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Preservice Teachers as Document Detectives

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Abstract. Literacy today relies on a readers' ability to analyse text critically. This case study investigated preservice teachers' critical analysis of media text containing visuals and representations. In particular, the analysis focused on mathematical factors that impact on readers' interpretation of diverse visuals.
Data was gathered from the 23 preservice teachers, enrolled in the Graduate Diploma program at one Australian university. They participated in a series of mathematics learning sessions focused on the critical analysis of a selection of media items.
The paper argues that the ability to critically analyse graphs and visuals relies on mathematical knowledge and that the ability to critically analyse such representations is a necessary component of mathematical literacy and everyday literacy. Mathematics teachers require well-developed critical analysis competencies to enable them, and ultimately their students, to critically analyse representations in everyday text. The paper illustrates that drawing on diverse visuals from the media can be productively used to develop critical analysis competencies.

Introduction

Political, social, commercial, and economic information is routinely communicated through a variety of graphs, tables, and other visuals. These representations frequently give the illusion of authority, and portray particular views which have the potential to influence readers' opinions.

Graphs, tables and other mathematical illustrations are often integrated into media text (e.gs, Monteiro & Ainley 2004, 2007). Data is summarised in such visuals, partly to aid ease of access to the information and partly to establish the authenticity of the reports. However, mathematical knowledge plays a role in, for example, the process of readers interpreting visual or tabular advertising data that has the purpose of encouraging consumers to buy a product (e.g., Watson & Fitzallen, 2010, p. 45), and in graphs and visuals that do not clearly portray the inherent relationships (e.g., Monteiro & Ainley, 2003, p. 5). In-depth interpretation of such visuals can depend on knowledge of mathematical concepts, and the process of interpretation can result in misconceptions about the actual data.

The inadvertent or advertent misrepresentations of mathematical ideas in text has been described by authors (e.g., Monteiro & Ainley 2007; Watson, 2015), contributing to what has come to be known as 'fake news' today. As for other text, messages in visuals can be misrepresented through specific emphasis, inherent bias, and disguised information, for

example. Thus, students need to be aided "to look beyond the literal meaning of texts" (Robertson & Hughes, 2011, p. 39) to discover deeper and less obvious meanings.

Due to the potential of bias and misrepresentations in text, an important element of literacy today focuses on learners' mastery of critical analysis competencies relating to the understanding of text, including text containing diverse visuals and representations. As scholars have noted (Monteiro & Ainley, 2003, 2007, 2010; Stoessiger, 2002; Watson, 2015; Watson & Fitzallen, 2010), mathematical concepts, often embedded in media text, play a significant role in the critical analysis of diverse representations.

Literacy and critical thinking are commonly stressed in contemporary school curricula, an example being the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority, 2018a). The Australian Professional Standards for Teachers highlights the importance of teachers knowing and understanding literacy strategies (Standard 2.5) (Australian Institute for Teaching and School Leadership Limited, 2018), including the ability to analyse text critically. Together, such documents point to the merits of preservice teachers and teachers developing critical analysis skills, as a first step towards them carrying related skills into the classroom.

The importance of extending critical analysis competencies in order to deepen preservice teachers' understanding of the potential bias and misrepresentations in contemporary text, inspired the study. In particular, the investigation involved a group of preservice teachers' critical analysis of media text that included mathematical representations.

The study examines the preservice teachers' understanding of critical analysis practices. The paper argues for the importance of preservice teachers being encouraged to collaboratively construct knowledge of critical analysis practices, through interrogation of media text containing graphs and representations, the process of analysis dependent on ideas from mathematics. Further, the paper describes the value of using items from the media as resources for enhancing knowledge of critical analysis practices.

Literature Review

Together with a focus on other literacy practices, the key role of critical analysis is often evident in literacy learning frameworks, an example being the Four Resources Model from literacy education (Freebody & Luke, 2003). Freebody and Luke (2003) argued that literacy learning involves mastery of a variety of literacy practices, key to utilising text with varying content, contexts, and social and cultural purposes. They proposed that effective reading and writing depended on proficiency with four categories of literacy practices. The first, namely code breaking, referred to readers' ability to use the features such as grammar, layout, headings, and conventions in text, and their ability to use the graphic symbols and to relate them to spoken language. The second referred to the readers' ability to participate in and make meaning of the text based on stated and unstated information and relying on prior experiences and knowledge. Such meaning-making practices are built upon the view that meanings do not emerge directly from text, rather they are constructed by readers in socio-cultural contexts, readers having agency in the process (Serafini, 2012). The third category emphasised readers' ability to use the cultural and social functions of various genres found in text. This included text constructed for varying purposes including pleasure, learning, and information gathering.

The fourth dimension of the Four Resources Model, and the dimension that is most important in this study, focused on readers' understanding that text is not neutral. Drawing attention to the influencing and misleading elements in text, the category focused on readers'

ability to critically analyse text by questioning its bias, truth, and power. As described by Freebody and Luke (2003), critical analysis of text depends on learners:

> *Understanding and acting on the knowledge that texts are not transparent windows on the world, that they are not ideologically natural or neutral, that they represent particular views and silence others, influence people's ideas; and that their designs and discourses can be critiqued and redesigned in novel and hybrid ways. (p. 57)*

In his web seminar in 2012, Luke stressed the importance of a learner developing the ability to engage with text including everyday text, and developing "a healthy scepticism" (Luke, 2012) towards their contents.

Based on the discussion in Freebody and Luke (2003), critical analysis was theorised as follows for the current study (Fig. 1). In brief, critical analysis relies on readers' developing a critical stance with the aim of uncovering the purpose, truthfulness, and bias in the text, through analysing who created a text, and its purpose and audience (Freebody & Luke, 2003)

Critically analysis includes …

- understanding that text is written for set purposes, hence may influence readers in various ways;
- establishing the truth, fairness, and bias and identifying the misleading elements and omissions in text;
- understanding the view portrayed by particular words or diagrams. for instance;
- establishing the facts/opinions, views and power, author's background and intentions, and other views; and
- understanding of the different ways of presenting the same set of information or construction of text with different points of view (through use of different pictures, headings, choice of words, colours etc.).

Critiquing ability is seen as important in terms of locating reliable sources of information and avoiding scams.

Figure 1: Critical analysis based on Freebody and Luke (2003).

Educators, including mathematics educators, have referred to the importance of critical analysis of varied visuals in terms of readers' developing the ability to access messages in media text and text used in the classroom. The key role of developing critical analysis competencies is highlighted in Whitin and Whitin's (2008) statement that "being a critical reader of data is an integral part of being fully literate in today's information age" (p. 432), enabling readers to look beyond the superficial meanings portrayed in text. Reinforcing this, a focus on critical thinking and analysis is evident in educators' work from diverse curriculum areas such as English, mathematics, and science (e.g., Freebody & Luke, 2003; Monteiro & Ainley, 2003, 2007, 2010; Robertson & Hughes, 2011, Watson & Fitzallen, 2010).

Further, educators have highlighted the value of using resources from the media for the development of critical analysis competencies (e.g., Flores-Koulish, 2006). Students require practice to aid them to participate in the media-rich world (Robertson & Hughes, 2011), including practice with analysing more than the superficial meanings in text. This includes developing an understanding of origins and authenticity of ideas presented and the effects that text can have on readers' opinions. Activities that focus on critical analysis practices with respect to media text have the potential to aid readers to construct deeper understanding of misleading elements of text, thereby decreasing the likelihood that they will be influenced by media (Green, 2006; Robertson & Hughes, 2011).

Effective critical analysis depends on developing familiarity with factors that contribute to the misleading nature of text (Stack, Watson, Hindley, Samson, & Devlin, 2010; Whitin & Whitin, 2008). Since representations are often mathematically orientated, they can be analysed from a mathematical critical perspective. In mathematics, Whitin and Whitin (2008) outlined factors that contribute to bias in text. They observed that bias can be attributed to the purpose of the data, the sample investigated, the wording of questions, the definitions, categories, and representations used, and the conclusions reached. More specific misleading factors listed in the Australian Curriculum Mathematics under the descriptor ACMSP148 include broken axes, non-linear scales, and no scales in graphs, and claims unrelated to data being proposed (Australian Curriculum, Assessment and Reporting Authority, 2018b). Since representations are often mathematically orientated, it is theorised that extending knowledge of mathematical factors that contribute to bias and misrepresentation is important for deep critical analysis of such items.

Text from the media that provides suitable opportunities for critical analysis include visuals on accident rates, mobile call rates, and average yearly wages. Examples of such media text, suitable for use with preservice teachers, can be found in newspapers and in the literature (e.g., Monteiro & Ainley, 2003, 2007, 2010; Stack et al., 2010; Watson & Fitzallen, 2010). Such resources make use of data from samples that may or may not be representative. The data is depicted in a chosen way and the resources often include titles, conditional statements and inferences, a combination of which can result in the deceptive portrayal of information (Watson, 2000). Use of such resources is advocated by educators (e.g., Watson, 2011; Wall & Benson, 2009), having the potential to assist learners to construct links between different subject areas and everyday contexts. Text such as this can be used to scaffold critical analysis competencies, aiding readers to think critically and to question values (Flores-Koulish, 2006; Freebody & Luke, 2003; Luke, 2012; Robertson & Hughes, 2011).

Research Process

This study was part of a doctorate case study completed in 2016 (see Quinnell, 2016). In particular, this part of the doctorate study was inspired by the importance of extending preservice teachers' understanding of the potential bias and misrepresentations in contemporary text. This study focuses on preservice teachers' ability to comprehend text from the media, in particular text that included mathematical representations. Interrogation of such text has the potential to deepen students' understanding of text that they may encounter in society. The long term aim of interrogating such text in preservice classrooms would be to encourage the preservice teachers to carry such skills into the classroom.

During the research, a variety of media text that included graphs and representations was investigated and critically analysed by the preservice teachers. The research questions were:

1. Why is it important to refer to ideas from mathematics, in the process of critically analysing media text containing visual representations?
2. What resources can be used in the process of scaffolding critical analysis competencies?

The case study research involved 23 preservice teacher participants who were enrolled in the Primary Graduate Diploma program at one Australian university. The participants were involved in a series of learning sessions, the learning taking place once weekly for four weeks in a university classroom. A selection of six samples of media text containing tables, graphs, and varied visuals were collaboratively discussed and critically analysed by small groups of five to six preservice teacher participants. The process was guided by a mathematics

education lecturer, who fulfilled the role of the facilitator of learning, encouraging and guiding the learners to participate in extensive critical discourse relating to the content and context of the media items. During the process, data presented in the tables and graphs were used to justify, confirm, disconfirm, and summarise ideas, and make decisions, thereby aiding collaborative construction of meaning. The preservice teachers' critical discussions about the media items were recorded and data collated. The paper describes the participants' analysis of the text, and examines the data gathered from the student discussions and work samples. This leads to answering of the research questions.

Critical Analysis and Discussion of Various Media Items

Hail Mary Article (MX, 2012, July 31, p.11)

Hail Mary ... Fall from Grace.				
	G	S	B	T
China	9	5	3	17
USA	5	7	5	17
France	3	1	3	7
North Korea	3	0	1	4
Italy	2	4	2	8
South Korea	2	2	2	6
Russia	2	0	3	5
Kazakhstan	2	0	0	2
Japan	1	4	6	11
Australia	***1***	***2***	***1***	***4***

Figure 2*:* Data on the Olympic Games 2012 (which were held from July 27 to August 12, 2012).

The first example focused on critical analysis of a newspaper article titled *Hail Mary ... Fall from Grace. How they stand* (Fig. 2). The article considered Australia's medal tally in the 2012 Olympic Games, a topic seen to be interesting and relevant to a wide range of learners. The text was published in a newspaper, the purpose being to engage and entertain the readers, suggesting a need for deeper interrogation of its contents. Analysis of the article by the preservice teachers depended on a repertoire of social, cultural, and religious knowledge about Australia, sports, and the Catholic religion, in order to fully comprehend the text.

Through discussion about the table, the preservice teachers deepened their understanding of the text, shaped by the group of participants' prior experiences and knowledge of the context. For instance, one participant who queried the meaning of the symbols G, S, B, and T was aided by others who recognised these as Gold, Silver, Bronze, and Total. The full meaning of the title, which suggested a fall from grace, was clarified by some participants who were familiar with Australia's excellent results in previous Olympic Games, such as the Sydney Olympics in 2000. The discussions also revealed differing views and knowledge of the Catholic religion, which affected interpretation of the title. Importantly, the discussion enhanced understanding of how some individuals may be precluded by unfamiliar topics because of differing prior knowledge and experiences.

As discussed by Stack et al. (2010), the plausibility of text can at times be questioned, based on the reputability of the source. The current research participants noted that the Hail Mary article was written by an unknown author and printed in a newspaper, suggesting possible credibility issues.

Further, dialogue about the text enabled the preservice teachers to critically analyse elements of the text that influenced their ideas, thereby enabling them to build understanding of the perspectives reflected in the text. While some of the participants struggled to articulate their thoughts, others noted that the title, *Hail Mary ... Fall from Grace* (MX, 2012, July 31, p. 11), would covertly position readers by portraying a view that Australia was faring badly and suggesting the need to pray for help. Drawing on critical analysis, as discussed by Freebody and Luke (2003), the title portrayed the author's perspective, evidence that the text was not neutral. As noted by Avgerinou and Petterson (2011), such titles can influence interpretation. A preservice teacher in one group noted another source of bias. The authors' viewpoint was based on data from only the first few days of the Olympic Games, a way of silencing all other information. Thus, the participant suggested that more information was needed to fully understand the Olympic results. Also referred to by Freebody and Luke (2003), further discussion focused on how the meaning of the text was altered by arbitrary choices made when the data was represented. A number of the preservice teachers noted the arbitrary positioning of the countries according to number of gold then silver then bronze medals, placing Kazakhstan with a total of 2 gold medals above Japan with a total of 11 medals. A preservice teacher in one group observed that if the number of gold, silver and bronze medals were equal, alphabetical order was used to order the countries, placing South Africa two places below Georgia with the same number of medals. Drawing on mathematical ideas, the participants suggested other possibilities for ordering, such as placing weights on the different medals, three points for gold, two for silver, and one for bronze, or placing them in alphabetical order, which would *place Australia on top*. Reading beyond the information given in the report resulted in discussion about whether Australia should be able to compete with countries like China with its huge population, hence bringing the title of the report into question.

Deep interpretation of the item depended on critical analysis of its contents, including the identification of the author's background and perspectives and consideration of the choices made when representing the data. Providing information for answering the research questions, the process relied on use of specific metalanguage to articulate the ideas as well as on mathematical understandings related to reading and presenting data in tabular format.

Public Health System Graphs (Davis, 2012, February 16, p. 6)

The next example related to critical analysis of a graph titled *Public Health System at* '*Breaking Point',* sourced in a small local newspaper (Fig. 3). Referring to the graph, several preservice teachers noted that the data was not randomly chosen, but rather gathered in an online survey from a small sample of 2300 persons, meaning that the data set was unlikely to represent the population of Australia. Presentation of data from the small sample of voluntary online participants meant that all other voices were silenced (Freebody & Luke, 2003). Also observed by some participants, credibility issues were aroused by the unknown identity of the author. The purpose of the graph was unclear, and the data collection questions were not provided, potentially altering the nature of the data collected by silencing certain voices (Whitin & Whitin, 2008). Notably, although some preservice teachers were able to make valid statements about the above ideas, others were less able to do so, possibly constrained by limited knowledge of the metalanguage necessary to describe the situation.

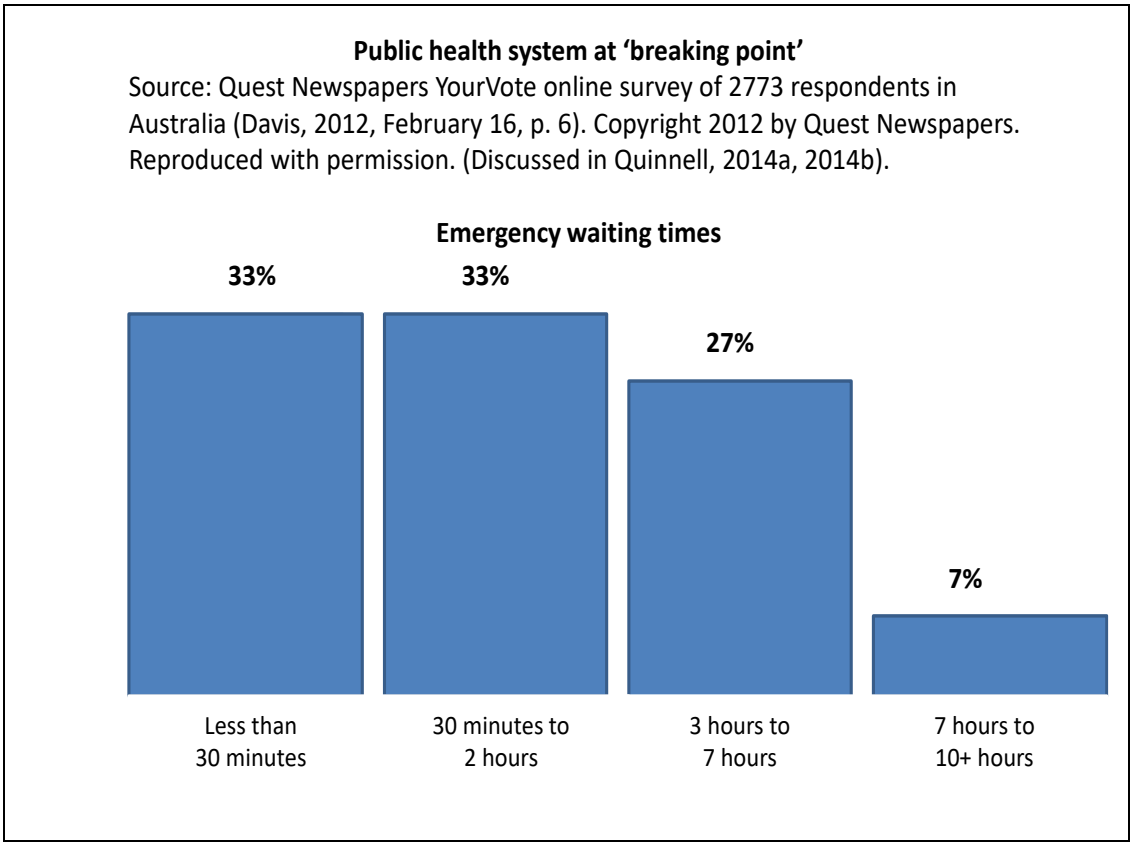

Figure 3: Public health emergency waiting times.

Two preservice teachers from different groups noted that in conflict with the title, the presented data may not represent a crisis, one participant suggesting that the 7% of people who waited the longest probably had trivial complaints. Others stated that no information was provided about the nature of the emergencies/injuries, or home localities of the voluntary online participants. They suggested that the emotive title (Public Health System at 'Breaking Point'), presented an exaggerated view, one purpose being to engage the readers. This concurs with Freebody and Luke (2003), who suggested that article titles may alter opinions. In this case, the title of the graph presented an opportunity for critical analysis, because of its likelihood of influencing readers' ideas and interpretation. During the process of critical analysis, discussion about the title and the other above-mentioned factors led the preservice teachers to question the truthfulness of messages portrayed by the representation.

In order to identify the overt and covert messages in the text, further consideration was needed of the mathematical elements of the graph (Robertson & Hughes, 2011). Discussion turned to the optimum labelling of the interval 7 hours to 10+ hours, which gave no information about the maximum waiting time. One participant suggested using 7 to 10 hours, but others noted that this would exclude those who waited in excess of 10 hours, thus would impact on the messages given by the graph. With guidance from the facilitator, subsequent discussion in the different groups focused on other factors that may impact on interpretation of the graph. Careful inspection of the graph revealed a gap of one hour (between 2 and 3 hours) on the horizontal axis, although the sum of the percentages was one hundred percent. This omission suggested credibility issues. Further, inherent in the graph were subtle ways of influencing readers, through the use of inconsistent intervals of time represented by the bars, the first three bars representing 30, 90 and 240 minutes respectively although all bars are the same width. Critically analysing the consequence of such choices, a preservice teacher in one group observed that the short time interval represented by the first

bar had the effect of decreasing the height of the bar, thus influencing readers' impressions. Of note such choices and use of different samples when representing data can yield very different graphs (Whitin & Whitin, 2008), thereby influencing readers' interpretation of the data.

Text such as the public health graph may appear neutral and authoritative to readers. However, deep understanding relies on analysis of underlying purposes, bias, misrepresentations, and views. Critical analysis of the graph requires consideration of the contextual factors that may influence readers as well as the deeper mathematical ideas in the graph. These include consideration of the choices of graph-type and selection of the sample, amongst a raft of other factors.

In this case, critical analysis depended on understanding of a broad range of factors that can cause bias in such text. Drawing on Freebody (2000) it can be argued that through reading, viewing, writing, speaking, and listening, a combination of the preservice teachers' linguistic, mathematical, and cultural knowledge, learnt from prior educational experiences and from everyday life, were blended to aid them to becoming more effective consumers of the text. Referring back to the description of critical analysis by Freebody and Luke (2003), it could be noted that the design and representation of the public health data presented specific messages to readers, messages at times different to the messages in the original data.

Critical analysis of the above-mentioned item encouraged the construction of links between different subject areas such as areas of literacy and mathematics. Discussion assisted the participants in analysing the text to ascertain its credibility, and enabled them to draw justified inferences, and to search for underlying purposes and agendas, thereby diminishing their beliefs about the authority of the text. The discussion exemplified Robertson and Hughes' (2011) statement that "critical media literacy skills help students interrogate, deconstruct, and uncover the layers of media messages" (p. 38). A focus on the factors that cause misrepresentations in text led the participants towards construction of a deep understanding of the text. Importantly, the process depended on mathematical knowledge, such as knowledge of representative sampling and effective labelling of the axes on a graph. The example illustrates the importance of specific metalanguage and mathematical knowledge in the process of critical analysis of such text.

Money in a Banking Account

In the *Life Saver account* graph (Fig. 4), four different graphs are used to represent the same information, a hypothetical depiction of an individual's bank savings in an account in 2010 and 2011. Critically analysing the graphs, a preservice teacher from one group noted that data from more than two years is necessary in terms of building an understanding of the long-term balance in the account. This concurred with the comment in Freebody and Luke (2003) that other data should not be silenced. Other preservice teachers in different groups observed that the title, the different widths and colours of the bars, the use of 3D bars, and the use of a *y*-axis that begins at a non-zero number, all contribute to deceptive messages in the graphs. Such critical observations draw attention to the differences between the actual data and the messages given by the different representations of the data. For example, the 2011 bar in the bottom right hand graph (Fig. 4), is wider than the 2010 bar, exaggerating the increase of money in the bank account. Extending this, Mackinlay (1999) listed factors such as colour, density, volume, area, angle, slope, length, and position, all of which add information to visuals (Mackinlay, 1999), potentially distorting the meaning of the text. In the bottom right hand graph in Figure 4, the different colours and volumes of the two bars would be factors that would impact on the perceived meaning of the graph. Importantly,

presentation of data in graphic or visual format requires careful execution, in order to preserve the inherent meaning of the data (Monteiro & Ainley, 2010). Irrespective of such care, unbiased representations are arguably unlikely, with construction of graphs dependent on the selection of the data or sample, the selection of the graph-type and data groupings, the wording of the labels, other variations in the graphs, and the readers' role whilst interpreting the graph.

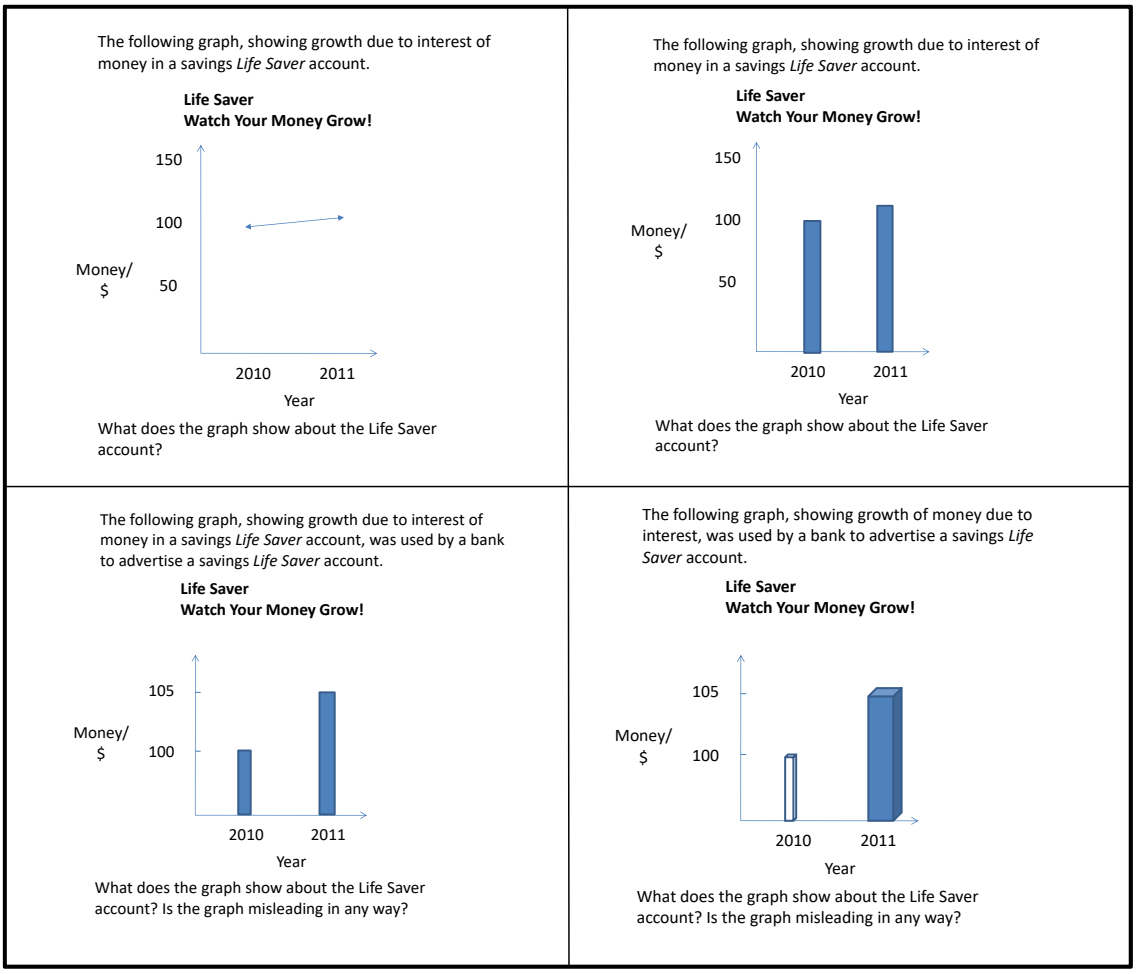

Figure 4: Graphs showing banking deposits over a two year period.

The preservice teachers expressed different views about the most accurate representation of the information depicted in the graphs in Figure 4, most needing scaffolding to encourage them to contribute to the conversation. The top left hand graph (Fig. 4) presents the most accurate depiction of the situation, representing a display of continuous data by a straight line with the *y*-axis starting at zero. Use of a bar graph suggest discrete data not a continuous upward trend of the money in an account. Most of the preservice teachers were unfamiliar with the differences between continuous and discrete data and their most appropriate representations, these differences dependent on mathematical understandings. Three preservice teachers in different groups noted that in the bottom two graphs, the *y*-axis is cropped, a quick perusal of the graphs suggesting a hundred percent growth in savings, whereas the actual figure is only a five percent increase. Dependent on both conceptual mathematical understanding and consideration of the context, misleading representations result if the *y*-axis starts from a non-zero number, in cases in which it is important to understand the variation of data as a percentage of the total (Watson, 2015). A number of

preservice teachers observed that the growth of savings is further exaggerated by the use of the 3D bars in the last graph, use of 3D graphs being another means of adding deception to the messages in graphs. The fact that the bottom two graphs do not start from zero on the *y*-axis also means that future predictions may pose difficulties to readers. Such predictions also rely on prior knowledge, such as knowledge that the trend would depend on factors such as interest rates and withdrawals. Through discussion of the differences between the representations, the participants gradually extended their understanding of factors that influence the perceived meaning of different representations. Notably, an understanding of mathematical ideas was crucial in the analysis process, demonstrating the importance of referring to ideas from mathematics when scaffolding critical analysis competencies.

To elaborate, a variety of mathematical factors contribute to misrepresentation of data in visuals and graphs, factors that are considered under the banner of the term *lie factor* (Monteiro & Ainley, 2010, p. 22). Possible deception results when parts of a visual are emphasised or disguised (Monteiro & Ainley, 2003), such as when a slope is exaggerated, a misleading caption is used, or viewers' attention is drawn to salient parts of a graph through the use of angle and perspective (O'Halloran, 2005). Different choices of graph-type can lead to deception (e.g., Mackinlay, 1999), and graphs that are three dimensional or include different colours or widths of bars may be misleading (Wall & Benson, 2009).

Number of Serious Injuries in Smithton

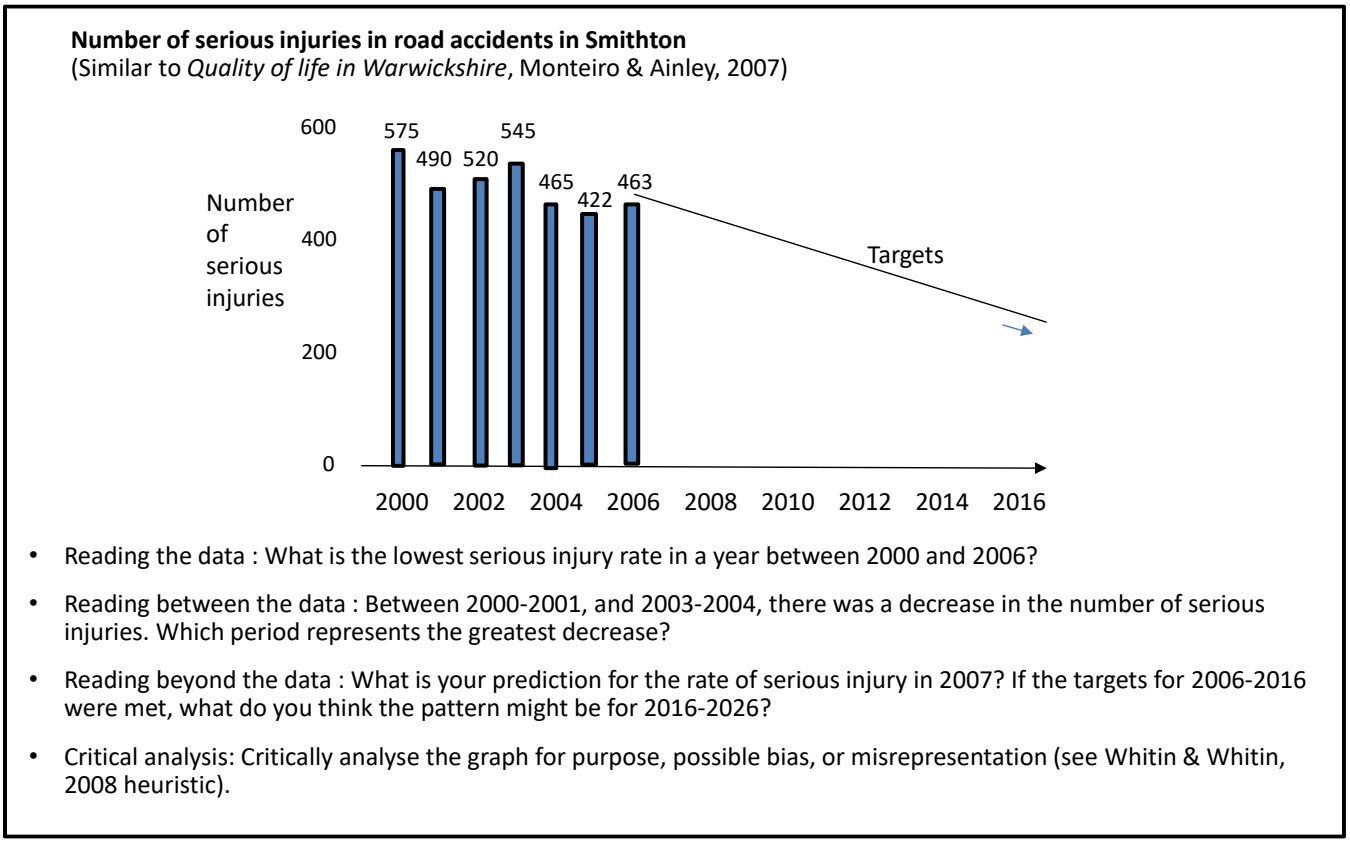

Figure 5: Example question on serious injuries in Smithton.

In the hypothetical question on injuries from road accidents in Smithton (Fig. 5), the sub-questions become increasingly complex, thereby initiating thinking that extends beyond the superficial meanings of the graph. The questions focussed on reading the data, reading

between the data, and reading beyond the data, three levels of questioning described by mathematics educators (e.g., Monteiro & Ainley, 2007).

The preservice teacher participants in the different groups were mostly successful with the first question, but had less success with the second and many needed scaffolding from others to extend their understanding and enable them to fully answer the last two questions (Fig. 5). The last two questions required reading beyond the data, including critical analysis with reference to the trend line. In line with statistical ideas of inference, varied answers are possible for the last two questions provided that they are fully supported, with the use of subtle language to portray a degree of uncertainty (Watson & Fitzallen, 2010; Woodward & Pfannkuch, 2007). For instance, one preservice teacher's prediction of a serious injury rate of between 420 and 460 in 2007 was acceptable with justification that the rate seemingly stabilised between 2004 and 2006. Another prediction of an injury rate of approximately 100 by 2026 was fine, with reference made to the decreasing trend shown by the trend line.

Extending this further to critical analysis, the answers led the preservice teachers in two groups to question the credibility of trend line. One preservice teacher observed that the trend line was too ambitious, predicting a serious injury rate of about 100 by 2026. Two participants noted that the trend line started above the top of the bar in 2006 and sloped more steeply than the given figures indicated. Based on everyday knowledge and experience, one participant noted that injury rates were unlikely to constantly decrease, especially considering that they possibly corresponded to an increasing population. Engaging in the discussion, another participant volunteered that factors such as speed restrictions may bring about decreases in injury rates. Further thinking about the context led the preservice teachers to question the meaning of key terms such as *serious injury*, the definition of which would impact on the data collected. Notably, answering the last two questions on reading beyond data and critical analysis (Fig. 5), relied on knowledge of the context and of probability, and on a level of statistical understanding (Watson & Fitzallen, 2010; Woodward & Pfannkuch, 2007). The process involved critical analysis. For example, the participants attempted to investigate the credibility of messages presented in the text, credibility being one element of critical analysis referred to by Freebody and Luke (2003). In this case, the inclusion of the trend line had the potential to influence readers' ideas, possibly drawing readers to inferences that did not match the original data.

As stated by Serafini (2012), "the reader as interrogator must consider the production of images and multi-modal texts and the intended audiences for such texts when constructing meanings during the act of reading" (p. 160). This includes exercising critical analysis competencies, based on increasing realisation that the selection of data and choices made in representations may affect the perceived meaning of the visual. Messages in graphs are often not transparent, but are interpretations reliant on a hybrid of literacy practices, based on formal mathematical knowledge and prior knowledge of context. An in-depth understanding of such messages can be built through collaborative discursive practices that arise within classroom cultures. Illustrated in an example such as this, carefully chosen tasks can encourage learners to critically analyse graphs and visuals, with mathematical knowledge playing a role in the process of critical analysis.

The article and questions on injuries in Smithton is an example of a strategy that teachers can use to "guide the pedagogical setting towards situations in which statistically relevant aspects are discussed, such as posing questions related to the critical analysis of data" (Monteiro & Ainley, 2007, p. 189). In the above mathematical approach readers are encouraged to read the data, read between the data, and read beyond data (Watson & Fitzallen, 2010), the third category allowing for critical analysis. Monteiro and Ainley (2004, 2007) proposed that this strategy allows the contents of graphs to become more transparent to

learners, encouraging them to use their cognitive knowledge of graph structures, their knowledge of the context, and their beliefs. According to Monteiro and Ainley (2004, 2007), a combination of these contributed to meaning making and critical analysis of the graphs.

Further Discussion

Students require opportunities to engage with everyday text that reflects authentic cultural and social practices (Lemke, 2003), to aid them to efficiently utilise text that they encounter in everyday situations (Monteiro & Ainley, 2010). Engaging everyday examples can aid preservice teachers (and other students) to "become media detectives themselves, looking for cases of poor practice or reporting" (Watson, 2000, p. 5). Use of such text can aid them to uncover cases where text is written to influence ideas through presenting certain views and silencing others, for instance (Luke & Freebody, 1999).

In the current study, dialogue about the above-mentioned text depended on a deep engagement with the subtle meanings in the visual text by the preservice teachers. Elements of the dialogue reflected critical analysis, referring to the views portrayed in the text, the purposes, bias and misrepresentations, disguised information and specific emphasis, the author's background, and choices made when presenting the data. However, in general, the preservice teachers struggled to comprehensively critically analyse the text.

As evident in the examples, with focus on such media visuals and scaffolding from other students and the facilitator, the preservice teachers were encouraged to collaboratively construct knowledge of critical analysis practices relating to tables, graphs, and varied visuals. This aligns with the focus on critical thinking in contemporary education, a focus which is evident in work by educators (e.g., Freebody & Luke, 2003; Robertson & Hughes, 2011), and is highlighted in contemporary school curricula such as the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority, 2018a).

Evident in the examples, knowledge of specific metalanguage is important when describing and critically analysing such situations. For example, in the data on Olympic results, knowledge was needed of ideas such as authenticity, author's views, and exaggerated and silenced data. Discussion of the graph on the Public Health System, required knowledge of the language necessary to discuss random sampling and the choice of different categories.

As illustrated in the examples, mathematical knowledge is often crucial in terms of drawing deep understanding and critically analysing and describing such visuals and representations. This indicates the importance of extending preservice teachers' knowledge of mathematical ideas in order to scaffold their ability to critically analyse media visuals (as a first step towards them conveying such skills to their students). In this study, relying on mathematical ideas to analyse the text at times posed challenges to the preservice teachers. For example, an understanding of the importance of random sampling when collecting data is crucial in terms of critically analysing the messages in such presentations. Further, an understanding of the impact that the presentation of the data can have on the perceived meaning is also crucial in the critical analysis process. With input from others and guidance from the facilitator, discussion can be extended to factors including mathematical factors that can impact on the authenticity of messages presented in graphs and visuals, such as the factors outlined in Figure 1 and discussed in the above-mentioned examples.

Critical analysis competencies depend on a range of factors. Evident in these examples and in examples described by Monteiro and Ainley (2007), readers' prior knowledge of the real-world contexts and their personal beliefs aid critical analysis practices. Also apparent is the importance of cautious reading of all constituents of graphs and visuals, including titles, background (numbers, grid, legends or keys, pictures, colouring), labels, and

specifiers (visual dimensions e.g., bars or lines; Watson & Fitzallen, 2010). Integration of information from the entire text, together with familiarity with key words and mathematical concepts, are needed in terms of constructing a deep understanding of such text. This includes understanding of contextual and mathematical factors that contribute to biased representations. Readers may be intentionally or unintentionally misled by such representations. Misleading mathematical factors include factors linked to the collection and presentation of data, such as the period over which the data were collected, the type of representation used, and the numbering on the *y*-axis, some such factors discussed in this article and others discussed by Whitin and Whitin (2008). Further, insufficient detail is at times provided about the data collection, meaning that adequate understanding of the underlying deceptions in text may be difficult to achieve. Promoting an understanding of the factors that lead to deception in graphs and visuals has the potential to enhance critical analysis competencies, one element of developing deep understanding of text. However, extending understanding of factors that cause bias and misrepresentations may take time to develop, dependent on exposure to diverse learning experiences and contexts (Watson, 2015), and on knowledge of mathematical ideas.

The media resources selected in this study proved to be useful resources for the preservice teachers, providing opportunities for them to develop their ideas about critical analysis. This concurs with other studies that found such items to be useful resources for scaffolding preservice teachers' critical analysis competencies (Monteiro & Ainley, 2003, 2004, 2007; Robertson & Hughes, 2011). Notably, these examples illustrate the significance of mastery of critical competencies in terms of constructing a deep understanding of mathematical information presented in media text. Investigation of such text in instruction has the potential to enhance understanding of the mathematical messages depicted in visuals and of claims made about the visuals (see Watson, 2015), and place learners in a better position to draw deep understanding of both the mathematical content and its representation in text.

Examples of useful everyday resources include advertising, commercial, and political material, with relevant and current contexts, such as newspaper articles that present authors' agendas and overstated views designed to influence and engage readers. Designed to address purposes of profit or power (Robertson & Hughes, 2011), such text often contains deceiving parts, hence presenting opportunities for critical analysis. When carefully chosen, such everyday text provides opportunities to stimulate mathematically oriented debate and discussion and to enhance learners' competencies to view text critically, by reading beyond the data. In this way learners are prepared for a world in which they will be confronted with deceptive information (White, Mitchelmore, Wilson, & Faragher, 2009; Zammit & Downes, 2002) presented in the form of graphs and varied representations.

In answer to the research questions, the examples illustrate the importance of a focus on mathematical ideas and language when scaffolding critical analysis competencies, a deep understanding of media visuals and representations often being dependent on mathematical knowledge. In the examples, mathematical ideas were clearly crucial in terms of the preservice teachers' ability to navigate, make deep meaning of, and describe the given text. In many instances, the preservice teachers in this study required scaffolding to expand their critical competencies based on mathematical ideas. This indicates the importance of preservice educators endeavouring to aid their students to navigate such text, similar text commonly found in the media rich world.

The study exemplified the value of using visuals and representations from the media in teaching and learning, thereby scaffolding preservice teachers' ability to critically analyse text that they may encounter in society. Further the preservice teachers were in general enthusiastic about the possibility of including a focus on critical analysis in their teaching. In

fact, at least one of the preservice teachers trialled the example of the Olympic Game results in his teaching and spoke highly about the success of the activity, especially in terms of engaging the students. This is an example of a teacher conveying critical analysis skills to school students. The example suggests the value of using visuals and representations from the media as a means of developing critical analysis competencies in school classrooms.

Although the study addressed the research questions, the outcomes of the study are limited by the small number of participants and small amount of media text investigated, and the fact that the study was non-longitudinal. The results, do however, have the potential to aid understanding of the challenges faced by preservice teachers in the critical analysis of graphs and representations and the value of using media text in this regard. These results can be extended by further comprehensive studies on the topic.

Conclusion

The study drew attention to the importance of preservice teacher educators aiding preservice teachers to build critical analysis skills, first giving them a clear understanding of why this is necessary in contemporary times. Meaningful literacy activities that incorporate critical analysis are important because preservice teachers (and other learners) encounter everyday text that is not neutral, in newspaper reports, political circulars, and advertisements (O'Halloran, 2005; Watson, 2015). In particular, because graphs, tables, and other visuals in such text are designed for specific purposes, such visuals often portray an incomplete and prejudiced picture of situations (O'Halloran, 2005). In order to master deep understanding of the distracting and biased elements of such text, learners require enhanced knowledge of critical analysis practices (Freebody & Luke, 2003; Stack et al., 2010; White et al., 2009). Text, such as the examples discussed, can be used to aid preservice teachers (and other students) to develop a questioning attitude and to assist them to search for deep underlying meanings, fairness, truthfulness and bias. This needs to be combined with some emphasis on the mathematical factors that can lead to deceptive messages in graphs and visuals, since often mathematical ideas are interwoven with other ideas in the visuals and representations.

A focus on critical analysis offers a number of advantages to preservice teachers. It has the potential to expand their thinking from traditional rote and recall teaching and learning to more active participation (Robertson & Hughes, 2011), a better alignment with the current Australian Curriculum. Analysis of text from the media such as those described in the article has the potential to aid preservice teachers (and other students) to gradually move towards more competent use of graphs and visuals, a process that depends on knowledge of context and personal experience, and on conceptual understanding from the field of mathematics. Importantly, such activities are the foundation of competent use of text containing visuals and representations in society. Ultimately, such knowledge potentially places the preservice teachers in a better position to competently include a focus on critical analysis in their own teaching.

However, such teaching and learning poses challenges to preservice teachers. As suggested by Robertson and Hughes (2011), such pedagogy may be unfamiliar to them, as the skills and concepts required by preservice teachers are constantly changing. A focus on critical analysis also depends on particular resources and on students' knowledge of specific metalanguage to articulate critical ideas. Further, as evident in this study, deep critical analysis of graphs and representations from the media depends on an understanding of mathematical ideas and language. In order to overcome such difficulties, the study indicates that preservice teachers will need practice and guidance with myriad well-selected examples, with discussion that focuses on relevant metalanguage for critical analysis, as well as on

important mathematical ideas. This is a first step towards enhancing their ability to deconstruct the messages in media text, with the view to ultimately conveying critical analysis skills to their students.

Pedagogy based on such learning stands to enliven the classroom through discussion of interesting and controversial topics and topics that can be chosen to promote social action. Pedagogy with a focus on critical analysis has the potential to place preservice teachers (and hopefully their future students) in a better position to deeply analyse text that they encounter in everyday media.

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