EG UK Computer Graphics & Visual Computing (2022)
M. Turner and P. Vangorp (Editors)

Towards Developing a Digital application for the Five Design-Sheets Methodology

Aron E. Owen[†] and Jonathan C. Roberts[‡]

Bangor University, UK

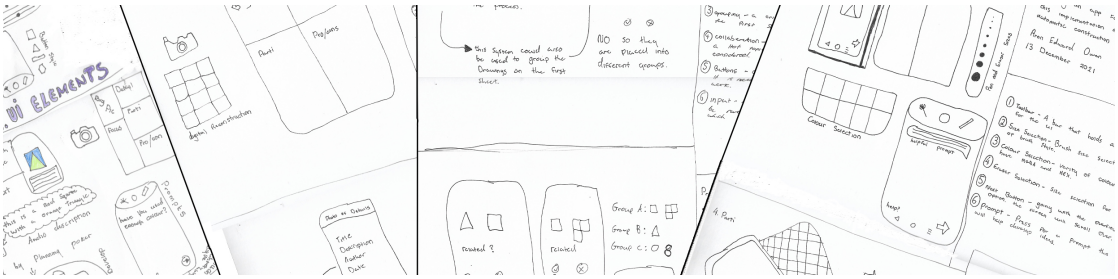

Figure 1: *On the left is sheet one with many ideas, progressing to the right as each idea is refined.*

Abstract

The Five Design-Sheet Methodology is a sketching methodology that helps people ideate different designs; it has been used to develop computer interfaces, games and data visualisations. Traditionally, it is a paper-based process that structures the developer to think about their design solution over five sheets with five sections. However, with the rise of mobile phones and tablets, there is an emerging opportunity to achieve the sketched design ideation process in a digital form. This work investigates the transition of the Five Design-Sheets from a paper-based methodology into a digital sketching application. The paper introduces how we considered the challenge, and have started to develop an application. Currently our application implements the first sheet of the FdS process. We describe the application and present a brief evaluation of the work with designers and developers.

CCS Concepts

• ***Human-centered computing*** → ***visualisation;*** • ***Computing methodologies*** → ***Computer graphics;***

1. Introduction

The journey of creative ideation employs several processes, from divergent thinking to creative and critical thought. When tasked with creating data visualisations [Man11], and novel designs, it can seem insurmountable—having a plethora of alternative ideas flowing through your mind with no clear direction of getting started. As the nobel prize winner Linnas Pauling said, "if you want to have good ideas you must have many ideas. Most of them will be wrong, and what you have to learn is which ones to throw away" [Cri96]. This design journey is not easy for everyone. It can be difficult for people to know where to start, or how to contemplate the solution from different angles, or even move past one dominant solution [RHR16b].

While designers create many design solutions by sketching, spider diagrams, taking notes, and so on [Bux10, CC09, CV90], they are ad hoc. The challenge is therefore how to encourage the developer to have productive design session. Ad hoc design sessions do not assist designers in structuring the ideation process. What is required is a structured methodology that embodies the consideration of the multitude of ideas, distils pertinent ones, and refines the specific solutions.

The Five Design-Sheet methodology (FdS) is one such method, traditionally achieved using pen and paper. The FdS is a way of formalising sketching to allow designers to explore their ideas without

† email: a.e.owen@bangor.ac.uk
‡ email: j.c.roberts@bangor.ac.uk

DOI: 10.2312/cgvc.20221174

worrying about the technical aspects [Rob11, RHR16b, RHR17]. The use of digital technologies such as tablets has thus far been dissuaded, arguing that digital design with the FdS is a substantially lengthier process than with pen and paper. When allowed to remove mistakes, the delete key is used more than the sketch tool—causing people to miss out on adapting mistakes into happy accidents that inevitably come with pen and paper [RHR16b]. With pen and paper, these mistakes would be left in to the final document. In fact, mistakes help people think critically, learn about the idea space, and are often used to spark better ideas.

While there are written resources and papers on the FdS, it is not easy for a new person to the FdS to follow the methodology in detail. Therefore, if we can develop an application that can help run through these stages, people will be able to follow it more consistently. While digital design forms are becoming popularised, it is not a simple task to take paper-based methodologies and convert them into a digital medium. The initial impression shows the FdS is a simple process – five sheets, with five parts per sheet. However, often the teacher needs to describe the process and help lead learners through the process. This information tacit knowledge is taught through classes, tutorials [RHR16a] and books [RHR17].

Therefore the first task of our design process, was to precisely articulate the stages of the FdS. Then consider how to develop the digital version. We contemplated several research questions:

1. Do all processes need to be made equivalent in the digital form?
2. How do we deal with the smaller input interface that are found on digital devices (e.g., mobile phones or tables)?
3. How can the digital interface effectively encourage and lead developers through the ideation process?
4. What additional help and prompts can be developed in the digital design space?

This paper highlights the FdS process and the journey of transforming the FdS, predominantly paper-based, into a digital application that embodies the FdS process. Secondly, the investigation of other tools and design methodologies [Mun09] and techniques that designers utilise [Sch21]. Thirdly, an evaluation of the created application by several students with varying experience of the FdS.

2. Background and Related Work

Fundamentally the Five Design-Sheet methodology provides structure to an otherwise chaotic process. The method divides a design session into five stages, allowing the designer to sketch a myriad of design solutions. The method was initially presented in 2011 [Rob11] at the education stream of the Eurographics conference, then published in IEEE TVCG in 2016 [RHR16b] and a book [RHR17] in 2017.

Design methodologies such as Nested Models [Mun09] and SQVID [Roa09] have been used to help designers create different visualisations. Design techniques exploring how data can be beautiful [McC12], and tools that help designers do what they do best [TLLS20, Sch21]. Many of them follow a process of starting off with general solutions and refining them. For example, the ADDIE model is popular for instructional design [Wel07]. It consists of five stages: Analyse, Design, Develop, Implement, and

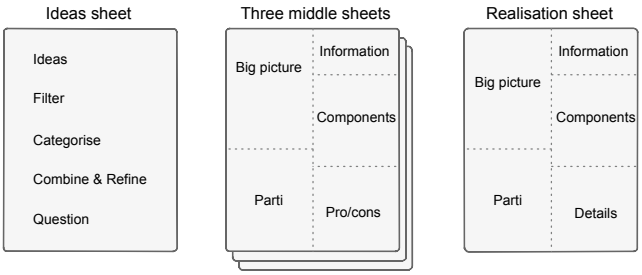

Figure 2: *The Five Design-Sheets method contains five sheets, each with five parts. After completing the ideas sheet, people focus on three alternative designs (the middle sheets) before completing the realisation sheet.*

Evaluate. The SQVID visualisation model, likewise presents several structures to help the developer contemplate the ideas, from Simple ideas, the Quality and Vision, to Individual and Design components. Finally, the nested model [Mun09] encourages the developer to think about the problem from four layers (1) domain problem characterisation, (2) data/operation abstraction design, (3) encoding /interaction techniques of the design, and finally (4) visualisation algorithm design.

Recently there have been a rise of graphic tools that help designers think or create designs of visualisations, many online. For example, Microsoft PowerPoint has a design button to redesign the current slide. While, template based systems, such as canva.com permit people to mix design ideas. Some of the online systems allow users to share and discuss ideas together. Shared whiteboard spaces, such as miro.com provide a visual collaborative platform allowing individuals and groups a blank canvas to explore their ideas. Other online tools support the creation of schematic diagrams. Tools have been created to support the creation of spider diagrams, such as lucidchart.com, creately.com, and asana.com, can be used to create online diagrams. While each of these tools help create specific outcomes, they do not integrate a process to help the developer consider, reconsider and critically think about different designs in a systematic way. Finally, we note that there are many tools and design-guidelines that designers can use to learn how to make better designs and visualisations [Sch21] and books to help people design better visualisations [War12, McC12] and contemplate different design ideas [Joh11].

3. Summary of the FdS Methodology

The first sheet is where the myriad of designs are explored. The purpose is to encourage the designer to consider the many alternative designs at their disposal; this is not an exercise in not only generating many ideas, but recognising the good designs from the many [Cri96]. This process should spark new ideas. Subsequently, the first sheet is not a linear process (in that one idea leads to another), but instead ideas flow from previous ideas, as the designer considers different solutions. Nor does the first sheet represent one eureka moment [Joh11]. Good ideas come after hard work and research. Three ideas progress from the first sheet to be explored in greater detail.

Each idea (on the middle sheets) is explored through five viewpoints (see Figure 2), as follows:

- **Information Panel**: The title, author, sheet number, and project description (a description in two lines of text) are recorded.
- **The Big Picture**: People sketch what it would look like if built. They annotate and identify the main parts.
- **Components**: The interface facets and design components, labelling the components similar to those in the big picture.
- **Parti**: The primary design concepts and organising principles are sketched and labelled. This part expresses the revolutionary idea, the uniqueness of the design.
- **Pros and Cons**: of the idea are discussed.

The fifth sheet is the realisation sheet, which records the final design. It develops the idea from a middle sheet and provides more detail. The structural difference is that this sheet replaces the pros/cons with more information, recording how the design idea can be taken forward.

4. FdS Application Design

Our design goals for the FdS application were to create an application that embodied and enhanced the user experience of the FdS from its paper-based form into its digital format. The first design stage was to complete our own FdS on the application to understand the limitations of a mobile application and how we could overcome some of the critical aspects of the FdS as seen in figure 1, such as categorisation. Once we had a design, the next step was to formalise the process as a roadmap of the application's required features. There were many design decisions on the journey, from the initial concept of building an application for the FdS and having an actual application. This section will introduce, explain, and justify these design decisions.

One of the decisions was to build a mobile application instead of a web application. This decision is still an exciting discussion point that we are making, as the tool continues to develop. The essential advantage of a web application would be that there are no device compatibility issues; however, it does introduce some concerns, such as scalability and security, which are not present in a mobile application. In addition, we have had prior experience building Android applications. Subsequently, our current solution is to develop an Android application. Regarding the user experience, we followed Shneiderman's golden rules [Shn86]. We also looked at usability and followed Krug's research [Kru05] that suggests users do not want to think about how to use something. It should be as natural and obvious as possible. Implementing the breadcrumb enabled users to visualise this process. The final design decision was the colour scheme. We followed accessibility guidelines around accessibility concerns such as colourblindness [Tol22]. and considered the colour pallet [AW13]. We chose a colour-safe palette, and simplified the users' colour choice by including a reduced set of colours for the drawing pens in the application.

5. Implementation and Results

The application has undergone many iterations, starting with a direct copy of the FdS process, and developing it into an application that not only embodies the FdS but can also guide the user through the process. Figure 3 shows five stages of the application. It has been implemented using Android Studio. Initially, Kotlin was going to be used, but the sketching functions were very slow. So we moved to Java, and this issue was resolved. Once the whole application is complete, rather than just the first stage, the idea is to publish it on google play store, to be compatible with Android 6 (Marshmallow and above, which is 97% of android devices).

Figure 3a shows the ideation step. The user is shown a blank page that they can sketch on. Along the top is shown five selection buttons to indicate the process along the FdS (as a breadcrumb). In the FdS paper version, the user creates many different ideas, sketching them down the page. In this application, the user sketches one idea, and then hits the next button. They can then enter a category name, as shown in Figure 3b. People can add many different design ideas. Sketching, naming, and hitting next, and so on, for as many designs as they want. When users have created all their ideas, they can go onto the next stage. The next step is to Filter the ideas. To decide if they are good or can be improved. In the App we achieve this by having a Like button, Figure 3c. The system runs through each of the ideas (previously sketched and named), allowing the person to like or dislike the ideas. If they dislike an idea, the program asks them how they could improve it. The next step is to "Combine and refine" ideas. By combining ideas, hopefully new ones can be created. In the application the system runs through the stored ideas (showing two at a time) and asks the user how two sketches can be combined into one image and asks them to sketch what a combined image would look like, Figure 3e. If the user does not want to combine the images, they can draw something new or something that embodies the two images displayed. The final stage is to "question". The user is asked if they wish to add any more ideas. If they are finished then all the images are combined into one large sketch (much like the output of the FdS process), that can be saved or downloaded.

6. Evaluation case study

We have performed a small user evaluation on the usability of the application (shown in 4). Five people were recruited through word of mouth, and represent a convenient sample. The experiment got people to spend 10 minutes to explore the application and another 10 minutes to complete the task. We asked them to design a new variant of the popular arcade game frogger, where the player controls a frog and has to cross dangerous obstacles such as traffic and rivers. Using a Likert scale we asked them to grade their technical knowledge, how often they sketched, answer the questions of the System Usability Scale (SUS), say whether the digital version would replace the paper version, and write their views of the system in a free text field.

Each participant had different design and technical knowledge backgrounds. The participants with a high technical understanding and possibly lacking in design ability scored the application highest, while those with a lower technical background but were more design-oriented scored lower. According to the SUS, the goal is to score higher than 70/100 [BKM08] for a good design. Across the five participants, the average completion time was 8 minutes for the application, 6 minutes and 43 seconds for the survey. The average participant score according to the SUS was 79/100, evaluating the

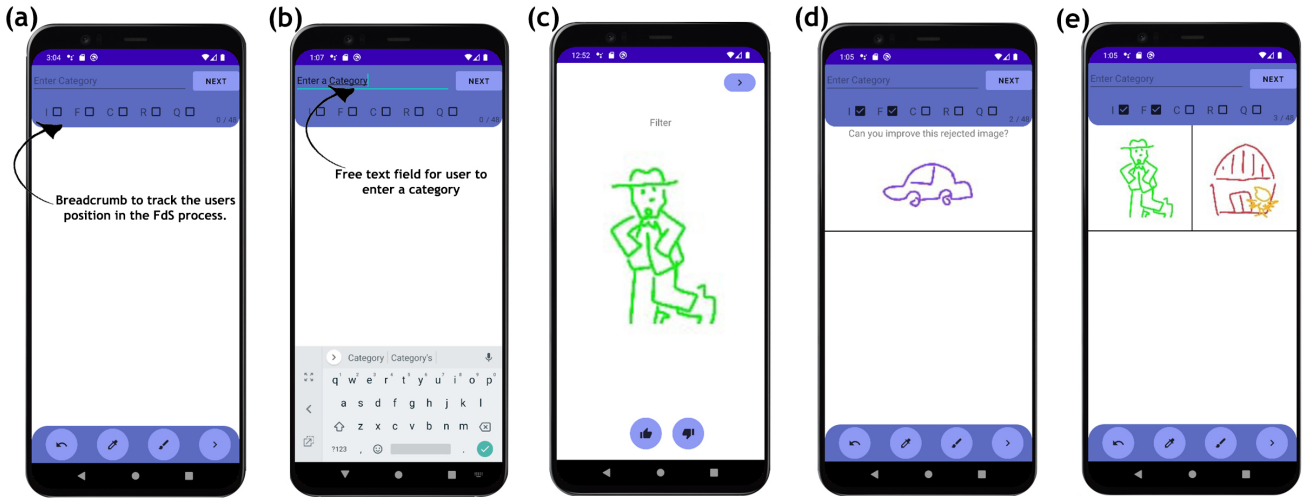

Figure 3: *In the ideation stage (a) the user creates multiple sketches around the idea. The user can categorise (name) the ideas (b). Putting the same name on the image allows the user to group similar sketches. In the filter process (c) the user can decide if they like the image or not. If they select to unlike an image then they are given the chance (as show in (d)) to improve it. Finally they can Combine and Refine ideas (e). The combine and refine stage is where a user is displayed two random images from their sketches and allowed to combine these two images or improve either image; this stage can be iterated as often as the user wishes.*

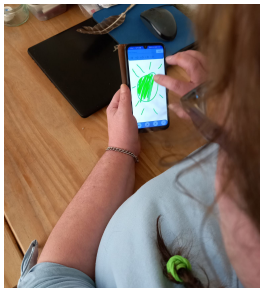

Figure 4: *The FdS application in use, during the evaluation.*

application as a good design. Answering the question about how often they sketched, one said 'all the time' and the others chose 'sometimes'. They were positive on the open-ended questions. One said, it is "based on a simple system" and another said it was "fairly simple to use, simple concept".

One of the core design goals is that users do not need to be familiar with the FdS to use the application, which is achieved according to these results. Only one of the participants had heard of the FdS before, but none had used it. In contrast, there is a continued argument about whether digital sketching can replace the traditional pen and paper approach, only one out of five participants held this opinion. Only two of our five participants come from a fairly technical background. When the participants were asked where they would use the application, a prevailing opinion was that the Application would be good for "on-the-go quick design" thinking or "personal projects", and "general design". These views support our view that a digital form of the FdS would be useful. However, none of the participants worked in design but they do each utilise some design elements in their professional lives. They did mention that different technologies could be used for different stages. Ideation and filter were ideal for mobile, they stated, but would rather be able to utilise a larger screen and potentially a graphics tablet for combine and refine, which is a fascinating concept and bodes well for the application's continued development.

7. Summary and Conclusion

We have explored the creation of the Five Design Sheet application. We have developed a solution for the first sheet of the FdS process. We have explored some of the issues and design challenges of moving from a paper-based solution to a digital one, and we have evaluated the system on five participants. While there is still much to develop, we have demonstrated that there is much potential to a digital sketched version of the FdS. We have calculated a good SUS score, and received many positive comments from the participants.

In conclusion, the application was proven to be user-friendly among the five participants. The application did not require any prerequisite knowledge of the Five Design Sheet methodology, which was a primary goal of this application. The evaluation has inspired new routes of research to explore with this application, including exploring other technologies. In the future we plan to further consider whether the web solution would be better, complete the other sheets of the FdS and perform an in depth study.

8. Acknowledgements

We thank the reviewers for their comments to improve the paper. We thank the study participants for their time. This work received ethics approval under clearance number CSEE-R-2022-CG-001.

References

[AW13] ALBERS J., WEBER F. N.: *Interaction of Color*, 50th anniversary edition ed. Yale University Press, 2013. 3

[BKM08] BANGOR A., KORTUM T. P., MILLER T. J.: An empirical evaluation of the system usability scale. *International Journal of Human–Computer Interaction* (2008). doi:10.1080/10447310802205776. 3

[Bux10] BUXTON B.: *Sketching user experiences: getting the design right and the right design*. Morgan Kaufmann, 2010. 1

[CC09] CRAFT B., CAIRNS P.: Sketching sketching: outlines of a collaborative design method. In *Proc. British HCI* (Swindon, UK, 2009), British Computer Society, pp. 65–72. 1

[Cri96] CRICK F.: The impact of Linus Pauling on molecular biology. In *The Pauling Symposium: Special Collections, The Valley Library, Oregon State University, OR* (1996). 1, 2

[CV90] CURTIS G., VERTELNEY L.: Tutorial 33, storyboards and sketch prototypes for rapid interface visualization. In *CHI '90* (Seattle, Washington, 1990). 1

[Joh11] JOHNSON S.: *Where Good Ideas Come From: The Seven Patterns of Innovation*. Penguin, 2011. 2

[Kru05] KRUG S.: *Don't Make Me Think: A Common Sense Approach to Web Usability*, second ed. New Riders, 2005. 3

[Man11] MANOVICH L.: What is visualisation? *Visual Studies 26* (03 2011), 36–49. doi:10.1080/1472586X.2011.548488. 1

[McC12] MCCANDLESS D.: *Information Is Beautiful*. Harper Collins Publishers, 2012. 2

[Mun09] MUNZNER T.: A Nested Model for Visualization Design and Validation. *IEEE transactions on visualization and computer graphics, vol. 15, no. 6, November/December 2009* (2009). 2

[RHR16a] ROBERTS J. C., HEADLEAND C., RITSOS P. D.: Sketching Designs for Data-Visualization using the Five Design-Sheet Methodology. In *Tutorials of at the IEEE Conference on Visualization (IEEE VIS 2016), Baltimore, MD, USA* (Oct. 2016). 2

[RHR16b] ROBERTS J. C., HEADLEAND C., RITSOS P. D.: Sketching Designs Using the Five Design-Sheet Methodology. *IEEE Transactions on Visualization and Computer Graphics* (Jan. 2016). doi:10.1109/TVCG.2015.2467271. 1, 2

[RHR17] ROBERTS J. C., HEADLEAND C. J., RITSOS P. D.: *Five Design-Sheets – Creative design and sketching in Computing and Visualization*. SpringerNature, 2017. doi:10.1007/978-3-319-55627-7. 2

[Roa09] ROAM D.: *The Back of the Napkin: Solving Problems and Selling Ideas with Pictures*. Portfolio, 2009. 2

[Rob11] ROBERTS J. C.: The Five Design-Sheet (FdS) approach for Sketching Information Visualization Designs. In *Proc. Eurographics 2011 – Education Papers* (2011), Maddock S., Jorge J., (Eds.), The Eurographics Association, pp. 27–41. doi:10.2312/EG2011/education/029-036. 2

[Sch21] SCHWABISH J.: *Better Data Visualizations*. Columbia Unversity Press, 2021. 2

[Shn86] SHNEIDERMAN B.: *Designing the user interface: strategies for effective human-computer interaction*. Addison-Wesley Longman Publishing Co., 1986. 3

[TLLS20] THOMPSON J., LIU Z., LI W., STASKO J.: Understanding the Design Space and Authoring Paradigms for Animated Data Graphics. *Eurographics Conference on Visualization (EuroVis) 2020* (2020). doi:10.1111/cgf.13974. 2

[Tol22] TOL'S P.: Paul tol's notes - colourblind colour pallets, 2022. URL: https://personal.sron.nl/~pault/. 3

[War12] WARE C.: *Information Visualization: Perception for Design*. Morgan Kaufmann, 2012. 2

[Wel07] WELTY G.: The 'Design' Phase of the ADDIE Model. *Journal of GXP Compliance, Vol. 11, No. 4, July 2007, pp. 40-48* (2007). 2