

POSTGRADUATE DISSERTATION ASSESSMENT: EXPLORING EXTANT USE AND POTENTIAL EFFICACY OF VISUALISATIONS

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ABSTRACT

In the context of assessment, two specific challenges face South African academics. The first is that their universities have experienced an unprecedented increase in postgraduate students without a concomitant increase in supervision capacity. The second challenge is that many South African students are studying in a second or third language and struggle to express themselves in English. It is notoriously difficult to write text that is easy to read. Examiners are thus finding it challenging to maintain their own existing high standards of consistency, accuracy and fairness. This paper focuses on identifying a way of making the assessment of dissertations more efficient, while retaining rigour and fairness. In so doing, we want to provide students with a tool that will help them to communicate their research more effectively. In seeking an intervention, we noted the emerging use of visualisation as a communication facilitator in other areas of academia. Given the innate human ability to understand and remember visual representations, and the deep level of cognitive processing required to produce such visualisations, the considered inclusion of visualisations could be the means we are seeking. In this paper we report on an investigation into the extant use and potential usefulness of visualisation in a number of dissertations. We also explore supervisor expectations with respect to the use of visualisation in research reporting. Based on our findings, we propose that a discourse be opened into the deliberate use of visualisation in postgraduate research reporting.

KEYWORDS

visualisation, assessment, postgraduate, dissertation

INTRODUCTION

Assessment is a core activity in higher education. Rowntree (1987) argues: "If we wish to discover the truth about an educational system, we must look into its assessment practices" (p. 1). The pressure for universities to demonstrate effective performance is evident from the studies of Pounder (1999) and Bitzer (2010). More recently, the drive has focused on ensuring the quality of the contribution (Simmonds & Du Preez, 2014). In this paper we focus on *dissertation* assessment, and specifically the role that visualisation could play in improving assessment practices.

Academics in South African universities in particular, are under increasing pressure to deliver postgraduate students. There are a number of reasons for this, including the following:

1. Universities across the globe are enrolling increasing numbers of postgraduate students (Taylor, 2002; Kruss, 2006). More students, with the same number of academics under increasing pressure, mean more dissertations to be assessed in the same time period (Van Biljon & De Villiers, 2013). For example, at the University of South Africa the number of dissertations more than doubled from 2010 to 2012 while the supervision capacity did not increase accordingly (ibid).
2. T'Anson and Smith (2004) mention the pressure that comes from millennium trends in higher education, including widening access, coping with large groups of students and the increasing occurrence of plagiarism.
3. The realities of South African society have led to the admission of student cohorts who vary in readiness for postgraduate study. This places additional pressure on supervisors to provide the necessary interventions the students need to meet the exit standards of postgraduate study (Van Biljon, Van Dyk & Naidoo, 2014).
4. Besides postgraduate supervision and evaluation, university lecturers also have other responsibilities like tuition, community engagement, academic citizenship, administration and carrying out their own research (Sanders & Pilkington, 2014; Bezuidenhout, 2015).
5. South African students are often studying in a second or third language (Pretorius, 2002; Webb, 2002). Depending on their English proficiency this may add to the difficulty of communicating their research in English (Armbruster & Anderson, 1985; Herminingsih, 2013), the predominant language of instruction in South African universities.
6. There is a clear need for greater consistency in assessment of dissertations (Webster, Pepper & Jenkins, 2000). Indeed, Brits et al. (2014) report on a study comparing mini-dissertation grading that found an unacceptably high variance in terms of grades awarded, so this is another issue that adds pressure on examiners.

An in-depth discussion on assessment methods is beyond the scope of this paper, but the studies mentioned support the argument that there is pressure on examiners (not all of whom are equally experienced) to deliver high-quality assessments under severe time constraints. South African examiners are challenged by the need to apply assessment metrics consistently under these pressures. This necessitates some kind of support mechanism to ease the assessment process while maintaining fairness.

The time taken to examine a master's dissertation is more or less directly proportional to the number of pages since the examiner has to read through the entire dissertation in order to assess individual criteria and assign a final grade. Many examiners will attest to the value of an abstract in delivering a quick overview before they embark on the detailed reading process. It helps them by giving a meta-view of the content and establishes a set of expectations in the examiner's mind. Indeed, Brown and Atkins (1988) specifically recommend that examiners start off by "getting a global impression" and that they do so by reading the title and abstract and then the final chapter. They argue that this will help the examiner to get a quick view of the problem the student tackled, within its context.

However, textual, summary-like portions of the dissertation have limitations for both assessor and student. The assessor effectively processes text sequentially and its limited length constrains its information payload. The student, on the other hand, needs a solid mastery of English in order to be able to deliver a coherent, readable piece of text that summarises the research effectively. Even if these limitations are set aside for the present, it must be acknowledged that an abstract delivers only an overview of the research report *as a whole*. It does not necessarily deliver insights into the level of knowledge mastery achieved by the student. Since there is also a global drive to assess dissertations using specific institutionally defined criteria (Saunders & Davis, 1998; O'Donovan, Price & Rust, 2004) this quick scan probably no longer suffices as it used to when Brown and Atkins (1988) published their research. To carry out a fine-grained assessment the textual abstract falls short.

In searching for an intervention, we became aware of the increased use of visualisation in common practice. Some conferences have recently started requiring academics to provide video previews of their papers, and Elsevier asks for graphical abstracts of accepted papers.¹ CHI 2014's website² said the video previews were intended to "... help them (readers) discover interesting and important work ...". Elsevier's website states that graphical abstracts: "... allow readers to quickly gain an understanding of the main take-home message of the paper". Hence these more visual summaries essentially augment the papers, providing the potential reader with a snapshot that can be quickly assimilated *as a unit*, in parallel, far more efficiently than reading the entire paper or, apparently, the textual abstract.

Visualisations, in general, have characteristics that make them powerful communication mechanisms (Card, Mackinlay & Shneiderman, 1999). Most humans interpret images more quickly and effectively than they do words (Bresciani & Eppler, 2009). According to Burkhard (2005; p. 242) "knowledge visualisation examines the use of visual representations to improve the transfer and creation of knowledge between at least two persons". Such visualisations can be expected to communicate very effectively and efficiently. The publishers we mentioned may well have identified a way to improve assessment. Their emergent practice led us to wonder whether visualisations might have a role to play in easing assessment of postgraduate dissertations too. This raises the question: "*How useful are visualisations in improving the effectiveness, efficiency and satisfaction of examiners?*" Visualisations require additional effort and expertise; their use is optional and not regulated or specifically rewarded in the dissertation evaluation criteria. It would thus be interesting to see how frequently they were used, if at all. An empirical investigation is out of the question since we cannot ethically assign students to experimental and control groups to be evaluated by the same examiner, with or without visualisations. Therefore we considered the questions that could realistically be investigated retrospectively.

The first research question was: "*How prevalent are visualisations in examined dissertations?*" If visualisations were indeed used, then it might be useful to know something about their distribution, introducing the next two questions. "*In which parts of the dissertation are they situated?*" and "*Does their use have any impact on the student's mark?*". These three questions were formulated to help us to gain an understanding of the extant use and possible usefulness from a quantitative perspective. From a qualitative perspective, we also need to consider the supervisors' viewpoints to gain insights into the possible usefulness of visualisations in postgraduate dissertation assessment. We carried out an investigation into how visualisation had been used in postgraduate dissertations published over a 10-year period at one South African university. The sample of 22 information systems dissertations represents 73% of the dissertations completed during that period (2002-2012).

We found that visualisations did indeed appear in these dissertations and we also found evidence that their distribution across the dissertation chapters seemed to impact the final grade. Such a finding, especially since the sample is small and the correlations were relatively weak, does not imply causality. It does, however, suggest that we need to open up a discourse on the use of visualisation in postgraduate assessment. The interviews with supervisors also revealed specific interesting expectations about the use of visualisations in dissertations.

In the next section we provide an overview of related literature on visualisation in information and knowledge transfer before we present our study.

1. <http://www.elsevier.com/journals/surface-science-including-surface-science-letters/0039-6028/guide-for-authors>

2. <https://chi2014.acm.org/>

LITERATURE REVIEW

KNOWLEDGE VISUALISATION CONSTRUCTS

It is necessary to understand the basics of knowledge visualisation before proceeding to any discussion of how these could be utilised. The fundamental constructs are those of *data*, *information* and *knowledge*. These can be described as follows (Chen et al., 2009):

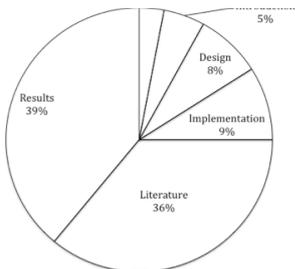
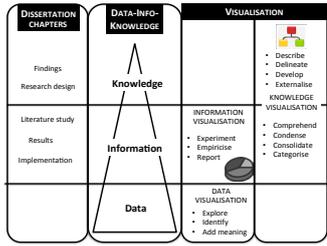
- **Data** – a representation of facts, concepts, or instructions in a formalised manner suitable for communication, interpretation, or processing by human beings or by automatic means.
- **Information** – the meaning that is currently assigned by human beings or computers to data by means of the conventions applied to the data.
- **Knowledge** – understanding, awareness, or familiarity acquired through education or experience. Anything that has been learned, perceived, discovered, inferred, or understood. The ability to interpret information.

According to these definitions, processed data becomes information and interpreted information becomes knowledge. The processing can be automated to a large extent but human cognition remains central to the process of sense-making. This means that each level of abstraction adds bias due to the subjective selection of processing procedures. The only way to manage the accountability of the process is to state the assumptions and take cognisance of the constraints at each step of the process (Muller, van Biljon, & Renaud, 2012).

Any study of knowledge visualisation should recognise the connection to the more established fields of information and data visualisation. Data visualisation is the use of a visual representation to gain insight into an information space supporting the transitioning of data to information (Chen et al., 2009). Information visualisation supports pattern identification and knowledge creation (Card et al., 1999). Knowledge visualisation's goal is that knowledge can be better accessed, discussed, valued, transferred and generally managed (Eppler & Burkhard, 2007). Burkhard (2005) provides a discussion on the essential differences between data, knowledge and information visualisation.

Van Biljon and Renaud (2015) summarised the differences between data, information and knowledge visualisation presented by Burkhard (2005) and supplemented that with examples, as depicted in Table 1.

TABLE 1: DIFFERENCES BETWEEN DATA, INFORMATION AND KNOWLEDGE VISUALISATION

	Data visualisation	Information visualisation	Knowledge visualisation
Goal	Support exploration of data using graphical metaphors	Support exploration of data using graphical metaphors	Support exploration of data using graphical metaphors
Benefit	Makes data mining more accessible	Identification of patterns, exploration of large data sets	Augmenting knowledge transfer between individuals; communicating knowledge
Context	A large volume of data which needs to have meaning identified	Explicit data such as facts and numbers	Experiences, insights, instructions, assumptions
Answers question	Where	What	Why, Who, How
Example	See Figure II 	Depiction of an author's research areas 	See Figure I 

Source: Van Biljon & Renaud, 2015

Knowledge visualisation's primary aim is knowledge creation and transfer (Burkhard, 2005; Eppler & Burkhard, 2007). In education, the essence of the educational assessment process requires knowledge to be communicated (transferred) by means of academic writing. This, then, is where knowledge visualisation might well play a mitigating role.

Eppler and Burkhard (2007) structure the knowledge visualisation formats into seven main groups, namely: structured text/tables, mental (non-material) visualisation and visual storytelling, heuristic sketches, conceptual diagrams/concept maps, visual metaphors, knowledge maps, and graphic interactive environments. Taking cognisance of the variety of visualisation formats is important in terms of grasping the potential for knowledge creation, representation and transfer.

In this study the focus will be on structured text (tables) and conceptual diagrams with some examples of visual metaphors and knowledge maps that will be classified as figures. The dissertation format limits the visualisation to the constraints of a two-dimensional static model. A model is an abstracted, simplified, concise representation of something else (phenomenon) in the world for the purpose of comprehending the phenomenon (Weber, 2012). Models compromise precision to achieve cognitive economy and therefore models and knowledge visualisations have the same focus and some of the same constraints.

APPROPRIATENESS OF VISUALISATION IN RESEARCH REPORTING

We will consider the potential benefits of visualisation from the perspective of the consumer (supervisor) and the producer (student).

First, the visualisation consumer, who, according to the literature, should be able to understand the visualisation more easily than the text, and be able to do it faster than reading text.

- a. **Innate visual processing abilities:** A number of studies explain that humans have innate visualisation processing abilities. For example, Ungerleider and Haxby (1994) point out that visual processing is the most richly represented sensory modality in the human brain. Reading relies on the same visual areas, but requires additional processing and cognition, and is more resource-intensive.
- b. **Superiority to text:** Bauer and Johnson-Laird (1993) carried out empirical studies and showed that visual representations were superior to verbal sequential representations when people carried out tasks. This suggests that the visual representation is easier for people to understand.
- c. **Supports pattern recognition:** The basic rationale behind the visualisation of information is to provide a means for people to spot and identify patterns since humans are better than computers at identifying visual patterns (Ellis, 1938). Visualisations are innately superior to text in depicting boundaries, arranging and ordering concepts and therefore conceptual frameworks can only benefit from visualisation (Fisk, Scerbo & Kobylak, 1986; Mayer, 1989).
- d. **Stronger memory trace:** There are superior memorial effects too: visual recall seems to be more reliable than verbal recall, which suggests that a visualisation should “stick” longer than verbal descriptions (Kosslyn, 1980)
- e. **They provide an indication of how the producer sees the world:** Giullemmin (2004) argues that drawings help people to depict how they make sense of a concept. She says that it allows the consumer to extract meaning in a way that is not constrained by the use of text. Kind (2004) found that when students were asked to depict their understanding of a concept in a drawing it was quickly clear which students did not understand the underlying concepts.

The producer can also benefit, by expressing themselves in a language-neutral format, by consolidating all their knowledge into one coherent unit.

- a. **Ameliorating language difficulties:** Flower and Hayes (1980) say, “A writer in the act of discovery is hard at work searching memory, forming concepts, and forging a new structure of ideas, while at the same time trying to juggle all the constraints imposed by his or her purpose, audience, and language itself” (p. 21). If a writer is hampered by language limitations they are bound to find it difficult to express their ideas properly.
- b. **Pictures are sometimes better than a description for depicting complex topics:** Andriessen, Kliphuis, McKenzie and Van Winkelen (2009) explain that pictures can actually capture more nuances of a complex subject than a textual description.
- c. **Drawing helps to clarify ideas in the producer’s mind:** Frankel (2005) explains that “thinking how to visually express an idea is also a means of clarifying the idea for the person making the drawing” (p. 155). He cautions that the production of the drawing must be for the purpose of communication; this adds the crucial extra dimension to the activity that consolidates the concepts in the person’s mind.

This snapshot literature review demonstrates the benefits of visualisations in other contexts. The purpose of this research was to determine whether visualisation could be used in postgraduate reporting, in order to facilitate more effective assessment.

APPROPRIATENESS OF VISUALISATION IN DISSERTATION ASSESSMENT

The surveyed literature on assessment did not reveal any studies related to the explicit use of information or knowledge visualisation in postgraduate assessment. This apparent omission warrants further investigation in the light of the following facts about visualisation.

Visualisations could be useful in supporting dissertation assessment for two reasons. The first is that it helps the assessor by reducing the cognitive overload. The visualisation is a coherent unit, presented in a format that the human brain prefers to process. It is visually available and provides a launching pad into the dissertation as a whole.

The second reason is that it provides evidence of the student understanding and engagement as is often measured by mastering threshold concepts (Kiley & Wisker, 2009). Both new and adapted visualisations appear to provide evidence of a relatively deep level of mental processing. Consider the following two approaches to coming up with visualisation:

1. **Create it anew.** This requires the drawer to engage deeply with the subject matter and to come up with a way of visualising it (Chen et al. 2009). Rowe and Cooke, (1995) assessed people’s mental models in a high technology workplace where a particular level of knowledge is essential to carry out tasks properly. They tested four different mechanisms and identified a strong relationship between the person’s ability to produce a high quality diagram of a situation and their proven ability to troubleshoot a problem.
2. **Adapt it from, or extend, another researcher’s visualisation.** Laseau (2000) argues that extending someone else’s image also helps the learner to expand his/her thinking.

Both these actions suggest that a relatively deep level of mental processing is involved in creating visualisations.

METHODOLOGY

RESEARCH QUESTIONS

The meta-research question that motivated this study was: “How useful are visualisations in postgraduate assessment?” This broad investigation goal was translated into specific research questions:

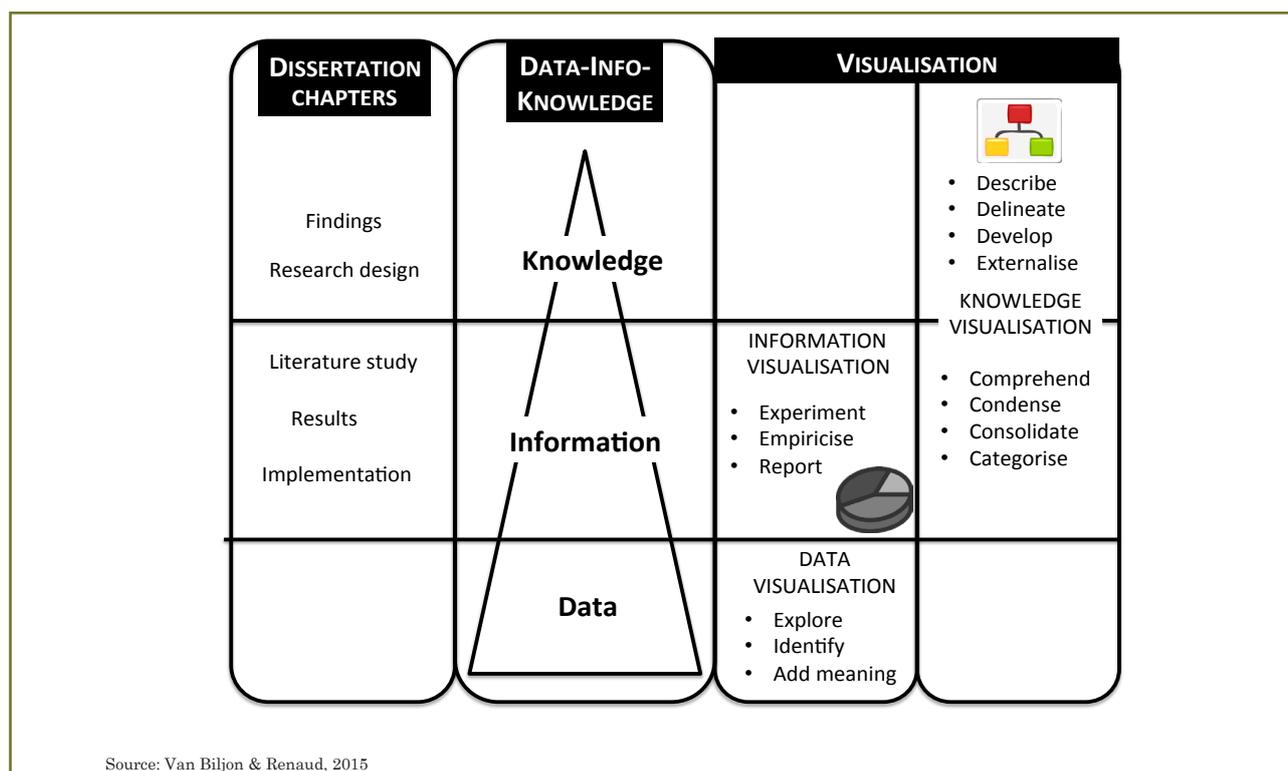
- How prevalent are visualisations in postgraduate dissertations (total number and position)?
- How are the visualisations distributed across the dissertations?
- Does the use of visualisation impact the final mark?
- What are supervisors’ expectations, in terms of visualisation deployment, in dissertations?

RESEARCH CONTEXT

The postgraduate supervision capacity in the School of Computing has changed drastically due to rapidly increasing student numbers. In June 2010, there were 88 registered masters and doctoral students; in June 2011, there were 131; while in June and in November 2012, there were 197 and 226 students respectively. Over the same period, supervision capacity increased marginally, but nowhere near the more than double the student numbers since 2010 (Van Biljon & de Villiers 2013). Dissertations in Computing may include tables, diagrams and visual images of equipment or participants, but photos, since they are rarely used, were excluded from the analysis. It should be noted that knowledge visualisations (tables and figures) were not incentivised or explicitly rewarded at this institution. Furthermore, we could only evaluate masters’ dissertations since we wanted to explore impact on final grade and doctoral studies are not awarded a final grade at this institution.

Figure 1 depicts the traditional constructs involved in information and knowledge visualisation, as discussed earlier. We also explain how different kinds of visualisations map onto the pyramid, in terms of their purpose. In the left column we suggest a likely spread of information and knowledge visualisation in a postgraduate dissertation.

FIGURE 1: MAPPING VISUALISATION TO CHAPTERS AND DATA-INFO-KNOWLEDGE PYRAMID CONCEPTS



RESEARCH APPROACH

The methodology entails a mixed-methods approach. This study extends the results of earlier work on visualisation (Van Biljon & Renaud, 2015) by revisiting the dissertation analysis and interviewing more supervisors. In this study 22 Master's dissertations in Computing from the University of South Africa were obtained through the university's official website. No permission is required to use the dissertations for academic purposes. Ethical clearance was obtained from the Research and Ethics Committee to access the students' marks, and also to regulate the interviews with the supervisors.

To answer the first question, namely "How prevalent are visualisations in postgraduate dissertations (frequency)", the number of visualisations (figures and tables) in the dissertations were tallied. To answer the second question, relating to the distribution (positioning of the visualisation within the dissertations), the number of visualisations in the specific sections of the dissertations were tallied.

The section categorisation was based on the categorisations of evaluation report for Masters' dissertations in information systems from the University of Pretoria, the Tshwane University of Technology and the University of South Africa. Identified sections were: Introduction, Literature study, Research Design, Implementation, Results and Findings. (Note that the *Requirements* and *Implementation* chapters were not relevant to all research designs but *Implementation* was retained so as not to obscure the results in the other categories found in most dissertations.) The third question concerned the possible impact of visualisation usage on the final mark. To answer this question, the correlations between the total number of visualisations in each of the sections, and the final mark, were calculated.

The fourth question relates to the supervisor perspective with respect to the role of visualisation in dissertations. We interviewed 15 experienced supervisors and asked them to complete a short questionnaire which asked about their supervision experience, their expectations related to the use of visualisation by their students generally, and specifically on the role of visualisation during assessment.

RESULTS

DISSERTATION ANALYSIS

We analysed 22 dissertations in information systems (IS) (a sub-discipline of Computing). There were 10 male and 12 female students representing 73% of the masters' dissertations submitted to the institution in the 2002 to 2012 period.

There were no dissertations without figures and only two without tables. The sum, minimum and maximum number of figures and tables are given in Table 2. The dissertations averaged 29.64 figures and 18.59 tables.

TABLE 2: SUMMARY STATISTICS

	Figures	Tables	Total
Sum	652	409	1,061
Min	3		3
Average	29.64	18.59	48.23
Median	25.5	15.5	41.5
Max	87	48	120

The number of dissertations evaluated is too small for any analysis to deliver statistically significant results. However, it can be observed that visualisations were provided by all candidates and, indeed, used frequently in many cases. Figures were used more often than tables. Having ascertained that visualisations were indeed used, the next step was to consider which sections they appeared in. The distribution of the 1,061 visualisations across the 22 dissertations is shown in Figure 2.

FIGURE 2: SPREAD OF VISUALISATIONS ACROSS THE DISSERTATIONS

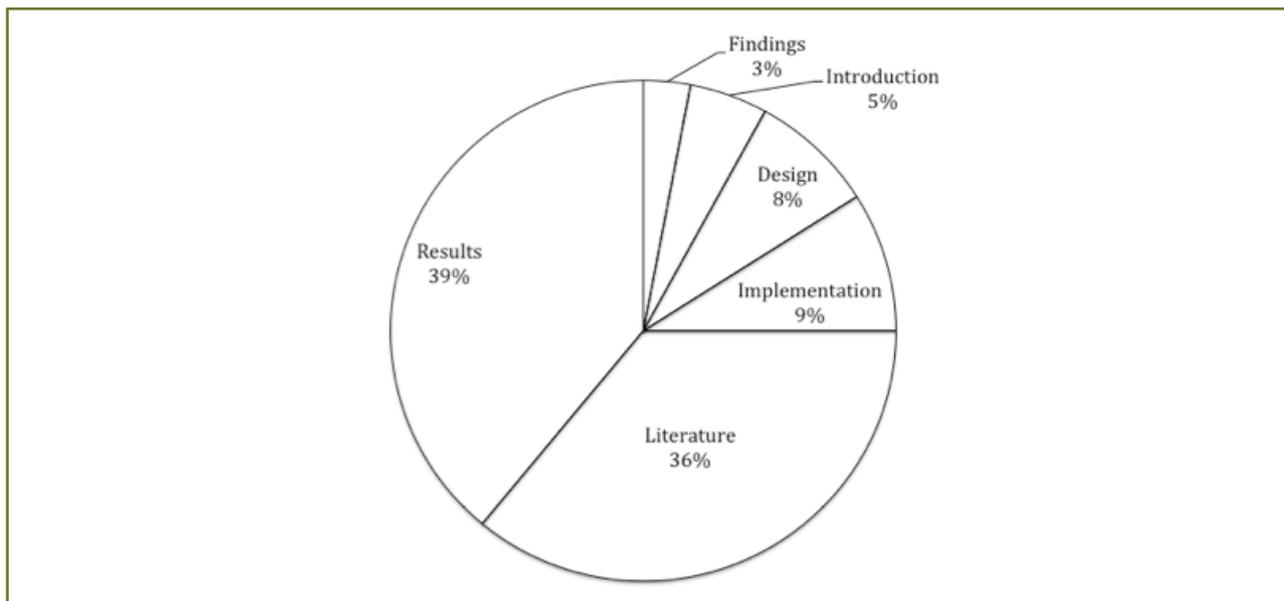


Table 3 shows the correlations between the final grade and the number of visualisations in the relevant chapters. The negative correlation of -0.107 between the total visualisation count and the students' final marks suggests that gratuitous use of visualisation could detract from the perceived value thereof, as judged by the final assigned grade. Moreover, depictions of existing diagrams, (-0.238), often found in the literature review, or information visualisation, as found in the results section (-0.08), do not seem to impact the final mark to any great extent. However, the number of visualisations in the research design and findings sections correlates modestly with the final mark. This may imply that knowledge visualisation was more useful and meaningful to examiners when they appeared in these chapters. It is possible that the examiners subconsciously used these as evidence of mastery or knowledge contribution.

TABLE 3: CORRELATIONS BETWEEN FINAL MARK AND VISUALISATIONS IN DIFFERENT SECTIONS

	Visualisation (total)	Literature review	Research design	Results	Findings
Mark	-0.107	-0.238	0.38	-0.08	0.40

Given the small sample of 22, we can only identify these trends as a topic for confirmation or rejection through further investigation. Figures 3 and 4 depict, using a bubble diagram, the correlations between the candidate's final mark and the visualisations in a specific section of the dissertation. The figures thus depict a 3-tuple space (Final mark, Total visualisation, Number of visualisations in section). The graphs plot the final marks of the students against the total number of visualisations in their dissertations for the specific section. The number within the bubble depicts the number of visualisations in the Results Section, in Figure III, and the number within the Findings section, in Figure IV. The colour of the bubble varies according to the number of visualisations in the applicable section of the dissertation, the darker the colour the higher the number of visualisations.

Note that the negative correlations (Literature Overview and Results sections), as depicted in Table 3, occurred where the visualisations were information visualisations or a mixture of information and knowledge visualisations. Figure 3 depicts the individual dissertation's visualisation in the Results section. The positive correlations occurred where the visualisations were mostly knowledge visualisations appearing in the Findings section, as shown in Figure 4.

FIGURE 3: FINAL MARK VERSUS TOTAL VISUALISATION. BUBBLE DEPICTING VISUALISATIONS IN THE *RESULTS* SECTION. (THESE ARE MOSTLY *INFORMATION* VISUALISATIONS).

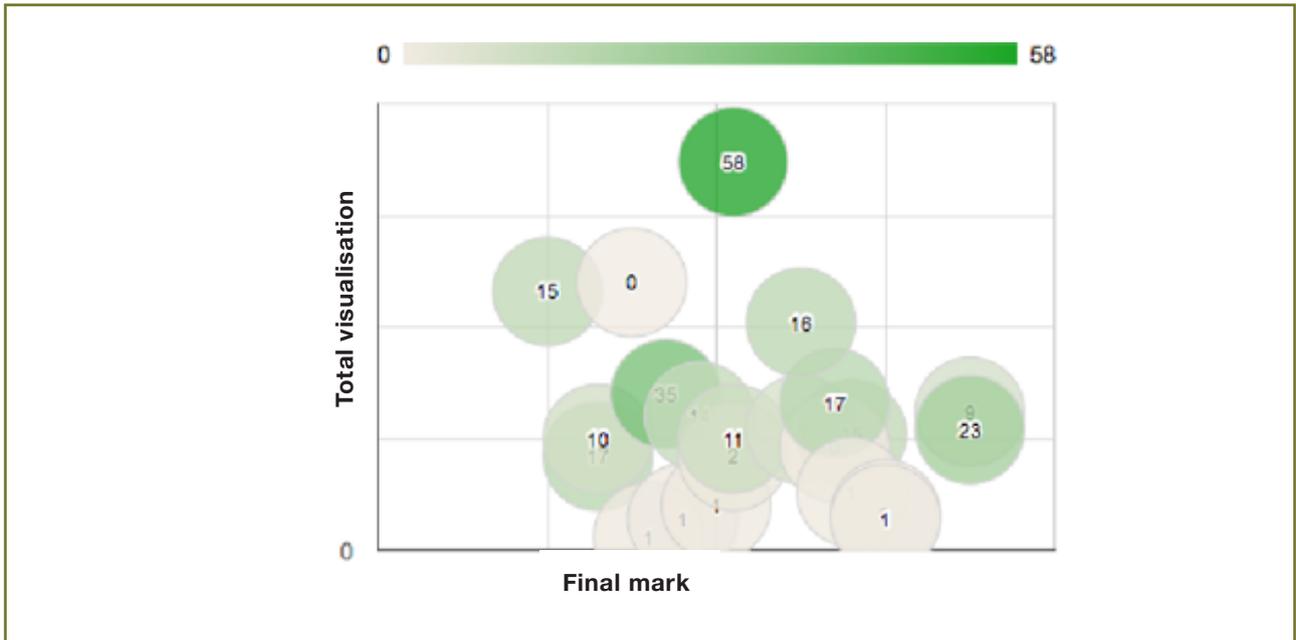
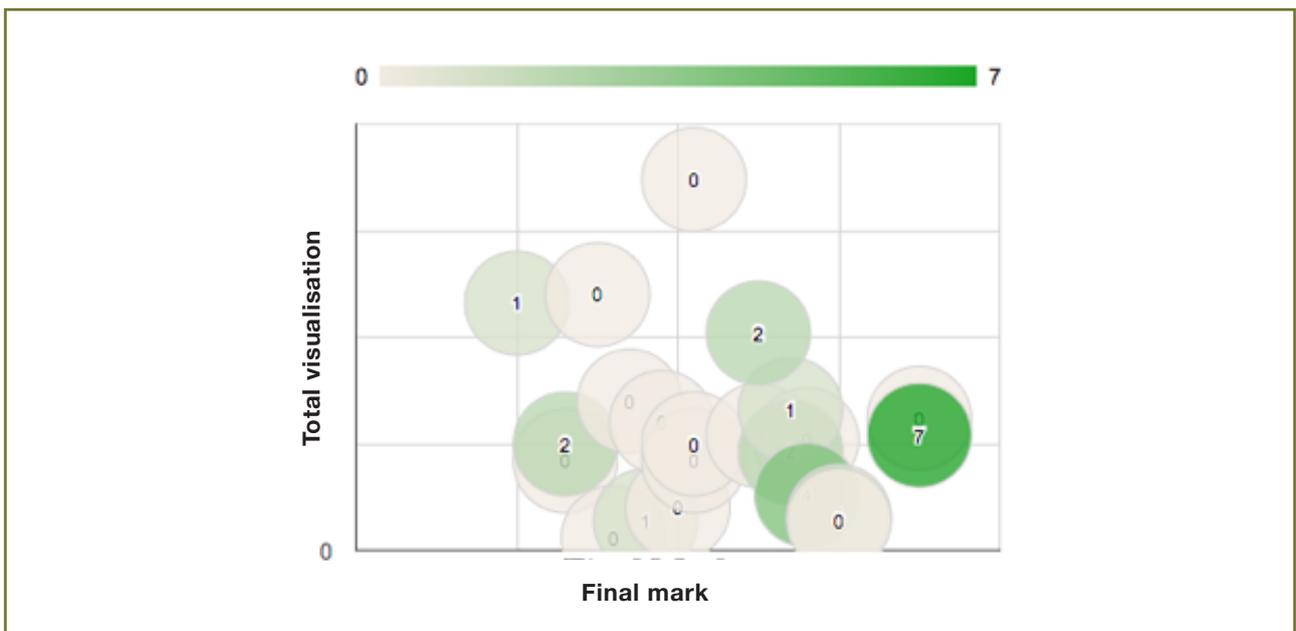


FIGURE 4: FINAL MARK VERSUS TOTAL VISUALISATION. BUBBLE DEPICTING VISUALISATIONS IN THE *FINDINGS* SECTION. (THESE ARE *KNOWLEDGE* VISUALISATIONS)



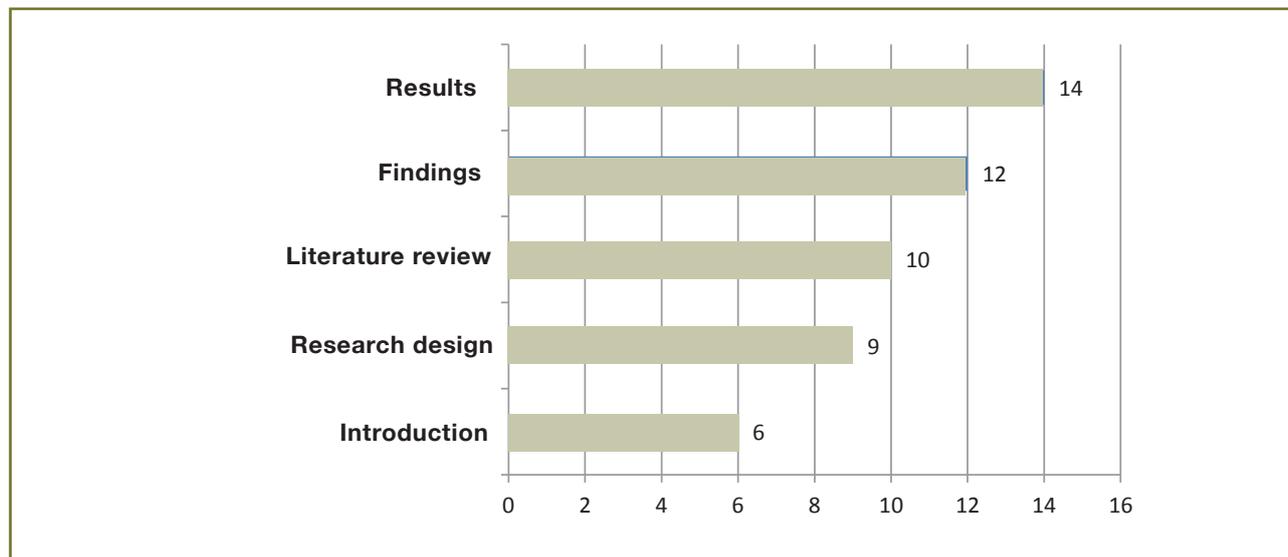
Visualisations in the Research design section resonate with the use of conceptual frameworks in postgraduate dissertations as advocated by Leshem and Trafford (2007). Kiley and Whisker (2009) introduced the idea of generic doctoral-level threshold concepts to provide a framework for research learning and teaching at graduate level. The practice of constructing a conceptual framework is, first and foremost, for the student’s benefit. It seems as if structuring and sense-making of the abstract and theoretical process in terms of a conceptual framework that can be visualised is generally rewarded in the final mark. The same argument might explain the positive correlation between the Findings section and the final mark. In the next section we consider the supervisors’ views on the deployment of visualisation in masters’ dissertations.

FEEDBACK FROM SUPERVISORS

All 15 interviewees had supervised masters’ students to completion and examined masters’ dissertations (half had supervised more than five students to completion). The participants all encouraged their students to use visualisations. Eleven always did so, one often and two sometimes, and one responded with “rarely” (no-one answered “never”).

When asked if they appreciated the presence of knowledge visualisations when assessing dissertations, 13 interviewees answered “yes” and two interviewees responded with “sometimes”. This indicated a discrepancy between their expectations and the instructions given to the students, i.e., not all of those supervisors who appreciate visualisations when assessing actively encourage their students to produce visualisations. Figure 5 depicts the number of supervisors (out of a total of 15) who would encourage visualisations in the given dissertation section.

FIGURE 5: THE PARTS OF THE DISSERTATION WHERE SUPERVISORS(SAMPLE OF 15 INTERVIEWEES) ENCOURAGED VISUALISATION



The supervisors were asked to explain the motivation for having visualisations in the different sections. We explained that the research was focused on masters’ dissertations but the supervisors did not express a need to differentiate between the visualisation requirements and expectations for masters’ and doctoral students. Supervisor comments were as follows:

- **Introduction and overview** (six supervisors encouraged visualisations): “To provide an overview of the anticipated structure; to indicate the sequence of events, for example a thesis map or chapters’ map; to show interrelationships”.
- **Literature review** (10 supervisors encouraged visualisations): “To provide an overview of essential concepts; outline and scope the literary environment; to summarise the literature and demonstrate the connection of theories; as a summary to compare themes and show patterns; a timeline for theory development”.
- **Research Design** (nine supervisors encouraged visualisations): “To show the research process, research flow and how the different terms (epistemology, theoretical framework, methodology and methods) are interrelated, to depict triangulation”.
- **Presentation of results** (14 supervisors encouraged visualisations): “Use in summarising results. charts and graphs where appropriate and other forms such as time lines, networks with indications of relationships”.
- **Presentation of findings** (12 supervisors encouraged visualisations): “Summation of findings; used for ‘sense making’ in communicating with the reader; results and findings especially in quantitative studies; building or confirming a model; and checking the logical flow from the research design to the findings”.

Regarding the *Literature Review* section, where two-thirds of the examiners expected visualisations: visualisations placed there could be very useful to the examiner. For example, the student performs a literature review, which mines the relevant research literature. The writer of each of the sources contributed new knowledge to the field but to this particular student this is information, to be understood, consolidated, synthesised and presented in a coherent format. A good master’s student may well produce new knowledge in this chapter, perhaps in the form of taxonomy or a consolidation from a novel perspective, but that is unusual and certainly not expected. Interestingly, the dissertation analysis yielded a negative correlation between the number of visualisations in the literature review and the final mark. It could be because the visualisations included here often replicate other researcher’s visualisations – a practice not recommended by the supervisors.

All but one of the interviewees expected to see visualisations in the *results* section, which concurs with the distribution we observed in Figure 2, but not with the negative correlations between visualisations and the Results section as depicted in Table 3. The explanation might be that the results are not yet knowledge: they represent *information* that needs to be conceptualised and reflected upon. Visualisation thereof, perhaps in the form of a graph accompanied by an interpretation, could constitute knowledge, and this is usually reported in the findings chapter. The majority of respondents expected visualisations in the findings chapters; this concurs with the positive correlations between the

visualisations in those sections and the final mark (see Table 3). The analysis of the dissertation revealed a relatively low number of actual visualisations in the Findings chapter (Figure 2) and this could be of interest to supervisors.

It can be concluded that the visualisations in the introduction and conclusion sections constitute “good practice” as far as writing scientific reports is concerned, but one does not expect to see new knowledge reported in either of these chapters – only a summary or a précis thereof. Knowledge is presented within the body of the dissertation and that explains the relatively low number (40%) expecting visualisations in the “Introduction” section.

Finally there is the negative correlation between visualisations and the final mark, as depicted in Table 3. Could it be that the quality of the visualisations was not acceptable, did the visualisations demonstrate the student’s lack of understanding, or could it be that the students used visualisations instead of text, or replicated other authors’ visualisations? There could be a number of explanations and without explicitly investigating each case it is difficult to rule one way or another.

Besides the effort involved for the student, there seems to be little argument against including visualisations as a mechanism of knowledge representation in postgraduate dissertations. A further investigation using a bigger sample to conduct a deeper investigation into expectations related to the use of visualisations, and the other factors that could influence this correlation, is required.

DISCUSSION

This research addressed three questions, namely “*How prevalent are visualisations in examined dissertations?*”, “*In which parts of the dissertation are they situated?*”, and “*Does their use have any impact on the student’s mark?*”. In response to the first question, related to the prevalence of visualisation, we can confirm that visualisations, in terms of figures and tables, were often used, with a preference for figures. Visualisations were not explicitly required or assessed by this institution and no information was provided on how visualisations should be crafted. The prevalent use of visualisations, despite the lack of incentive or regulation, might provide evidence for an inherent appreciation of the value of dissertations. The discrepancy between appreciating visualisations and encouraging students to produce them further supports the need to investigate the deliberate use of visualisations in dissertation assessment.

The second research question was related to the distribution of the visualisations across the dissertations, and there we found that the visualisations were mostly found in the literature and results sections. Regarding the potential impact we found that the candidate’s final mark was correlated, albeit weakly, to the particular section where visualisations appeared. A positive correlation was observed between the final mark and the number of visualisations in the research design and findings chapters. Given the small number of dissertations we analysed and the many other factors that can influence the final mark, we cannot claim causation. This finding does, however, motivate further investigation. In speculating on possible explanations for this correlation we consider a number of aspects.

The first is that the assessor was subconsciously rewarding knowledge visualisations appearing in the research design and findings sections. If this were the case it could be that such visualisations make it clear to the assessor what knowledge was being reported, without first having to read through pages of text. The visualisation could be providing a précis, a quick and powerful overview of the text. If this is true, the assessor gets an informative aid, something that allows them very easily to get a sense of what is being reported.

The second possible explanation could be that the visualisations are evidence that the student has indeed mastered the material. In crafting the visualisations, the students reach a deeper level of understanding of the topic area, and this was reflected in the quality of the whole report. If this were true, the quality was a side-effect, a consequence of their delivering the visualisations. As noted before, there is the argument that learning styles are based on individual modal divisions i.e., the visual, kinesthetic and aural (Fleming, 1995), which may well impact on the learning facilitated by visualisations. However, whether the visualisation is a medium or an artifact, there does seem to be a positive impact of the students spending time crafting and including one or more knowledge visualisations in their dissertations.

There is clearly a proviso: that visualisations should be used with care. If used appropriately, they can impact the mark positively, but mindless inclusion of visualisations could depress the final mark. The challenges pertain to the type of visualisation, as well as the distribution. Regarding the types of visualisation, we observed that many were mere reproductions that added no value except, perhaps, the aesthetic. The negative correlation (albeit small) – between the total number of visualisations and the mark – could confirm the argument that the mere presence of visualisations does not automatically improve the candidate’s final grade: it has to be done thoughtfully and constitute a meaningful artifact that supports assessment.

In summary, we conclude that given the innate human ability to understand and remember visual representations, the considered inclusion of visualisations could support objectivity, consistency and fairness in assessment. It could also help students to engage in more depth with the subject matter, reaching a profounder understanding thereof, in the process of producing the visualisations. In practice this means that we should consider instructing candidates to include specific standard visualisations such as a chapter map, a literature overview diagram and a visualisation of their conceptual framework. This could support efficient assessment by allowing triangulation with the traditional

text-based assessment. The use of visualisation admittedly poses risks. The risks could be both designer and user induced and relate to cognitive, emotional and social human aspects (Bresciani & Eppler 2009). Hence the promotion of the use of visualisation in research reporting should be based on validated guidelines and standards. Kelleher and Wagener (2011) provide useful guidelines for effective data visualisation in scientific publications, but those guidelines need to be refined and customised for dissertation knowledge transfer. Furthermore, visualisations are proposed as a mechanism to complement other assessment criteria, never as the sole assessment artifact.

Finally, the fact that the surveyed examiners recommended the use of visualisations to their own students, and expected to see them in the dissertations they examined, seems to suggest that visualisations are already making their way into dissertations. At the moment, their use seems to be dependent on the whim and preference of the supervisor and the student. If, as we believe, visualisations can be helpful to both students and examiners, it is necessary for us to formalise their inclusion and provide more guidance to all students to support their production and effectual use.

LIMITATIONS

The use of visualisation needs to be guided by some assumptions and delineations. Machanick (2014) warns that imposing technology between the teacher and the students can create a barrier, and that is a real concern in the use of visualisations. Therefore it has to be acknowledged that the intended focus of a visualisation is the cognitive activity of representing knowledge while the technology is merely the tool and should not be given overdue attention or used for obfuscation.

CONCLUSION

Despite the potential of visualisations for improving knowledge transfer, there is little evidence of the deliberate use of visualisations to improve the efficiency of assessment. We considered the extant use and potential usefulness of visualisations in postgraduate assessment. We conclude that the use of visualisations in adding value for: (1) the student, (2) the examiner and (3) influencing the final mark, warrants further investigation. Arguably the appropriateness of visualisation usage may be related to the subject area, but the general benefits of visualisations in knowledge generation and transfer are not related to a specific subject area. No comprehensive guidelines seem to exist on the appropriate use of information and knowledge visualisations in postgraduate dissertations. If these can be produced to the satisfaction of the assessors then visualisation could well be an efficacious assessment and learning aid. The choice to use visualisations should remain the prerogative of the student, in consultation with the supervisor. This decision should be taken against the background of having usable guidelines, together with evidence-based awareness of the potential of visualisations to relieve assessment pressure. This is the discourse we would like to propose for further debate. As future work, we should consider how to provide guidance on standardising the expectations and assessment of visualisations in postgraduate dissertations, as well as the provision of guidance for students in the production of “good” visualisations in this context.

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