How do we present complex systems to outside stakeholders? A study on the usability of complex interactive diagrams.

ABSTRACT

As designers acknowledge the increasing complexity of the world we're designing for, there is an increasing need to understand the dimensions of the artefacts we deliver to the stakeholder we so desperately fight to include in the process. The objective of this study was to gauge whether or not an interactive and zoomable map allowed participants to more quickly understand, use and explore a complex system map compared to a static and layered map. The bigger aim of the study was to shed light on an interesting discussion regarding the difference between things that are complex and things that are complicated, and the implications that has for the system maps created.

The investigation was done in the form of a controlled experiment. A total of 10 participants were recruited. Participants were asked to explore one of the two complex system maps. One being a multi-layered interactive system map, the other a static diagram sliced up in to it's individual parts. Participants were asked to notify the researcher when they felt they had a good understanding of the diagram, the time from introduction to understanding was timed. Participants were then asked to fill out a questionnaire which aimed to capture data on ease of use and satisfaction. Finally a short informal interview was conducted to probe deeper in to participants feelings towards the system maps.

The questionnaire data provided inconclusive data, with both diagrams scoring similarly. Participants spent significantly less time to understand the interactive multi-layered diagram on average, and generally scored the interactive diagram better in the informal interview.

The data presented suggests that there is a difference in performance between the two conditions, participants spent less time on the interactive map on average, and rated it better in the interview. Counter to this, the questionnaire data suggest that there is little difference when it comes to preference between the two diagrams. This was attributed to

the fact that the interactive map was more engaging and fun to use compared to the static map, a variable that was not measured in the questionnaire. Overall, the data is inconclusive on whether or not the interactive diagram presents strictly better usability, but does show that it may provide some benefits depending on the information and diagram type.

1. Introduction

The role of a designer has changed significantly in the last ten years, a focus on design as a strategic tool through novel and holistic approaches such as service design, systems ergonomics and systems oriented design has allowed designers to work with increasingly more complex systems (Sevaldson and Vavik, 2010 , Valtonen and Ainamo, 2008). The world has become more complex, more stakeholders and interdisciplinary teams need to be consulted and involved through the participatory design processes. A process that has increased in scope and complexity. The need to deal with issues such as sustainability, business factors, culture, politics and social factors have become more important (Brown et al., 2010 , Klein et al., 2003 , Sevaldson, 2011).

Due to the complex nature of these factors, the notion of the «wicked problem» has re-emerged. Initially formulated by Rittel and Horst (1979), a «wicked problem» is a unique problem, which has no exhaustive formulation, no success criteria and is by definition, a problem that is a symptom of another problem. As an example, violent crime rates can be a symptom of moral decay, economic status, liberty, deficient opportunity, but these problems are again symptoms of bigger issues and systems (Rittel and Webber, 1979). These interdependent «systems within systems» interact in non-simple ways, creating processes and systems that can be impossible to understand, predict and explore (Buldyrev et al., 2010 , Kirlik, 2011).

These wicked problems and systems are now being discussed by designers through very overlapping approaches. System ergonomics, service design and systems oriented design all try deal with the complexity of these issues by tapping in to our human abilities for system representation and visual thinking to frame and understand design problems. (Cheng, 2012 , Roam, 2009 , Sevaldson, 2011 , Stickdorn and Schneider, 2012). These approaches incorporate similar tools to deal with the complexity in the systems at hand.

Through visual thinking designers create system maps, journeys and process maps that all play a major role in the facilitation of exploration and understanding of these systems. The main goal of these mapping methods is to map out the numerous information exchanges and interactions between humans and humans, humans and machines and machines and machines to gain an understanding of the emotions, tasks and interactions involved in these systems within systems (Segelstrom, 2010 , Stickdorn and Schneider, 2012).
The system maps are often shared not only within the interdisciplinary design team, but also with external stakeholders who may not have been involved in the initial map creation and discussion stage. Therefore, it is very important to create easily understandable system maps and present them in an ‘easy to use’ manner, but there exists little research on how to create and present complex and multi-layered system maps. This forced constraint on the system map creators means that as part of the design process diagrams must be easily understandable and easy to use while at the same time describing complex systems and interactions. Newly introduced interactive mapping and presentation tools such as Prezi, Adobe Edge Animate and MapsAlive, could enable us to create diagrams and maps that are interactive, e.g. hyperlinking, zooming in/out. This development also allows us to create narratives and contexts that have previously been hard to do. There is great potential to explore how these new tools could be used to improve the usability of complex systems diagrams.

Research in to the representation of interactive multi-levelled maps is lacking. There is also an interesting split in the community. Sevaldson (2011) puts forward that complex systems must be represented as complex systems, and that the design process needs to be more complex to deal with the complex issues (Sevaldson and Vavik, 2010). Sevaldson explains the use of the «GIGA-maps», similar to «rich picture» diagrams described by Avinson et al. (1992), these GIGA-maps aim to showcase the complexities of the systems represented. This is done to keep as many elements as possible in play during the design process, to ensure that the decisions made are sound and informed.

This view is slightly controversial, as it is in stark contrast to the views of previous literature, Hahn & Kim (1999), Razali et al. (2008), and Biuk-Aghai and Ao (2013) describe the need for diagrams to be complete and simple with clear rules present. The focus has been on creating diagrams that work within the boundaries of cognitive processes. This focus on human comprehension is interesting in that it highlights why wicked problems are

so wicked, they are inherently hard to define, formulate and solve which make them hard to fully comprehend.

The question that presents itself is whether or not it is easier to understand these complex system maps if the multi-layerered system diagram is interactive with layers presented in context compared to a static diagram that has each layer separate.

In an effort to explore this issue of shareability and usability of complex system maps, an experiment to investigate the usability of interactive multi-levelled maps was conducted.

2. The Experiment

This section describes the methodology used in pilots and the following experiments for the evaluation of mapping methods in terms of usability. A total of 20 participants were recruited to the study, 10 of these were part of the main data collection while the other 10 participants were part of the pilot study, pilot results were deemed to be appropriate for data analysis. Each participant was only exposed to one map, as learning effects were a key concern.

2.1 Methodology

Due to the complex nature of systems and user interactions with these systems, they exist as subjective experiences and encompass several layers of variables (from high level comprehension to colour preference). Therefore, a pragmatic approach and a mixed methods methodology was chosen as best suited.

2.2 Sample

A cluster sampling method was chosen as it represented a good compromise between feasibility and cost. The sample consisted mainly of students from Loughborough Design School. This group was deemed appropriate based on their working knowledge and exposure to design methods, diagrams and system maps. A total of 20 participants were recruited.

2.3 Usability framework

This paper presents an investigation in to the usability of these multilevelled mapping methods. While it is tempting to describe usability as simply «ease of use», Frøkjær et al. (2000) and Bevan (1995) define usability as consisting of three distinct aspects:

- Effectiveness, which is the accuracy of interactions.
- Efficiency, which is based on the resources spent to achieve goals.
- Satisfaction, which is the users attitudes and comfort when interacting with the diagram.

These three factors are consistent with factors explored and defined in similar research (Cepeda and Guéhéneuc, 2010 , Coltekin et al., 2009 , Razali et al., 2008).
To effectively assess the usability factors described, a triangulation of methods was employed:
A questionnaire to asses users own feelings regarding their own understanding and accuracy of understanding, this was heavily based on similar work by Jun (2007) and Biuk-Aghai and Ao (2013). This method aims to capture parts of both satisfaction and efficiency.

Time between the introduction of the diagram and to the point where participants feel they have a good understanding of the diagram. This method aims to capture parts of effectiveness and efficiency.

A semi-structured interview to explore the factors involved in diagram satisfaction and ease of use. This method aims to capture participant's satisfaction and other possible aspects that may arise.

2.4 Ethics

Ethics were a part of the main considerations of the study. The project was approved by the Loughborough University Ethical Advisory Committee before data collected was started.
Anonymity was a core aspect of this, participants were only required to sign the consent form, which would be separate from data collection coding. Consent forms were presented in a clear and concise manner before the session to ensure participants awareness of the study's aim and scope. Participants were later reassured that the study's aim was to measure map performance, not their abilities. Participants were also reassured and

reminded about the ethical stance of the experiment post-experiment to make sure that participants were comfortable with the data collected. The data was stored on a separate online dropbox connected to the university e-mail, completely separate from the researchers private e-mail.

2.5 Design

An independent sample design was employed to avoid learning effects. The experiment consisted of 1 diagram, projected in two different ways. The diagram was heavily based on the healthcare process map presented in Jun (2007), which describes the healthcare process involved in transitional care (moving patient from hospital to home). It focuses on actors, stakeholders and their communication. It consisted of two main levels, the hospital as a whole, and the ward within the hospital involved in the transition. It represented a real semantic system to maximise external validity.

The diagrams consisted of between 5 ± 2 main nodes and designed to comply with diagram guidelines described by Purchase et al.,(2002) which aims to maximise line orthogonality and include as few crossing lines as possible. One of the diagram styles was designed be zoomable and interactive using the Prezi presentation software. This allowed for interactivity and the ability to view the individual layers of the diagram in context and in their natural place. For example, the ward exists within the hospital, and is therefore placed as node inside with appropriate lines connected. The second style was a more classical static style, with each layer as a separate diagram in a PDF format. This style was not interactive beyond scrolling between the two pages. 10 participants were tasked to explore the static diagram, while the other 10 were asked to explore the interactive diagram.

2.6 Procedure

The experiment was conducted in a single session. Participants were tasked to only explore one diagram type, to avoid learning effects. Participants were asked to explore one map at their own pace, and were asked to signal when they felt they had a good understanding of the system. There was no time limit, and the participants were free to ask questions. This was allowed as to mimic a real life collaborative session, but was also implemented due to some participants struggling to get started.

The participants were given complete control of the navigation of the diagram and were free to zoom and pan to explore. In the static diagram this was mainly done by scrolling between the two layers or pages. In the interactive diagram, navigation was mainly done through use a mouse and keyboard to zoom and pan.

A stopwatch was used to time participants from their introduction of the diagram to their own point of understanding it. When participants felt they had a good understanding of the system, they were asked to fill out a questionnaire regarding the diagram. These questions were mainly based on their own feelings regarding the described process and diagram, to capture participants feelings on the individual sections, but also the map as a whole. Participants were then interviewed in an informal manner, to give them an opportunity to voice their opinion of the map in terms of usability.

2.7 Pilot

A pilot was used to evaluate the feasibility and as a means to gain insight in to possible improvements. The pilot included 10 participants, 5 for each diagram. The results of the pilot were promising, with only a few issues. One question from the interview had to be reworked. The questions: «Do you see any way of making it easier to understand or use?» and «What would help you understand it?» caused confusion with participants, and resulted in duplicate answers. Therefore the question «What would help you understand it?» was cut from the interviews.

Part of the interview as initially designed to check to what degree users understood the diagram by asking questions regarding the actual map. This was removed, as all participants got the questions right, leaving them useless. Additionally, it was originally intended that the experiment was purely observation from the researchers side, but due to the complicated nature of the maps and participants feeling lost, this was changed to a more moderate participation role. Despite of this, the results of the pilot are considered to be valid, and will form a part of the overall results of the study.

2.8 Analysis

The triangulation of methods in the study allows the results to both be analysed separately, but also in relation to each other.

The time measurement will contrast the average times and the total times for all participants in the two different conditions.

Questionnaire data will be coded on a 1-5 scale (1=strongly disagree, 5=strongly agree), statistical analysis will be done with an independent T-test with the use of SPSS. Interview data will be analysed with Nvivo software, and will attempt to find common themes and links between these themes.

3. Results

This section describes the total results of the study, including the results from the pilot. This study included 3 methods for measures of usability: time, questionnaires and informal interviews.

3.1 Time

During the experiment, time was taken from the point where the participants were exploring the map and stopped when participants felt they had a good understanding of the map contents.
The static map had a mean time of 7 minutes and 27,3 seconds. In total, the time for all participants in the static map group was 1 hour, 14 minutes and 33 seconds.

Static	7:27.3	1:14:33
Interactive	6:49.8	1:08:18

37,5 sec.	6,15 min.

The interactive map had a mean time of 6 minutes and 49,8 seconds. In total, the time for all participants in the interactive map group was 1 hour, 8 minutes and 18 seconds.
This produces a mean difference between the two groups of 37,5 seconds, and a total time difference of 6 minutes and 15 seconds.

3.2 Questionnaire

Participants were asked to fill out the questionnaire after using the map. The questionnaire consisted of 5 questions, each with a 5 point likert scale from strongly disagree to strongly agree which was coded from 1 - 5. The result were then analysed with an independent t-test for statistical significance. While there were differences in the answers between the two groups, none were considered statistically significant.

3.2.1 This diagram is easily understandable with instruction given.

Participants reported overall that the interactive map was more easily understood with the instructions and information given as an introduction. All participants responded with «agree» or better, with participants exposed to the interactive map scoring it slightly higher.

Stimuli	Mean	Std. Deviation
Interactive	4,3	.48305
Static	4,0	.00000

Stimuli	Agree	Strongly Agree
Interactive	7	3
Static	10	0

3.2.2 This diagram is helpful in better understanding and communicating how the system works.

The static map performed slightly better than the interactive map on this question. Again all answers were agree or better.

Stimuli	Mean	Std. Deviation
Interactive	4,1	.31623
Static	4,2	.42164

Stimuli	Agree	Strongly Agree
Interactive	9	1
Static	8	2

3.2.3 I enjoy using the map

The biggest difference was seen in this question. Participants exposed to the interactive scored it consistently higher than the static group. Participants seem torn on the question, as the spread of data is noticeable.

Stimuli	Mean	Std. Deviation
Interactive	3,9	.99443
Static	3,3	.67495

Stimuli	Disagree	Neutral	Agree	Strongly Agree
Interactive	1	2	4	3

Stimuli	Disagree	Neutral	Agree	Strongly Agree
Static	0	6	4	0

3.2.4 The map is easy to use

«Easy to use» in this scenario was defined as the ease of interaction and the resources involved in controlling and exploring the map. The interactive and the static received similar opinions, the spread in opinions on the interactive map is noticeable compared.

Stimuli	Mean	Std. Deviation
Interactive	3,9	.56765
Static	3,9	.31623

Stimuli	Neutral	Agree	Strongly Agree
Interactive	2	7	1
Static	1	9	0

3.2.5 The information of the map is easy to understand

While similar to question 2.2.1, this question aims to gauge users own feelings of how easy the information is perceived, while question 2.2.1 aims to gauge the usefulness of the diagram itself. Again a similar result, with the interactive receiving slightly better scores. The spread of the data is similar as well.

Stimuli	Mean	Std. Deviation
Interactive	3,5	.70711

Stimuli	Mean	Std. Deviation
Static	3,2	.78881

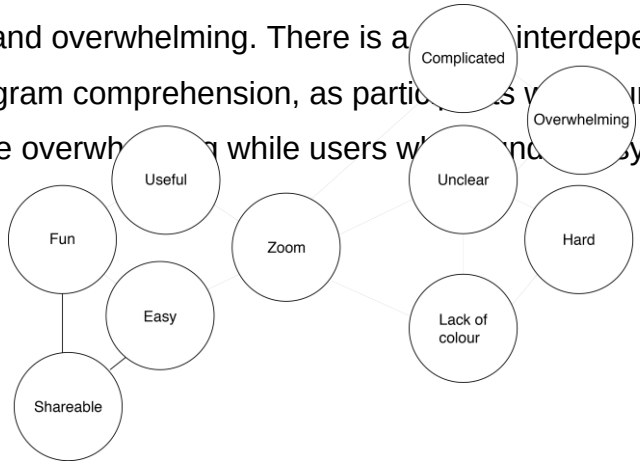
Stimuli	Disagree	Neutral	Agree
Interactive	1	3	6
Static	2	4	4

3.3 Interviews

After the questionnaire was completed, a standardised informal interview was conducted to gather qualitative data on participants feelings towards the diagrams in terms of enjoyment, possible improvements and usefulness. The interview guide consisted of 5 questions, and with ample opportunity for participants to comment. Analysis was done by clustering nodes and themes with the use of the Nvivo software.

3.3.1 Interactive map

The main feedback on the interactive map was that it was fun and easy, while at the same time daunting and overwhelming. There is a[n] interdependency between the factors involved in diagram comprehension, as partic[ipants] s[aw] [a]nd it complicated map often reported it to be overwh[elm]ing while users w[ho] [fo]und [i]t also found it fun.



The map view started as the top view, some participants noted that they would have liked it to start on the bottom view, and then work themselves up.
«Hard» was also a main node and represents two core concepts. Participants were asked whether or not they would consider creating similar maps if they were to represent a similar system. Participants reported that they were concerned about time/effort and that the map would be hard to make. The other mentions of hard, are linked to the map being hard to understand and use in terms of controls.

Participants noted that due to it's interesting interactive format, it could more easily be used by more than one user.

Regarding possible improvements to the diagram, users reported that colour-coding and more prominent use of colours would be useful. In addition to this, clearer controls, clearer instructions and a clearer legend were noted as possible improvements.

3.3.2 Static map

Qualitative feedback on the static map provided similar results to the interactive map, with participants finding it complicated, unclear and overwhelming, while at the same time reporting it being easy and useful after using it.

Participants reported clearer and thicker lines, clearer legends and more information as the main problems with the diagram.

Some participants found that the diagram was lacking colour, and therefore found it boring it use.

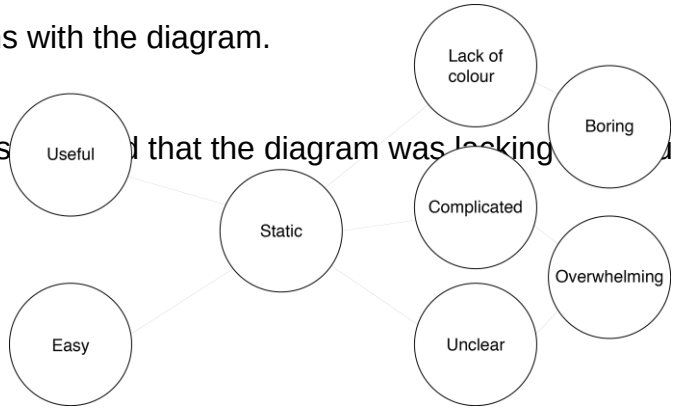


Figure 2: Node cluster of themes appearing in the informal interview analysis regarding the interactive maps.

Figure 1: Node cluster of themes appearing in the informal interview analysis regarding the interactive maps.

4. Discussion

The objective of this experiment was to gauge whether or not an interactive and zoomable map allowed users to more quickly understand, use and explore a complex system map compared to a static and layered map. The data collected through time measures, questionnaires and interviews show that users were quicker and enjoyed the interactive map more than the static, but also that some data is conflicting.

The interactive map scored higher in the qualitative measures and on time, but is rated similarly to the static diagram in the questionnaires. The fact that none of the questions in the questionnaire produced a significant result is surprising. It is also very interesting as it shows that the factors potentially involved in the 37,5 second gap in average times between the interactive and static diagrams are based on other factors than the ones explored in the questionnaire. The questionnaire shows us that the difference between the interactive and static map when it comes to participants understanding and ease of use is minimal. Still, an interesting point is that the biggest difference in answers in the questionnaire was present in the question on enjoyment. This coincides with the qualitative node analysis of the qualitative data, where the interactive diagram was clearly considered more fun and engaging compared to the static diagram.

Fun and engagement

Fun and enjoyment as a tool in design is nothing new, Shneiderman (2004) and Walter (2011) both point out the link between fun and pleasurable interactive experiences. Shneiderman (2004) points to several aspects of a user interface that can make it pleasurable, with «attractive graphics» and «appealing animations» being especially relevant to this paper. This link is clear in the qualitative data, participants who rated the interactive diagram as fun, also thought it was easier and spent less time to understand it.

Norman (2003) adds to this by drawing a link between attractive graphics and usability. This is interesting in this experimental context, as the diagrams (i.e graphics) were aesthetically the same, only the form of interaction was different. The data does suggest that Norman is correct in his assumptions, as both diagrams scored well in the questionnaire, but it also suggests that usability can be influenced by the method of interaction with the diagram. This could also help explain why the static diagram performed poorly relative to the interactive in the time tests and the qualitative feedback, while performing similar to the interactive in quantitative measures, as it is aesthetically the same diagram.

This links to the topic of performance vs preference in usability testing. Bailey (1993) and Nielsen & Levy (1994) both conclude that performance doesn't necessarily equal preference, and the data presented is in-line with this assessment. While preference data collected from questionnaires was similar, performance data based on time suggests that participants needed less time to fully understand the interactive diagram. A weakness of this study is that the term «understand» is subjective, and may mean different things to different people.

Colour as part of diagrams

Adding to this, colour, or the lack thereof, was noted as a core issue for most participants. This issue is interesting for complex systems as it has two distinct trains of thought. One issue is that by colour coding, a pre-set emphasis is set on parts of the system diagram. As an example, lines in red will potentially be interpreted as more important of more critical than blue ones. Sevaldson (2011) notes that due to the complex nature of systems and the design process, small things that seem insignificant at first can become crucial at later stages in the process. This poses a problem to map makers, as emphasis in colour can exaggerate this problem. Added to this there is a need to avoid «fixation» at an early stage, which is the inability to see alternative solutions when an interpretation of the diagram has been reached (Jun et al., 2011 , Suwa et al., 2001). This runs counter to Shneiderman's (2004) emphasis, which is to extensively use colours and attractive graphics to create fun and engaging interactions. Participants noted that they wanted colour as a way of quickly understanding information, for example colour coding differences in actors and interactions. Fundamentally this issue comes back to the

difference between preference and performance, that what people like about diagrams might not be what makes a diagram easy to use. This needs further research, as the data collected is conflicted on this matter. The data suggests that users prefer more use of colour in diagrams, but the data does not say whether or not this has an impact on performance.

Complicated vs complex

There is also the issue of the diagrams simply being complicated instead of being truly complex. As the participants didn't have in-depth knowledge about the system, it may have existed in a static state of simply being complicated. According to Cillers (1998), complexity is dynamic and ever changing. A complex system is complex not as the sum of it's components, but the relationships between these components. While the systems presented are complex in their true from, participants are not aware of the dynamic and emergent properties of the system. This is somewhat of a paradox, does describing a complex system in a non-dynamic form transform it to a complicated system?

This is an issue that there has been little discussion about, complicated things are different from complex things, but we often use them interchangeably when referring to systems. A computer system is complicated, it has a lot of components and wires that intersect, interact and communicate. But they communicate in clear and predictable ways, which means that understanding how a computer works is a complicated task. On the other side of this, complexity can exist in simple things, a conversation is complex because there is an almost infinite possible responses, as tone, volume and body language shape the meaning of what is being said. So what we have in some instances when mapping is that the focus on complexity results in complicated things being presented as complex things, and vice-versa. GIGA-mapping has this main flaw I would argue, that the medium of GIGA-mapping automatically transforms a complex thing in to a complicated thing regardless of whether or not the complex system was complicated. The medium for showing complexity should be complex, not complicated. The deeper issue here of course that operationalising complex systems is difficult as by definition complex systems have unclear boundaries and exist in a world where they cannot always be quantified. This is an issue that needs to be investigated in future research.

Big picture or delicately sliced?

Truly, the overreaching question in this discussion is whether or not participants prefer to have their information regarding complex systems presented as a whole top down view, or if they want a «teaspoon by teaspoon» view of the individual components that together make the system. «Information overload» is a concern when working with complex systems, and as Speier et al. (1999) states: «Information overload occurs when the amount of input to a system exceeds its processing capacity. Decision makers have fairly limited cognitive processing capacity. Consequently, when information overload occurs, it is likely that a reduction in decision quality will occur.». There is some evidence for this view, as some participants noted that the zoomable top down view was initially overwhelming and intimidating. This despite the steps taken in this study to keep the system maps fairly tidy by applying the guidelines for diagrams proposed by Purchase et al., (2002). A fascinating element to the statement by Speier et al. is that the outcome of information overload is the (reduced) quality of the decisions made. This comes back to the core aspect of system mapping, as a tool for making good and informed decisions when it comes to the systems explored. And this is also where the literature has two interesting views.

Sevaldson's (2011) proposed GIGA-map methodology takes the fear of information overload, and tosses it out the window. The reason for this is that conventional diagrams are set in their ways, and as Sevaldson (2011) puts it: «work like diagrammatic "strait jackets" on the information because they tend to lead towards a tidy sorting and "over-designing" of the information.». This process of presenting data creates a barrier between the actual system and the diagram, where the system structure has been transformed and manipulated to fit a diagrammatic representation. Hahn & Kim (1999) describes this process as «the algebra of diagrams», where adding, subtracting, multiplying, and dividing diagram components is done. Hahn & Kim (1999) also point out that users are mostly on their own when deciding on which diagram to use, which lead to the use of diagrams that are not fit for the data. Here the GIGA-map methodology presents an interesting development, as there are few rules and guidelines, giving freedom to diagram creators.

More formal mapping notations like UML or flowcharts follow the algebra of diagrams approach, with strict rules and views. The goal of these formal mapping methods is to simplify the system to make it easier to understand. This study runs somewhat counter to this, as participants found the top down and zoomable view more interesting, engaging

and more efficient. While some simplification has occurred in this study, the top down interactive represents a much more complicated view compared to the static diagram. Another mechanism of the interactive diagram is that it is initially overwhelming, requiring users to engage more in the diagram. This supports Sevaldson's (2011) initial assessment, that oversimplification and strict diagrammatic rules can hinder users in perceiving the information presented in a meaningful way. Still, this issue comes down to what happens to this information when perceived, the quality of the following decisions as a variable has not been considered in this study, but presents itself as an avenue for future research.

5. Conclusion

This paper has presented an empirical assessment on the usability of a static complex system diagram compared to an interactive and layered complex system diagram. The experiment presented used a triangulation of two quantitative measures (time, questionnaire) in combination with a short informal interview. The data presented suggests that there is a difference in performance between the two conditions, participants spent less time on the interactive map on average, and rated it better in the interview. Counter to this, the questionnaire data suggest that there is little difference when it comes to preference between the two diagrams. This was attributed to the fact that the interactive map was more engaging and fun to use compared to the static map, a variable that was not measured in the questionnaire. Overall, the data is inconclusive on whether or not the interactive diagram presents strictly better usability, but does show that it may provide some benefits depending on the information and diagram type

Additionally, the bigger picture conclusion is that when it comes to multi-levelled complex system maps, users prefer to have the complete map presented on one big canvas instead of having individual pieces of the system separate.

The results presented in this paper are interesting as it shows the potential benefits involved in creating and presenting multi-levelled interactive diagrams. It also suggests that designers and other map makers should not exclusively focus on creating maps based on human comprehension, but also consider presenting information as close to the

semantic system as possible. Additional factors such as fun, engagement and colour were also presented as potential aspects of increased efficiency and usability.

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