CREATIVE STORY WRITING AND INTRODUCTORY STATISTICS LEARNING: UNLIKELY BED PARTNERS?

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ABSTRACT

This qualitative exploratory study examined non-statistics specialist students' perceived benefits and limitations of learning statistical concepts through creative story writing. Stories can be a powerful tool as it provides an opportunity for statistics learners to refine their statistical understanding in different contexts – ones that are relevant to their personal experience and interest. The added benefit of learning through creating stories is how it can shift the focus from dealing with numerical data and formulae exclusively to the meaningful application of statistical concepts. Interview and observation data involving seven social sciences undergraduate students at an English university revealed a range of perceived cognitive and affective benefits as well as some limitations of this innovative statistics learning approach.

Keywords: *Introductory statistics; statistical anxiety; creative story writing; picture book*

1. INTRODUCTION

A deficit in quantitative skills among UK university graduates has recently been highlighted as a major cause for concern. In its position statement, titled *Society Counts*, the British Academy (2012) - the UK's national academy for the social sciences and the humanities - expresses its deep concern in the UK's weakness in the quantitative skills, particularly of non-statistics specialist (NSS) students within the social sciences and humanities disciplines. The report also highlights how such deficit can have serious implications not only for the future of the UK as a world leader in research and higher education, but also for its graduates' employability and its economy's competitiveness.

While the focus of these aforementioned disciplines is not mathematical *per se*, the recent drive for research-based teaching in higher education (e.g. Jenkins & Healey, 2005) implicitly requires the students in these disciplines to be confident in using their quantitative, particularly statistical, skills, to help critically interpret statistical data (as reported in some articles within their field of study) and, where applicable, to help them quantitatively analyse data for their own research-based dissertation project.

However, as Hodgen, Pepper, Sturman and Ruddock (2010) point out, fewer than 20% of all upper secondary (post-16) students in England, Wales and Northern Ireland participated in some form of mathematics study, representing the lowest participation level across 24 advanced industrial nations (Hodgen et al., 2010). To make the matter worse, statistics teaching at university is not often delivered to students in a relevant and exciting way (British Academy, 2012). Taking into account these issues, it is hardly surprising that statistical anxiety among

university students, particularly those within these disciplines, has been widely reported (e.g. Arumugam, 2014; Lalayants, 2012).

As part of an effort to help make statistics learning more accessible and engaging for NSS students, the current study would like to draw the attention of the statistics education research community to an innovative statistics teaching strategy whereby students are encouraged to produce a creative story that incorporates a statistical concept in its storyline. Justification for this approach is provided in the following sections. It is worth pointing out here that the focus of this paper will not be on measuring the impact of this approach on students' statistics learning. This is something that will be done in the next phase of the study. Instead, the focus of this paper will be on qualitatively exploring NSS students' perceived benefits and limitations of the approach. It is hoped that their perceptions will help the researcher further develop a more refined approach for the next evaluative phase of the study.

2. LITERATURE REVIEW

2.1 STATISTICS EDUCATION

The research field of statistics education is primarily concerned with studies that aim to explore different ways to make statistics learning and teaching more effective, and in some cases, even more enjoyable. In relation to the current study, two key strands of relevant studies include those that focus on transferability of statistical knowledge, and those that focus on associating statistics learning with something lighthearted and enjoyable.

Concerning the former strand, Groth and Bergner's (2005) study in the USA, for example, investigated the role of metaphors in providing insights into students' statistical thinking. Whilst the focus of Groth and Bergner's (2005) study is on using metaphors to reveal pre-service elementary school teachers' understanding of *statistical sample* (e.g. "a sample is one toy off a toy shelf" (p. 34)), it can be argued that the underlying principle of using metaphors is deep-rooted in the concept of transferability which can be applied to any group of students and any statistical topic. Through the use of (judicial) analogy, Martin (2003) also demonstrates how transferability can be a powerful tool. He highlights that statistical concepts, such as *null hypothesis* can be compared to the judicial process where defendant is innocent, while *Type I error* can be compared to conviction of an innocent person, for example.

Concerning the second strand, Friedman, Friedman and Amoo (2002) argue for the use of humour in statistics teaching and learning. Specifically, they argue that humour can be used to build relationships and enhance communication between students and instructor, as well as can be used as a stress-reducing tool in statistics classes. Through interviewing 38 students who were randomly selected from those enrolled on a first-year Psychology course in Australia, Neumann, Hood and Neumann's (2009) use of humour was evaluated. It was found that "humor aided teaching by providing amusement, breaking up content, bringing back attention, lightening the mood, increasing motivation, reducing monotony, and providing a mental break" (para. 1). Interestingly, they also pointed out that "students that were already motivated and interested in statistics derived less benefit from humor, finding it at times irrelevant and distracting" (para. 1).

Whilst the aforementioned studies represent an attempt to make statistics learning more accessible and enjoyable, the current study would argue that the effectiveness of these attempts to improve statistics learning and teaching experience is limited due to their lack of emphasis

on embedding statistics learning in a relevant and meaningful context. This study thus sets out to explore the perceived benefits and limitations of getting students to write a lighthearted creative story whereby statistical knowledge and understanding are required to construct a storyline.

2.2 CREATIVE STORY WRITING AS A LEARNING TOOL

Drawing from Bruner (2003), Haven (2007) defines stories as "a detailed, character-based narration of a character's struggles to overcome obstacles and reach an important goal" (p. 79). Dismayed by the common perception that stories are a non-serious pedagogical tool, Haven (2007, p. 17) stated:

> Stories have been sidetracked into the kiddy corner and labeled, "just for fun". We believe that story is the opposite of logic, that stories aren't effective for conveying serious and important concepts. And without ever consciously pausing to consider either the veracity or implications of our assumptions, we set aside the most powerful communications and teaching tool available to humans and then idly wonder why our efforts to communicate and to teach concepts, ideas, beliefs, values, attitudes, and facts do not succeed.

Such view resonates that of Egan and Judson (2016, p. 4) who argue that "the old distinction of arts dealing with imagination and academic subjects dealing with reason has led to a neglect of engaging students' imaginations in learning academic subjects". This, they argued, acts as a key barrier to effective teaching and learning. The use of creative stories (whether as consumer or producer) thus has a great potential to bridge this gap.

The current study would argue that two key features underpin the creative story writing approach, namely 1) *transferability and knowledge application in meaningful context*, and *2) self-motivation through relevance of and emotional engagement in the story*. As highlighted by Groth and Bergner (2005) with metaphor and Martin (2003) with analogy, transferability one's (statistical) knowledge and understanding from, for example, statistics textbooks (context-free) to their own story (context-rich) encourages them to first think carefully about what the concepts are, and then engage in higher order thinking by applying the concepts in a meaningful context. This process is crucial as Tannen (1999, as cited in Haven, 2007, p. 64) argues that "Story merges abstract information with common sensory details to create context and relevance for the abstract". Both context and relevance, as Haven (2007) argues "trigger the conscious mind to pay attention and to remember" (p. 64). Additionally, when learners get to think of a context or storyline for their own story, they are more likely to be engaged and self-motivated in their own learning process and become more emotionally invested not only in the story (Egan & Judson, 2016), but also in the ownership of their knowledge construction.

Attempts have been made to bridge this artificially constructed and misguided polarization between imagination and cognition. For example, Takahashi's (2008) *'The Manga Guide to Statistics'* and, more recently, Field's (2016) *'An Adventure in Statistics: The Reality Enigma'* have both shown that introductory statistics textbooks can also be fun and full of stories with meaningful situations in which statistical concepts can be applied. It may be worth pointing out that these texts are vastly different from, for example, Gonick's (2000) *'Cartoon Guide to Statistics'* and Klein's (2013) *'The Cartoon Introduction to Statistics'*, which are essentially

illustrated statistics textbooks, peppered with cartoon characters with no storylines or plots.

At the school level, the Hong Kong Statistical Society, for example, has been organising the Statistics Creative-Writing Competition (SCC) for secondary school students in Hong Kong since 2009, with all the winning entries in each year being collated as a single on-line publication, available for download freely on its website (www.hkss.org.hk/index.php/scc$en). This is an important signal by a well-respected and established statistical society, supporting the integration of creative story writing and statistical learning.

In terms of research, to the best of the author's knowledge, only one small empirical study has been conducted to explore the potential benefits of using creative stories in statistics learning. The study, by D'Andrea and Waters (2002), set out to examine how short stories can be used to reduce statistical anxiety among her 17 graduate Education students enrolling on an introductory statistics course in the USA. Using the Statistical Anxiety Rating Scale (STARS), the survey results showed that the students' anxiety towards the statistics course steadily declined when their ratings before and after the course were compared. However, one key limitation of this study is how the short stories were written by the researchers (i.e. the course instructors) themselves, as opposed to providing an opportunity for the students to create their own stories – a shortfall that the current study aims to address.

3. THEORETICAL PERSPECTIVES

This study argues for a statistics teaching and learning strategy that is grounded in the intersection of two theoretical perspectives, namely Donaldson's (1987) concept of *embedded thinking* and Papert's (1993) theory of *constructionism*.

The importance of embedding learning in a meaningful context has long been advocated by key developmental psychologists, such as Donaldson (1987). Using the concept of *embedded thinking*, she argued that learners are more competent when their thinking takes place in an embedded context or one which makes *human sense* than when their thinking takes place in disembedded contexts which are devoid of any meaningful context. This latter type of thinking was referred to as *disembedded thinking* or "thought that has been prised out of the old primitive matrix within which originally all our thinking is contained" (p. 76). In the context of mathematics (and hence statistics), Egan (2005) refers to this process as *humanizing* whereby "putting content much more into the lives of people than is currently normal, bringing out the fact that all the […] math we know was discovered or invented by someone for some human purpose" and ultimately "placing it in the context of others' lives for whom it had emotional meaning" (p. 120). The emphasis on embedding statistical concepts in a meaningful context thus features prominently in the current study's proposed strategy.

Additionally, the current study is also largely influenced by Papert's (1991) theory of *constructionism*. Unlike constructivism, *constructionism* places a great deal of emphasis not only on internationalization, but also the process of *externalization*. More specifically, constructionists argue that construction of knowledge takes place both *in the head* (internalization) and supported by "construction of a more public sort 'in the world'" (externalization), whereby learners creating *a public artefact* of what they know that can be "shown, discussed, examined, probed, and admired" (Papert, 1991, p. 142). In turn, this process helps to shape and sharpen the knowledge (Ackermann, 2001). In the context of the current study, such public artefact is the story created by the learners where knowledge and

understanding of the assigned statistical concept is first required before applying such knowledge and understanding to construct their storyline.

4. THE CURRENT STUDY

The current study is exploratory in nature, and it sets out to investigate perceived benefits and limitations relating to the use of creative story writing to learn introductory statistics. To achieve that goal, perceptions of NSS undergraduate students were explored. More specifically, the key research question asks: *What are non-statistics-specialist undergraduate students' perceptions of key benefits and limitations of learning and teaching introductory statistics through creative story writing?*

5. METHODOLOGY

5.1 RESEARCH DESIGN

This study is predominantly qualitative, reflecting a recent call from the research field of statistics education and cognition to move beyond it being a purely quantitative field (Groth, 2010; Kalinowski, Lai, Fidler & Cumming, 2010).

The data collection took place in May and June 2016, and it primarily involved semi-structured interviews with first-year undergraduate NSS students within the social sciences discipline. To allow the students to form well-developed perceptions of the approach, they were asked to attend a three-hour session where they mostly worked in pairs to independently research a given statistical concept for the first 30 minutes. This independent learning was supported by making a range of introductory statistics textbooks available to them during the session. They were also encouraged to watch tutorial videos available on Youtube on their electronic devices. For the remaining 2.5 hours, they were then asked to collaboratively produce a creative story to illustrate that concept. Before they started creating the story, the participants were asked to vote on the format of their story output, and everyone voted for the picture book format, over two other choices, namely the graphical novel and the story book formats. Audio recordings were made of each team's discussion whilst they were working on separate tables. A week after the session, each team was interviewed separately and they were asked to reflect on their own experience of using creative story writing to learn introductory statistics at the interview. Together with the stories produced, these multiple sources of data were used as a form of triangulation to maximise the degree of reliability in the analysis.

Standard deviation, as a measure of variability, was chosen as an introductory statistical concept for the participants to base their story on. This was due to its importance as a building block to more advanced statistical knowledge, such as sampling distributions, inference, and p-values (delMas & Liu, 2005).

5.2 SAMPLING STRATEGIES AND SAMPLE SIZE

Three layers of sampling strategies were adopted in this study. Firstly, non-random convenience sampling was employed to choose the department(s) and the university the researcher drew the data from. Due to it being convenience sampling, limitations of the study (e.g. its inability to generalize its findings) are fully acknowledged. The university is a large

public research-intensive university in the south east of England, and the two social sciences departments initially approached were Education and Psychology. However, no students in the Psychology department expressed their interest in being part of the study, so only Education students were recruited.

The student participants were in their first year of a 3-year undergraduate primary teacher training degree that offers four specialisms: Mathematics, English, Art and Music. An e-mail was first circulated to all Year 1 students in the programme (N=67; Male = 8, Female = 59) inviting them to participate in the study. For this stage, non-random purposive sampling strategy was used to ensure that students with Mathematics or Statistics post-16 academic qualification (commonly referred to as *A Level* in England) were excluded in the selection. This resulted in students doing the Mathematics specialism on the programme being excluded in the study as one of their admission requirements is to have secured Grade A or B in either A Level Mathematics or Statistics.

Of the 15 students who had expressed that they would like to be part of the study and who met the selection criteria, six were chosen using non-random purposive sampling strategy to ensure a fair representation of both gender and specialisms. Consequently, three male and three female students with two students from each of the three remaining specialisms were chosen. (While female students outnumbered male students on the Education programme, this is not necessarily the case for other social sciences departments. Thus, proportional allocation was not adopted here as the focus is not necessarily specific to Education students). One of the male students, Ryan (pseudonym) did not confirm his participation by the agreed deadline, prompting the researcher to recruit an additional student, Olivia, as no other male students were available. Thus, a total of 7 students attending the session. Ryan also did not turn up for the scheduled interview, resulting in having interview data from only 6 students.

5.3 PARTICIPANT CHARACTERISTICS

Students were split into two pairs and one triad: Team 1 (all male students) with Jim and Dylan, Team 2 (all female students) with Maria and Sarah, and Team 3 (mixed) with Rosie, Ryan and the additional student - Olivia. The justification for including both single-sex pairs and a triad of male and female students in the study was to minimise any impact certain type of pairing could have on the learning experience, and hence the students' perceptions. All are English native speaking students of Caucasian origin, aged ranging from 18 to 19 years old.

5.4 DATA ANALYSIS

Due to the study being exploratory in nature and not aiming to test any particular existing theory, an inductive thematically-coded approach to qualitative data analysis was adopted. Audio recording transcripts of both the group discussions during the session and of the interviews after the session were read and reread to identify emerging themes. The process was done manually without the use of any software. The researcher alone did the coding, and thus fully acknowledges the limitation this presents in terms of the reliability of the analysis.

5.5 ETHICAL CONSIDERATION

This study received an ethical clearance from the Ethics Committee of the University of Reading's Institute of Education. The director of the programme and the students were given full information about the project. They were asked to sign the consent form should they wish to be part of the study and were fully informed that they could withdraw from the study at any point. To protect the participants' identity, pseudonyms were used to report the participants' views. After the data collection stage was completed, each student was given a £20 Amazon voucher to thank them for their time.

6. RESULTS

As previously mentioned, this study sets out to explore NSS undergraduate students' perceptions of key benefits and limitations of learning and teaching introductory statistics through creative story writing. Before the findings are presented and discussed, it is worth briefly describing the nature of the stories the three teams of students created during the session.

Team 1 (Jim and Dylan) created an 8-page picturebook, called 'Examination Deviation' (see Appendix A), which is about a teacher, named Mr. Smith, who wanted to find out the spread of test scores of his two statistics classes. He wanted to do this so that if the spread of scores was found to be very large in one of the two classes, he would then have to change his groupings around to minimise the learning achievement gap within each class. The researcher felt that not only this team was able to show how to correctly calculate standard deviations, they also did well in coming up with a meaningful context where the knowledge of standard deviation would be useful. The context was very relevant to both Jim and Dyland as they were trained to become a teacher. That said, a visual representation of the concept would have strengthened the quality of their picturebook further.

Team 2 (Maria and Sarah) created an 8-page picturebook, called 'The League of Pirates' (see Appendix B), where there were two teams of six pirates each, and these teams were The Ferocious Ocean Warriors and The Mighty Sea Sharks. Each team worked towards collecting 200 coins on average as a group. In addition to working out the average number of coins collected for each group, Maria and Sarah also showed how standard deviation could be calculated, and revealed that not only The Ferocious Ocean Warriors, on average, collected more gold coins (202.5) than The Ferocious Ocean Warriors (190), the spread of the data points of the former team was also larger than that of the latter team. The researcher felt that, while the team was able to show how standard deviation was correctly calculated, the story could have made it more explicit why having standard deviation, in addition to the average scores, might be useful. An attempt was also made to visually show the spread of the data points.

Team 3 (Rosie, Ryan and Olivia) created a 5-page picturebook, called 'The Standard Awakening' (see Appendix C), which is about a teacher (no name given) who had to soon teach the concept of standard deviation to his class, but was not sure what it is about. His colleague, Jeeves, offered to help by reminding the teacher of a sports day where the two of them and another colleague, Larry, won different numbers of medals on the day, and how the standard deviation ("simply how far away from the mean our scores are") was quite large. This, according to Jeeves, meant the results became "less predictable". Unlike the other two teams, while Team 3 showed the formula to calculate the standard deviation, they did not show how

to then calculate it step by step. Similar to Team 2, an attempt was also made to visually show the spread of the data points.

6.1 PERCEIVED BENEFITS

Perceived Cognitive Benefits

Drawing from the analysis of the interview data from the students, four key cognitive skills were reported to have been developed as a result of the creative story writing approach, namely *understanding, application, visualization* and *communication*. The interview questions used to stimulate the participants' responses include "What are some of the key aspects of using creative story writing to help with your statistics learning that you really like?", "To what extent has the creative story writing helped you learn (or consolidate your understanding of) standard deviation? Please explain." and "To what extent has the creative story writing helped to make statistics learning more engaging and less scary for you? Please explain." In relation to the two latter questions, the emphasis was on "To what extent" to help ensure that the questions did not lead the participants to give a particular answer.

Concerning ***understanding***, in order for the participants to come up with a storyline, they first had to understand what the given statistical concept (standard deviation) was. For example, Rosie explained that "The process helped me because I had to concretely understand what the statistical concept was and what misconceptions there may be before we started writing the book". This resonates well with Dylan's view as he stated that "I think it helps because you have to completely get every single step of it … know how to do it … you will have to go over it all before you were able to even start thinking about how could we use this in the task [story]".

Application is another key cognitive skill put forward by the students. Using creative story writing to learn statistical concepts requires learners to think carefully of a meaningful and purposeful context in which the concepts can be applied. This encourages them to contextualise statistical concepts. Dylan, for example, explained that "figuring a story that would fit around it […] makes you think about how could I use it in real life – where it would be applicable. I think […] having to put it in the story helps you understand it quite a lot." Such view is also echoed separately by Maria who stated that: "having to work out a context for the story where there would be a need to use standard deviation further helped. […] If it doesn't have a context, it doesn't really make sense. It's harder to understand it". From the observation, the following extract of a dialogue between Jim and Dylan best demonstrates this point:

Jim: Mr. Smith's marking two classes' test scores.
Dylan: Yeah, you'll get a lot of results then. […] And he wants to find out … […] Which group has done better?
Jim: Is it … It's not which has done better though. It's which …
Dylan: Oh it's which …
Jim: Which group's results are closest together? So do we know why they try to work it out?
Dylan: Yeah why do they do it in here? [referring to the storyline found in the statistics comic book] I'll have a look at the cartoon one [the statistics cartoon textbook].

Jim: I suppose it shows … that way I can … to see who's far away from the average, isn't it?
Dylan: To see whether it was more consistent or whether there were spikes which spikes it up.
Jim: So yeah, that way I can see if the group results are scattered. If they were scattered, then he may have to change his groupings around [to ensure that both groups are similar in ability levels].

The dialogue above illustrates how Jim's and Dylan's conceptual understanding of standard deviation was arguably developing through their discussion about the context for and application of the concept. Thus, allowing students to select a context that makes sense to them is key.

As previously mentioned, all participants voted to present their story in the picturebook format. Whilst originally not central to the key research question, several participants cited the benefits of the format, particularly ***visualization***, as contributing to the development of their understanding of standard deviation. More specifically, the students themselves highlighted how the format encourages them to think about how statistical concepts can also be represented visually through illustrations. Jim explained that "I think it gives you different ways to learn because you might be a visual learner. The pictures will help", highlighting how producing creative story in the picture book format could cater for diverse learning styles. As noted at the beginning of this section and as can be found in Appendixes 2 and 3, both Teams 2 and 3 attempted to visually represent the spread of data through page illustrations.

Finally, ***communication*** – another key cognitive skill that came up several times in the interview with the students. This is primarily concerned with how the creative story writing approach explicitly requires authors to break down the concept and communicate it to their readers. Jim, for example, explained that "It's also about breaking it down into a narrative that other people can understand because you write it for other people, so you have to … not dumb it down … but you would certainly break it down, and I think it helps you understand it that way". For Maria, she linked this aspect of the approach to teaching: "You're *teaching* it and you remember it better when you're trying to teach something rather than when you're just listening. We're writing a story to teach other people what it was".

As noted earlier in this paper, this phase of the study is not concerned with measuring the impact, if any, of creative story writing (as a statistics teaching approach) on the development of students' statistical understanding. However, when definitions of standard deviation, as given by the students themselves at the beginning and at the end of the session, were examined, it is interesting to note that their understanding of the concept evidently became more refined over the course of the three-hour session, as Table 1 illustrates below. Granted that it is impossible to make any claims about the development of students' statistical understanding without using well-tested tools, such as the Comprehensive Assessment of Outcomes in a First Statistics course (CAOS). However, it is hoped that the content of Table 1 offers a glimpse into what the students knew about standard deviation before and after they learned the concept using the creative story approach.

Table 1. Students' definition of standard deviation before and after the session

Students	Pre-session Definition	Post-session Definition
Team 1		
Jim	"I recognise the phrase, but I don't know what it means or what it is."	"It is the scattering of data and shows the deviation from the mean result of a group."
Dylan	"I know nothing."	"The concept used to tell how close results were together, with the lower number being the closer together."
Team 2		
Maria	"The measure of the spread of the data."	"The measure of the spread of data – how far the data is away from the average."
Sarah	"I don't know."	"Finding the distribution of a set of data."
Team 3		
Rosie	"How far the results deviates from the mean."	"How far the scores deviate from the mean of the scores. The larger the standard deviation, the less 'predictable' the scores are and they are classed as unusual or unpredictable."
Ryan	"I don't know."	"It is the average distance between each result in the most specific way possible."
Olivia	"I don't know."	"To find the average distance between a collection of results, using the mean result. It enables you to gain a clear representation of a whole collection of data, without one extreme result impacting it overall."

The majority of the students were not familiar with the concept of standard deviation at all before the study. More specifically, when asked to define standard deviation at the beginning of the session, everyone – except Maria and Rosie – either wrote "I don't know" or "I know nothing". Maria wrote "The measure of the spread of the data", and Rosie wrote "How far the results deviates from the mean", demonstrating that only two students had some basic understanding of the concept. Interestingly, the participants who were not at all familiar with the concept prior to the session were later able to articulate that standard deviation measures the spread of the different data points in relation to their mean average. While the definitions offered by Sarah and Ryan did not make clear the relationship between the data points and their mean average, it can be argued that their understanding is still emergent. Even for Maria and Rosie who already had some understanding of the concept prior to the session, the definition of the concept that they offered after the session was more detailed.

Perceived Affective Benefits

Different aspects of the story writing approach were highlighted by the participants as helping to make statistics learning more engaging. Rosie, for example, pointed out that "Personally, maths has always been my nemesis, so for me [the story writing] puts maths and statistics in a lighter viewpoint rather than being factual and quite off putting". Similarly, Olivia – echoing Egan and Judson's (2016) – found herself fully engaged in the process as she

explained that:

> Before the session, the thought of statistics was fairly scary to me and seemed like something I would struggle to engage with. […] But, as the story writing process began, I was able to view standard deviation from a less scary lens. Before I realised, I was fully engaged with the story writing activity, rather than focusing on how scary the topic was initially.

Through its hands-on approach, Sarah and Jim commented about how the story writing approach helped to make them more engaged in statistics learning than they would otherwise be in traditional lectures. Sarah, for example, highlighted that:

> The activity was enjoyable and therefore more engaging than if I'd just read about standard deviation in a text book or been told about it in a lecture. Being able to have fun with it and produce something creative helped me to really get into it and actually want to pay attention to getting it right.

Jim also highlighted how learning statistics through story writing is more enjoyable and less scary when "you've got a picture involved for a start and you're making a narrative". This resonates well with Maria's view. Not only did she attribute the positive statistics learning experience to the story writing, Maria also attributed it to the picture book format specifically, as she explained "Picture books are also associated with happiness and adventure and putting statistics into a picture book can make statistics seem more exciting". Her view emphasises how the combination of story writing and the picture book format seems to compliment each other quite well.

The way these students described statistics and its learning in itself is revealing: *'nemesis', 'scary', 'factual', 'struggle', 'complicating', 'mundane'* and *'off putting'*. These choices of words arguably highligh how disengaged these students would have carried on feeling towards the subject had it not been because of the story writing approach to learning statistics. When examining how the same students described statistics and its learning using the story writing approach, the positive attitudes towards statistics learning became apparent: *'fun', 'fully engaged', 'more exciting', 'creative', 'more engaging', 'more accessible', 'immersed', 'more switched on', 'lighter viewpoint'* and *'your own knowledge'*. These participants' views arguably illustrated the change of their self-reported attitudes towards statistics learning.

6.2 PERCEIVED LIMITATIONS

To address this aspect of the research focus, the interview participants were also asked the following question: "What are some of the key aspects of using creative story writing to help with your statistics learning that you don't really like?". Sarah, Dylan and Jim said none, while Maria, jokingly, said she wished she and her team partner could have more time to work on their book. Olivia said she found coming up with a storyline for the standard deviation concept somewhat challenging, while both her and her partner (Rosie) said they found having to communicate the concept of standard deviation in an accessible manner to their readers difficult. To a large extent, one might argue that the points raised by Olivia and Rosie are not specific to learning statistics through the creative story writing approach, and that these issues

could simply be a reflection of their emergent understanding of standard deviation. It can be argued that the more they understand the concept, the easier it would be for them to try to explain the meaning of the concept in an accessible manner, and the easier it would be for them to try to think of a context in which the concept could be meaningfully embedded in.

When all the students were further prompted by the researcher if they thought the approach could be perceived as off-putting to any particular groups of students, Rosie and Sarah stated that the approach might put off some people who did not view themselves as being "artistically gifted", while Olivia explained "naturally mathematically minded students or people who are comfortable and engaged with statistics already, may become frustrated with the act of writing a story". For Maria, Dylan and Jim, they did not believe that any particular group of students would be against the approach.

Building on this previous question, the students were further asked if university students in general might find learning statistics through producing a creative story in the picturebook format somewhat patronizing. Rosie, Jim and Dylan said some students in a "straight math degree" might find the approach a bit "degrading" or "childish". However, they all also agreed that once they give it a go, they would accept it as Dylan put it: "When they just saw 'Oh it's picture books' … I'm not sure they'd be too keen. But once you look at it in a bit more detail, I think they'd use it." Similarly, Maria said "Once they get started, everyone would really get into it. It's sufficiently challenging as you try to fit it [the statistical concept] in a story book and makes it make sense to other people." Olivia succinctly articulated her view by stating that:

> I believe that if you do not understand something, your stage in life or study is irrelevant. It always remains important to break a new topic down into simple terms and build understanding up from there. The picture book idea does not have to be a childish theme, it can use language that applies to an older or more academic audience, at the same time as supporting the learning of a new topic.

Finally, the students were asked if male and female students would enjoy the approach equally or whether one might prefer the method less than the other, everyone agreed that they believe both male and female would enjoy the approach equally. In particular, Olivia stated that:

> Although different genders may naturally lean towards slightly different themes within their stories (as with all individuals) the activity itself remains the same. It allows all pupils to write about something they are interested in.

7. CONCLUSIONS

7.1 KEY FINDINGS

Overall, the approach, according to the students, appears to make use of four key cognitive skills, namely *understanding, application, visualization* and *communication*, and these are labelled as *perceived cognitive benefits*. Concerning ***understanding***, in order for the participants to come up with a storyline, they first had to understand what the given statistical concept (standard deviation) was. ***Application*** is another cognitive skill that is put forward by the students. Using creative story writing to learn statistical concepts requires learners to think carefully of a meaningful and purposeful context in which the concepts can be applied. This

encourages them to contextualise statistical concepts, and highlights the role of what Donaldson (1987) referred to as *embedded thinking*. The students themselves highlighted that the picturebook format encouraged them to think about how standard deviation could be represented visually through illustrations. This is particularly relevant when ***visualization*** is often seen to be a key mode of representation that can help learners develop their mathematical and statistical understanding (e.g. Bruner, 1966; Haylock, 1982; Haylock, 1984; Haylock & Cockburn 2013). Finally, ***communication*** is another key cognitive skill that came up several times in the interview with the students. This is primarily concerned with how the creative story writing approach explicitly requires authors to break down the concept and communicate it to their readers.

Equally important, the students reported that the creative story writing approach motivated them to engage in learning introductory statistical concepts, as this is labelled as *perceived affective benefits*. The students particularly enjoyed incorporating humour in their storyline and page illustrations. The fact that laughter could be heard throughout what was essentially a statistics lesson was very encouraging as it demonstrates that it is entirely possible to have an enjoyable statistic teaching strategy that, according to the students, also helped them learn an introductory statistical concept. This is in line with the findings of Neumann et al.'s (2009) study that found students to be more motivated in their statistics learning process when they were able to include humour in their statistics learning.

Finally, concerning perceived limitations of the approach, there were no particular issues raised, except how some participants believed that students on a mathematics degree might find the approach somewhat off putting. Since mathematics- and statistics-specialist students have never been the target audience of this approach anyway, the study would argue that this concern and perceived limitation is not relevant to the research focus of this study.

7.2 IMPLICATIONS FOR FUTURE RESEARCH

It would also be of interest to investigate the perceptions of learners with special learning needs, such as those with Dyslexia and, in the context of English-speaking countries, those learners with English as an additional language, to see if they find any particular aspect(s) of the approach challenging for them, and how those issues could be addressed. This is particularly important if inclusivity is to be ensured in statistics classrooms.

Additionally, as the majority of the students have chosen to consult Takahashi's (2008) *'The Manga Guide to Statistics'* over other more 'standard' introductory textbooks made available to them during the session. It would be useful to explore, in future studies, what are some of the key characteristics of this type of statistics comic or graphic novel that makes them a preferred choice for NSS students, and to establish empirically whether it is more effective in helping students to grasp introductory statistical concepts.

7.3 IMPLICATIONS FOR PRACTICE

The study highlights the potential benefits of using creative story writing, particularly in the picture book format, as an alternative introductory statistics teaching tool for NSS students. According to the participants in this study, such benefits are thought to be both cognitive and affective in nature. Additionally, whilst the students in this study were undergraduate students, this study would argue that both high school and postgraduate students could also find the

approach beneficial.

7.4 LIMITATIONS OF THE STUDY

The participants in the current study created their story in an arguably clinical setting, as opposed to their authentic learning experience. Additionally, it is important to remember that these participants chose to be part of the study and each was also offered a £20 Amazon voucher. Taken together, it can be argued that the views and attitudes of this group of participants might be potentially different from those who are required to engage in creative writing as part of their course, with no monetary rewards for their involvement. Thus, any findings emerge from this study must be treated with caution, and this highlights the need for this study to be replicated in an authentic learning environment.

Additionally, as the students created their story collaboratively with a partner(s), this obviously raised the issue of confounding impact on their perceptions. The researcher fully acknowledges that any perceptions reported in this paper could be a consequence of students learning statistics collaboratively with their peers, as opposed to them being a consequence of learning statistics through creative story writing. For future studies, it will be useful to include participants who produce a story independently as well to address this issue.

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REFERENCES

Ackermann, E. (2001). *Piaget's constructivism, Papert's constructionism: What's the difference?* Cambridge, MA: Future of Learning Group.

Arumugam, R. N. (2015). Student's attitude towards introductory statistics course at public universities using partial least square analysis. *Interdisciplinary Journal of Contemporary Research in Business,* 6(4), 94-123.

British Academy (2012). *Society counts.* London, UK: British Academy.

Bruner, J. (1966). *Towards a theory of instruction*. Cambridge, MA: Belkapp Press.

Bruner, J. (2003). *Making stories: Law, literature, life*. Cambridge, MA: Harvard University Press.

D'Andrea, L., & Waters, C. (2002). Teaching statistics using short stories: Reducing anxiety and changing attitudes. In B. Phillips (Ed.), *Developing a statistically literate society: Proceedings of the Sixth International Conference on Teaching Statistics*. Voorburg, The Netherlands: International Statistical Institute.

delMas, R., & Liu, Y. (2005). Exploring students' conceptions of the standard deviation. *Statistics Education Research Journal*, 4(1), 55-82.

Donaldson, M. (1987). *Children's minds.* London, UK: Fontana Press.

Egan, K. (2005). *An imaginative approach to teaching*. Danvers, MA: Jossey-Bass.

Egan, K., & Judson, G. (2016). *Imagination and the engaged learner: Cognitive tools for the classroom*. New York, NY: Teachers College Press.

Field, A. (2016). *An adventure in statistics: The reality enigma*. London, UK: SAGE.

Friedman, H. H., Friedman, L. W., & Amoo, T. (2002). Using humor in the introductory statistics course. *Journal of Statistics Education*, 10(3), http://www.amstat.org/publications/jse/v10n3/friedman.html

Gonick, L. (2000). *Cartoon guide to statistics*. New York City, NY: William Morrow.

Groth, R. E. (2010). Situating qualitative modes of inquiry within the discipline of statistics education research. *Statistics Education Research Journal,* 9(2), 7-21.

Groth, R. E., & Bergner, J. A. (2005). Pre-service elementary school teachers' metaphors for the concept of statistical sample. *Statistics Education Research Journal*, 4(2), 27-42.

Haven, H. (2007). *Story proof: The science behind the startling power of story*. Westport, CT: Libraries Unlimited.

Haylock, D. (1982). Understanding in mathematics making connections. *Mathematics Teaching*, 98, 54-56.

Haylock, D. (1984). A mathematical think board. *Mathematics Teaching*, 108, 4-5.

Haylock, D. & Cockburn, A. (2013). *Understanding mathematics for young children*. London, UK: SAGE.

Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010). *Is the UK an outlier? An international comparison of upper secondary mathematics education*. London, UK: Nuffield Foundation.

Jenkins, A., & Healey, M. (2005). *Institutional strategies to link teaching and research*. York, UK: The Higher Education Academy.

Kalinowski, P., Lai, J., Fidler, F., & Cumming, G. (2010). Qualitative research: An essential part of statistical cognition research. *Statistics Education Research Journal,* 9(2), 22-34.

Klein, G. (2013). *The cartoon introduction to statistics*. New York City, NY: Hill and Wang.

Lalayants, M. (2012). Overcoming graduate students' negative perceptions of statistics. *Journal of Teaching in Social Work*, 32(4), 356-375.

Martin, M. A. (2003). "It's like... you know": The use of analogies and heuristics in teaching introductory statistical methods. *Journal of Statistics Education*, 11(2), www.amstat.org/publications/jse/v11n2/martin.html

Neumann, D. L., Hood, M., & Neumann, M. M. (2009). Statistics? You must be joking: The application and evaluation of humor when teaching statistics. *Journal of Statistics Education*, 17(2), http://www.amstat.org/publications/jse/v17n2/neumann.html

Papert, S. (1991). Situating Constructionism. In I. Harel & S. Papert (Eds.). *Constructionism*. Norwood, NJ: Ablex Publishing.

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer*. New York, NY: Basic Books.

Takahashi, S. (2008). *The manga guide to statistics*. San Francisco, CA: No Starch Press.

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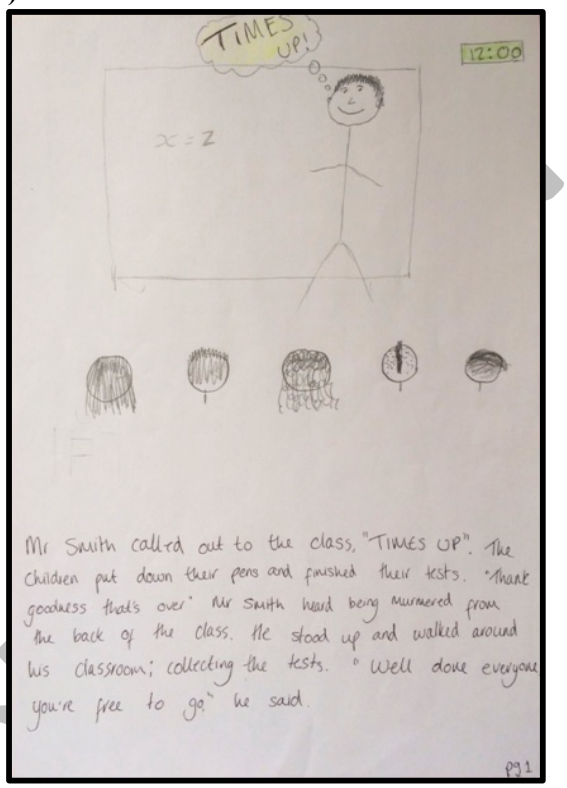
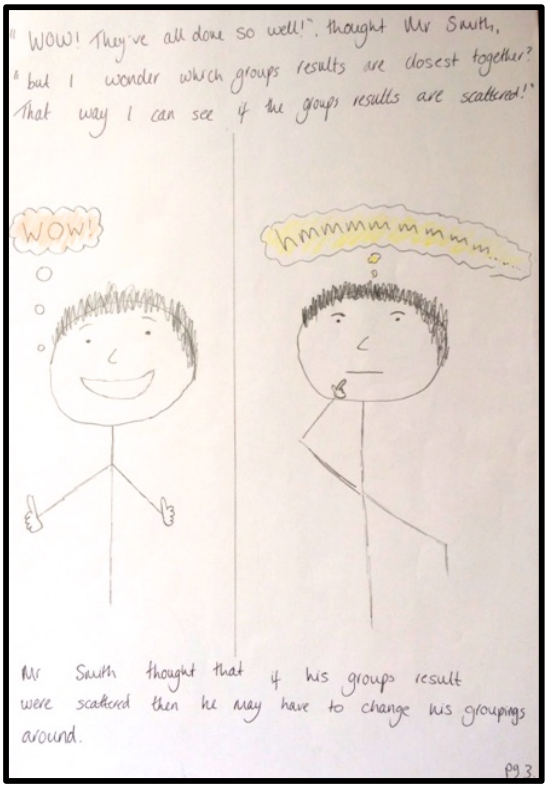
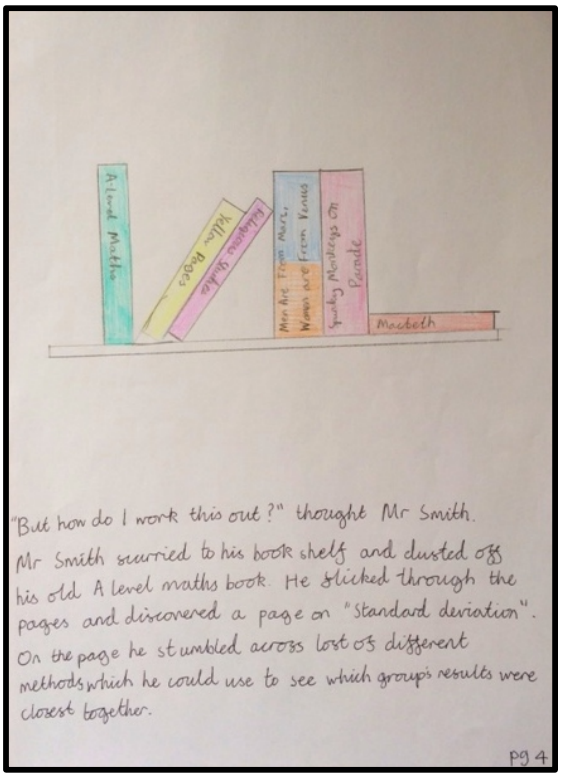
APPENDIX A (An example of the story by Jim and Dylan)

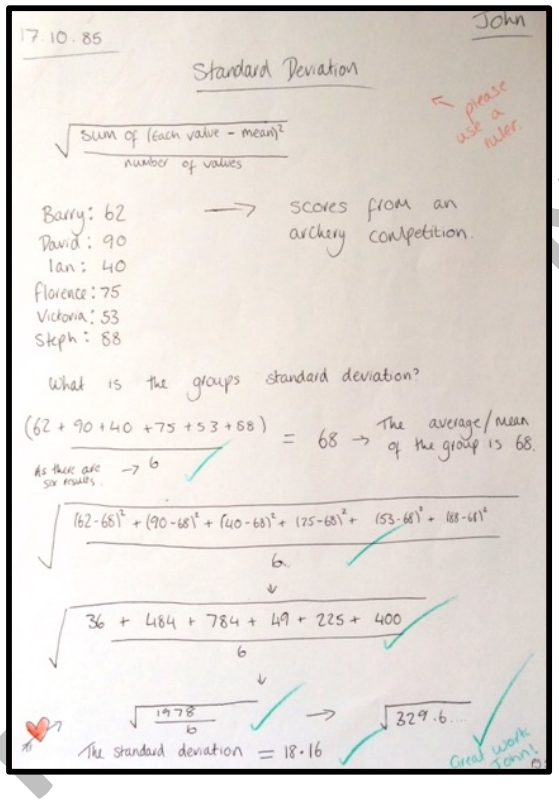




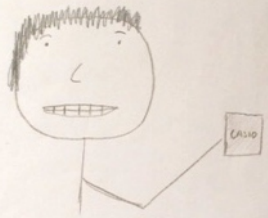


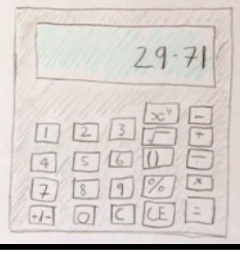
"But how do I work this out?" thought Mr Smith.
Mr Smith scurried to his book shelf and dusted off his old A level maths book. He flicked through the pages and discovered a page on "standard deviation". On the page he stumbled across lots of different methods which he could use to see which groups results were closest together.

pg 4



Using this formula, Mr Smith worked out the two groups standard deviation. First he worked out each groups mean result. Next he subtracted this mean result from each of the childrens results. Following this he squared these results and added them together. He divided this total by 6 and found the square root of this total. He divided it by 6 as there were 6 children in each group.





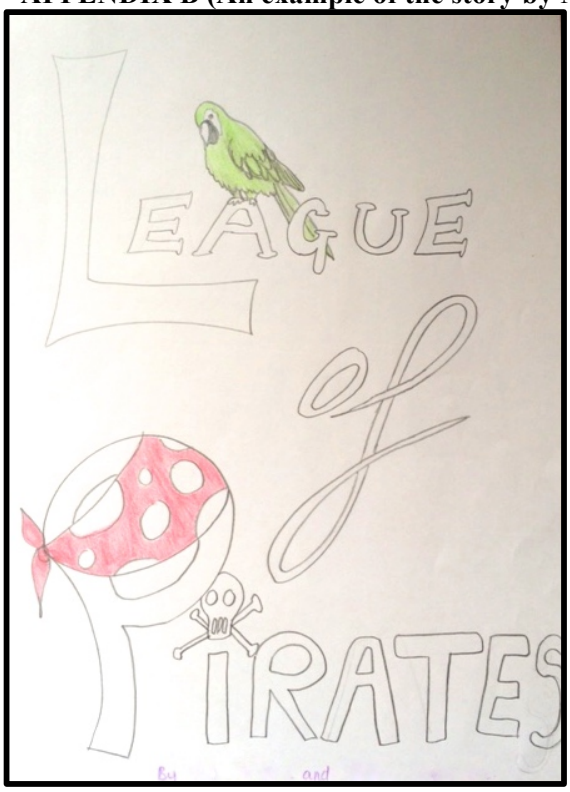
pg 6

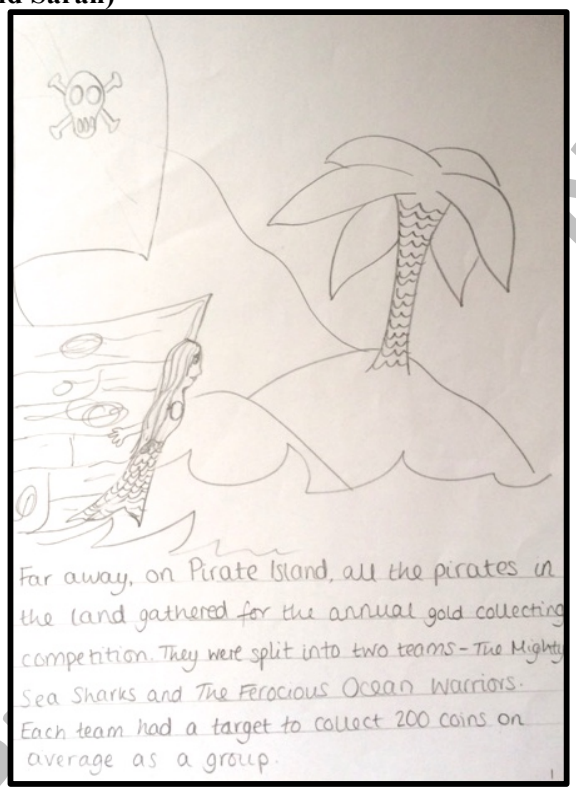
Mr Smith was shocked by the results!

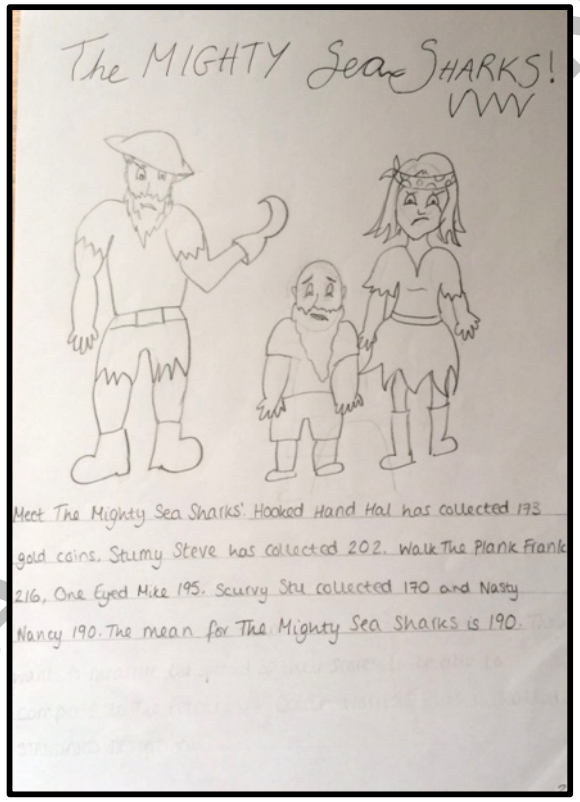
Red group had a very small standard deviation of 7.33, whereas green group's deviation was much higher at 29.71. "Blimey!", thought Mr Smith, I guess I'll need to swap some members in green group around." He packed up the tests, finished his cup of tea and hit the hay, dreaming of what tomorrow's maths lesson may bring.

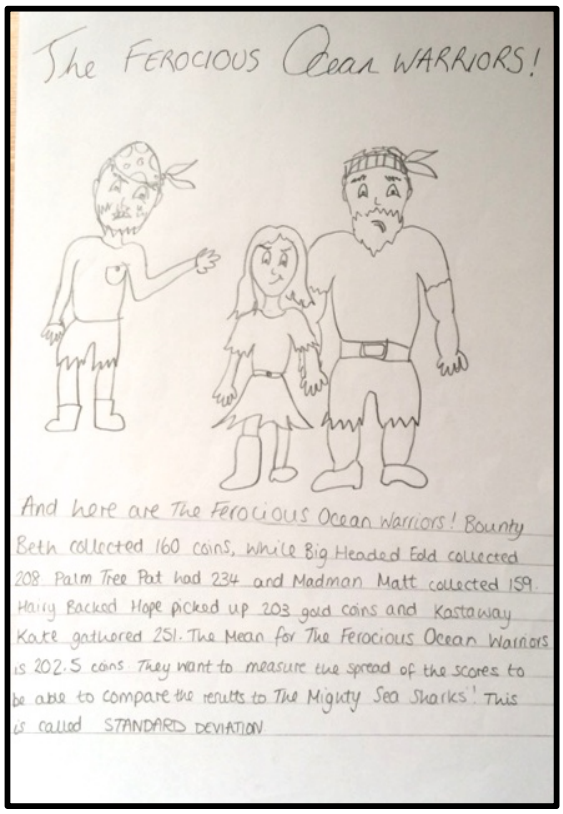
pg 7

APPENDIX B (An example of the story by Maria and Sarah)

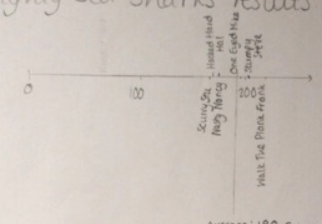




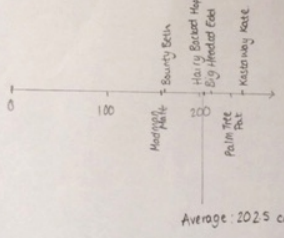




The Mighty Sea Sharks' results



The Ferocious Ocean Warriors' results



The Ferocious Ocean Warriors reached the target and were

VICTORIOUS!

4

The Mighty Sea Sharks

$$\sqrt{\frac{\text{sum of (each value - mean)}^2}{\text{number of values}}}$$ ← This is the equation for working out the standard deviation

$$\sqrt{\frac{(173-190)^2+(202-190)^2+(216-195)^2+(195-190)^2+(170-190)^2+(114-190)^2}{6}}$$

$$\sqrt{\frac{-17^2+12^2+21^2+5^2+-20^2+-6^2}{6}}$$

This is how the standard deviation is worked out for The Mighty Sea Sharks

$$\sqrt{\frac{289+144+441+25+400+36}{6}}$$

$$\sqrt{\frac{1,335}{6}}$$

$$\sqrt{222.5} = 14.916$$

The standard deviation for the team is...

5

The Ferocious Ocean Warriors

$$\sqrt{\frac{\text{sum of (each value - mean)}^2}{\text{number of values}}}$$ ← Here is the equation again

$$\sqrt{\frac{(160-202.5)^2+(208-202.5)^2+(234-202.5)^2+(159-202.5)^2+(203-202.5)^2+(251-202.5)^2}{6}}$$

$$\sqrt{\frac{-42.5^2+5.5^2+31.5^2+-43.5^2+0.5^2+48.5^2}{6}}$$

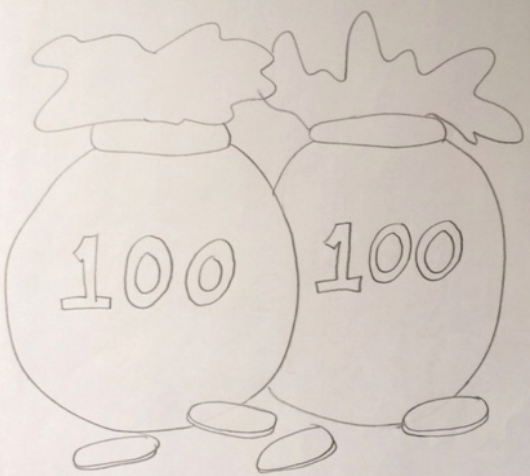
$$\sqrt{\frac{1,806.25+30.25+992.25+1,892.25+0.25+2,352.25}{6}}$$

$$\sqrt{\frac{7,073.5}{6}}$$

$$\sqrt{1,178.9} = 34.335$$

The standard deviation for The Ferocious Ocean Warriors is larger than for The Mighty Sea Sharks!

6



The larger standard deviation for The Ferocious Ocean Warriors means that their scores are more spread out - the measure of their scores is wider.

7

APPENDIX C (An example of the story by Rosie, Ryan and Olivia)