Do Visualizations Ease Dissertation Assessment?

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ABSTRACT
South Africa is working hard to improve the education levels of all their citizens, and, as a consequence, many South African Universities have seen an impressive increase in the number of postgraduate students. On the other hand, South African Universities have not been able to employ experienced supervisors at the same rate. Given the increasing workload, examiners struggle to maintain their own high standards of consistency, accuracy and fairness. Assessing dissertations requires a serial traversal from beginning to end, sometimes repeatedly, since words are an imprecise communication tool and writing ability variable. Is there any way of making the process more efficient while retaining rigour? We cast the net wide to find a way, and, in doing so we noted the emerging use of visualization as a communication facilitator in other areas of academia and decided investigate it as a mechanism for easing the assessment process. As a first step, we need to determine the current extent of usage. Such usage is not incentivized nor is it explicitly rewarded. If we detect an impact on final grades, this will justify further investigation. We carried out a study that revealed weak correlations with the final grade, depending where the visualizations appeared and also consulted supervisors for their views. The contribution of this paper is to suggest a discourse on the deliberate deployment of visualization to ease postgraduate assessment.

Categories and Subject Descriptors
I.2.6 [Learning]: Knowledge acquisition

General Terms
Measurement, Performance, Standardization

Keywords
Visualization, postgraduate assessment

1. INTRODUCTION
Academics in South African Universities are under increasing pressure. There are a number of reasons, including the following:

1. Universities across the globe are enrolling increasing numbers of postgraduate students [16, 26]. In South Africa, in particular, the pressure on institutions and academics to deliver more postgraduates is rising [3].
2. I'Anson and Smith [17] 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 the South African society has led to the admission of student cohorts who vary in readiness for post graduate study. They also argue that it places additional pressure on supervisors to provide the necessary interventions the students need to meet the exit standards of postgraduate study [28].
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 [25].

More students, with the same number of academics under increasing pressure, mean more dissertations to be assessed in the same time period. 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 [29]

Examiners are challenged by the need to apply assessment metrics consistently under mounting workloads. Calls for less ambiguity in assessment of dissertations exacerbate the pressure on examiners [30]. Some Computer Science departments implement double marking in order to ensure fairness. However, Pathirage, Haigh, Amaratunga, Baldry and Green [23] argue that this can lead to game playing by markers, with marks converging to the average since that strategy successfully avoids the attentions of stakeholders who might question the awarded mark if it were to be extreme in either the high or low direction. In the long run these strategies could lead to students not getting the marks they deserve. Annetts, Jones and van Deursen [1] investigated the process of peer review in conjunction with developing communities of practice within research teams to maintain the high level of reliability whilst achieving the aim of reducing double marking. An in-depth discussion on assessment methods is beyond the scope of this paper but these studies are noted to 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. That necessitates some kind of support mechanism to ease the assessment process while maintaining fairness. The time taken to examine a masters dissertation is more or less directly proportional to the number of

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pages since the examiner has to read through the entire dissertation in order to assess it and assign a 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. However, textual abstracts have two limitations: they, too, are processed sequentially and the limited length of abstracts, by their very nature, constrains their information payload. Moreover, an abstract delivers an overview of the research report as a whole, and does not necessarily deliver insight into the level of knowledge mastery achieved by the student in particular areas.

Are we, as examiners, missing some valuable mechanism that could make this assessment process more efficient? Is it possible that we could require students to provide something extra, or different, to ease the process, while at the same time providing a benefit for the students too? We searched for this "silver bullet", and we discovered something that seemed to have this hidden potential. Some conferences[1] have recently started requiring academics to provide video previews of their papers, and Elsevier[2] asks for graphical abstracts of accepted papers. CHI 2014 said the video previews were intended to "*…to help them (readers) discover interesting and important work …*" Elsevier 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.

Visualizations, in general, have characteristics that make them a powerful communication mechanism [6]. Most humans interpret images better than they do words: images communicate with our emotions and can thus inspire, appeal, motivate and energize since they impress, express and represent reality [4]. According to Burkhard [5] p.242) '*knowledge visualization examines the use of visual representations to improve the transfer and creation of knowledge between at least two persons*'. Such visualizations can be expected to communicate very effectively and efficiently.

The publishers we mentioned may well have identified a way to speed up and improve assessment. Their emergent practice led us to wonder whether visualizations might have a role to play in easing assessment of postgraduate dissertations too. We focused our attention on a South African University since these Universities are particularly affected the above-mentioned pressures. We carried out an investigation into how visualization had been used in postgraduate dissertations published over a ten-year period. The sample of 22 Information Systems dissertations represents 73% of the dissertations completed during that period (2002-2012).

We found that visualizations 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 suggest that we need to open up a discourse on the use of visualization in postgraduate assessment. In the next section we provide an overview of related literature on visualization in information and knowledge transfer before we present the findings of our study.

2. LITERATURE REVIEW

First, the Basics

It is important to understand the basics before proceeding to any discussion of how these can be represented. The fundamental constructs are those of data, information and knowledge. These can be described as follows [7]:

- **Data** - a representation of facts, concepts, or instructions in a formalized 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.

Research generates data; the researcher attributes meaning to it, and thereby converts it to information. Interpretation of this information potentially delivers insights that can be termed "new knowledge" [22]. Knowledge Visualization can be described as "the use of visual representations to improve the creation of knowledge and the transfer thereof between at least two persons" [5, 9]. The concept lies at the intersection of the fields of knowledge management and visualization. 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 visualization may play a role. Knowledge visualization's goal is that knowledge can be better accessed, discussed, valued and generally managed [9].

Any study of knowledge visualization can benefit from findings from the more established fields of information- and data-visualization. Data visualization is the use of a visual representation to gain insight into an information space supporting the transitioning of data to information [7]. Information visualization supports pattern identification and knowledge creation [6]. Knowledge visualization's primary aim is knowledge transfer. Burkhard [5] provides a discussion on the essential differences between data, knowledge and information

[1] http://chi2014.acm.org/authors/video-previews

[2] http://editorsupdate.elsevier.com/issue-29-march-2010/graphical-abstracts/

visualization, as summarized and supplemented with examples in Table 1 .

We believe visualizations could be useful in supporting assessment for two reasons. The first is that it helps the assessor since the visualization 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 student understanding and engagement. Both new and adapted visualizations appear to provide evidence of a relatively deep level of mental processing. Consider the following two approaches to coming up with visualization:

1. Create it from scratch. This requires the drawer to engage deeply with the subject matter and to come up with a way of visualizing it [7]. Rowe and Cooke [24] 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 visualization. Laseau [18] argues that extending someone else's image also helps the learner to expand his/her thinking.

Table 1: Differences between data, knowledge and information visualization

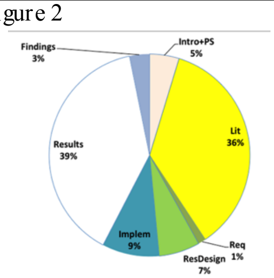
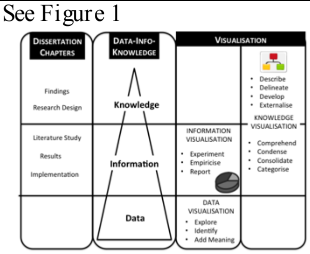
	Data Visualization	**Information Visualization**	**Knowledge Visualization**
Goal	Support Exploration of data using graphical metaphors	Support Exploration of Large Amounts of Data & Knowledge Creation	Ease Knowledge Transfer; Creation of New Knowledge
Benefit	Make data mining available to everyone, not just experts	Identification of patterns, exploration of large data sets	Augmenting knowledge transfer between individuals; communicating knowledge
Content	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
Recipients	Data miners	Data Explorer, Pattern Spotter	Knowledge Workers
Influence	Data mining	Data analysis, Data exploration	Knowledge Transfer
Example	See Figure 2 	Depiction of an author's research areas 	See Figure 1 

Figure 1 depicts the constructs involved in information and knowledge visualization, as discussed earlier, and suggests a likely spread of information and knowledge visualization in a dissertation.

Appropriateness of Visualization in this Context

The surveyed literature on assessment did not reveal any studies of the explicit use of information or knowledge visualization in postgraduate assessment. This omission is probably an oversight and deserves consideration. A number of studies explain that humans have innate visualization processing abilities. For example, Ungerleider and Haxby [27] point out that visual processing is the most richly represented sensory modality in the human brain.

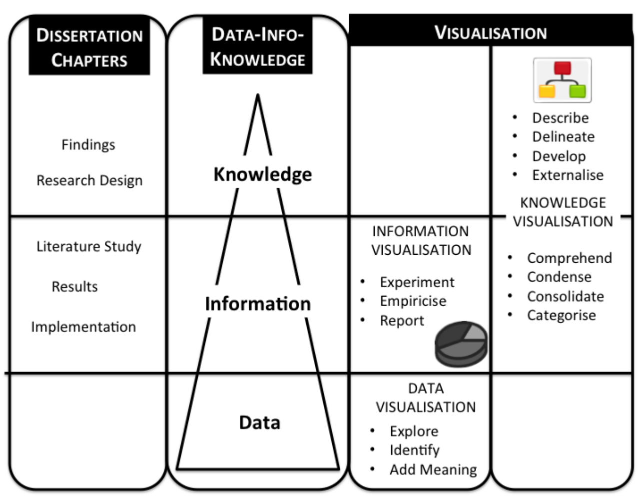


Figure 1: Mapping Visualization to Chapters and the DIK Pyramid

Reading relies on the same visual areas, but requires additional processing and cognition, and is more resource-intensive. Bauer & Johnson-Laird [2] carried out empirical studies and showed that visual representations were superior to verbal sequential representations when people carry out tasks, which suggests that the visual representation is easier for people to understand. The basic rationale behind the visualization of information is to provide a means for people to spot and identify patterns since humans have been known to be better than computers at identifying visual patterns [8, 14]. Visualizations are innately superior to text in depicting boundaries, arranging and ordering concepts and therefore conceptual frameworks can only benefit from visualization [10, 21]. There are superior memorial effects too: visual recall seems to be more reliable than verbal recall, which suggests that a visualization should "stick" longer than verbal descriptions [15].

The use of visualization needs to be guided by some assumptions and delineations. Machanic [20] warns that imposing technology between the teacher and the students can create a barrier, and that is a real concern in the use of visualizations. Therefore it has to be stated that the intended focus of visualization 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. There is also the argument that the learning styles i.e. the visual, kinesthetic and aural [11] are based on individual modal divisions and may impact on the learning that will result from this process. That is generally beyond the scope of this study where we investigate the impact of knowledge visualizations, but we will return the argument in the discussion.

3. METHODOLOGY

3.1 Research Questions

The meta-research question that motivated this study was: "*What is the use and usefulness of visualization in postgraduate assessment?"* This broad investigation goal was translated into specific research questions:

- How prevalent are visualizations in masters' dissertations (total number and position)?
- Did the use of visualizations correlate with the final mark?
- How do examiners see the role of visualization in assessment?

3.2 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-doubling of the student numbers since 2010 [29]. 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 visualizations (tables and figures) were not incentivized 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 mark at this institution.

3.3 Research Approach

The methodology entails a mixed-methods approach where the analysis of the quantitative data allowed us to identify pertinent issues regarding visualization usage. Twenty-two master's dissertations in Computing from the University of South Africa were obtained through the university's official website. The site hosting the dissertations is open and no permission is required to use the dissertations for academic purposes. Ethical clearance was obtained to access the students" marks, which we needed to investigate correlations between the number of visualizations and the final mark. The first step was to analyze the dissertations to categorize and tally the visualizations (figures and tables). To answer the first question, namely 'How is visualization used in master's dissertations (frequency and positioning)?', the number of visualizations in specific sections of the dissertation were tallied. The section categorization was based on the categorizations 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, Requirements, Research Design, Implementation, Results and Findings. (Note that the Requirements and Implementation chapters were not relevant to all research designs but were retained so as not to obscure the results in the other categories found in most dissertations.)

The second question concerned the possible impact of visualization on the final mark. To answer this question, the correlations between the total number of visualizations in each of the sections, and the final mark, were calculated.

The third question relates to the examiner perspective with respect to the role of visualization in assessment. We interviewed 12 experienced examiners and asked them to complete a short questionnaire which asked about their supervision experience, their expectations related to the use of visualization by their students generally, and specifically on the role of visualization during assessment.

4. RESULTS

4.1 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	1061
Min	3	0	3
Average	29.64	18.59	48.23
Media	25.5	15.5	41.5
Modus	21	0	38
Max	87	48	120

The numbers are clearly too small for any analysis to deliver statistically significant results. However, it does seem that visualizations were provided by all candidates and, indeed, used frequently in many cases. Figures were used more often than tables. Having ascertained that visualizations were indeed used, the next step was to consider which sections they appeared in. The average, maximum and minimum per section is depicted in Figure 2 and the spread of visualizations across the dissertations is shown in Figure 3.

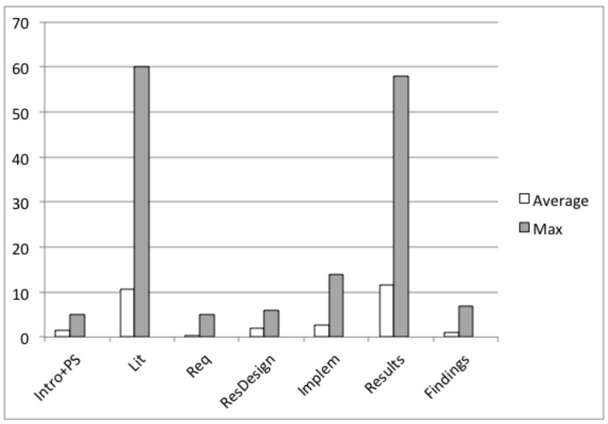


Figure 2: Maximum and Average numbers of Visualizations in Generic Sections

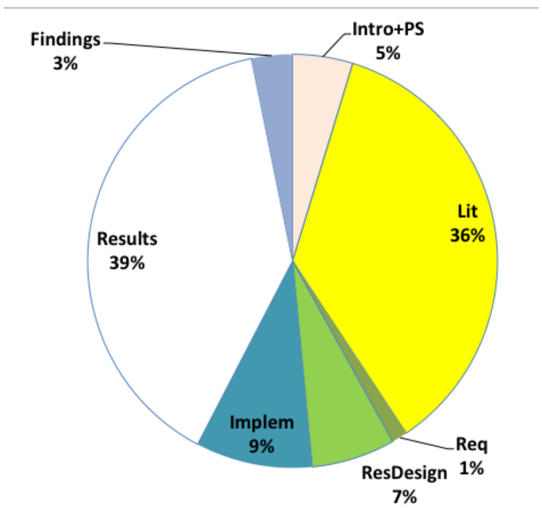


Figure 3: Spread of visualization across the dissertations

Table 3 shows the correlations between the final grade and the number of visualizations in the relevant chapters. The negative correlation of -0.107 between the total visualization count and the students' final marks suggests that gratuitous use of visualization 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 visualization, as found in the results section (-0.08), do not seem to impact the final mark to any great extent. However, the number of visualizations in the research design and findings sections correlates modestly with the final mark. This may imply that knowledge visualization 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 visualizations in different sections

	Visualization (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 4 and 5 depict the correlations between the candidate's final mark and the visualization in a specific section of the dissertation in a bubble diagram.

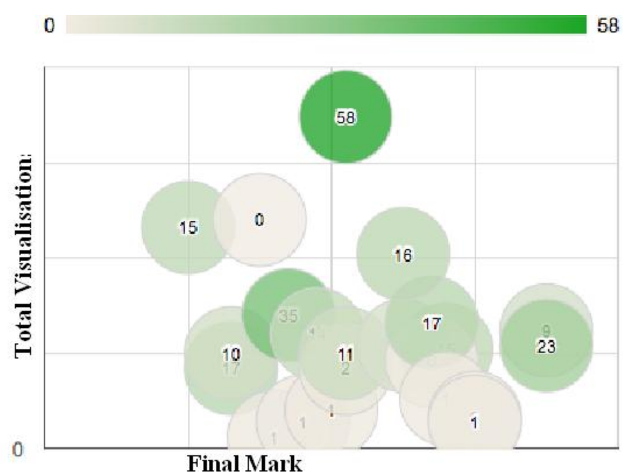


Figure 4: Final mark versus total visualization. Bubble depicting visualizations in the **Results** Chapter. (These are mostly information visualizations).

Note that the negative correlations (*Literature overview* and *Results sections*) as depicted in Table 3 occurred where the visualizations were *information* visualizations or a mixture of information and knowledge visualizations. Figure 4 depicts the individual dissertation's visualization in the Results sections. The positive correlations occurred where the visualizations were mostly knowledge visualizations appearing in the *Research Design* and *Findings* sections, as shown in Figure 5.

Visualizations in the research design section resonate with the use of conceptual frameworks in postgraduate dissertations as advocated by Leshem and Trafford [19]. Kiley and Whisker [13] introduced the idea of generic doctoral-level threshold concepts to provide a framework for research learning and teaching at graduate level. Could constructing visualization demonstrate threshold crossing? 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 visualized 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 considered the supervisors' view on the use of visualization in masters' dissertations.

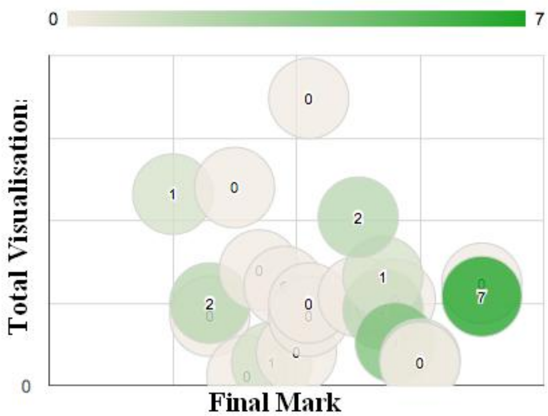


Figure 5: Final Mark versus Total Visualization. Bubble depicting visualizations in the **Findings** Chapter. (Note that these are ***knowledge*** visualizations)

4.2 Feedback from Supervisors

All twelve of the interviewees had supervised masters' students to completion and examined masters' dissertations (half had supervised more than 5 students). The participants all encouraged their students to use visualizations, 10 always did so, 1 often and 1 sometimes (no one responded with "rarely" or "never"). When asked if they appreciated the presence of knowledge visualizations when assessing dissertations: 10 answered "yes" and 2 responded with "sometimes". Table 4 depicts the number of supervisors who would encourage visualization in the given dissertation section together with their motivations as to why they believe it to be useful.

Table 4 : The parts of the dissertation where respondents encouraged visualization

Section of the dissertation	Yes	Comments on when appropriate
Introduction and overview	5	To give an overview of anticipated structure; In presenting a thesis map; Chapter map, indicating sequence and interrelationships
Literature review	9	Outline + scoping of environment; To demonstrate connection of theory; Tables and figures which explain an overview of a country's or continent's data; In summarizing the literature; More in the form of a table to summarize and compare themes. Often also repeating one or more models proposed in the lit, especially if they were going to be used later. To show an overview of essential concepts
Research Design	8	To show flow of research; To give an overview of anticipated structure; Definitely-especially a visual explanation of the research methodology is important. Also how the different terms (epistemology, theoretical framework, methodology and methods) are interrelated; Research process, summarizing methodology
Presentation of results	12	Almost always; Definitely-revisit methodology and show how the results address the different aspects for the methodology; In summarizing results; Graphs where appropriate and other forms such as time lines, networks with indications of relationships; Just charts and graphs
Presentation of findings	10	Summation of findings; Almost always some need; If more "sense making" required to help reader; Results and findings especially if qualitative; In summarizing findings; This may be building or confirming a model. To check a coherent framework and findings; Just charts and graphs

Considering the comments as provided in Table 4 it can be concluded that the visualizations 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 (42%) expecting visualizations in the *Introduction* and *Overview* sections.

Regarding the *Literature Review* section, 75% of the examiners expected visualizations. Visualizations situated 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, synthesized and presented in a coherent format. A good 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 visualizations in the literature review and the final mark. It could be because the visualizations included here often replicate other researcher's visualizations thus do not represent knowledge acquisition by the candidate.

All the interviewees expected to see visualizations in the results section, which concurs with the distribution we observed in Figure 2 but not with the negative correlations between visualizations 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 conceptualized and reflected upon. Visualization thereof, perhaps in the form of a graph, with an interpretation thereof, could constitute knowledge, and this is usually reported in the findings chapter. The majority of respondents expected visualizations in the findings chapters, this concurs with the positive correlations between the visualizations in those sections and the final mark (see Table 3) but the analysis of the dissertation revealed a relatively low number of visualizations (Figure 2) and this could be of interest for supervisors.

Finally there is the question about the negative correlation between visualizations and the final mark, as depicted in Table 3. Could it be that the quality of the visualizations was not acceptable – or did the visualizations demonstrate the student's lack of understanding, or could it be that the students used visualizations instead of text, or replicated other authors' visualizations? There could be a number of factors involved but besides the effort involved for the student, there seems to be little argument against including visualizations 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 visualizations and the other factors that could influence this correlation is necessary.

5. DISCUSSION

This research addressed three questions: In response to the first question, related to the prevalence of visualization, we can confirm that visualizations, in terms of figures and tables, were often used, with a preference for figures. Visualizations were not explicitly assessed by this institution, and hence probably not incentivized.

The second research question was related to the usefulness of visualizations. We found that the candidate's final mark was correlated, albeit weakly, to the particular section where visualizations appeared. A positive correlation was found between the final mark and the number of visualizations in the research design chapter and in the findings chapter. The correlations do not imply causation but this finding might well motivate further investigation. Speculating on possible explanations for this correlation we consider the following aspects.

The first is that the assessor was subconsciously rewarding knowledge visualizations in the research design and findings sections. If this were the case it could be that such visualizations make it clear to the assessor what knowledge was being reported, without their having first to read through pages of text. The visualization 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 quickly and easily to get a sense of what is being reported.

The second possible explanation could be that the visualizations are evidence that the student has indeed mastered the work. In crafting the visualizations, 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 visualizations. As noted before, there is the argument that learning styles are based on individual modal divisions i.e. the visual, kinesthetic and aural [11] which may well impact on the learning. However, whether the visualization is a medium or an artifact, there does seem to be a positive impact of the student spending time crafting and including one or more knowledge visualizations in their dissertation.

There is clearly a proviso: that visualization should be used with care. If used appropriately, they can impact the mark positively, but mindless inclusion of visualizations could depress the final mark. The challenges pertain to the type of visualization, as well as the distribution of visualizations. Regarding the type of visualization, we observed that many visualizations were mere reproductions that added no value except, perhaps, the aesthetic. The negative correlation (albeit small) − between the total number of visualizations and the mark – could confirm the argument that the mere presence of visualizations does not automatically improve the candidate's final grade: it has to be done thoughtfully and be 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 visualizations could support objectivity, consistency and fairness in assessment. It could also help students to engage more deeply with the subject matter, reaching a deeper understanding thereof, in the process of producing the visualizations.

In practice this means that we should consider instructing candidates to include specific standard visualizations such as a chapter map, a literature overview diagram and a visualization of their conceptual framework. This could support efficient assessment by allowing triangulation with the traditional text-based assessment. The use of visualization admittedly poses risks. The risks could be both designer- and user-induced and relate to cognitive, emotional and social human aspects [4]. Hence the promotion of the use of visualization in research reporting should be based on validated guidelines and standards. Kelleher and Wagener [12] provide useful guidelines for effective data visualization in scientific publications but those guidelines need to be refined and customized for dissertation knowledge transfer.

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

6. CONCLUSION

Despite the potential of visualizations for improving knowledge transfer, there is little evidence of the deliberate use of visualizations to improve the efficiency of assessment. We considered the use and usefulness of visualizations in postgraduate assessment and conclude that the use of visualizations in adding value: for the student, the examiner and the final mark, warrants further investigation. Arguably the appropriateness of visualization usage may be related to the subject area, but the general benefits of visualizations in knowledge generation and transfer are not related to a specific subject area. No comprehensive guidelines on the appropriate use of information and knowledge visualizations in postgraduate dissertations seem to exist. If these can be fashioned, then visualization could well be an efficacious assessment aid. This is the discourse we would like to propose for further debate.

7. ACKNOWLEDGMENTS

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