Towards a multi published student atlas: an evaluation of design operators

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Abstract. The landscape of map design has changed rapidly over the last few years. This has occurred mainly due to the release of major multi-scale map products, such as *Google Maps*, *Here*, *Bing* and *Mapbox*. These products, providing the possibility to generate seamless multi-scale maps have ushered in a new way of exploring the Earth and man's impact on it—through the provision of timely and accessible map products. When provisioned with such products, users can pan and zoom their way around our planet, search for places and features quickly and easily to discover new information about geography.

Considering how this new wave of spatial technology has enhanced the provisions available in digital resources 'toolboxes', we seek to determine whether the need for a hard copy map or atlas has died. Will one ever need to open a paper atlas again, to pass an enquiring finger across an unpronounceable mountain range, or thumb through an index searching for mysterious and wonderful places?

Publishers continue to invest in the publication of hard copy atlases, particularly those aimed at students. We see that the challenge presented to publishers is how to engage their readers across both print and digital media, offering fast and dynamic digital maps, whilst, simultaneously, teaching students the skill of reading maps, understanding how and why they use different projections and how they can locate geographical features using an alpha-numeric and latitude and longitude grid.

As part of a broader research project that is investigating a conceptual workflow for multi-publishing student atlases, a smaller research component has also been undertaken, which supports the major research effort. This research attempts to discover some standard 'design operators' that can be applied to design features (fonts, symbols and line weights) on print maps to convert these across to a digital map design. One of the impediments in design consistency is the variability of device screen resolutions—from display monitors to handheld devices. We sought to ascertain whether a 'design operator' that takes into account these variable screen resolutions might be applied.

This paper outlines the research done and the methodology underpinning the user survey that was conducted to investigate design operators for multi-format (and multi-media) published maps.

Keywords: design: multi-publishing: multi-scale mapping: cartographic design: design operator

1. Introduction

The major objective of this research was to develop a conceptual workflow for multi-published student atlas production. As part of this broad research topic major questions have emerged, such as: *What is the most effective point size for text on digital maps? What scale factor should symbols and line styles be multiplied by when moving from print to digital? and What factor does screen resolution of devices have when creating digital atlases?*

It is thought that the outcomes from this research will provide significant information in the Australian context, as there has been little research done in student atlas production (in Australia). The most recent research conducted was mainly done by Dr Rod Gerber (1993) and later by Dr Cristiane da Silva Ramos (2012) during her PhD research.

Internationally research has been undertaken to develop design operators for generalisation of features on tile maps (Roth, et al, 2011), known as 'ScaleMaster'. The research outlined in this paper builds on the ScaleMaster model by investigating 'design operators' that are dependent upon the user's screen display resolution. With the plethora of devices available to consumers, and the rise of BYOD (Bring Your Own Device) in education and the workplace, it is important for cartographers to understand which 'multipliers' are relevant when creating maps that are designed to be read using many media and on multiple devices. Understanding this element is critical for developing a conceptual workflow of atlas design and production.

It is envisaged that the results of this research will be used to inform the developers of future student atlas publications in Australia, and internationally. The ultimate beneficiaries from this research will be school students—the users of these products. No doubt the research will also contribute to the general knowledge relating to atlas and map production across various media in more broad terms.

As Australian atlas publishers are in a transition phase, moving from hard-copy student atlases to digital student atlases, or developing combinations of the two, as such, developing innovative and timely production methodologies will be critical to support their production effectiveness and, thus, profitability moving forward.

2. Research Goal

The specific topic of enquiry for this research was to determine how close, or similar, a digital map design can be to a print map design, accounting for the variability in users' display types—be they PCs or laptops, tablets, smart phones or other devices. By applying variable 'design operators' to map fonts, symbols and line weights and viewing these on different devices, some conclusions might be determined about which 'operator' works best, and for which feature at a particular screen resolution.

3. Research Method

The survey to determine the suitability of the conceptual 'design operators' relied on qualitative feedback from a diverse group of spatial industry professionals. Papers were presented at two industry conferences—the International Map Industry Association (IMIA), Asia Pacific Conference held in Melbourne in August 2014, and the GSR_3 Conference, held at RMIT University, Melbourne in December 2014, encouraging attendees to participate in the survey, as well as explaining its background. Additionally, attendees at the Geography Teachers Association of Victoria (GTAV) Melbourne Conference in August 2014, were invited to participate in the survey by direct invitation from a trade show booth. Finally social media was used in the form of Twitter, to encourage followers to retweet the link to survey and participate in the survey themselves. Interestingly, this last method of invitation received the most responses.

In consultation with the Statistical group in the School of Mathematical and Geospatial Sciences at RMIT University, a survey was designed to achieve measurable outcomes from qualitative questions. The survey aimed to compare five variables—font size, line weight, symbol size, the user's operating system, and the resolution of the screen they were viewing the design on. The survey results were measured using Regression Analysis (Montgomery, 2013) to discover if a P-value variance was greater than 5% to determine if a 'design operator' was significant to the survey respondents. Additionally, the survey results would be further analysed using the Taguchi method (Tsui, 1992), comparing just three variables—font size, line weight and symbol size, as a check on the Regression Analysis results.

Three design components were selected (font size, symbol size and line weight) and compared in a matrix of nine variables with the 'design operator' altered in one of three ways: presented at 1x multiplication factor, a 2x multiplication factor or a 3x multiplication factor. The resulting matrix of design components and 'design operators' is shown in Table 1.

	FONT	SYMBOL	LINE
A	1	1	1
B	1	2	2
C	1	3	3
D	2	1	2
E	2	2	3
F	2	3	1
G	3	1	3
H	3	2	1
I	3	3	2

Table 1. Matrix of design operators.

The original assumed font conversion factor from print to digital was 1.75, as a minimum 6 point font for print was translated to a minimum 10 pixel font for digital. The minimum line weight conversion factor was 0.25 line weight for print, to a minimum 1 pixel line weight for digital, a 4 times conversion. Symbol size was a bit more problematic, however a 1 millimetre sized symbol, was translated 12 times to a size of 12 pixels.

The minimum font size for print (6 point) was taken from Robinson's *The Look of Maps* (1952), whilst the minimum font size for digital (10 point) was taken from Jenny et. al.'s paper on *Map Design for the Internet* (2008).

After discussion with Statistics group, it was determined that a sample size of around 50 people would be adequate for compiling meaningful statistical results from the survey.

As described earlier, numerous groups of participants were approached, however in the space of four months. Thirty valid responses to the survey were received. This was deemed to be adequate for determining a reasonable result.

4. Similar Research

The research design is similar, though not exactly the same, as that undertaken by Phillips, et al. (1990). This research surveyed two separate groups of map readers, one highly skilled (drawn from a cartographic conference) and another group of unskilled students. Phillips' survey looked at variance in cartographic symbol design (specifically cuttings and embankments on topographic maps) and offered alternatives. Respondents were given a time limit to answer each question.

5. Survey Design

The electronic survey was hosted on the Typeform (http://typeform.com) survey platform. One of the benefits of this system was the analytics, which could determine number of unique visitors, operating systems used by visitors and also type of device, which would prove invaluable in the results of the survey.

The survey asked participants to download and print on their everyday home or work printer a colour version of a sample atlas map, in this instance a map of the state of Queensland, Australia, that could be used in a printed student atlas. This map was specifically produced for this purpose and it is typical of atlas products produced for Australian school atlases. This printed sample was used as a reference to determine how effectively the digital design matches the print design (Figure 1).

Participants were first asked to determine the screen resolution of the display with which they were viewing the survey (http://dpi.lv/) which displayed the resolution of the user's monitor in pixels per inch (ppi). As a secondary step in the calculation of the resolution, participants were asked to measure using a ruler the size of a square in millimetres. This second step was used to confirm if they had included the correct figure in the first question.

The second part of the survey required the respondents to view 9 images of the same digital map (of Queensland), each image containing a slight variation in either the font size, symbol size or line weight (Figure 2). Various images had a 'design operator' applied to each of these features and re-

Figure 1. Original student atlas map design for print survey participants were asked to review.

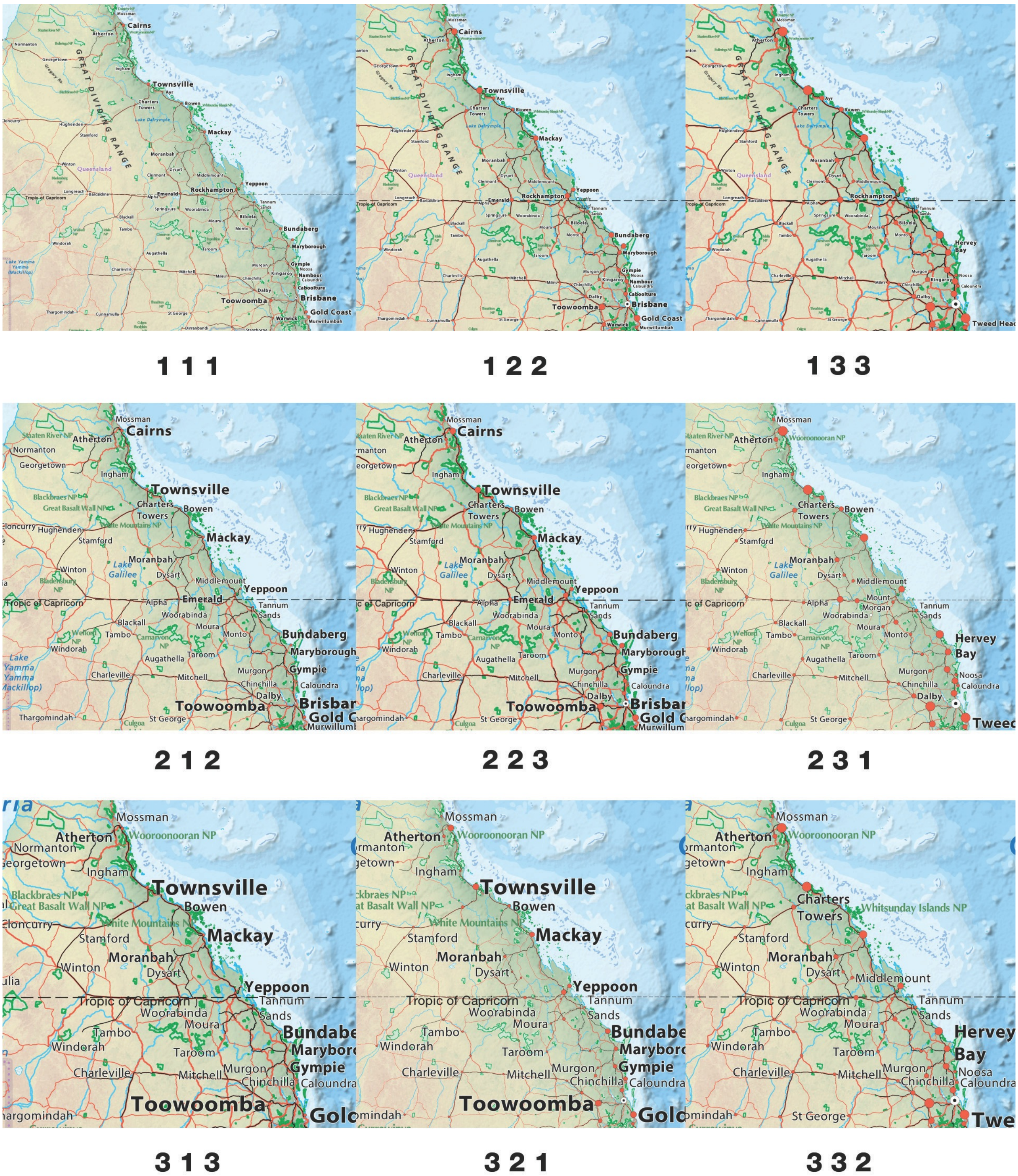

Figure 2. The 9 versions of the digital map of Queensland with the various 'design operators' applied.

spondents were asked to assess, qualitatively, how well each image matched the printed version of the map. Respondents were asked to assess the quality based on a Likert-scale of 1 to 10, with one being least effective and 10 being most effective.

Respondents results would vary based on the screen resolution of the device they were viewing the survey on. For analysis, screen resolutions were segmented into four categories shown in Table 2.

Category	Resolution
A	<= 100 px
B	101 to 200 px
C	201 to 300 px
D	>= 301 px

Table 2. Screen resolution categories developed for analysis.

Data was recorded using direct electronic entry via the survey website Typeform. During data collection, data was stored on the Typeform website servers. At the completion of the survey period, data was downloaded from the Typeform servers in Microsoft Excel spreadsheet for analysis.

6. Survey Participants

The inclusion criteria for the participants was to elicit information from a sample group of attendees at three major map/atlas conferences to held in Melbourne, Australia during August to December 2014, plus the use of social media to further spread the request internationally. It was determined that participants from these four groups would provide a pool of educated professionals with sufficient skills to allow them to make judgements on atlas design needed to provide survey integrity.

Participants were all over the age of 18, with no particular gender bias, they participated voluntarily and were not compensated or induced for their participation in the survey.

7. Results

The survey fell short of collecting the 50 respondents required, gathering only 30 valid responses, however from this we were able to gather measurable results. The Typefom survey tool provided some useful analytics about survey visitations and, even though the sample size was small, we could draw some conclusions about the results.

In total there were 277 unique visits—148 from PCs and laptops, 13 from tablets, 38 from smartphones and 78 other (these have not been specified by Typeform).

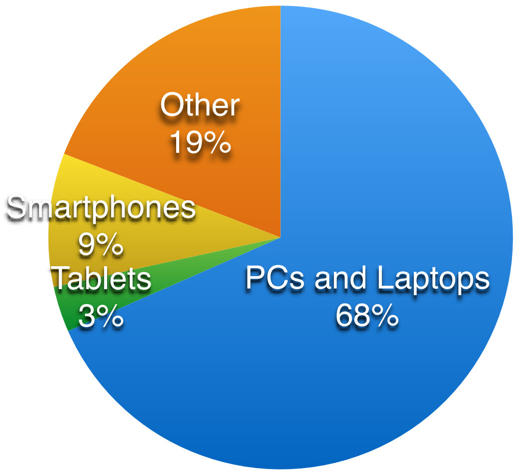

Figure 3. Devices versus unique visits.

Of the 150 visits from PCs and Laptops only 25 (17%) went on to complete the survey, and took an average time of 31 and a half minutes. This average time to complete the survey was a surprise. However, the reason for this may be due to the fact that one participant took 42 minutes to complete, whilst another completed the survey over a period of one week, leading to a skewing of the average time figure. Most participants spent between 3 and 5 minutes to complete the survey, which was much less than the 10 minutes suggested in the survey's introduction.

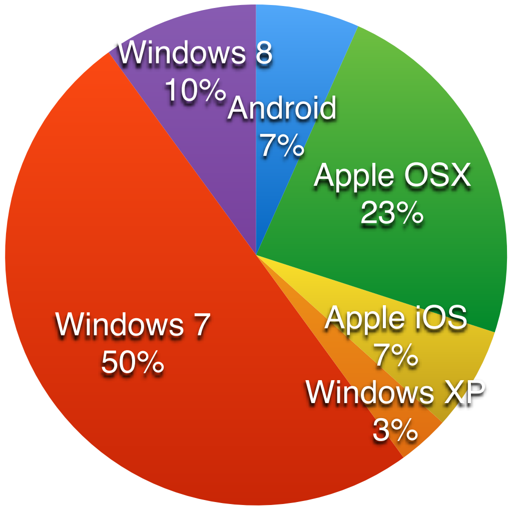

Figure 4. Operating Systems used.

A mixture of operating systems were used to view the survey—50% Windows 7, 10% Windows 8, 23% Mac OSX, 7% Apple iOS and 7% Android.

Reviewing the results from the professional judgements of the respondents brought out some interesting results. The most preferred 'design operator' applied to Fonts was 1, that is to say, the digital map that had the base design operator applied to the font (1.75) was preferred regardless of the operating system or screen resolution viewed. This can be seen in Figure 5 where, using the Taguchi method of analysis the design operator with the highest mean value (4.816) from our Likert Scale was 1.

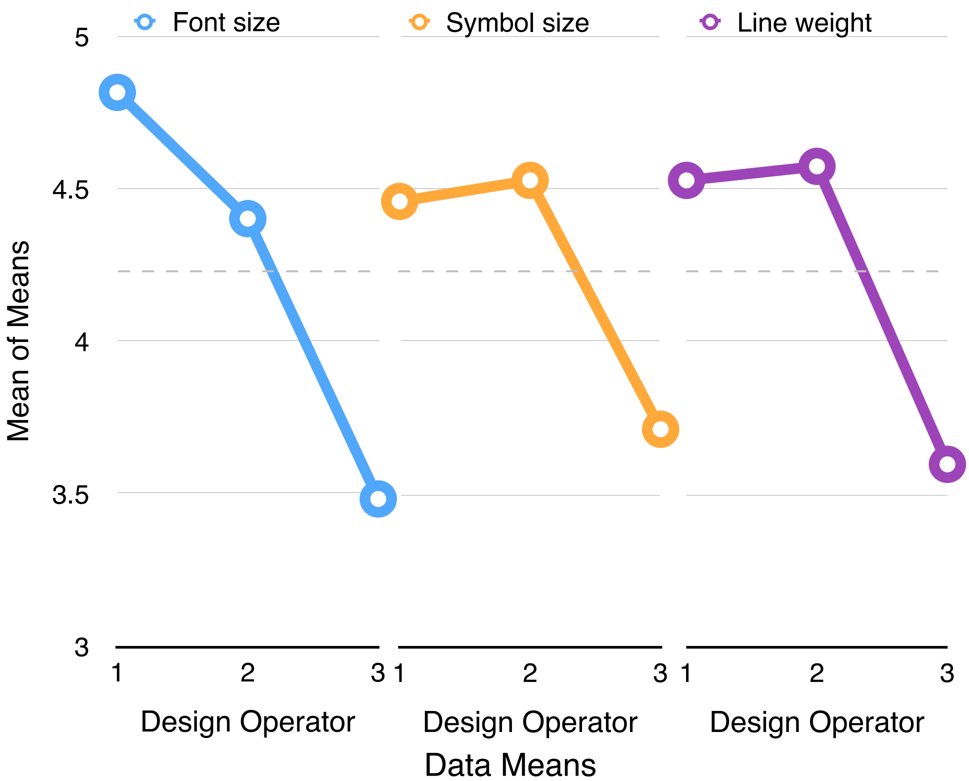

Figure 5. Main effects plot for means of the three design variables, font size, symbol size and line weight.

Interestingly, symbol size and line weights were preferred with a 2x design operator applied, indicating that our earlier assumptions of multipliers were incorrect, though they were only marginally ahead of our original assumptions.

These results were confirmed when analysing the data using Regression Analysis. The P-value was greater than 5% for design operator 1 in font size, design operator 2 in symbol size and design operator 2 in line weight.

Term	Coefficient	SE Coefficient	T-value	P-value	VIF
Constant	3.563	0.885	4.03	0.000	
Font					
2	-0.400	0.303	-1.32	0.189	1.33
3	-1.289	0.303	-4.25	0.000	1.33
Line					
2	0.044	0.303	0.15	0.884	1.33
3	-0.900	0.303	-2.97	0.003	1.33
Symbol					
2	0.067	0.303	0.22	0.826	1.33
3	-0.722	0.303	-2.38	0.018	1.33
OS					
iOS	1.363	0.865	1.58	0.116	3.03
OSX	0.499	0.738	0.68	0.499	6.35
Windows 7	0.770	0.703	1.10	0.274	8.04
Windows 8	0.761	0.800	0.95	0.342	3.75
Windows XP	-0.111	0.960	-0.12	0.908	1.93
Resolution Category					
B	1.393	0.480	2.90	0.004	2.94
C	1.064	0.580	1.83	0.068	2.53
D	3.06	1.07	2.85	0.005	2.42

Table 3. Regression Analysis results.

The operating system used by respondents did not seem to have an effect on results, which is not all that surprising, however the resolution of the screen display did have an effect, and the screen resolution category that was preferred was category D, that is a resolution greater than 300 pixels.

8. Conclusion

All conclusions drawn from the survey need to be considered with the knowledge that the sample size was less than required, however we can draw some interim conclusions based on the results.

Our first assumptions based on earlier research appears sound, with the series of design operators established for font size, symbols size and line weights to be correct. To produce a 'one size fits all' web map, line weights and symbol sizes could be increased to allow for better understanding of the digital map. A distinguishable hierarchy of fonts, symbols and lines would greatly enhance the digital map, particularly for students.

The design of the digital map appears to be not affected by the operating system used, whilst the modern high resolution screens (for either desktop or mobile) appear best to display digital maps.

The concept of a 'design once, publish many' approach to map publishing can be achieved across multiple devices and different screen resolutions by carefully considering the design operator that can be applied to each design element.

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