VisVoyage: A Co-Designed Tabletop Game to Support Data Visualization Learning Among Office Workers

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Abstract

Data visualization (DV) is increasingly recognized as a vital skill for enhancing workplace competitiveness, leading more office workers to seek DV knowledge from a novice level. However, existing DV processes and models are predominantly designed for experts, often overlooking the diverse range of DV tools and making them less accessible to beginners in the workplace. Moreover, current engaging DV teaching methods are largely focused on classroom environments, neglecting the specific learning needs of office workers. This research addresses these gaps through a user-centered design approach, developing an engaging and competitive tabletop game that teaches core DV concepts, such as data attributes, chart types, and the DV design process, to office workers. This dissertation presents the design and development of *VisVoyage*, a co-designed tabletop card game, and includes a literature review, methodology explanation, design phases, and reflective analysis. The study not only offers a gamified solution to bridge the existing educational gap but also contributes to the broader need for effective DV education and engaging teaching methods specifically tailored to office workers.

Research Ethics Approval

Instructions: *Agree with your supervisor which statement you need to include. Then delete the statement that you are not using, and the instructions in italics.*

Either complete and include this statement:

This project obtained approval from the Informatics Research Ethics committee.

Ethics application number: 760956

Date when approval was obtained: 2024-06-01

The participants' information sheet and a consent form are included in the appendix.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(*Shuomeng Zhang*)

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Chapter 1

Introduction

A growing body of literature emphasizes the critical role of data visualization (DV) as a vital skill in the modern era. Increasingly, office and knowledge workers across various fields are required to develop competencies in data analysis and visualization to enhance their professional effectiveness, leveraging data for communication and insight generation [21]. In the business sector, for instance, data visualization is pivotal in transforming large datasets into comprehensible visuals, facilitating communication and informing strategic decision-making processes [25]. Similarly, in the media industry, data-driven journalism utilizes visualization techniques to reveal and narrate the intricate stories embedded within datasets [71][34]. Employees proficient in DV gain substantial benefits, including enhanced career prospects and the potential for higher earnings [73].

In recent years, the rapid development of data science and related fields has equipped clients across various industries with advanced DV techniques. This growth has led to an explosion of new DV tools and frameworks [58]. Tools such as Tableau, Flourish, and Rawgraphs have become increasingly prevalent, offering comprehensive functionalities and making interaction with visualizations significantly easier [44]. However, despite the growing accessibility of these tools, many office workers who could benefit from them often lack the necessary expertise in visualization construction and foundational knowledge in data-related disciplines. Even with user-friendly platforms and tools, there remains a fundamental requirement for understanding data structures and visualization processes, which can be particularly daunting for those without a background in data science [6]. Office workers often face setbacks and trial-and-error when selecting and learning software due to differing industry backgrounds and visualization needs. Additionally, they struggle to transfer skills from one tool to another, as each platform presents its own learning curve and associated costs [16]. Therefore, it is crucial to

explore and develop straightforward, practical frameworks for initial DV education that are adaptable to various backgrounds and tools [42][30][3]. By addressing these diverse learning needs and the complexities of the tool landscape, office workers can better navigate the evolving demands of their professions and acquire the necessary skills to thrive in a data-driven world.

Learning new skills, including DV, in the workplace is often hindered by time constraints and the need for practical, immediate application. Traditional educational resources, such as tutorials, official documentation, and textbooks, frequently fail to engage beginners, especially in fast-paced, high-pressure work environments [26][54]. Customized educational tools designed to cater to the unique needs of office workers remain in short supply. Thus, in addition to identifying appropriate introductory content for DV, there is an urgent need to develop engaging and flexible teaching methods that prioritize efficiency, adaptability, and user engagement.

Tabletop games, including both board and card games, are analog games played on a flat surface [53]. They have been increasingly recognized as valuable tools for teaching data and computing concepts, as their rules and mechanisms can embody fundamental ideas and practices related to these fields [7][35]. Through gameplay, learners can engage with abstract concepts in a more tangible and interactive way. In the context of office environments, tabletop games are also effective for enhancing collaboration and improving learning efficiency [67]. This dual capacity to teach both technical and soft skills makes tabletop games a promising method for educational purposes.

This study aims to explore how office workers with limited data experience can rapidly develop an understanding of DV with the ability to navigate the diverse landscape of DV tools. The project focuses on two key areas: first, developing a framework for DV learning content tailored to workplace novices and beginners; and second, using co-design methods to create a tabletop game-based approach for teaching DV concepts. The research targets office workers who require DV skills for their jobs but are not data professionals, defining novices and beginners as individuals with limited to no experience or familiarity with DV. The dissertation outlines the design process for creating a game-based educational tool that addresses these research questions. The structure of the study is as follows: Chapter 2 provides a comprehensive literature review, identifying gaps in existing research and theoretical foundations. Chapter 3 details the methods used throughout the project, outlining the tasks that culminated in the final design solution. Chapters 4 through 6 document the stages of the design process, highlighting the outcomes and insights derived from the design methods and

explaining the rationale behind major design decisions. Finally, Chapter 7 offers a critical reflection on the project's contributions and limitations.

Chapter 2

Related Works

2.1 Data Visualization Construction for Novices

Although modern tools such as Tableau enable users to upload and visualize data with ease, constructing effective visualizations remains a significant challenge for DV novices. The difficulty arises from the lack of a standardized, entry-level framework for DV education. As an interdisciplinary skill, DV draws upon a diverse array of fields, including computer science, design, and cognitive science, leading to wide variations in learning objectives and practices [5][17]. Moreover, the motivations for learning DV differ significantly among individuals, ranging from task-specific needs to aspirations for mastery in data science [4]. These varied learning needs often lead to DV education resources that are either overly comprehensive and overwhelming for novices or too narrowly focused on specific audiences or tools [30]. The vast landscape of available DV tools further complicates the learning process. Although these tools allow almost anyone to create visualizations, their complexity and constant evolution can be overwhelming for novices [3]. Hence, establishing a general and easy-to-understand framework for DV construction is essential for guiding novices through the process.

There are several models of the visualization process that explain the steps users follow when constructing visualizations. Card et al.'s reference model for visualization, for instance, outlines essential steps such as data transformations, visual mapping, and view transformations [13]. Similarly, Spence identifies key stages including selection, encoding, and presentation, which help transform raw data into meaningful visualizations [61]. Ware's model divides the process into four stages: data collection and storage, data pre-processing, image construction, and human perceptual and cognitive processing of the images [70]. While these models provide comprehensive

frameworks for constructing visualizations, they often cater to experts and use complex terminology that can be difficult for novices to grasp. Bridging these gaps is critical for non-professionals attempting to learn DV. For novices, the process can be distilled into a simpler framework that involves selecting data attributes, choosing appropriate visualization templates, and defining visual mappings that link data attributes to corresponding visual properties [30]. The NOVIS model offers a more detailed breakdown of the cognitive activities required for novice learners [45]. Research suggests that among these steps, the selection of visual metaphors or visual encoding is often the most challenging [33]. This stage is also referred to as the selection of visualization, visual metaphors, or visual encoding [22][68][27]. From the existing models, it can be inferred that for non-professionals to effectively learn the construction of data visualizations, they should master these three processes and concepts.

i) Data Attribute Selection: The ability to identify and select relevant data attributes is essential for creating meaningful visualizations [38].

ii) Visual Structures: Understanding different types of visualizations and their properties is crucial for choosing the most appropriate form to represent data effectively [14].

iii) Visual Mappings: Novices must learn how to connect data attributes with visual properties, such as color, size, and shape, to accurately convey their message [22][68][27].

By focusing on these core components, novices can build a solid foundation in DV, enabling them to navigate the complexities of the field and create visualizations that are both informative and visually coherent. However, previous models and research often overlook the challenges that DV novices face in mastering the diverse and complex landscape of DV tools. This gap is particularly significant in the office work environment, where the construction of effective data visualizations is closely linked to the proficient use of these tools. This study aims to explore the DV process within the specific context of using DV tools, focusing on how office workers, often with no prior data background, learn to construct data visualizations and the barriers they encounter.

2.2 Data Visualization Education for Broader Audience

The expanding field of DV education highlights the growing interest in this area, as evidenced by the increasing availability of textbooks, courses, workshops and other educational resources [47]. In higher education, diverse curricula have been developed

to teach information visualization [23], incorporating innovative approaches such as critique-based learning [41] and data physicalization [32]. For younger audiences, DV has been introduced through engaging and gamified activities designed to make learning accessible and enjoyable [18][72]. These approaches guide students in exploring data and understanding charts and visualizations, often utilizing unconventional teaching methods such as storytelling [11], online platforms [1] [9], physical objects, and gameplay. For example, the "Choose Your Own Adventure, with Data Visualization" exercise uses a story-driven adventure to lead users through the process of visualizing abstract data [11]. C'est la Vis introduces young children to different types of visualizations using concrete examples and animations, while Construct-A-Vis allows children to create free-form visualizations on tablets [1][9]. Hands-on tools, such as LEGO bricks and other physical objects, foster a collaborative and interactive learning environment by helping students physically build their visualizations [72]. Similarly, game-based learning tools like Diagram Safari and the Ball Chart Game educate children about diagrams and charts, further promoting DV learning through play [28]. These creative tools are primarily designed for classroom use, assisting teachers in guiding students and providing timely feedback.

However, outside of classroom settings, playful and engaging tools for teaching DV to adults are limited. While physical visualization methods, like building with LEGO bricks, remain useful for adult workshops [36], such tools are typically employed as supplementary aids rather than primary learning resources. The Play and Viz study explored the use of entertainment games such as Townscaper and Stardew Valley as platforms for interactive data visualizations [39], but these platforms offer limited structured DV learning and serve more as creative outlets than comprehensive educational tools. For DV novices, using such tools alone is insufficient for mastering core DV concepts, such as data attributes and visual mapping. In contrast, tools like VizAssist provide interactive user assistance for visualization tasks, guiding learners through the complexities of visualization software and supporting the acquisition of DV skills [10]. While useful, especially for office workers learning DV tools, these user assistance platforms often lack the fun and engagement necessary to maintain interest. Thus, balancing learning efficiency and engagement is a key challenge in designing educational tools for adult learners. Moreover, digital tools in office environments can be complex, as their installation often requires complex approval processes. For this reason, accessibility and ease of use become critical factors in selecting DV teaching tools for office workers. Simple, enjoyable, and non-digital tools may be better suited

to this context.

Building on these insights, this study seeks to develop a playful approach to introducing DV concepts to office workers, emphasizing engagement, efficiency, and broad applicability. The approach aims to balance learning effectiveness with enjoyment, ensuring that office workers can acquire essential DV skills with fun.

2.3 Tabletop Games for Learning

Tabletop games have been recognized as effective tools for enhancing understanding across a wide range of subjects, including complex scientific topics such as mathematics [24][37][59][60]. Despite the diversity of topics these games cover, researchers agree that their engaging nature can motivate learners to tackle tasks that might otherwise seem monotonous. Additionally, specific game mechanics and structures are believed to support learning in unique ways [53]. Research indicates that when an activity is labeled as a game, learners tend to view it more positively [46]. Quiz-based or trivia games, widely used as educational tabletop tools, motivate learners by incorporating questions related to the subject matter [49]. In these games, players typically roll dice or draw cards and respond to questions, earning points or advancing toward game objectives for correct answers. Studies of these games show that learners not only enjoy them but also experience measurable educational gains [8][50][55]. More complex tabletop games are designed with learning embedded in their mechanics, rather than being products of executing game mechanics [53]. These games often align closely with the knowledge being conveyed and are capable of immersing players in a flow state, making learning more contextualized [20][31]. For instance, rolling dice and counting while moving a game piece strengthens number sense and mathematical knowledge [60][24][59]. For more advanced educational content, such as complex systems and models, tabletop games are also considered effective because players can manipulate different mechanics and components within the game to explore how they influence the systems [15]. In the realm of data-related and computing education, tabletop games are also considered to hold great potential. Even in games not specifically designed to teach these subjects, players often engage in computation as part of the gameplay [7]. This implicit engagement with computing makes tabletop games a valuable tool for teaching DV and other computing-related concepts.

Moreover, tabletop games are uniquely positioned to encourage collaboration, as many are designed with tasks that cannot be completed alone [52]. This feature is

particularly valued in workplace training, where collaboration is critical. For instance, a company was able to reduce 80 hours of employee training to half the time by converting the training content into a collaborative game format [67].

In summary, unlike digital games, tabletop games offer transparent mechanics that make the rules and processes more explicit and easier for players to understand [35]. Their inherent connections to number sense and computing further highlight their potential for aiding DV learning. Additionally, considering office workers as the target audience, tabletop games provide the added benefit of fostering collaboration and social interaction, both of which are valuable in professional settings. Thus, this project aims to design a tabletop game that leverages these strengths to facilitate effective DV education for office workers.

2.4 Discussion

From the literature review, it is evident that the current teaching content for DV construction remains largely designed for experts and relies on complex terminology, making it difficult for novices to understand [13][61][70]. Helping users grasp core concepts such as data attributes, visual structures, and visual mappings is essential to bridging this gap. Additionally, while there is a growing reliance on DV tools for creating visualizations, there is a lack of introductory teaching frameworks that focus on practical, tool-based DV processes for novices.

Playful and engaging teaching methods for DV education, such as gamified approaches, are predominantly used in primary and higher education classroom settings [28][72][1]. However, there is a noticeable gap in similar approaches tailored for adult learners, particularly office workers. These learners would benefit from methods that emphasize not only engagement but also learning efficiency and broad applicability. Given this context, tabletop games emerge as a promising tool for teaching DV to office workers, as they have already proven effective in teaching numerical and mathematical concepts and align well with the collaborative nature of office environments [7][24][59].

Based on these insights, this research will focus on two main objectives: first, to adapt existing DV models to be more novice-friendly in workplace settings by incorporating practical knowledge of DV tools; and second, to design and develop a tabletop game that teaches DV to office workers, balancing engagement with learning efficiency. This approach aims to make DV education more accessible and relevant to office workers who need these skills in their day-to-day tasks.

Chapter 3

Methodology

3.1 Double Diamond Design Process

The primary objective of this study was to design a tabletop game to introduce fundamental concepts and processes of data visualization to novices in workplace settings. To comprehensively consider the target audience, scenario, and educational goals, this study followed the Double Diamond model as the framework guiding the design process toward the final design.

The Double Diamond model, established by the British Design Council in 2004 [19], is a widely accepted depiction of the design and innovation process. It outlines the steps taken in any design project, regardless of the specific methods or tools employed. The model consists of two diamond-shaped parts, which represent cycles of divergence and convergence, encompassing "designing the right thing" and "designing the thing right" [66]. This process corresponds directly to the two core issues addressed in this research: "what to teach" and "how to teach it", which involve identifying the data visualization learning needs of the target audience and designing a game-based creative approach to meet those needs. These two parts include four stages: Discover, Define, Develop, and Deliver.

The Double Diamond process does not prescribe specific methods within each phase. Instead, it allows for flexibility, with methods chosen based on the design problem, context, and the designer's conceptualization [19][57]. In this study, the focus was on methods that encourage empathetic engagement with users and empower stakeholders in the design process [62][65]. The main techniques adopted include interviews, thematic analysis, co-design workshops, observations, and user testing. Figure 3.1 provides an overview of the individual process steps, methods, and activities,

all structured according to the Double Diamond model. The following sections will provide a detailed description of each step and a comprehensive breakdown of the methodology implemented during each stage.

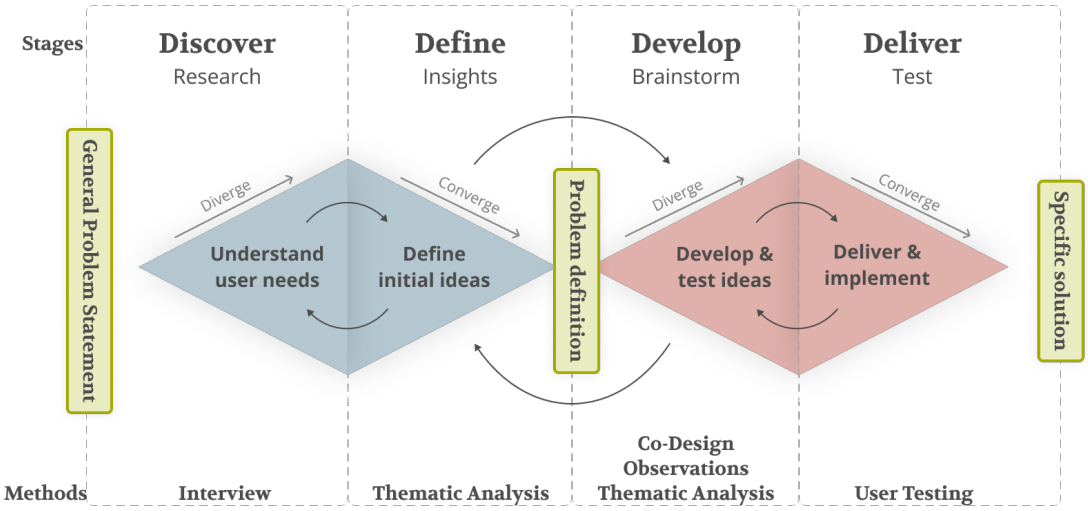


Figure 3.1: Double Dimond model and methods in all stages

3.2 Designing the Right Thing

The first half of the Double Diamond process focuses on designing the right thing, which includes the discover and define stages. Discovery is an exploratory phase where the problem space is examined, while definition involves sensemaking and analysis, to refine the challenge and develop a design brief.

In the discovery phase, semi-structured user interviews were conducted to collect data on the experiences and needs of the target audience—office workers who are DV novices and need to create visualizations as part of their job. Given the specific selection criteria for this study, participants were recruited through personal networks to expedite the process. Five participants from diverse professional backgrounds were selected, none of whom had data-related background but all had experience learning DV skills in the workplace. This diversity allowed for a broader understanding of the learning paths of DV novices. The interviews aimed to gather deep insights into the target audience's experiences and inform the design of educational content and the game. Specifically, the interviews explored how office workers learn and address DV needs in their work, the challenges they face in learning DV, and their experiences with efficient and enjoyable ways to learn new skills in the office environment.

In the define phase, the information gathered from the Discover phase was processed and analyzed to develop a clear set of design requirements and goals. Since the interviews produced a large amount of qualitative data, thematic analysis was employed to identify key themes [12]. A total of 11 themes were extracted from the interview transcripts, providing valuable insights into participants' understanding of DV education and their preferences for learning new concepts. Based on these themes and the literature review in Chapter 2, a DV learning pipeline tailored for office workers was developed. Additionally, participants' expectations for the co-design workshop were formalized, guiding the subsequent stages of the design process. Further elaboration on the results from this phase can be found in Chapter 4.

3.3 Designing the Thing Right

The second half of the Double Diamond process focuses on designing the thing right, which includes the development and delivery stages. Development involves the creative production of potential solutions, while delivery focuses on finalizing the best solutions.

In the development phase, a co-design methodology was employed to generate multiple ideas for the tabletop game. Co-design is a collaborative approach that involves a wide range of stakeholders and users in the design process [56]. In addition to the design outputs produced during the co-design process, the thoughts, decisions, and behaviors of participants can also provide valuable insights. Based on the DV education requirements identified in the previous phase and the needs articulated by participants for the co-design workshop, a card-based tool was designed as a scaffold for the workshop. Nine participants, including target users and tabletop game experts, were recruited and divided into two groups to participate in the co-design workshops. The data generated from the co-design sessions was analyzed using thematic analysis [12], resulting in the identification of five key themes. These insights, along with interesting and effective game elements designed during the co-design process, were incorporated into the final design. Chapter 5 provides a more detailed exploration of this phase.

During the delivery phase, the diverse ideas generated during the development phase were refined and converged into a final design that was then subjected to small-scale testing. Based on the thematic analysis of data from the co-design workshops, a refinement strategy was developed, leading to the design of a card game named *VisVoyage*. To evaluate the feasibility of the game design and gather insights for future iterations, a testing session was conducted. The feasibility of the design was validated

through this process, confirming its readiness for delivery. Further details on this phase can be found in Chapter 6.

3.4 Conclusion

In summary, this study adopted the Double Diamond model as the guiding framework for the design of a tabletop game aimed at introducing DV concepts to office workers who are novices in the field. Each stage of the Double Diamond process was meticulously followed, with methods such as interviews, thematic analysis, collaborative design, and observation used to inform and refine the design. Therefore, a user-centered product that balances the exploratory research and the target audience's needs and requirements can be developed, providing an innovative and engaging approach to DV education.

Chapter 4

Discover and Define: Interview and Thematic Analysis

4.1 User Interview

Semi-structured interviews were conducted with each participant, aiming to understand their background and expectations regarding learning DV in the workplace. These in-depth interviews provided valuable insights, helping to identify a set of criteria for the final design. Moreover, they offered inspiration for organizing and designing the workshop in the subsequent design process, including aspects such as participant composition, the design of activities, and the selection of tools for co-designing possible solutions.

Compared to structured and unstructured interviews, the semi-structured interview approach allows the researcher to ask predefined open-ended questions related to the research topic, facilitating the exploration of a previously defined problem space [29]. Simultaneously, it provides participants with the flexibility to guide the conversation and share their experiences and opinions freely. For this study, ensuring that the interview remained focused on key topics while allowing flexibility to gather additional information based on the participant's background was particularly important. Therefore, the semi-structured interview was the most suitable approach.

At this stage, the study aimed to address two main questions through the interviews:

Firstly, what are the general DV knowledge and skills needed in the workplace, and how do these help office workers with non-DV backgrounds fulfill their work requirements?

And secondly, what methods and activities facilitate the learning of new skills in the

workplace, and what aspects do participants value in the learning process in general?

Clarifying this information will help us identify the two most critical aspects of designing for DV novices in the workplace: what to teach and how to teach it.

In addition to these primary topics, I also explored their perspectives on game elements and gamification in educational and workplace contexts, as well as their needs and expectations regarding co-design workshops. This information will assist in the development of a workshop that better aligns with user needs and curiosity, thereby enhancing participants' engagement and creativity.

The interviews were conducted in a semi-structured manner, following a predetermined script that encompassed five main topics, each introduced with one to three lead questions. Subsequent conversations within each topic were guided by the participants' responses, with the interviewer encouraging participants to provide further insights until no new information emerged. The five main topics for the interviews are shown in Table 4.1.

Topic	**Lead Questions**	**Expected Information or Goal**
Background	Could you introduce your professional and personal background? In what situations do you engage in DV in your daily work?	To understand the participant's work background, experience, and data-related skills, enabling personalized follow-up questions.
Challenges and Needs in Learning DV	Could you summarize the process you follow to complete DV tasks in your work? What steps, knowledge, and tools are involved? What challenges have you encountered while learning and completing data visualization tasks?	To gain insight into the tools and methods participants use for DV and to identify the challenges they face in learning and applying DV.
Learning Experience in the Workplace	During the process of learning new tools or skills at work, what learning methods or processes have been particularly helpful to you? Do you have negative experiences of learning at work?	To explore effective learning methods, identify what methods or processes are perceived as enjoyable or frustrating, and understand why.
Gamification	Do you play games? Have you ever encountered gamification elements in your work environment? Have you ever used gamification methods in your learning experience?	To understand the role of gamification in both personal and professional contexts and to explore its potential application in learning and work settings.
Expectations for the Co-Design Workshop	If you were to collaborate with others to design a gamified approach for teaching the DV knowledge you possess, what information and tools would be most helpful to you?	To gather insights on participant expectations for the workshop, which will help in designing the session to better meet their needs.

Table 4.1: Topics and information gathered in semi-structured interviews

4.2 Participants

Five participants were recruited for the semi-structured interviews through personal networks, which allowed for the rapid identification of individuals with relevant experience and backgrounds. Before recruitment, candidates were asked to provide two key pieces of personal information for screening purposes. First, their educational background and professional situation were assessed, allowing the selection of candidates who do not possess specialized DV skills but are required to create charts and perform other basic DV tasks in their work. After this initial selection, candidates were further evaluated based on their familiarity with DV.

Since there is no standardized framework for categorizing levels of DV proficiency [5], and given that each candidate's DV skill needs and the complexity of their daily tasks can vary, this study employed a self-assessment approach. Candidates were asked to evaluate their DV skill level using the following categories: Novice, Advanced Beginner, Competent, and Proficient. Among these levels, those at the Competent and Proficient levels can complete DV tasks in their work proficiently, without significant challenges. Advanced Beginners can independently complete some DV tasks in their work but may require additional knowledge or assistance when faced with unfamiliar DV tasks. Novices are those who are not familiar with information visualization and visual data analysis.

In this study, Novices and Advanced Beginners were identified as the intended audience. Ultimately, considering the diversity of the participants' professions, five participants who met the criteria accepted our invitation to participate in the user interviews. The backgrounds of these five participants are summarized in Table 4.2.

4.3 Thematic Analysis of Interview Results

To enable an anonymized and detailed evaluation of the collected data, each interview was transcribed. The analysis of the interview transcripts followed Braun and Clarke's thematic analysis approach [12]. A total of 11 themes emerged from the data, of which 7 were related to the participants' experiences in learning and executing DV tasks in their work, 3 were associated with their learning processes and experiences, and 1 was related to participants' perspectives on co-design workshops. Table 4.3 provides a detailed account of all the themes extracted from the interview transcripts. The findings of this analysis are presented below, with text examples provided.

Participant	Background	Industry	Occupation	DV Skill
P1	Business Administration	Manufacturing	Project Manager	Advanced Beginner
P2	Computer Science	Corporate Venture Capital	Strategic Analyst	Advanced Beginner
P3	Industrial Design	Internet Company	UX Designer	Advanced Beginner
P4	Marine Science	Academia	Researcher	Advanced Beginner
P5	Visual Communication	Media	Graphic Designer	Novice

Table 4.2: Summary of participants' backgrounds

Purpose of DV in Work Contexts

The majority of participants indicated that their primary purpose in constructing DV was to facilitate communication and explain data insights. Three out of the five participants mentioned that they typically plan what they want to convey through the visualizations before creating them. For instance, P2 noted, "The construction of visualization depends on the KPI you need to report to your boss. How you report it will ultimately determine what data you include and how you visualize it." In contrast, only P4 described a process where they directly construct DV from raw data without a preset narrative, using the DV process to assess the data and identify relationships.

Challenges in Tool Selection and Use

All participants reported using software tools to construct DV in their work, and they all encountered challenges. A common difficulty was the uncertainty in selecting the right tools. For example, P5 stated, "I don't know how to identify which tools are used for those visually appealing charts and visualizations." Additionally, participants expressed dissatisfaction with the limitations of their current tools in meeting visualization needs. P4, for instance, used Matlab, a powerful data analysis tool, but found it lacking in visual optimization capabilities. P3 had to combine multiple software tools to ensure both accuracy and aesthetic quality in their visualizations, saying, "I first use Excel to generate the basic chart and then use Figma to enhance its appearance." P2 discussed the need to handle large volumes of textual data, requiring the use of both Excel and Airtable for visualization. P1 pointed out that some software struggles with

Number	Theme	Count
1	Identifying the purpose and context of DV usage	5
2	Diversity of DV tools, challenges in selection, and learning difficulties	5
3	The use of artificial intelligence (AI) tools and their assistance in DV construction	5
4	Dependence on templates and the need for step-by-step guidance in DV construction	4
5	Difficulties and uncertainty in chart selection	2
6	Understanding and selecting data	3
7	Selection and mapping of visual elements	2
8	Prior negative experiences of learning new skills in the workplace	3
9	Prior positive experiences of learning new skills in the workplace	4
10	Game elements in work and learning	4
11	The need for design constraints, tools and support in the co-design workshop	3

Table 4.3: Themes identified from interview transcripts

large datasets, noting, “When the data volume increases, like with tens of thousands of entries, Excel or PPT can become very slow.” In addition to the aforementioned challenges, the emergence of AI tools has had a widespread impact. Four out of five participants mentioned using AI tools to assist in DV construction. P3 remarked, “I start by asking questions to establish an initial understanding of the multidimensional data.” P2 mentioned, “Sometimes I use GPT to help extract data, which reduces the manual workload.” P4 shared their experience, “I tell it what kind of chart I want to create, and it provides me with a code snippet, which I then modify.” P5 simply stated, “ChatGPT can directly generate charts.” Only P1 noted that their company prohibits the use of AI tools to prevent data breaches.

Reliance on Templates and Structured Processes

While using software tools, four participants highlighted their reliance on charts and DV templates within the software, as well as the use of tutorials to replicate their desired visualizations. Three participants explicitly mentioned that gaps in their understanding

of data and charts hindered their progress in constructing DV, including challenges in understanding variable types, data selection, and the choice of visual elements. P2 additionally discussed the difficulties that arise in cross-departmental collaboration when improper data selection and incorrect visual mapping occur, stating, "Sometimes the person doing the charting isn't well-versed in data, and they get it all wrong. It might be that there's no one from the tech side to guide them at the start, and a salesperson ends up putting unrelated variables together."

Learning Experiences: Negative and Positive

Two key themes emerged from the interviewees' responses regarding their learning experiences. Three participants discussed negative experiences in learning new skills at work. These negative experiences were attributed to several factors, including time constraints, an overwhelming amount of dry learning materials, and a lack of proper guidance. For instance, participants mentioned the pressure of deadlines making it difficult to focus on learning, and the absence of mentorship left them feeling frustrated. In contrast, four participants shared positive experiences in learning new skills at work. Three of them highlighted that collaborative learning and discussions enhanced their enjoyment of the learning process and made overcoming challenges less daunting. Two participants emphasized that practical application and receiving positive feedback boosted their confidence in learning new skills. Additionally, one participant mentioned that having clear and specific learning goals helped them overcome difficulties.

Incorporating Game Elements in Work and Learning

Most participants recognized the value of incorporating game elements into both work and learning to enhance engagement and social interaction. Regarding gamified learning, one participant mentioned how the gamification features in the language learning app Duolingo helped them stay motivated to continue learning. Another participant mentioned that their company's internal learning materials incorporated quiz-based game elements to make the learning process more engaging. In terms of work-related gamification, two participants noted that playing card games and board games with colleagues significantly improved team bonding.

Perspectives on Co-design Workshops

Among the five participants, only one had previously participated in a co-design workshop. This participant believed that providing appropriate scaffolding and design constraints during the workshop could help participants better focus their efforts. Two other participants expressed a desire for more guidance and support from designers and professionals in such collaborative settings.

In summary, the thematic analysis revealed a diverse range of experiences and challenges related to DV tasks and learning processes in the workplace. These findings underscore the importance of tailored tool selection, a foundational understanding of data and charts, and the role of collaborative and gamified learning approaches in fostering skill development. The participants' insights into co-design workshops also suggest that structured guidance and professional support should be considered essential elements in such collaborative environments.

4.4 Conclusion

By integrating the DV-related knowledge and processes discussed in Chapter 2 with the challenges and difficulties faced by DV novices and beginners in the workplace, as revealed through the thematic analysis, the design requirements for an effective DV learning program can be summarized as follows:

i) Understanding the characteristics and selection of different DV tools.

Based on Themes 1 and 2, several dimensions need to be considered when selecting tools for constructing DV in the workplace:

- *Exploration vs. Explanation:* It is crucial to define the purpose of the DV—whether it is intended for exploring data (e.g., sensemaking, discovery) or for explaining data (e.g., communication, presentation). This distinction will determine whether the tool should be geared toward data discovery or towards presenting a specific story, message, or fact.

- *Utility vs. Aesthetics:* Some tools prioritize data functionality, offering precision and reliability (e.g., Excel, Tableau), while others emphasize visualization and aesthetics, potentially at the cost of some data-handling capabilities (e.g., Figma, RawGraphs).

- *Flexibility vs. Constraint:* Flexible tools, such as Tableau and coding-based solutions, offer more freedom and functionality but generally require higher technical skills. Conversely, constrained tools provide more templates and predefined formats, making them easier to use but with limited functionality (e.g., PowerPoint, RawGraphs, Airtable).

ii) Understanding data attributes and charts.

Themes 4, 6, 7, and 8 indicate that DV novices need to enhance their basic understanding of data attributes and chart features. This knowledge is essential for effective data abstraction and visual mapping.

iii) Understanding the DV design process.

Themes 6 and 8 suggest that DV novices often lack a comprehensive understanding of how to systematically achieve visualization, frequently relying on modifying existing templates. Learning the DV design process can empower them to construct visualizations independently when templates are insufficient, fostering greater creativity.

iv) Enhancing collaboration and communication, along with practical application and presentation.

Themes 9 and 10 highlight the importance of incorporating opportunities for collaboration and communication in the learning process. Coupled with practical exercises and presentations, these elements are critical to reinforcing learning in the workplace environment.

v) Co-designing with scaffolding and support for better outcomes.

To enhance learning outcomes, it is essential to introduce tools and scaffolding during the co-design process, supported by the involvement of relevant professionals. The potential use of AI tools should also be considered to further improve the learning experience.

In summary, points i), ii), and iii) focus on the content of learning DV, while points iv) and v) address the methods of teaching DV. Based on these insights, a DV pipeline tailored for office workers has been developed, as illustrated in Figure 4.1. This pipeline builds upon the DV process models and frameworks discussed in Chapter 2 [13][61][70] and is specifically designed for DV novices and beginners in a workplace context. It emphasizes the selection and use of DV tools and incorporates fundamental data knowledge to guide those with little or no prior data experience.

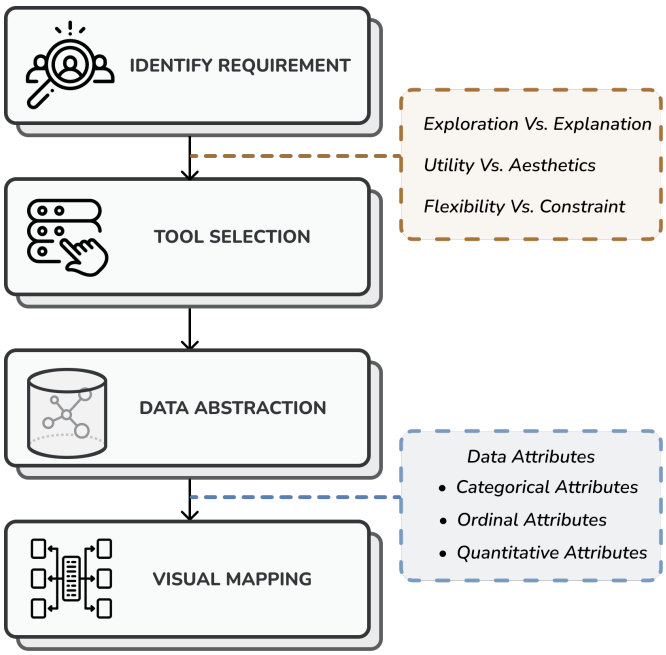


Figure 4.1: Data visualization pipeline for office workers

This DV learning pipeline and the identified instructional needs represent the most significant outcomes of this phase. They will inform the decisions made in subsequent stages of the design process, guiding the development of possible design solutions.

Chapter 5

Develop through Collaborative Design Workshop

5.1 The Goals of the Co-Design Workshop

Following the Discover and Define phases, the design requirements and content were established, leading to a collaborative development process where the games were developed from these requirements. The primary goal during this phase was to create a diverse array of potential problem-solving avenues. This divergent phase aimed to explore the solution space as broadly as possible, both in terms of concepts and potential outcomes. To achieve this, a co-design research methodology was adopted as a way of generating multiple ideas [63].

Co-design is defined as a design approach that involves broad stakeholder and user participation in the design process [56]. It brings together diverse parties to explore and co-create solutions through mutual learning [40]. In this study, I sought to gather insights from both the target audience and professional tabletop game players and designers during the development process. Therefore, co-design was identified as the optimal method to allow all participants to contribute equally, develop intrinsic interest, and generate new ideas through collaboration [2].

In addition to the design outputs generated through co-design, the thoughts, decisions, and behaviors of participants during the process were also critical. These insights helped ensure that the final solution remained aligned with user needs and experiences. Through the co-design workshops, the following key questions were addressed:

i) How does the game promote office workers' interest and efficiency in learning DV?

ii) Which game elements, mechanics, and gameplay deserve special consideration?

5.2 Designing a Card-Based Tool for the Workshop

In Chapter 4, several interviewees emphasized the importance of introducing tools and scaffolding during the co-design process. Given that games vary significantly in how they manifest, it is beneficial to provide materials that guide participants towards structured play (rules with a desired outcome) [64]. The advantages of pre-designed materials include their ability to set a framework and starting points for design collaboration, enable movement between specific fragments and the holistic view, provide visual stimuli for eliciting new associations, facilitate progress and decisions throughout the co-design process [69].

To better inspire participants, I designed a set of cards with two design goals. First, the cards were intended to provide DV knowledge and concepts in a manner conducive to game planning with clear and visual expressions. Second, they aimed to highlight the relationships among DV concepts, thereby inspiring participants in the design of game mechanics, scoring systems, and other gameplay elements.

Based on the DV learning requirements summarized in Chapter 4, I designed four types of knowledge cards, as shown in Figures 5.1-5.4. These cards introduce the fundamental DV concepts of data attributes, four typical charts in DV, DV requirements and tools, and visual mapping, all derived from Tamara Munzner's definitions [48]. The cards offer foundational content that can be gamified, and presented through concise descriptions, illustrations, and practical examples. For instance, the data attributes cards were designed with content on both sides: the front side provides examples of data variables, while the back side presents the corresponding attributes and explanations, functioning as basic quiz cards. The requirements and tools cards explain the dimensions for judging DV needs by listing representative DV tools and visualizing these dimensions in a coordinate system, making the cards easier to read. I also made efforts to establish connections between the different types of cards; for example, the chart descriptions mention which data attributes are best represented by each type of chart. Each card type is designed to be expandable, serving as a template that can be further developed or redesigned based on the participants' needs.

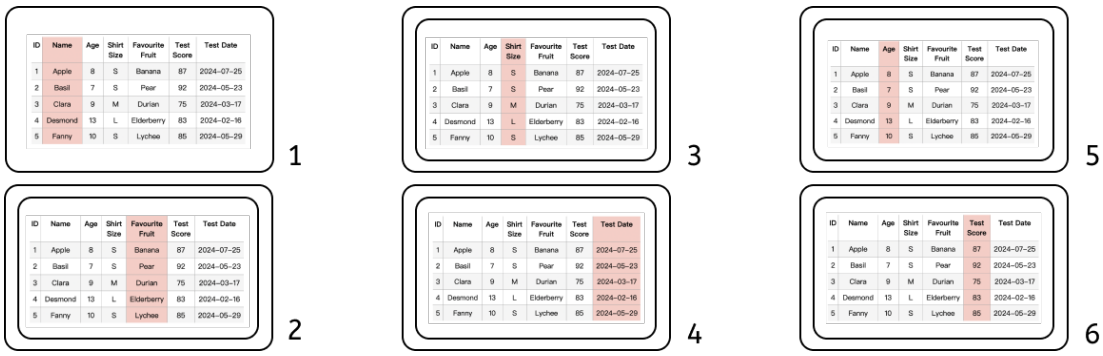


Figure 5.1: Data attributes cards (Front)

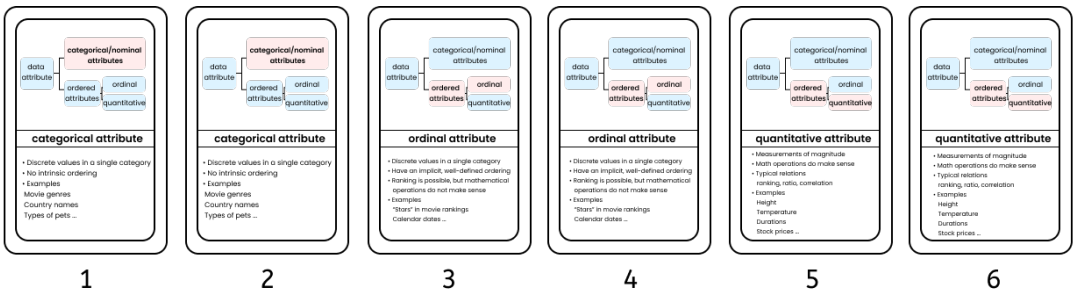


Figure 5.2: Data attributes cards (Back)

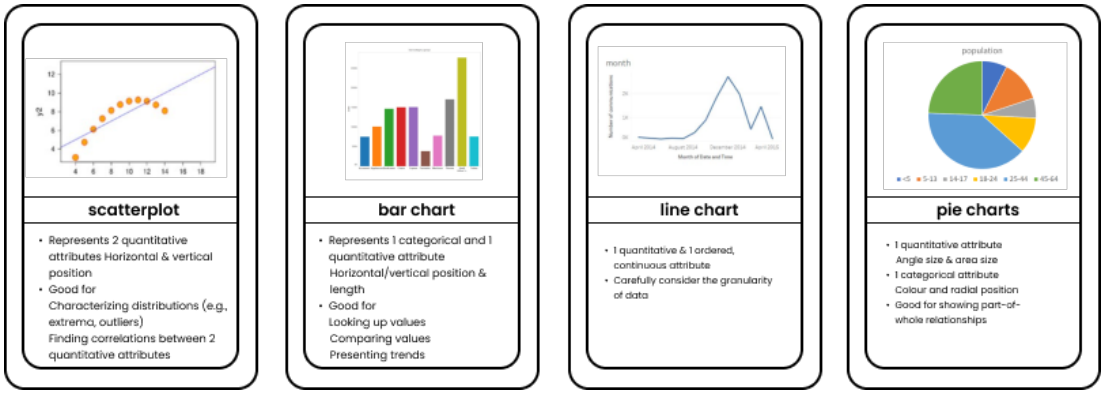


Figure 5.3: Four chart cards

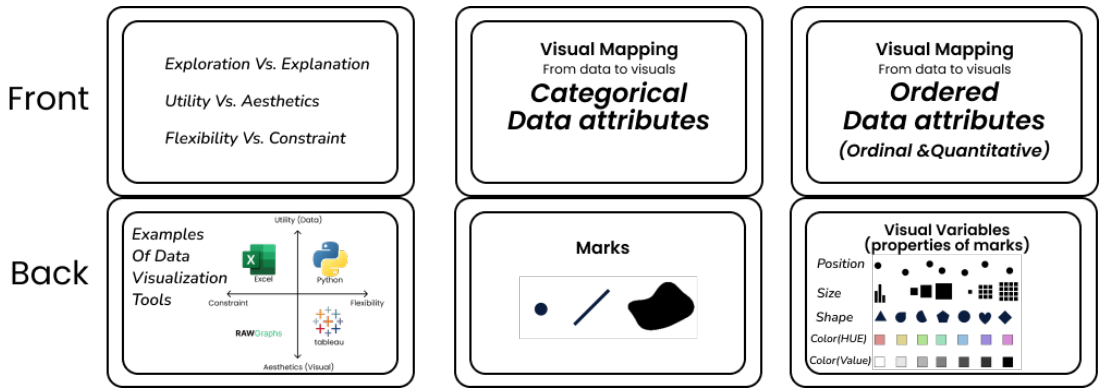


Figure 5.4: Data visualization requirements and tools cards and visual mapping cards

5.3 Workshop Structure

The workshop was designed in five parts, lasting approximately 75 minutes. The finalized structure of the workshop, including planned activities, timings, tools, and setup, is described below.

Icebreaker Session (10 minutes): The workshop started with introductions and a warm-up activity. Participants were given a brief overview of the research background and the objectives of the co-design workshop. A warm-up activity was conducted using the online collaborative platform FigJam, as shown in Figure 5.5. Participants created their own characters, which they used to introduce themselves and become familiar with other group members. This introduction included sharing their background, occupation, familiarity with DV, experience in learning DV, and any prior experience with tabletop games.

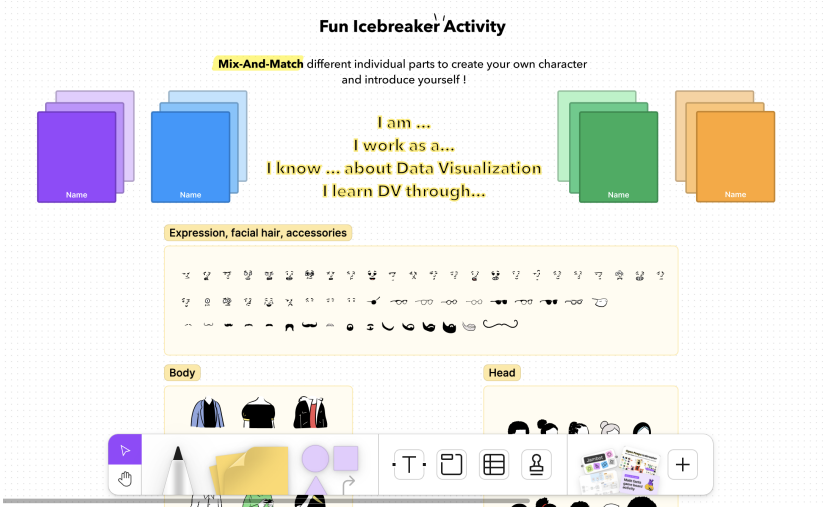


Figure 5.5: Warm-up activity in FigJam

Introducing the DV Pipeline (10 minutes): The participants were introduced to the DV learning pipeline for office workers, as discussed in Chapter 4. A discussion followed where participants reflected on their personal experiences and perspectives on the process of constructing DV.

Introducing the Card-Based Tool for the Workshop (10 minutes): The next phase involved introducing the card-based tool, designed to facilitate game ideation and help structure participants' thought processes.

Co-designing a Game Concept (30 minutes): The "Six-to-One" method was recommended for this session [43]. Participants had 10 minutes to generate six game ideas individually, after which they presented their concepts for group critique. Following the presentations, the group selected the best concept and spent the remaining 20 minutes refining and sketching it. Materials such as pencils, post-its, paper, UNO cards, and playing cards were provided. Throughout the session, participants were encouraged to ask questions and discuss various design features.

Closing (15 minutes): The workshop concluded with each group presenting their game concept, followed by a summary of the group discussions and final reflections.

5.4 Workshop Recruitment and Deployment

A total of nine participants were recruited for the workshops, five of whom were the same office workers who had previously participated in the interviews discussed in Chapter 4. Additionally, three tabletop game experts and one participant proficient

in DV skills were recruited. These nine participants were divided into two groups to conduct the co-design workshops. The groups were composed to ensure diversity in DV skills and included both office workers and tabletop game experts.

Due to scheduling conflicts, two participants requested to join remotely. As a result, Group 1's workshop was conducted in a hybrid format using FigJam and Zoom for remote collaboration, while Group 2's workshop was conducted in person. The participant groupings are listed in Table 5.1, where P1–P5 correspond to participants from Table 4.2.

Table 5.1: Participants' background and group for the co-design workshops

Participant	**Group**	**Occupation**	**DV Skill**
P1	2	Project Manager	Advanced Beginner
P2	1	Strategic Analyst	Advanced Beginner
P3	2	UX Designer	Advanced Beginner
P4	1	Researcher	Advanced Beginner
P5	2	Graphic Designer	Novice
P6	2	Student (with tabletop game design experience)	Novice
P7	2	Student (leader of a tabletop games association)	Competent
P8	1	Owner of a Tabletop Game Shop	Novice
P9	1	Data Journalist	Proficient

5.5 Evaluation and Findings

The workshops were audio-recorded and transcribed, and design outputs were documented through photographs. Participant observation was conducted throughout the co-design sessions. Thematic analysis was applied to the transcribed data, which was coded to identify relevant sections [12]. These sections were then categorized into themes using affinity diagrams.

The following is an overview of the findings from the two co-design workshops. Key findings are grouped under five themes that touch on aspects of: i) keeping the educational content concise; ii) engaging storytelling; iii) clear mapping between game

elements and educational content; iv) competition and interaction mechanics; and v) experience of play. This first theme addresses the first co-design research question (How does the game promote office workers' interest and efficiency in learning DV?), and the remaining addresses the second (Which game elements, mechanics, and gameplay deserve special consideration?)

5.5.1 Keeping the Educational Content Concise

Both groups filtered the DV content to be taught in the game, with the main motivation being to enhance the game experience and minimize the intrusion of heavy instructional content that could reduce the fun of the game. Group 1 proposed a speed action game, as shown in Figure 5.6. In this game, players quickly identify data attributes on the cards. When the attributes can be combined into a chart, players ring a bell. If the combination of data attributes is correct, the player earns a corresponding chart card; otherwise, they must return a chart card. The game focuses primarily on teaching data attributes and charts. One participant noted, "Visual mapping can also be reflected in this process—it's about identifying attributes and representing them with charts. The connection between these two concepts is strong, so integrating them into the game rules feels logical. Other content would be harder to fit in." During the design process, Group 1 also debated whether to keep the ordinal card in the data attributes set. One participant (P9) argued that distinguishing this concept might be too difficult for novices and could negatively impact the gameplay experience. However, other participants (P2 and P4) felt that the ordinal attribute was useful for understanding ordered but non-mathematical variables, such as time series, which are common and important in DV. Ultimately, the group decided to retain the ordinal attribute card. Similarly, Group 2 initially focused on data attributes and charts but later added concepts like DV tools and identifying DV requirements after incorporating a game narrative. In summary, both groups streamlined the educational content to focus on 2–3 concepts that were further developed from the card tools provided.

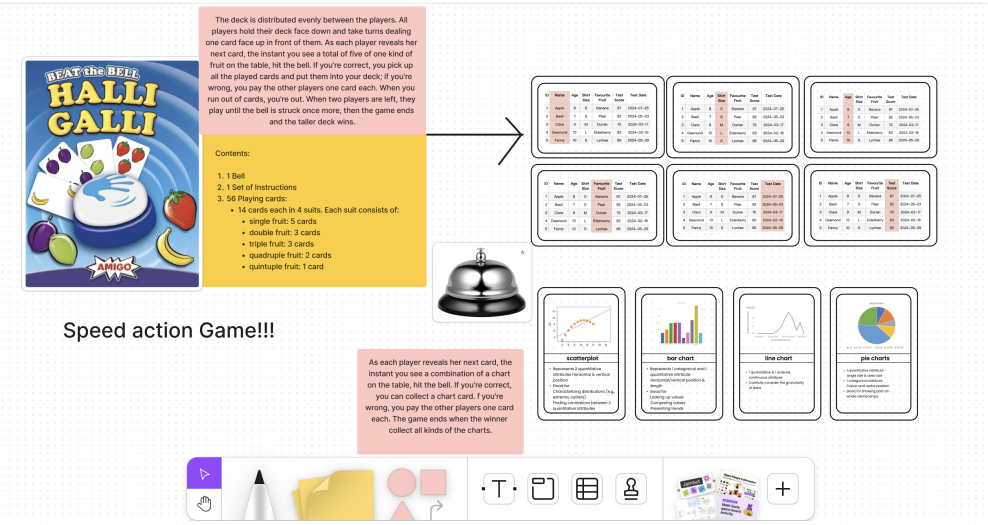


Figure 5.6: A speed action game concept from the group 1

5.5.2 Engaging Storytelling in Game Design

Engaging storytelling can immerse players in the experience and help integrate educational content more naturally. As shown in Figure 5.7, Group 2 designed a game with a nautical adventure background. Players were tasked with repairing four different ships, each representing different DV requirements, by finding the correct tools (DV tools) and unlocking these tools with the right keys (answering questions about charts). However, the available keys (data attributes) were limited, and using the wrong key or unlocking the wrong tool would result in failure. During the narrative development, Group 2 found that the story gave the game more flexibility in incorporating DV concepts into the game elements. The entire adventure could even be aligned with the DV design process.

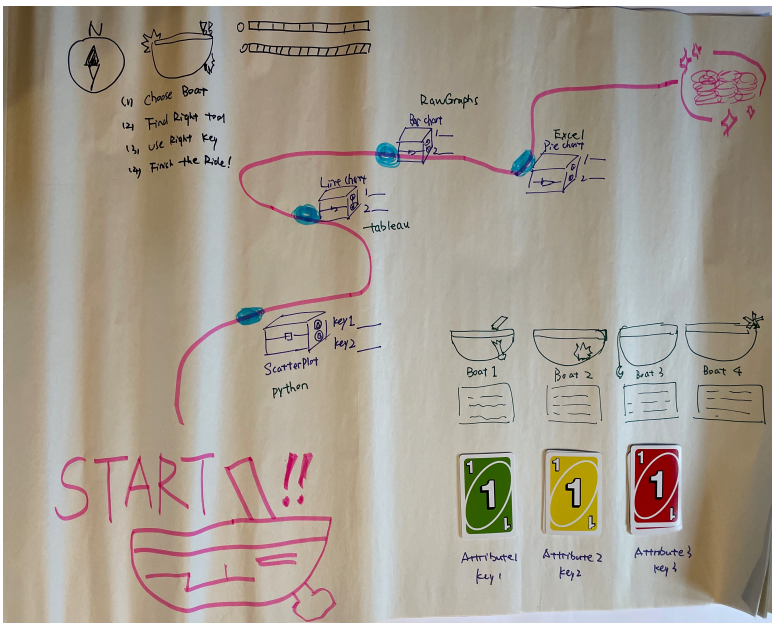


Figure 5.7: A nautical adventure game concept from the group 2

5.5.3 Clear Mapping Between Game Elements and Educational Content

Group 2 gave up an earlier game design called “Race to the End”, as shown in Figure 5.8. This tile-based game involved players randomly drawing track tiles and placing them to form a road. The first player to connect their road to the end won. In this design, charts were mapped to different types of intersections, and data attributes were mapped to different types of roads. However, because both concepts were mapped to similar game elements (different types of roads), Group 2 encountered significant challenges. They found that the game lacked differentiation, and players could win without understanding DV knowledge, thus undermining the educational purpose. In summary, clear and logical mapping between game elements and educational content is crucial in game design. The mapping and logic must correspond to the real-world DV knowledge they represent.

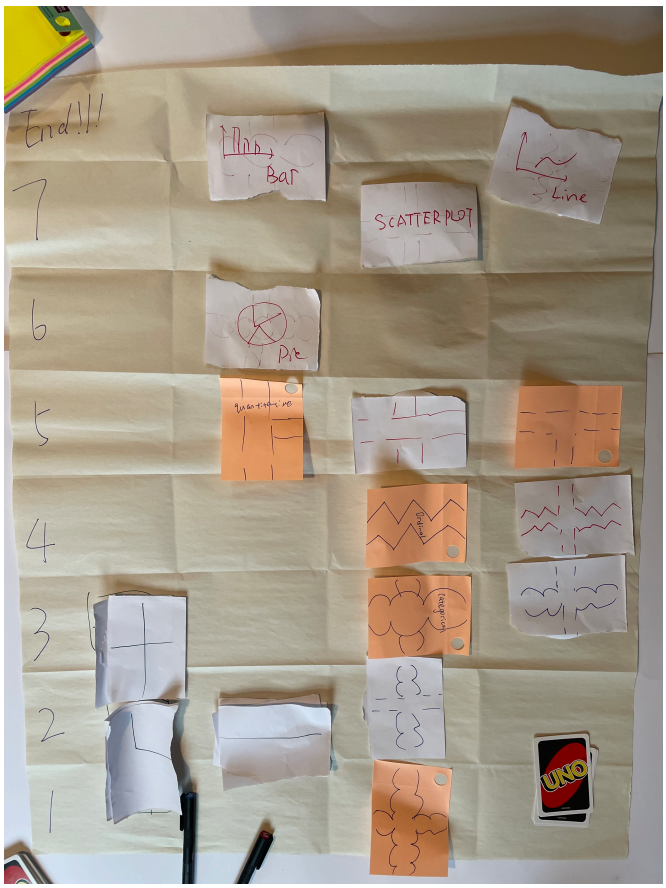


Figure 5.8: A tile-based game concept from the group 2

5.5.4 Competition and Interaction Mechanics

Competition and high levels of interaction between players tend to increase engagement and attention. Group 1's design used a bell-ringing mechanism to encourage players to compete in identifying the correct data attributes. This speed-based competition catered to multiplayer interaction and quickly helped players grasp the relevant knowledge. In contrast, Group 2's final design was a single-player, task-oriented game with little interaction. Players either succeeded or failed in their missions, with no direct competition or interaction between them. Participants from Group 2 noted, "It would be more fun if players could block each other from completing their tasks. Right now, it feels more like a quiz than an adventure." Therefore, encouraging player interaction and competition should be a key consideration in game design.

5.5.5 Experience of Play

Across both groups, participants' prior experiences with games influenced the types of suggestions they made and the interactions they had during the workshops. For instance, Group 1's gameplay concept was derived from P2's familiarity with the classic tabletop game Halli Galli. Group 2's initial tile-based game idea came from P7's enthusiasm for Carcassonne, a tile-based game. P6 frequently referenced Monopoly to explain his thoughts on game strategy and the mapping of game elements. In summary, participants' prior experiences with play and games significantly influenced the types of games they designed.

5.5.6 Conclusion

Both groups produced relatively complete game designs, including components and gameplay mechanics. They also used the card tools provided and developed their ideas further from these materials. Although the concepts and designs were still raw and generalized, and lacked detailed evaluation of feasibility, the insights and outputs from the co-design workshops collectively serve as valuable inspiration and source material. These insights will fuel the next phases of refinement for the design solution.

Chapter 6

Refine and Deliver the Final Design

6.1 Refining Strategy

Building on the foundational concepts derived from the co-design workshops, I transitioned into the final refinement stage. In this phase, the insights and ideas generated during the workshops were meticulously filtered and synthesized to determine the scope of the educational content and the format of the design solution. The final outcome involved integrating these ideas into a cohesive game narrative and mechanism, culminating in a high-fidelity game design. Subsequent test sessions were conducted, allowing participants to interact with the game and provide feedback, which informed future revisions and iterations. By this stage, a well-defined vision for the final game design had emerged. This chapter details how the outcomes of the co-design process were narrowed down and refined, ultimately leading to the delivery of a final solution for the end users.

Moving from a broad phase of creative exploration to one of focused refinement, I established several criteria to guide the narrowing down of concepts from the co-design workshops. The first criterion was to retain ideas with mature concepts, well-defined game mechanics, and high playability. The second was to prioritize concepts and requirements that were frequently mentioned and deliberated upon by the participants during the workshops. Lastly, I considered the overall coherence and completeness of the game, ensuring that the valuable elements selected could be seamlessly integrated into a unified game narrative and mechanism. Additionally, interaction and storytelling were key considerations.

During the development phase of the co-design process, the gameplay concept from Group 1, which involved exchanging data attributes and charts, was found to be effective

and engaging. The competitive and fast-paced nature of the mechanism heightened player interest and interaction, aiding in the quick familiarization with the concept of data attributes. Group 2's idea of a nautical adventure theme, centered around a task-oriented game mechanism (with story elements as metaphors), such as unlocking tools to represent the process of identifying DV tools, was also highly influential. The integration of other concepts as game props within the narrative was also valuable, such as using data attributes as keys to unlock chests. In the delivery phase, I chose to focus on these three core game elements and mechanisms, refining and merging them to design a game that was not only interactive and competitive but also rich in narrative and immersive experience. Additionally, these game elements encompassed the key concepts outlined in Chapter 4 regarding the data visualization pipeline for office workers, including how to identify DV requirements, select appropriate tools, recognize data attributes, and learn to visually map them.

In terms of the game's format and interaction method, I opted to continue with the card game format, which was most prominent in the co-design workshops. Compared to other analog games, such as paper-and-pencil role-playing games and board games, card games are better suited for presenting information and knowledge. Card games are easier to produce and share, as they can be quickly printed and distributed, making them more accessible for use in DV education. Moreover, in today's highly hybrid work environment, card games are more adaptable for use in online settings, such as on collaboration tools like Miro boards.

Thus far, the strategic decision to incorporate data attributes, charts, and the DV design process into a story-based strategic competitive card game has proven effective. This game will serve as an entry point for DV education, particularly for novices and beginners in the workplace, while also providing an engaging and enjoyable learning experience.

6.2 Refining Design

Based on the refining strategy, a card game named *VisVoyage* was designed. This section provides a detailed account of the game's components and rules and demonstrates their connection to DV education.

6.2.1 The Game Story

Extending and expanding upon the nautical adventure theme developed during the co-design process, the game was named *VisVoyage*. In this game, players assume the roles of fleet commanders tasked with selecting appropriate ships, recruiting the right crew members, and managing limited resources to complete challenging voyages. Each player must choose the most suitable DV tools (represented by different ships named after DV tools) based on the drawn destination cards and strive to collect the necessary charts (represented by crew members) by managing data attributes (represented by resource cards). The first player to successfully assemble a complete crew and reach their destination wins the game. The game's design incorporates elements of competition and resource allocation to enhance both playability and educational value, and it can be played by 2-4 players.

Throughout this process, players will learn how to identify data visualization needs (the mission objectives), select appropriate visualization tools, recognize different data attributes, understand the characteristics of various charts, and correctly match these attributes to the corresponding charts. The relationship between the DV concepts taught by the game and the game elements is illustrated in Figure 6.1.

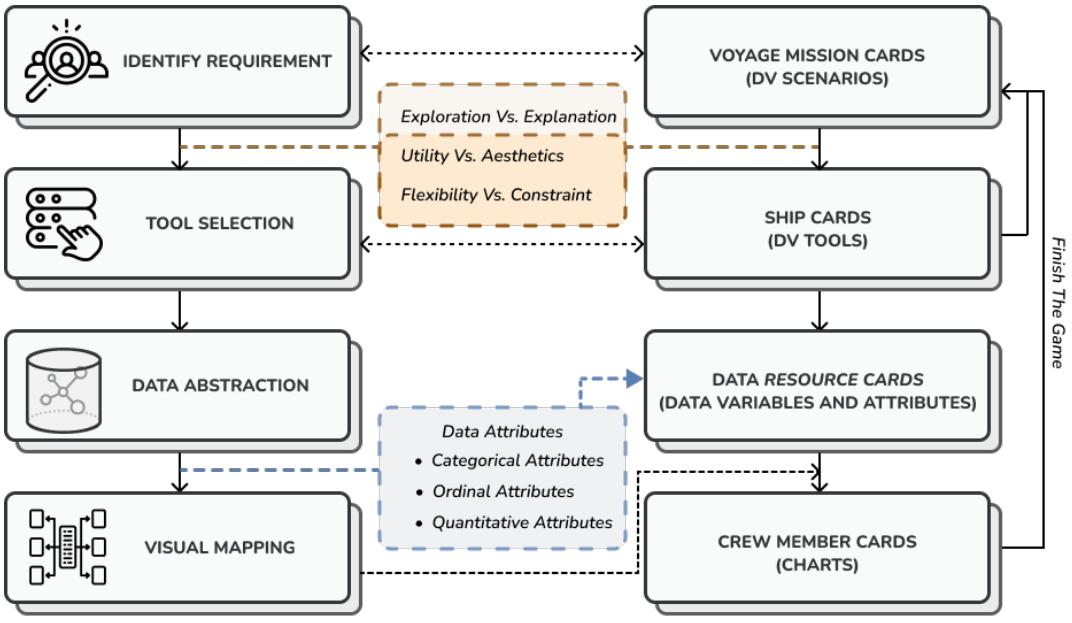


Figure 6.1: Mapping between game elements and DV pipeline

6.2.2 Components Design

1. **Voyage Mission Cards**: Each card specifies a unique voyage mission, requiring different types of ships. There are four missions, each corresponding to a different DV requirement: Polar Expedition (emphasizing flexibility and utility), Mediterranean Island (focusing on constraint and aesthetics), Port Cargo Transport (prioritizing constraint and utility), and Intercontinental Cruise (highlighting flexibility and aesthetics). The specific descriptions of each mission are detailed below, and the visual design of the cards is shown in Figure 6.2.

    - **Polar Expedition**: You are tasked with completing a scientific mission to Antarctica. This journey demands a ship capable of handling large volumes of complex scientific data. Due to unpredictable terrain changes and weather conditions, the data processing and visualization requirements are highly varied. The ship must be powerful and flexible, able to adapt to the diverse needs of the mission. Additionally, the ship's advanced and versatile functionalities require a highly skilled and specialized crew to operate effectively.
    - **Mediterranean Island**: You need to organize a luxurious water party on a Mediterranean island for a wealthy client. This journey only requires handling simple lifestyle data for the client, with a focus on visual expression to ensure that the client can post on social media (e.g., Instagram) and receive likes. The task calls for quickly generating aesthetically pleasing charts using basic templates and visualization tools. The ship does not need complex functionalities or operations, and professional crew members are not required; the client can even operate the ship themselves.
    - **Port Cargo Transport**: You are responsible for swiftly transporting cargo to a coastal port. The mission requires efficient processing of cargo data for customs and other logistics. The ship needs to excel in data processing capabilities but does not require advanced visual expression. It should be user-friendly with straightforward charting functions and low learning curve requirements.
    - **Intercontinental Cruise**: You are tasked with organizing an intercontinental cruise, managing data for thousands of passengers, and producing high-quality visualizations for travel agency advertisements. The mission requires a ship with strong visual and aesthetic capabilities, along with flexibility

in handling diverse visualization needs. The flexibility in visual functions means it demands a highly skilled and specialized crew.

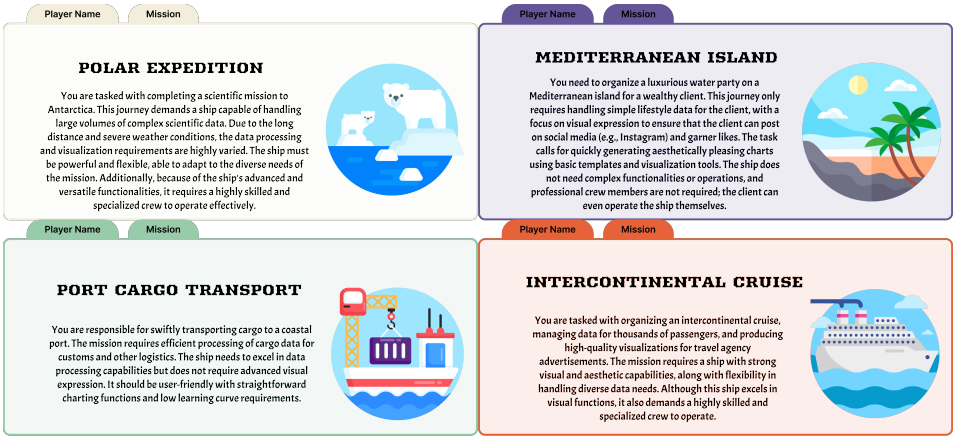


Figure 6.2: Four voyage mission cards

2. **Ship Cards**: Each ship represents a different DV tool. These four DV tools were selected as examples to introduce players to different tools, each with its strengths and areas of expertise. The selection of tools depends on your DV requirements. Corresponding to the Voyage Mission Cards, there are four Ship Cards, each named after a typical DV tool. The Ship Cards are designed to help DV novices quickly understand the basic DV tools and their characteristics. Depending on the players' professional backgrounds and the educational goals of the game organizers, additional DV tools may be introduced by expanding the number and content of Ship Cards. The visual design of the Ship Cards is shown in Figure 6.3, with the ships' images generated by generative AI DALL-E [51]. Only these four ship images use generative AI, while all other designs were created by myself in Figma.

    - **Python Antarctic Research Vessel**: High utility and flexibility, suitable for handling complex data and diverse visualization needs.
    - **Tableau Luxury Cruise Ship**: Highly flexible with strong visual capabilities.
    - **Rawgraph Small Yacht**: Excellent visual appeal but constrained functionality, suitable for simple tasks.
    - **Excel Small Cargo Ship**: Strong data processing capabilities but with constrained and template-based chart functions.

The Ship Cards also indicate the crew composition needed for each ship, allowing players to recruit the appropriate crew members after selecting their ship.

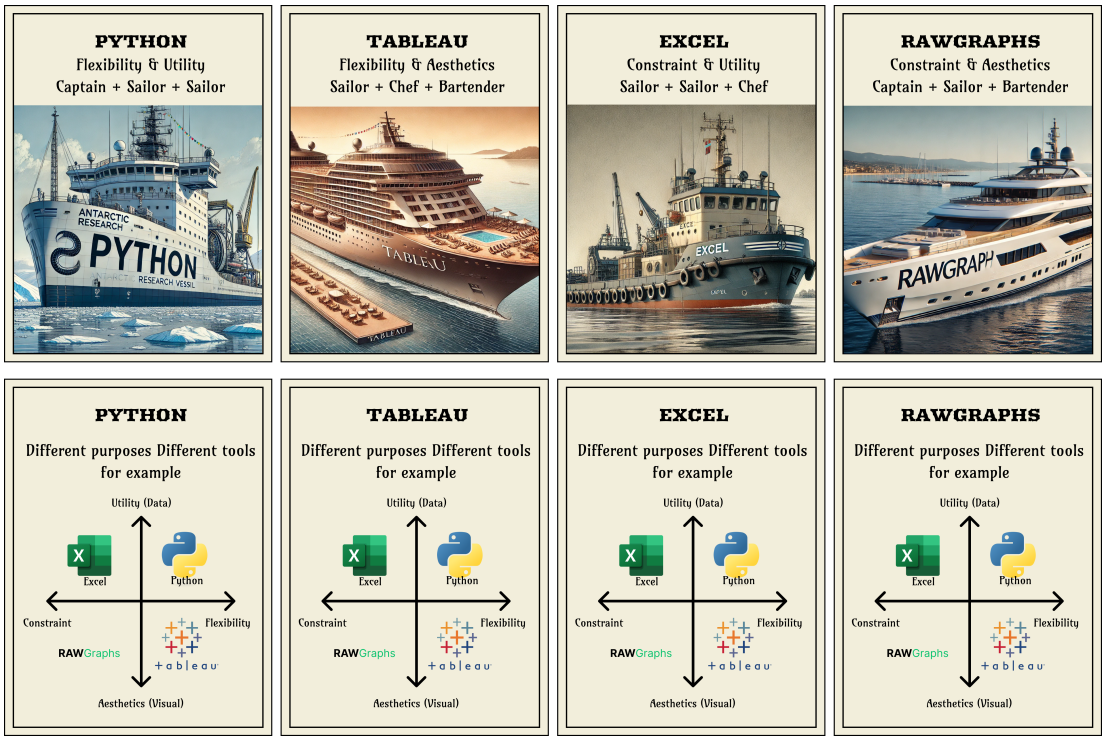


Figure 6.3: Four ship cards with front and back views

3. **Crew Member Cards**: Each crew member corresponds to a type of chart. Players need to determine the chart type represented by the crew member and identify the data attributes that can be used to form that chart. Before exchanging for a Crew Member Card, players can only see the front side of the card, while the back side contains the answers and information about different charts. The visual design emphasizes the connection between the crew members and the corresponding charts using diverse icons. For example, the Bar Chart corresponds to a bartender who uses bottles to draw bars; a chef corresponds to a pie chart; a sailor corresponds to a line chart with an anchor design; and a captain corresponds to a scatterplot with elements of a ship's wheel, as shown in Figure 6.4.

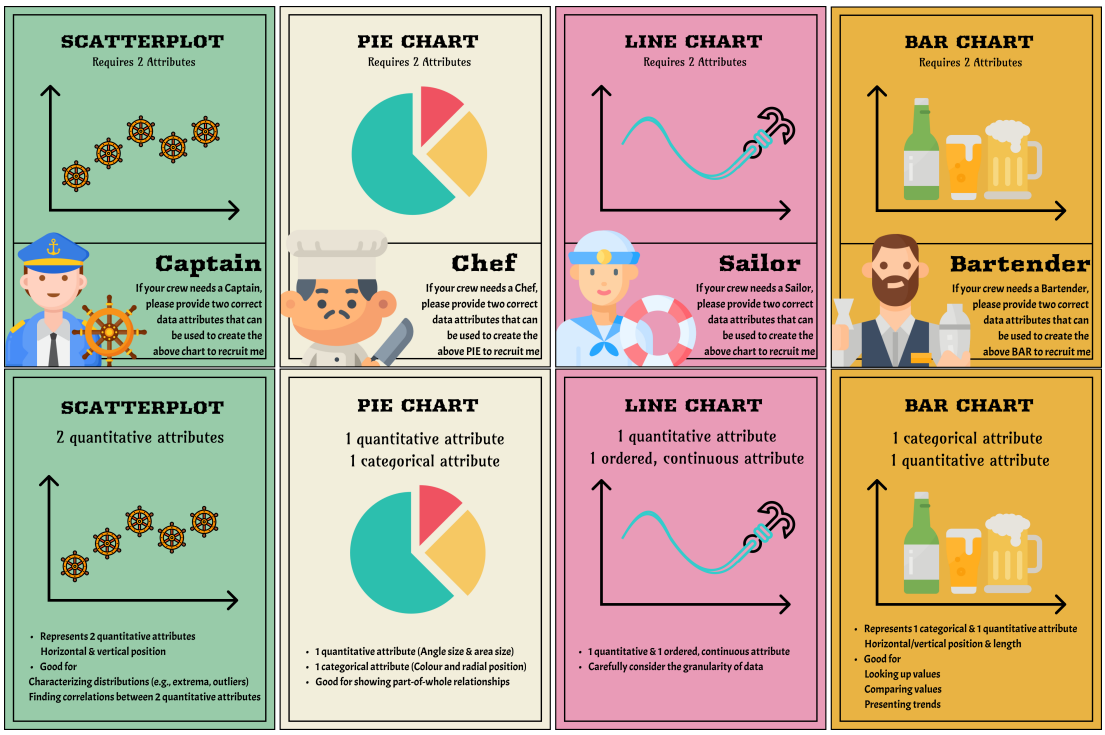


Figure 6.4: Four crew member cards with front and back views

4. **Data Resource Cards**: In this game, data is the most valuable resource. It can be used to exchange for crew members. A table of six variables covers three types of attributes, with two cards for each attribute. Similarly, the front side of the card displays the data variables that need to be identified, while the back side reveals the data attribute and a description of that attribute. Each player starts with three Data Cards, which can be used to familiarize themselves with the concept of data attributes. As the game progresses, players must quickly and correctly identify the necessary data attributes. The first player to identify the attribute correctly gains possession of that Data Card. Players can use Data Cards to exchange for Crew Member Cards. If the combination of Data Cards is correct, the crew member is successfully recruited; otherwise, the Data Cards provided for that attempt are lost.

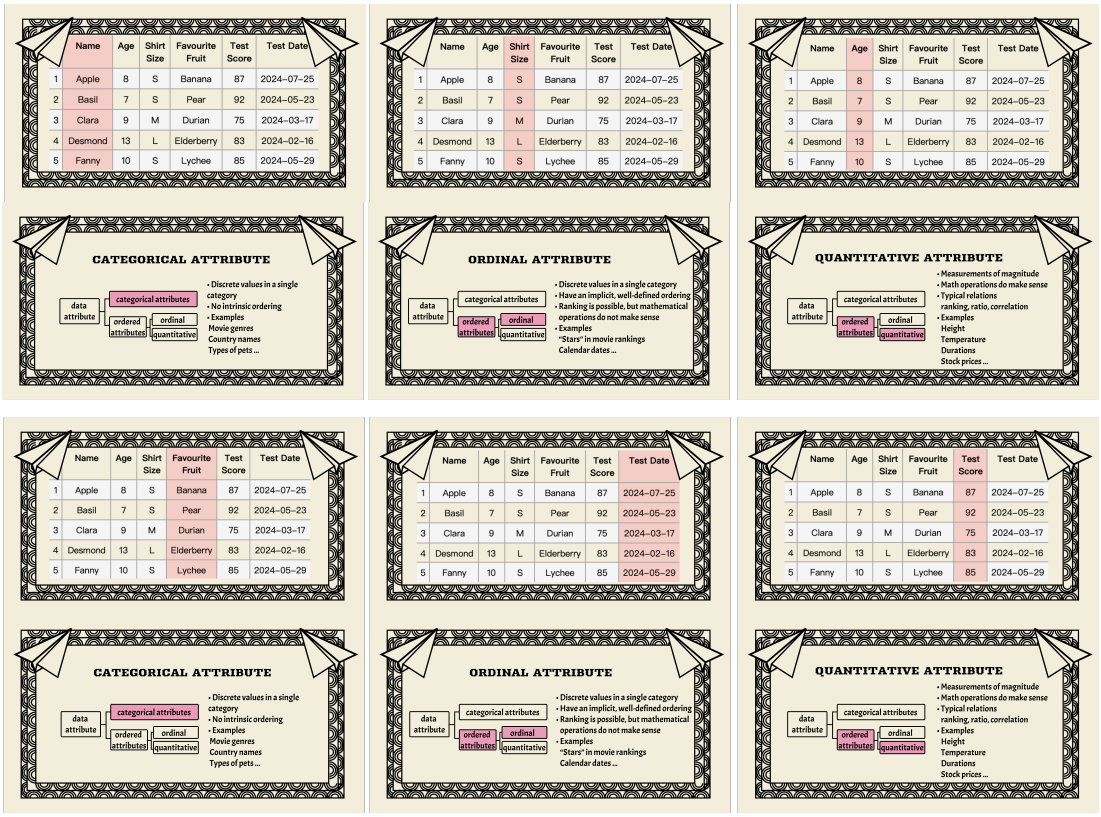


Figure 6.5: Six data resource cards with front and back views

6.2.3 Game Rules

1. **Mission and Ship Selection**:

   - **Draw a mission card**: Each player begins by drawing a mission card to determine their voyage objective.
   - **Select a ship**: Based on the mission requirements, players must select the most suitable ship.
   - **Penalty for incorrect selection**: If a player selects a ship that does not match the mission's requirements, they must discard a resource card and choose again. If the player has no data cards available, they must skip their turn.

2. **Resource Collection and Crew Recruitment**:

   - **Starting resources**: Each player starts with three data resource cards, one of each type. Players can examine both sides of these cards to familiarize themselves with the different data attribute categories.

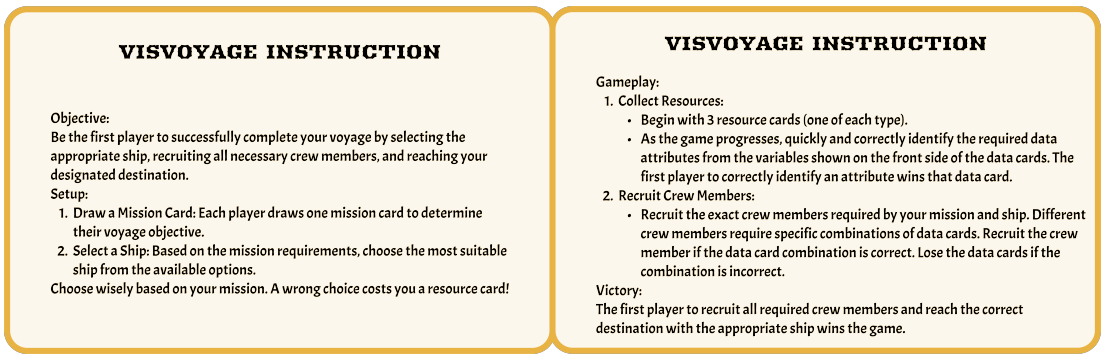
- **Data attribute identification**: As the game progresses, the data card is revealed one by one and players must quickly and correctly identify the data attribute on the front side of the card. The first player to correctly identify the attribute wins that data card.
- **Recruiting crew members**: Players can use their collected Data Cards to recruit crew members. To recruit a crew member, a player must provide the correct combination of Data Cards (based on the data attributes required by that crew member's chart).
  - **Success**: If the combination is correct, the player successfully recruits the crew member.
  - **Failure**: If the combination is incorrect, the player loses the Data Cards provided for that attempt.
- **Preparing for the voyage**: The first player to successfully recruit all required crew members for their mission is ready to begin the voyage and moves closer to winning the game.

6.3 Final Design Solution

The final design outcome of this project is a card game consisting of four types of cards and one instruction card. High-fidelity prototypes are shown in Figures 6.6 to 6.10. Table 6.1 outlines the number of sets for each type of card and the number of different cards within each set. These prototypes can be printed out and played as a tabletop game, or they can be directly copied to an online collaboration platform, allowing players to move digital cards to complete the game.

Table 6.1: Summary of card types and quantities

Card Type	Number of Sets	Cards per Set	Total Cards
Voyage Mission Cards	1	4	4
Ship Cards	1	4	4
Crew Member Cards	Sailors *6 Others *2	4	12
Data Resource Cards	6	6	36
Instruction Card	1	1	1



VISVOYAGE INSTRUCTION

Objective:
Be the first player to successfully complete your voyage by selecting the appropriate ship, recruiting all necessary crew members, and reaching your designated destination.
Setup:
1. Draw a Mission Card: Each player draws one mission card to determine their voyage objective.
2. Select a Ship: Based on the mission requirements, choose the most suitable ship from the available options.

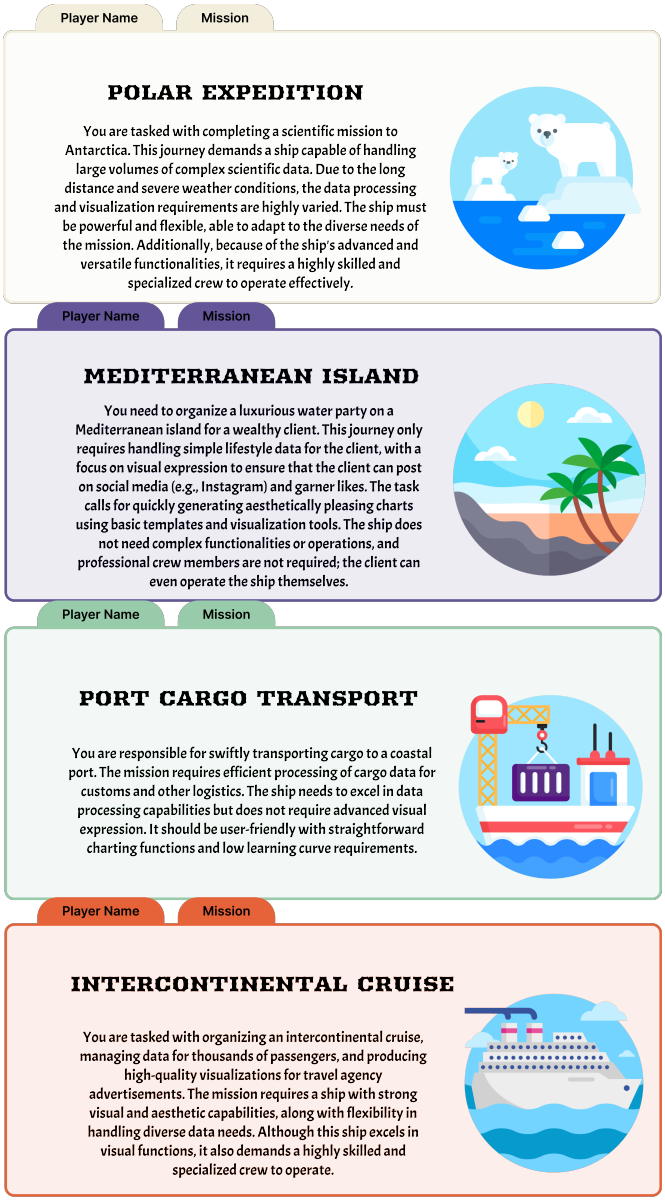
Choose wisely based on your mission. A wrong choice costs you a resource card!

VISVOYAGE INSTRUCTION

Gameplay:
1. Collect Resources:
   - Begin with 3 resource cards (one of each type).
   - As the game progresses, quickly and correctly identify the required data attributes from the variables shown on the front side of the data cards. The first player to correctly identify an attribute wins that data card.
2. Recruit Crew Members:
   - Recruit the exact crew members required by your mission and ship. Different crew members require specific combinations of data cards. Recruit the crew member if the data card combination is correct. Lose the data cards if the combination is incorrect.

Victory:
The first player to recruit all required crew members and reach the correct destination with the appropriate ship wins the game.

Figure 6.6: *VisVoyage* instruction card



Player Name Mission

POLAR EXPEDITION

You are tasked with completing a scientific mission to Antarctica. This journey demands a ship capable of handling large volumes of complex scientific data. Due to the long distance and severe weather conditions, the data processing and visualization requirements are highly varied. The ship must be powerful and flexible, able to adapt to the diverse needs of the mission. Additionally, because of the ship's advanced and versatile functionalities, it requires a highly skilled and specialized crew to operate effectively.

Player Name Mission

MEDITERRANEAN ISLAND

You need to organize a luxurious water party on a Mediterranean island for a wealthy client. This journey only requires handling simple lifestyle data for the client, with a focus on visual expression to ensure that the client can post on social media (e.g., Instagram) and garner likes. The task calls for quickly generating aesthetically pleasing charts using basic templates and visualization tools. The ship does not need complex functionalities or operations, and professional crew members are not required; the client can even operate the ship themselves.

Player Name Mission

PORT CARGO TRANSPORT

You are responsible for swiftly transporting cargo to a coastal port. The mission requires efficient processing of cargo data for customs and other logistics. The ship needs to excel in data processing capabilities but does not require advanced visual expression. It should be user-friendly with straightforward charting functions and low learning curve requirements.

Player Name Mission

INTERCONTINENTAL CRUISE

You are tasked with organizing an intercontinental cruise, managing data for thousands of passengers, and producing high-quality visualizations for travel agency advertisements. The mission requires a ship with strong visual and aesthetic capabilities, along with flexibility in handling diverse data needs. Although this ship excels in visual functions, it also demands a highly skilled and specialized crew to operate.

Figure 6.7: Voyage mission cards

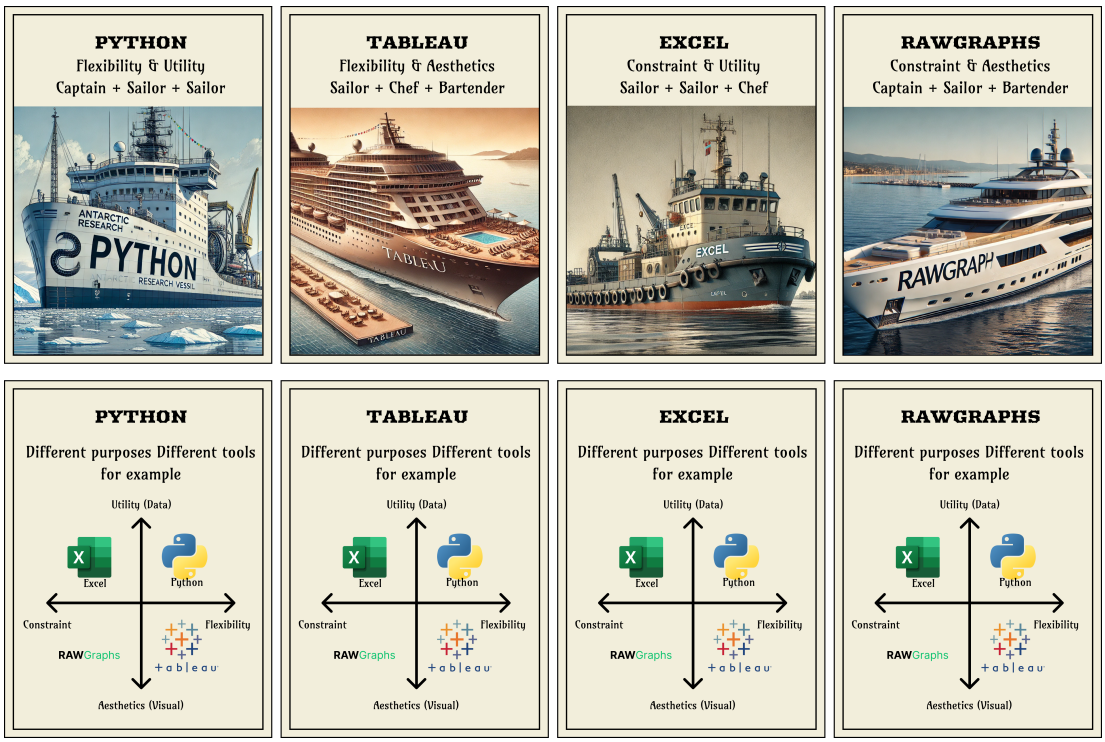


Figure 6.8: Ship cards

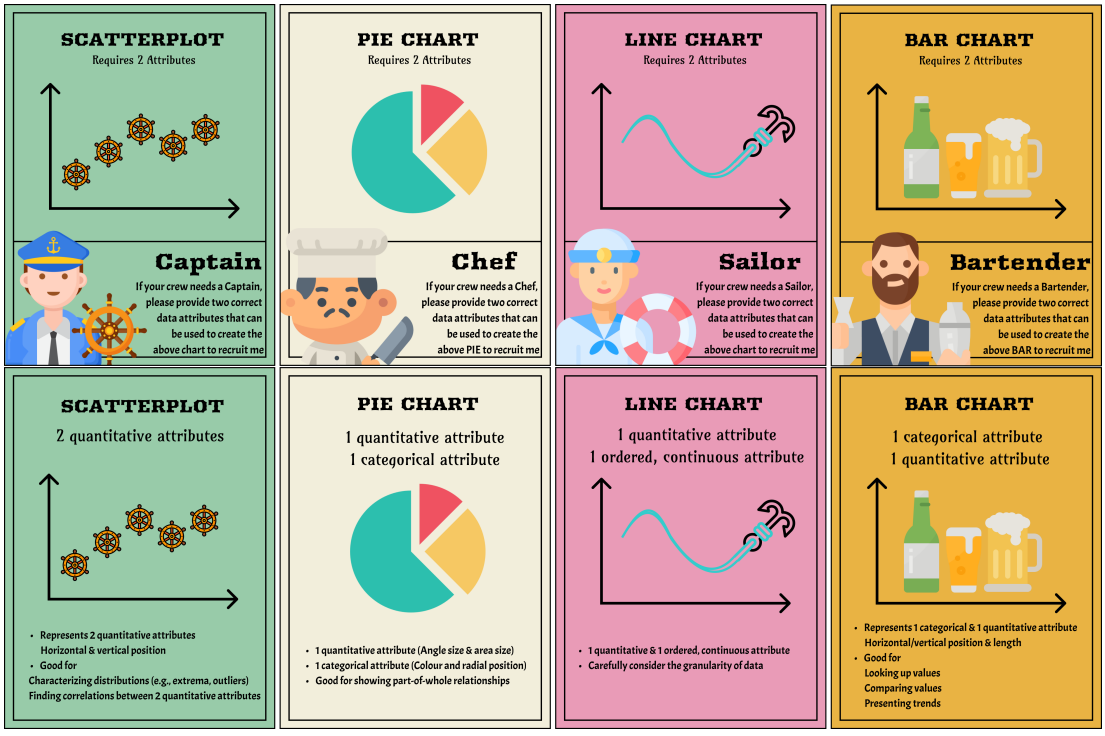


Figure 6.9: Crew member cards

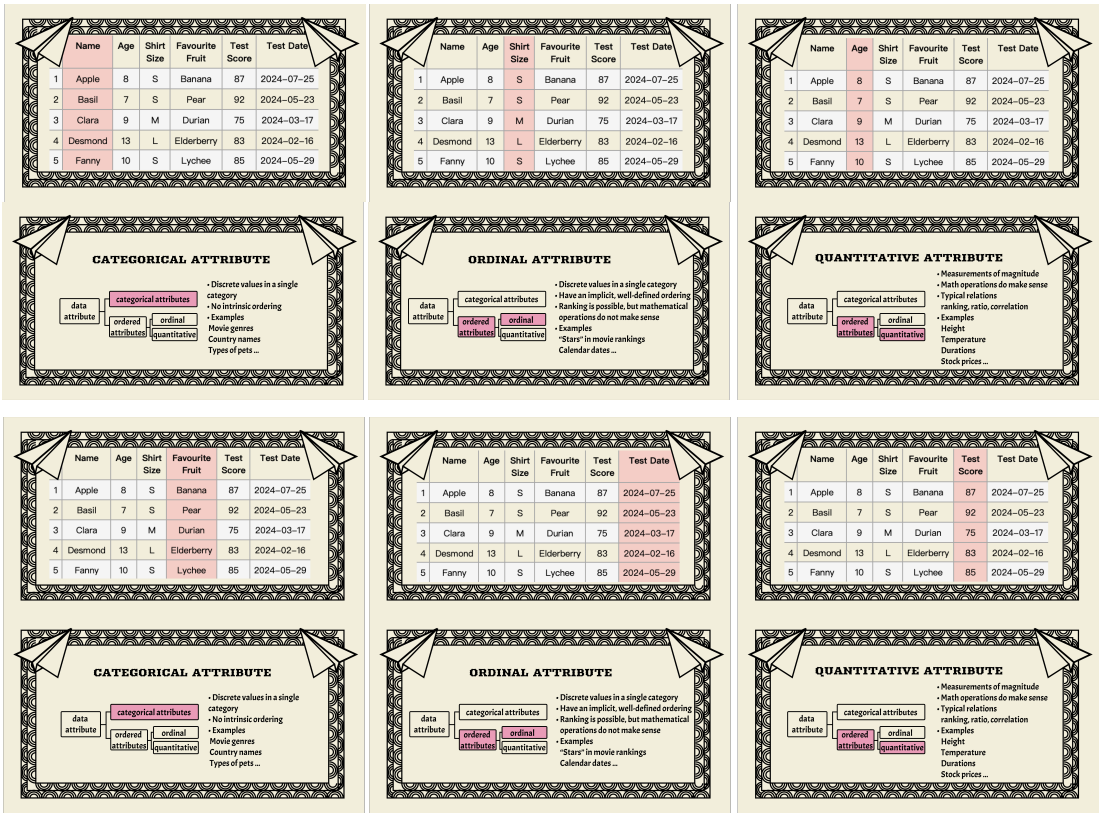


Figure 6.10: Data resource cards

6.4 Testing

To evaluate the feasibility of the game design and gather valuable insights for future iterations, a testing phase was conducted. A recruitment process similar to that used for the initial user interviews was undertaken to select participants for the test. Three office workers, none of whom participated in the earlier interviews or co-design workshops, were recruited for this testing. Among them, two identified themselves as DV novices, and one as a DV beginner.

The testing was conducted online, with the participants completing a single round of the card game on the FigJam platform. The pre-game and post-game interfaces are shown in Figure 6.11 and 6.12. The game was successfully conducted, and the feedback obtained from this test can be divided into two main parts.

Figure 6.11: Pre-game interface in FigJam

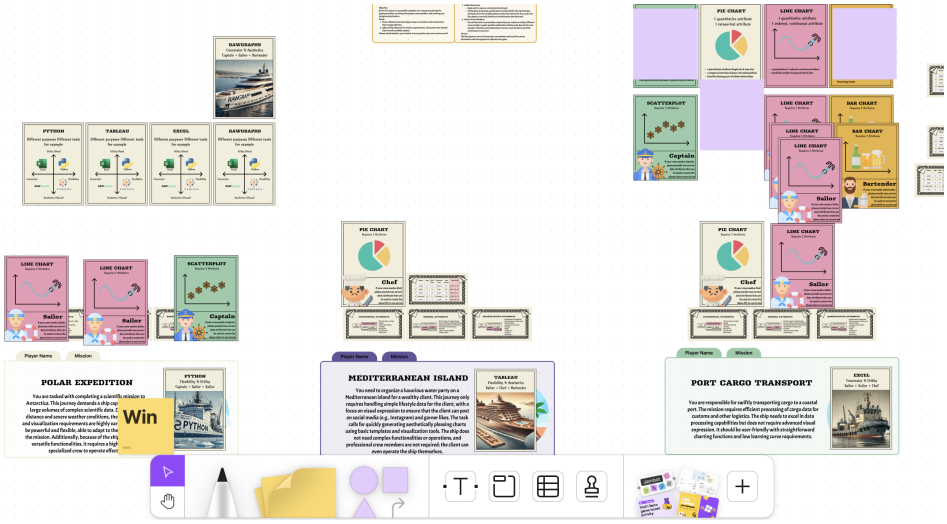


Figure 6.12: Post-game interface in FigJam

Firstly, to evaluate the efficacy of the card game in conveying data visualization knowledge, participants were asked to answer several questions about DV before and after playing the game. The answers provided by the participants are shown in Table 6.2, illustrating that all the participants experienced notable enhancement in their comprehension of the DV knowledge.

Secondly, after the game, participants were asked some open-ended questions (Q1–Q3) to gain subjective feedback on their experience with the card game.

Q1: Were there any rules or concepts during the game that you found confusing or misunderstood? One participant mentioned that the concept of data being used as

a resource to recruit crew members felt somewhat forced and suggested that a more futuristic or sci-fi story background could better embed this concept. Another participant noted that the game's design of different ships requiring specific crew members could be misleading, as it might imply that the DV tools (represented by ships) are directly related to the charts (represented by crew members).

Q2: What aspects of the game experience could be improved? Two participants felt that the game was too short. One participant attributed this to the varying response times and learning abilities among players, which created a significant advantage for some players in quickly securing data resource cards, leading to a swift victory. The other participant believed that the game required too few rounds to win and that the rules were relatively simple. They suggested adding obstacles or special effect cards to increase the game's difficulty and introduce more randomness, thus reducing the disparity between players.

Q3: How do you feel about teaching DV knowledge through this card game? All participants expressed satisfaction with the game's story and rules, noting that they found it highly engaging, with strong elements of fun and interactivity. They also highlighted the value of the illustrations and icons, which naturally drew their attention and encouraged them to actively learn the DV-related knowledge presented on the cards.

In summary, the feedback from the participants highlights both the benefits and the areas for improvement in the game design. These insights are invaluable and should be carefully considered in future iterations and updates of the game. Suggested improvements include modifying the story background to a more futuristic or sci-fi theme to better explain the concept of data as a foundational resource, such as exploring outer space or an AI takeover of Earth. Additionally, introducing action cards that allow players to draw extra resources, exchange resources, or trigger special effects could increase the game's difficulty and randomness, helping to mitigate disparities between players. Finally, adding explanations to the ship cards to clarify that the relationship between crew members (charts) and ships (DV tools) is purely a game mechanic with no real-world mapping could prevent potential misunderstandings.

Table 6.2: Participants' understanding of data visualization concepts before and after playing *VisVoyage*

Question	**User**	**Before**	**After**
What are the types of data attributes?	1	Text, numeric, etc.	Categorical and quantitative
	2	Numeric and text	Categorical and ordered
	3	Qualitative and quantitative	Categorical and quantitative
List a few DV tools and explain their differences.	1	PowerPoint and Word	Excel, Python, and Tableau; some are more powerful, others are simpler to use
	2	Don't know	Excel and Tableau; the former is better at data processing, the latter at visual expression
	3	Excel and Python; Python requires coding and is more difficult	Excel, Python, Tableau, and RawGraphs; these tools excel in different DV needs, such as Tableau and RawGraphs for creating more aesthetically pleasing charts, while RawGraphs is simpler; Excel and Python are better for data processing, with Python being more flexible
Describe the DV design process.	1	Choose charts and input data	Choose a tool, identify data attributes and chart types, and start visualization in the tool
	2	Don't know	Identify data attributes and select appropriate charts
	3	Select variables and generate charts	Select tools based on DV requirements, determine the variables to be represented and their data types, and visualize using the appropriate charts

Chapter 7

Discussion

This study presents the design and development of *VisVoyage*, a co-designed tabletop card game aimed at teaching DV concepts to office workers with limited data experience. This chapter provides a critical reflection on the project's process and outcomes, highlighting both its successes and limitations.

Following the Double Diamond model, the research on office workers learning DV skills was divided into two key areas: what to teach and how to teach. Each stage of the project utilized a user-centered approach, ensuring that the needs and insights of users were engaged throughout the discover, define, develop, and deliver phases. The initial user interviews and thematic analysis clarified the learning needs and challenges faced by office workers, particularly regarding challenges in tool selection and the need for structured processes—gaps not addressed in previous DV models. From this, several critical dimensions for selecting tools for constructing DV in the workplace were identified, leading to the development of a tailored data visualization pipeline for office workers. This pipeline provides valuable guidance for novice learners adapting to the diverse DV tool landscape and directly informed the subsequent design phases.

Co-design was adopted as a method for ideating the tabletop game design. While co-design is traditionally used to gather user insights, often resulting in more abstract and divergent outputs, this study structured the co-design workshops carefully to ensure that the results would contribute directly to the final design. The use of a card-based tool provided prompts to facilitate co-design within a limited timeframe, balancing both the breadth and depth of the design process. The co-design workshops demonstrated the effectiveness of these prompts, as the resulting narratives, game elements, and mechanics directly inspired and were applied to the final design. The role of the card-based prompts in supporting co-design for educational games was validated through

this process.

Finally, the refined game design was tested, and the polished card game successfully demonstrated its effectiveness in helping office workers learn key DV concepts such as data attributes, DV tools, and the DV process. The game was also found to be engaging and playful. In addressing both the lack of DV education content and engaging teaching methods for workplace environments, this research successfully filled a gap in providing accessible and enjoyable DV education for office workers.

While the project achieved its primary goals, several limitations were identified. Firstly, the small sample size of participants during the design process, including the interviews, co-design workshops, and testing phases, may limit the generalizability of the findings. Additionally, most of the participants involved were younger adults at the early stages of their careers. The study did not account for the perspectives of mid-career or later-career office workers who may face different challenges and have distinct needs when learning DV skills, especially during career transitions or in the context of a second curve in their careers.

Another limitation is the lack of diversity among the stakeholders involved in the co-design workshops. Although game design experts and target users were included, the study did not sufficiently address the complex scenarios of DV learning within workplace organizations. The research primarily focused on office workers' self-directed learning, but future studies could explore DV skill development in organizational contexts. For instance, involving human resources personnel, company management, and decision-makers in co-design workshops could provide a broader perspective on workplace learning strategies.

Furthermore, while the use of card-based prompts and scaffolding in the co-design workshops made the process more efficient and ensured useful outputs, it also somewhat limited the potential for more divergent and creative design ideas. In this study, the design brief was clearly established through interviews, ensuring that the prompts guided participants in the right direction. However, if co-design is used as the primary user research method, careful consideration should be given to the use of design prompts to avoid constraining creativity.

The hybrid format of one of the workshops, due to participant availability, also presented challenges. This group's interaction and output were affected, as the design process was primarily conducted through FigJam, limiting the ability to quickly sketch ideas and reducing the speed of communication and collaboration among participants. As a result, the overall efficiency of this workshop was lower compared to the in-person

session.

Lastly, while the final design of *VisVoyage* is comprehensive, functional, and effective, there remains room for iteration and improvement. Despite the small scale of user testing, valuable feedback was collected, providing directions for future refinement. For example, modifying the story background to a more futuristic or sci-fi theme could better explain the concept of data as a foundational resource. Additionally, introducing action cards that allow players to draw extra resources, exchange resources, or trigger special effects could increase the game's difficulty and randomness. Clarifying the relationship between crew members (charts) and ships (DV tools) by adding explanations to the ship cards would also prevent potential misunderstandings about the game mechanics and their real-world implications.

In summary, this study made innovative attempts in user research, the design process, DV education models, and the final game output, offering valuable insights and critical inspiration for future research.

Chapter 8

Conclusions

This study successfully developed *VisVoyage*, a card-based educational game designed to introduce DV concepts to workplace novices. Through a user-centered design process that incorporated insights from both interviews and co-design workshops, the project addressed key challenges faced by office workers learning DV in their work environments. The game proved effective in teaching essential DV concepts, such as data attributes and chart selection, while maintaining a fun and engaging format.

The broader implications of this project suggest that gamified approaches can make technical skill development more accessible and engaging for office workers. The positive feedback from testing indicates that tabletop games for learning hold promise for further research and application in workplace learning. In addition to the final game design, the process yielded other valuable contributions. A tailored DV learning pipeline for office workers was developed, combining insights from interviews and existing models. This pipeline emphasizes key decision points and necessary knowledge at each step, making it more practical and beginner-friendly while aligning with the diverse landscape of DV tools. Furthermore, the card-based tool created for the co-design workshops provided essential scaffolding for the game's development and can be reused or adapted for similar DV educational initiatives.

In conclusion, this project demonstrates the potential of combining gamification and educational design to create effective learning tools for office workers. It offers a novel approach to addressing the DV learning needs of office workers, with potential for expansion and adaptation to other technical fields. This dissertation underscores the innovative possibilities that lie at the intersection of gamification and education, particularly in workplace settings.

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Appendix A

Participants' information sheet

Participant Information Sheet

Project title:	Teaching Data Science Concepts for Visualisation to Office Workers through Creative Practice
Principal investigator:	Susan Lechelt
Researcher collecting data:	Shuomeng Zhang

This study was certified according to the Informatics Research Ethics Process, reference number [**760956**]. Please take time to read the following information carefully. You should keep this page for your records.

Who are the researchers?

The research team is based at the University of Edinburgh and includes:
Dr. Susan Lechelt, Lecturer in Design Informatics

Shuomeng Zhang, Msc student in Design Informatics

What is the purpose of the study?

In today's highly information-driven society, an increasing number of office workers and fields require the skills of data analysis and visualisation to assist in better work conduct. Although platforms like Tableau, Flourish, and RawGraphs have democratized the field, making data visualisation more accessible, they often come with limitations that can stop user creativity due to fixed functionalities. Furthermore, even with these platforms, there's still a requirement for foundational knowledge in data structure and query formulation, which can be daunting for those without a data science background.

This study is part of Shuomeng Zhang's broader MSc research, which will explore and develop tools to teach data science concepts for visualisation to office workers. This will be achieved by utilizing interactive, embodied and physical computing methods to assist office workers with non-professional backgrounds in understanding the fundamental concepts related to data visualisation, enabling them to use data visualisation tools and software more effectively and efficiently.

In this study, we will invite you to a 2-hour session where you will be interviewed about your background and experiences with data analysis and visualisation, as well

as engage with hands-on group workshops that explore how to familiarise yourself with data visualisation and data science. Your participation will help inform the design of new tools for teaching data science concepts.

Why have I been asked to take part?

You have been asked to take part in this study because you are currently or have previously been involved in data visualisation or data analysis in the workplace without having a professional background in these areas. Additionally, you may have an interest in interactive creative practices and education.

Do I have to take part?

No – participation in this study is entirely up to you. You can withdraw from the study at any time until 10th August 2024, without giving a reason. Your rights will not be affected. If you wish to withdraw, contact the PI. We will stop using your data in any publications or presentations submitted after you have withdrawn consent. However, we will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part?

If you decide to take part, you will attend a session of approximately two hours at the University of Edinburgh George Square campus. During the session, we will alternate between hands-on group workshops and interview-style conversations.

In the hands-on group workshops, you will be asked to understand data concepts such as data terminology, attribute types, and visual variables. You will use a variety of materials to explore how to familiarize yourself with these concepts more quickly and engagingly and apply them to data visualisation while collaborating and exchanging ideas with others. During these activities, we will take notes on how you interact with the materials and take photos of the process and the works created. The entire process will be video recorded.

In the interview components, you will be asked questions about your professional background and your experiences with data analysis and visualisation. You will also be asked about your experiences with exploring and creating with the materials. The interview components will be audio recorded, and we may also take notes to support our analysis of the audio recordings.

All data will be transcribed and anonymized after collection, removing personally identifiable information such as names and images that may identify you (e.g., including faces).

Are there any risks associated with taking part?

There are no significant risks associated with participation.

Are there any benefits associated with taking part?

Free snacks and drinks will be provided during the workshops. The study may help you better understand data analysis and attempt to produce great data visualisation works.

What will happen to the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of ten years. All potentially identifiable data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality.

Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number or a pseudonym rather than by your real name. Your data will only be viewed by the research team (Dr. Lechelt, and Shuomeng Zhang).

All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint) and all paper records will be stored in a locked filing cabinet in the PI's office. Your consent information will be kept separately from your responses in order to minimise risk.

What are my data protection rights?

The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk. For general information about how we use your data, go to: edin.ac/privacy-research

Who can I contact?

If you have any further questions about the study, please contact the lead researcher, Shuomeng Zhang at s.zhang-212@sms.ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information.

If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.inf.ed.ac.uk/infweb/research/study-updates.

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact Shuomeng Zhang at s.zhang-212@sms.ed.ac.uk

Participant Information Sheet

Project title:	Teaching Data Science Concepts for Visualisation to Office Workers through Creative Practice
Principal investigator:	Susan Lechelt
Researcher collecting data:	Shuomeng Zhang

This study was certified according to the Informatics Research Ethics Process, reference number [**760956**]. Please take time to read the following information carefully. You should keep this page for your records.

Who are the researchers?

The research team is based at the University of Edinburgh and includes:
Dr. Susan Lechelt, Lecturer in Design Informatics

Shuomeng Zhang, Msc student in Design Informatics

What is the purpose of the study?

An increasing number of office workers and fields require the skills of data analysis and visualisation to enhance their work performance. Although platforms like Tableau, Flourish, and RawGraphs have democratized the field by making data visualisation more accessible, they often come with limitations that can hinder user creativity due to fixed functionalities. Moreover, despite the availability of these platforms, there remains a need for foundational knowledge in data structure and query formulation, which can be daunting for those without a data science background. To address this, we developed a toolkit to teach data science concepts for visualisation to office workers.

The goal of this study is to evaluate this toolkit with office workers to understand whether, and how, it might support their interest in data visualisation and deepen their understanding of data science concepts for visualisation.

Why have I been asked to take part?

You have been asked to take part in this study because you are currently or have previously been involved in data visualisation or data analysis in the workplace without having a professional background in these areas. Additionally, you have an interest in interactive creative practices and education.

Do I have to take part?

No – participation in this study is entirely up to you. You can withdraw from the study at any time until 10th August 2024, without giving a reason. Your rights will not be affected. If you wish to withdraw, contact the PI. We will stop using your data in any publications or presentations submitted after you have withdrawn consent. However, we will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part?

If you decide to take part, you will attend a session of approximately 40 minutes at the University of Edinburgh George Square campus. During the session, we will alternate between hands-on activities and interview-style conversations.

In the hands-on activities, you will be asked to explore the education tool and use this toolkit to familiarize yourself with data concepts such as data terminology, attribute types, and visual variables. You will also attempt to create visualisations related to your work experience. During these activities, we will take notes on how you interact with the tool and take photos of the process and the works created. The entire process will be video recorded.

In the interview components, you will be asked questions about your professional background and your experiences with data analysis and visualisation. You will also be asked about your experiences with exploring and creating with the tool. The interview components will be audio recorded, and we may also take notes to support our analysis of the audio recordings.

All data will be transcribed and anonymized after collection, removing personally identifiable information such as names and images that may identify you (e.g., including faces).

Are there any risks associated with taking part?

There are no significant risks associated with participation.

Are there any benefits associated with taking part?

Free snacks and drinks will be provided during the workshops. The study may help you better understand data analysis and attempt to produce great data visualisation works.

What will happen to the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of ten years. All potentially identifiable data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality.

Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number or a pseudonym rather than by your real name. Your data will only be viewed by the research team (Dr. Lechelt, and Shuomeng Zhang).

All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint) and all paper records will be stored in a locked filing cabinet in the PI's office. Your consent information will be kept separately from your responses in order to minimise risk.

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a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk. For general information about how we use your data, go to: edin.ac/privacy-research

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Updated information.

If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.inf.ed.ac.uk/infweb/research/study-updates.

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact Shuomeng Zhang at s.zhang-212@sms.ed.ac.uk

Appendix B

Participants' consent form

Participant number:_____

Participant Consent Form

Project title:	Teaching Data Science Concepts for Visualisation to Office Workers through Creative Practice
Principal investigator (PI):	Susan Lechelt
Researcher:	Shuomeng Zhang
PI contact details:	Susan.lechelt@ed.ac.uk

By participating in the study you agree that:

- I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.
- My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.
- I consent to my anonymised data being used in academic publications and presentations.
- I understand that my anonymised data will be stored for the duration outlined in the Participant Information Sheet.

Please tick yes or no for each of these statements.

1.	I agree to being audio recorded.	☐ **Yes**	☐ **No**
2.	I agree to being video recorded.	☐ **Yes**	☐ **No**
3.	I allow my data to be used in future ethically approved research.	☐ **Yes**	☐ **No**
4.	I agree to take part in this study.	☐ **Yes**	☐ **No**

Name of person giving consent	Date dd/mm/yy	Signature

Name of person taking consent	Date dd/mm/yy	Signature

THE UNIVERSITY of EDINBURGH informatics

Participant number:_____

Participant Consent Form

Project title:	Teaching Data Science Concepts for Visualisation to Office Workers through Creative Practice
Principal investigator (PI):	Susan Lechelt
Researcher:	Shuomeng Zhang
PI contact details:	Susan.lechelt@ed.ac.uk

By participating in the study you agree that:

- I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.
- My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.
- I consent to my anonymised data being used in academic publications and presentations.
- I understand that my anonymised data will be stored for the duration outlined in the Participant Information Sheet.

Please tick yes or no for each of these statements.

1.	I agree to being audio recorded.	☐ **Yes**	☐ **No**
2.	I agree to being video recorded.	☐ **Yes**	☐ **No**
3.	I allow my data to be used in future ethically approved research.	☐ **Yes**	☐ **No**
4.	I agree to take part in this study.	☐ **Yes**	☐ **No**

Name of person giving consent	Date dd/mm/yy	Signature

Name of person taking consent	Date dd/mm/yy	Signature

THE UNIVERSITY of EDINBURGH informatics