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# A Method for Critical and Creative Visualisation Design-Thinking

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## ABSTRACT

Visualisation design requires critical thought: to understand important facets, investigate design suitability and explore alternatives. But, especially for learners, it can be difficult to structure a critical reflection of creative solutions. We introduce the Critical Design Survey (CDS): structured method that facilitates visualisation design analysis through reflective and critical thought. Applying the CDS helps someone to structure critical thought, provides a unified method that can be readily taught, learners can actively engage with the process and directly use it to write a critical-thinking report of their design ideas. The CDS contains three steps: Step 1, summarise and write down the essence of the idea. Step 2, perform an in-depth critique (we define 30 questions structured in six perspectives). Step 3, synthesise the ideas, implications, and decide on the next steps. We present the CDS, describe our design process (critical thinking workshops, talk aloud, and student use), and describe our use in teaching visualisation to undergraduate and postgraduate students.

**Keywords:** Visualisation Design, Design Critique, Pedagogy, Visualisation Theory, Information Visualisation, Teaching Visualisation.

## 1 INTRODUCTION

One important visualisation skill, when designing or creating, is the capacity to assess, critique, and reflect on one's creations. This involves exploring alternative designs, layouts, and visual arrangements to determine their suitability for specific use cases. But, when teaching visualisation, we realised students did not have know-how or vocabulary to critique. Furthermore they did not have the necessary skills to structure and report ideas in a systematic way. Students were struggling to logically analyse the viability of their designs, and were unable to write a systematically structured critical reflective report of their creative-design process. Experienced visualisation designers can perform this critique more easily, as they can frame their ideas against prior experience of what works (or does not). Design guidelines and heuristics can help (e.g., [8, 12, 19]) but learners still struggle to know how to proceed.

Our vision is to create a comprehensive framework. We want to equip individuals with powerful tools that enhances their design-thinking abilities, and enables them to create impactful and well-considered solutions. The purpose of the CDS is to guide individuals to critique their designs in a systematic and organised way, and challenge them to think deeply. By providing the structure we aim to prompt people to think critically and thoroughly about their designs, and ensure that key considerations are not overlooked. The method acts as a roadmap for individuals to navigate through the critical thinking process. Each step, and each question on the sheet, is carefully crafted to address specific aspects of the design. It forms a logical progression of steps, from a holistic viewpoint to specific facets of design. It helps them to consider aspects of perception, environment, interface, components, design and visual mappings.

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## 2 RELATED WORK AND DESIGN OF THE CDS

Existing design-strategies (e.g., Five-Sheets FdS [13], sketching [5]) guide the design process, without focusing on critiquing. Similarly design methods such as Bertin [4] expound visual inspection. While frameworks (e.g., Amar and Stasko [2], nested [11]) guide users in thinking about rationales and tasks, they lack a holistic and in-depth critical analysis structure. Design heuristics offer a good strategy for critical thinking (e.g., [6, 9, 15, 18, 19]) but lack a formal critical-thinking structure, needing to be interpreted by the individual.

The CDS is one outcome, of our ongoing research to investigate design guidelines and techniques for visual, creative and critical thinking [1]. We held an initial two-day workshop to investigate critical and creative visualisation vocabulary. Ten participants (from diverse subjects across the university) defined critical thinking, critiqued visualisations, and created a flow-chart of their approach. One participant (drawing on Shneiderman [16]) said "when we are critiquing .. we first need to understand what it is, then put aside bias and emotion. There are different levels of detail. We should look to the big picture before looking at details". Carefully considering the workshop findings we performed a reflective analysis. Our inspiration included questionnaires (SUS [3] and Usability Experience Questionnaire (UEQ) [10]), prior work on critical thinking (e.g., [14]). After deliberation, we adopted a UEQ-like structure with themed questions. Version 1 (V1) we evaluated with two talk-aloud sessions, using two company-based, experienced visualisation, software developers. From their input, V2 was developed with focused questions, edited phrasing, and the three-step process. Using the SUS and free-text fields, V2 was evaluated with students. One student wrote "has a good structure, but some questions needed more descriptive detail". Subsequently we added a longer descriptive guide, and included an additional lecture on critical thinking skills.

## 3 THE CRITICAL-DESIGN SURVEY

**Step 1, overview.** The initial task involves taking a holistic view of the design. This is achieved first by naming it, and second by writing a short summary. This is a crucial step as it helps to frame the problem, and enables individuals to synthesise the ideas, and encapsulate the essential aspects of the design in a simple description. By assigning a name to the design, it both helps individuals to clarify the core elements, purpose and fit of the idea, and provides an effective way to communicate the core essence of the idea, and conceptualise the design idea in a comprehensive way. This step is further reinforced by choosing five from twenty first-impression words (which were carefully chosen from sentiment word scores in the lexicon [17]). Seven positive (average, beautiful, clear, clever, reliable, sensible, spectacular), seven negative (bad, complex, indistinctive, pointless, confusing, useless, vague) and six neutral (fair, fulfilling, indifferent, moderate, organised, useful) words. **Figure 1** shows the sheet version of the CDS with each of the steps.

**Step 2, Detail.** For the 30-questions, to ensure a comprehensive analysis, a top-down approach is used (from broad aspects of the user's perspective to specific visual mappings). The questions are intentionally designed to encourage deep thought, while helping to maintain a focused viewpoint on specific design goals. Questions prompt individuals to consider how the **user** would view the solution, the **environment** of its use, how the **interface** and individual **components** work; overall **design** aesthetic; and finally how effective

are the visual marks. Individuals need to be both open-minded and impartial in their consideration of their answers; notes and relevant considerations should be made through the process, which can be used in a report of the work. This approach ensures that a systematic and thorough evaluation of the work is achieved, and facilitates clear documentation of the evaluation process.

**Critical Design Survey (CDS)**

**Step 1**  
 Name design : \_\_\_\_\_  
 Summarise essence : \_\_\_\_\_  
 Circle 5 (first impression) words: \_\_\_\_\_

**Step 2**

Question	Perception	Environment	Interface	Components	Design	Visual marks
1 Is suitable for the user and task	0	0	0	0	0	0
2 Is understandable for user and task to hand	0	0	0	0	0	0
3 It doesn't require guesswork	0	0	0	0	0	0
4 Is trustworthy	0	0	0	0	0	0
5 Would be useful	0	0	0	0	0	0
6 It would fit in with other technologies	0	0	0	0	0	0
7 Uses suitable technology	0	0	0	0	0	0
8 Has appropriate interaction	0	0	0	0	0	0
9 Its sizing is correct	0	0	0	0	0	0
10 Gives a positive ambience	0	0	0	0	0	0
11 Suitable user interface	0	0	0	0	0	0
12 Ergonomic interface	0	0	0	0	0	0
13 Facets are sized suitably	0	0	0	0	0	0
14 Interface suitably spaced	0	0	0	0	0	0
15 Suitable quantity of interface parts	0	0	0	0	0	0
16 Has all necessary components	0	0	0	0	0	0
17 Has all suitable output/view types	0	0	0	0	0	0
18 Clear relationships between parts	0	0	0	0	0	0
19 Task can be easily performed	0	0	0	0	0	0
20 Suitable organisation of components	0	0	0	0	0	0
21 Inspiring design	0	0	0	0	0	0
22 Aesthetic and visually attractive	0	0	0	0	0	0
23 Good composition and space utilisation	0	0	0	0	0	0
24 Suitable coverage of data/underpinning facets	0	0	0	0	0	0
25 Clear instructions, labels, legends to give context	0	0	0	0	0	0
26 Right choice of channels to communicate things clearly	0	0	0	0	0	0
27 Communicates appropriate relationships/morphisms	0	0	0	0	0	0
28 The types of marks used, communicate things well	0	0	0	0	0	0
29 Components are shown at the right level of abstraction	0	0	0	0	0	0
30 Nothing is hidden that shouldn't be hidden	0	0	0	0	0	0

**Step 3**  
 Reflect: \_\_\_\_\_  
 Improvements: \_\_\_\_\_

Total: \_\_\_\_\_

Average: \_\_\_\_\_

Score scale: -60 (Poor design) to 60 (Good design)

Figure 1: Three steps of the CDS: Summarise, Detail, Reflect

**Step 3, Reflection.** The final stage involves synthesising the critique into a cohesive whole. Individuals can consider each part in turn: the descriptive name, summary, choice of first-impression words, along with the score from the 30 questions. While the scores help someone to understand where issues may be, they should not be used as a quantitative measure of success/failure. Building upon the insights gained from reflection, this step focuses on contemplating improvements to the design, to identify areas of weakness or opportunities for enhancement. The individual could identify problems with the user interface, usability issues, require adjustments to design elements, or change the data-mapping to better align with the desired goals. At the conclusion of the process, individuals are encouraged to compile a list of actionable items (as improvements). This list would consist of tasks or steps that can be followed to address the identified areas for improvement. They should capitalise on opportunities for enhancement, which will ultimately lead to an effective final design solution.

#### 4 USE, EVALUATION AND DISCUSSION

We use the CDS in our visualisation assessments. Students are tasked to choose a data set, use the FdS [13] sketching method to consider alternative designs. They write a critical report utilising the CDS. The CDS helps individuals to assess strengths and weaknesses of their ideas and reflect on their lessons learned throughout the design journey. They implement their chosen design, then use the CDS to help them write a further critical report, which not only provides a valuable reference for iterations, but helps individuals

collect their knowledge and lessons learned. We have run this assessment for 5 years, and evaluated students each year, where they are positive (e.g.,) "it helps you see on paper what's good and what's bad". "The CDS asks you to be honest and rate different properties of the program, which helps spot things that could be improved". Additionally, our analysis on the first-impression word use, on a set of representative visualisations (bubble chart, pie, line graph etc.) shows that every word is used, with some more than other (e.g., indistinctive, fulfilling and spectacular were used least often) [1].

To present the CDS we first first teach critical thinking skills [7]. People must be well-informed, inquisitive, honest and so forth in their approach. We explain the six CDS perspectives and run a class-based critical-thinking activity; to develop confidence, knowledge, and skills. Students must comprehend their dataset, understand visualisation design principles, and user requirements. Furthermore, we emphasise that the critical-thinking process is more important than any final result. Our aim is to shift from people simply stating "it's a poor visualisation" to engaging in discussions and offering critiques on the specific nuances of each design. In conclusion, the CDS is a structured method for critical analysis in visualisation design, guiding individuals through the process of (1) thinking holistically, (2) performing a deep analysis, through 30 questions in six perspectives. (3) Enabling identification of enhancement, alteration and practical application. We acknowledge that the process of critical thought, especially critical design thinking, is both challenging and time consuming. The middle stage, is deliberately detailed, and is designed to engage people's minds in a deep and constructive way. By leveraging the CDS designers can evaluate, iterate, and work towards creating impactful visualisations that meet the desired objective and create meaningful experiences for users.

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