.	

Appendix 7 – UX Experts' Characterisation

Table 18 presents the characterisation of each UX expert that participated in the conducted Expert Reviews.

Table 18 – UX Expert's characterisation

Expert ID	Current professional occupation	Years of experience	Summary of the UX expert's experience
E1	PhD Research Fellow in a UX Laboratory	> 10 years	*"I have a degree in Communication Design (bachelor and master), and I work with HCI and Usability since 2007, having taught for 8 years in higher education courses related to design and multimedia. In 2017 I joined a funded and R&TD co-promoted project with industry in UI and UX and have been integrating expert reviews within UX in other projects since then."*
E2	UX/UI Design Researcher	1 - 5 years	*"On a day-to-day basis I investigate end-users through several UX methodologies, prepare UX and UI proposals, usability tests and their consequent evaluation."*
E3	Doctorate Researcher	> 10 years	*"My main research interests are related to User Experience Design, more specifically with Accessibility and Usability of multimedia products and services targeting users with special needs, namely visually-impaired and elderly people. Furthermore, I am involved and interested in developing products and services for other audiences. In the last 10 years, I have participated in 10 research projects (4*

			individual and 6 team) and 7 academic projects (5 masters and 2 undergraduate) and all of them had User Experience Design as a methodology and involved solutions for the customization of the system concerned."
E4	Doctorate Researcher	> 10 years	*"My experience with UX evaluation started during the development of my master's dissertation, in which I developed and evaluated a visualization tool of community interactions in an educational platform to support the a Master's Degree. From then on all the research work I developed in individual and team projects aimed at the UX evaluation of applications or products. Even in the disciplines I teach related to multimedia, User Experience is a topic approached and applied in the development of multimedia products/services by the students."*
E5	PhD Student, Multimedia Teacher and Freelancer	> 10 years	*"I have been involved in several UX evaluation processes (mobile and web) as: researcher/planner, supervisor, end-user evaluator and invited expert, in academic, research and business contexts."*
E6	Doctorate Researcher	5 - 10 years	*"My experience in User Experience started in 2008 with the evaluation of low and high fidelity prototypes with the target audience. In addition to my training in the area, I have experience in the co-creation of digital artifacts with user involvement, application of co-design strategies, informational architecture, interaction and visual design as well as*

			application and evaluation of the effectiveness of evaluation methods in UX both in situ and laboratory context."
E7	PhD Student, UX/UI Designer and Researcher	1 - 5 years	*"Since 2017 I've been working on projects closely related to UX, both in the prototyping process and in user testing (with a greater focus on accessibility and usability). My design process is summarized by understanding the user needs, organizing the information obtained (requirements list, sitemap, etc.), rapid sketching, wireframing, mockups and user testing, all in an iterative design process. The final stage consists of the development of a prototype of higher fidelity, with greater attention to the development of the UI."*

Appendix 8 – Issues identified in the Expert Review

Table 19 lists the issues identified by the experts, sorted in descending order, based on the Severity Ratings for Usability Problems (Nielsen, 1994). The issues were transcribed from each expert's written document and contextualised based on the session recording. Some recurrent issues were mentioned by different experts and were rated with different severities based on the rating scale applied.

Table 19 – Transcription of the issues identified by the experts

Problem description	Severity Rating for Usability Problems	Expert ID
Perceived affordance problem - e.g. "My Projects" button looking like a search input field.	4	E6
"My projects" button is "lost" in the middle of the page "Build your own cars".	4	E7
There is no option to reactive the tips after clicking "Hide all tips".	4	E7
Light grey cards – in the page "Build your own cards" – have low contrast with the white background.	4	E7
The cards customisation navigation elements are placed in peripheral areas of the screen.	3	E1
Tips should be given central prominence when they appear as they provide the instructions for interaction.	3	E1
Lack of option to return to the previous page. Ex. Home > Build your own cards. Relates to the 3rd heuristic of "Control and freedom", but also to the 1st of "Visibility of the system" (which would be achieved with a breadcrumb element).	3	E2
From the information given on the landing page, you can see that there are four steps, but when entering the first there are only two levels. When passing to the card builder its representation is already different. For better consistency and visibility, it could have a global stepper when creating a new	3	E2

deck of cards, complemented by the second (in the detailed creation of the contents of the cards) when justified.		
When going to the 2nd step of the first part of creation, there is no way to go back to the first (freedom and control; error prevention). Depending on the goal, either you are allowed to go back to step 1, or when going to step 2, there should be a warning that you cannot reverse the action (I would bet on the 1st suggestion).	3	E2
When editing a project, there is no interaction and/or feedback about step 1.	3	E3
Remove redundancy of edit (pop-up) buttons.	3	E5
Consistency in buttons - There are buttons that have an icon, others without an icon.	3	E6
Representation issues vs user language – In the layouts page, there are no variances in terms of size, to indicate what is the title, description, caption on the cards.	3	E6
In the layouts page, it might be hard for end-users to distinguish between title, description, caption on the cards.	3	E5
In create cards, the label to the + button is missing and the forward < > buttons look the same as the 'Background' and 'Illustrations' steps, eventually reporting that they are also locked (same visual appearance = same function indication).	3	E6
Ensure readability in the interface – see contrast of placeholder text with grey fields in the form (grey communicates not active) and control the positioning of the watercolour in relation to the text.	3	E6
Navigation issue. Attention to element's designation - allusive to the possible action of the user (e.g. build cards to see cards).	3	E6
Overly long descriptive text throughout the page (maximum three lines).	3	E7

Switch the background customisation to the last step as it is more decorative, while the illustrations will be more allusive to the card's content.	2	E1
Clicking on the "New project" button directs the user to the "New cards set" page - the action does not match the realisation. The concepts should be unified (just like when creating a new game).	2	E2
On longer pages, as is the case with the choice of the layout, it is possible to go to the next step at the top of the area (redundancy allows the user greater navigation agility and flexibility).	2	E2
In the confirmation modal between steps 2, 3 and 4 of the card's creation, it is missing to indicate why this is an action to confirm. I can still reverse the action, so I didn't understand the need for the modal. It seems more critical to me the submission of the cards in step 4, because I can only go back through editing, where I can no longer add cards (error prevention).	2	E2
"Help button does not seem easily 'visible'."	2	E3
"My projects" should be accessible through the user's profile.	2	E4
There is no mention of the inability of editing Step 1 of the cards.	2	E4
"'My projects' do not appear in the profile like 'My games'."	2	E3
Terms/language used in the messages.	2	E5
The button of Step 1 when editing the cards should be with another colour, indicating that it is not available.	2	E5
Allow users to progressively learn and familiarise themselves with the interface - e.g. interactive guides instead of a picture of the kit and its composition as well as action scenarios.	2	E6
Indication of the elements selected (e.g. those already chosen - watercolour).	2	E6
Prioritise recognition over recall: Contextual help instead of the help button with the information.	2	E6

Reinforce action feedback - e.g.: You are now ready to create your cards. Your cards are ready to be used. Start playing now.	2	E6
To edit the project requires selecting a list with steps, which is inconsistent with the previously presented canvas.	2	E7
The instruction for each task appears next to the step number in the canvas, which is not easy to read and transform it into an action on the canvas.	2	E7
There are scrolling issues, button colours, lack of colours and figures, among other points that demand A/B testing.	2	E7
The tips appear with the "hide all tips" button even on pages when there is only one tip.	2	E7
Define a floating navigation zone allowing the canvas area to be clearer.	1	E1
The use of a magnifying glass icon on the "My projects" button is slightly misleading - perhaps also because of the white background that resembles a search box (consistency).	1	E2
"There are two inactive arrows while creating the first card. It may not be immediately obvious that they are inactive."	1	E3