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THE ROLE OF STORYTELLING AS AN ANALYTICAL TOOL IN SCIENTIFIC RESEARCH

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ABSTRACT

This paper reports the preliminary findings from ongoing research on the potential role of storytelling as an analytical framework in assessing a research project. It is noted that most existing research on storytelling in science is focused on science communication. There is limited research on storytelling as an analytical tool for analyzing and synthesizing research plans and design. This research is based on the premise that the assessment of a research project and design is based on reviewing one or the other form of research communication, whether it is a research plan, a research report, or a presentation. Thus, the assessment is mediated by how well the research plan, proposal, report, or presentation, communicates the research to the reviewer and how well it connects the dots. The reported findings are based on studies with two different storytelling frameworks applied to assess research representations made by doctoral researchers as part of their annual research progress review. The paper reports the details of the research approach, the empirical study, and preliminary findings from the collected data.

Keywords: Storytelling, Science, Research methodologies and methods, Communication, User centred design

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1 INTRODUCTION

Storytelling is as ubiquitous as design. From everyday conversation to storybooks, movies, product storyboards, sales pitches, and advertisements, we hear and use stories everywhere. Storytelling goes way back to the beginning of human civilization when storytelling played a critical role as a cultural ratchet, allowing the transfer of knowledge and ideas from one generation to another. The medium ranged from oral narratives and folklore to visual representations in paintings and carvings. As society progressed and the capabilities in representation expanded and improved, the scope and form of storytelling extended beyond the traditional narratives and folklore to several other contexts and media. More recently, researchers have found that storytelling is innately engrained in humans as part of our cognitive evolution (Croxson et 2021). It has been noted that storytelling facilitates comprehension and sense-making for the audience and the listener, allowing them to connect the dots (Croxson 2021, Olson 2015, 2019). Stories tend to declutter our minds and provide clarity and simplification in otherwise complex scenarios (Croxson 2021, Olson 2015, 2019). As a result, storytelling is believed to be one of the most powerful ways to activate the human brain; enable engagement and voluntary participation; gain favourable responses towards change, and boost memory and recall (Croxson et 2021). Consequently, the importance of storytelling in design and scientific communication is increasingly acknowledged (Croxson et 2021).

In the design literature, storytelling has been widely adopted as an essential tool in various design fields, including animation, product, new media, and architecture design (Danisworo 2002, Parrish 2006, Truong et al 2006, Gausepohl 2016, Grimaldi et al 2016). The usage of storytelling in design has varied from user studies and journey maps in the initial understanding and research phase to instructional storyboards and visualization during prototyping, manufacturing and assembly to scenario visualization and communication for product promotion and marketing. In contrast, explicit discussion on the relevance of storytelling in science and scientific research is mainly focused on science communication. Some authors argue that storytelling in science communication can improve the comprehensibility of research-intensive articles, allowing readers to connect the dots (Avraamidou and Osborne 2009, Kryzwinski and Cairo 2013, Brian 2020, Croxson et al 2021, Davis et al 2021). These authors argue that scientists and researchers can also leverage storytelling to engage with and create awareness among the public to generate interest in science within society (Brian 2020, Croxson et al 2021, Davis et al 2021). However, as noted earlier, unlike design, where storytelling is also used as a framework for understanding the problem context and for design synthesis, storytelling in scientific research focuses primarily on science communication and narration. Thus, the following points can be stated about the existing research on the role of storytelling in scientific research. First, even though there is some literature on storytelling in scientific research, the role of storytelling in scientific research still needs to be explored. Second, whatever limited literature exists on the topic, most of the studies on storytelling in science are limited to science communication. Third, unlike design projects, where storytelling frameworks are also used to assess the problem context, there needs to be more research on the potential use of storytelling frameworks as analytical tools in assessing a research project.

Therefore, this paper reports the findings from ongoing research on the potential role of storytelling as an analytical framework in assessing a research project. The research approach is based on the premise that the assessment of a research project is based on the review of one or the other form of research communication, whether it is a research plan or a research presentation. Thus, the assessment is mediated by how well the research plan, proposal, report, or presentation, communicates the research to the reviewer and how well it connects the dots.

The reported findings are based on studies with two different storytelling frameworks, Olson's (2015, 2019, 2020) And-But-Therefore (ABT) framework and Clemens' (2018) framework, applied to assess research representations made by doctoral researchers as part of their annual research progress review. The paper reports the details of the research approach, the empirical study, and preliminary findings from the collected data.

The rest of the paper is structured as follows. Section two provides a brief review of the related literature. Section three outlines the research methodology and the research framework. Section four provides the details of the collected research data, followed by sections presenting the preliminary

research results and findings. The paper concludes with a brief discussion of the findings and an overview of ongoing future research.

2 BACKGROUND AND LITERATURE REVIEW

The study of storytelling has expanded across different disciplines (Croxson et al 2021). The diversity of literature on storytelling suggests that there are several ways to make storytelling impactful. Narrative is one of them (Olson 2019, 2020). Narratives reorder the events in storytelling so that the story persuades the audience and ultimately tells the truth. Narratives contextualise the actions in the story and reveal the resulting outcome. It is believed that humans have developed the ability to predict each other's behaviour based on stories (Olson 2019, 2020). Narratives tend to facilitate people in quickly assimilating complex information and give events meaning (Olson 2019, 2020). Stories and narratives enable people to follow characters over time, allow deliberations, responses, and cause-and-effect relationships, and foster a sense of satisfaction that comes with the resolution (Olson 2019, 2020).

In a narrative, the term "character" can refer to more than simply persons and personalities; it can also allude to the elements of science. A scientific theory might be a "principal character" that faces challenging tests and overcomes the challenges by depending on evidence and logic (Croxson et al 2021).

2.1 Storytelling in science

While some authors have highlighted the importance of storytelling in science communication, others have also raised ethical concerns and potential negative impacts of storytelling in science communication (Katz 2013, Dahlstrom 2021). Those emphasizing the importance of storytelling in science communication argue that storytelling techniques can improve the comprehensibility of research-intensive articles, allowing readers to connect the dots (Kryzwinski and Cairo 2013, Hawking 2018, Brian 2020, Croxson et al 2021, Davis et al 2021). These authors also argue that scientists and researchers can leverage storytelling to engage with and create awareness among the public to generate interest in science within society (Elshafie 2018, Brian 2020, Croxson et al 2021). In contrast, the authors who raise ethical concerns about the use of storytelling in science communication argue that the use of storytelling techniques in science communication may mislead people and result in an increase in pseudoscience or misrepresentations or misinterpretations of the facts or the state of the research (Katz 2013). They argue that reporting the scientific work should be direct, factual, rigorous, and devoid of any alterations or adjustments that may be required from the storytelling perspective to generate interest and excitement among the readers (Katz 2013, Dahlstrom 2021).

Nonetheless, there is no basis to claim or conclude that stories cannot be direct, factual, and rigorous. For instance, Croxson et al (2021) point out that the scientific method relies on logic, including deductive, inductive, and abductive reasoning. Deductive reasoning is the foundation of logical scientific communication, where the consistency and validity of the story can be assessed in claim accuracy. However, narrative communication adheres to inductive logic, and the veracity of its setting determines if it is legitimate (Croxson et al 2021). Abductive reasoning tends to hold valid in a certain set of circumstances. In abductive reasoning, the validity and consistency of the story are contingent on providing a convincing argument that the presented inferences or conjectures are the best plausible explanation given the current evidence or state of knowledge.

Croxson et al (2021) claim that the concepts, motivations, actions, and conclusions of scientific communication such as a scientific report are clearer and more memorable when they leverage storytelling techniques compared to matter-of-fact, linear, descriptive scientific writing. They argue that the elements of time, place, and character occur in a scientific context in the form of ideas, hypotheses, and methods, which must come together in a coherent form while retaining some challenges and uncertainty but leading towards a consequential juncture or results that we care about. Like any other story, scientific contexts include a change process from an unknown to a known situation and from conflict to resolution. Similarly, Croxson et al (2021) argue that we must explain the statistics because they do not speak for themselves. They argue that good editing alone cannot enhance comprehensibility, focus, and clarity of communication. Instead, we must also consider the appropriate use of rhetorical devices to best serve our objectives without compromising the rigour and formality of communication. Storytelling has the potential to reinforce arguments based on evidence.

2.2 Storytelling frameworks

A review of academic and non-academic sources shows no single authoritative storytelling framework. Therefore, multiple storytelling frameworks from the public domain were identified from different sources to assess commonalities and differences. The search and collection of storytelling frameworks are not exhaustive. Still, it was deemed adequate in this research because the objective is not to create or identify the best framework but to check whether an acceptable framework can be used to assess a research project for consistency in its story. Table 1 lists some of the identified frameworks and the key elements in each of these frameworks.

Table 1: A sample list of storytelling frameworks and reviews reported in the public domain

Framework source: Elements of storytelling
Good Charts Workbook Storytelling with Data Toolkit (Berinato, S 2016): Setup, Conflict, Resolution
The science and secret of the storytelling superpower (Brian, M 2020): Category, setting, Rising action, Climax/Apex, Falling action, Resolution, Lesson (helping teach something)
Toulmin Argumentation Model (Toulmin, S 1958): Claim, Grounds, Warrant, Backing, Modality, Rebuttal
Story Arc (Mckee, R 2016): Ordinary world, Conflict, Climax, Resolution
Scientific Storymaking/ Storytelling in contextual behavioral interventions (Davis et al 2021): Organization, Composition, Abstraction, Generalization
Capacity Model of comprehension (Fisch 2000): Processing of Narrative (Characters, Location, Sequential events within the story, Use of the appropriate word); Processing of educational content (Key concept); Distance (Relationship between above two elements, smaller the distance between the two, better the understanding)
Storytelling in Science, Nature Methods (Kryzwinski and Cairo 2013): Introduction, Question, Conflict, Buildup, Resolution
Story Proof: The Science Behind the Startling Power of Story (Havel, KF 2007): Engagement (use of pauses, tone of voice, hand gesture, eye contact, posture); Transportation (aimed at building trust between story, storytell and narrative being told); Influence (attract not just behaviour but also attitude, belief and knowledge); Relevance
Science and storytelling (Hawking, L 2015): Imagination, Relatability, Creating sense of anticipation, Relief of the word "once upon a time"
Data storytelling is not storytelling with data… (Matei and Hunter 2021): Surprise, Question, Interest, Personal Engagement, Learning
Narrative is everything: The ABT framework and narrative evolution (Olson 2020): And, But, Therefore
Storytelling in Science- Writing a page turner… (Clemens 2018): 9 Elements of storytelling– Main Theme, setting, Character, Tension, Climax, Plot, Resolution element, Purpose, and Chronology
Story Cycle- What makes a hero? (Winkler, M 2012): Call to adventure, Assistance, Departure, Trials, Approach, Crisis, Treasure, Results, Return, New Life, Resolution, Status Quo
Making science meaningful for broad audiences through stories (Elshafie 2018): Protagonists, Inciting Incidents, Obstacles, Stakes, Broad Theme

Among the reviewed frameworks, the following two frameworks were chosen for the research study: (1) The ABT framework by Olson (2019) for its simplicity, fewer number of elements, and prior application to scientific storytelling, and (2) the "Writing a Page Turner (9 elements of storytelling)" by Clemens (2018) for its higher level of granularity and detail, and prior application to scientific storytelling. Hence, further details of these two chosen frameworks are presented.

2.2.1 The And-But-Therefore (ABT) framework

The ABT framework has a three-act structure following the words And-But-Therefore. The structure moves from agreement to contradiction to consequence. AND conveys agreement and goodwill. It is built around the concept of affirmation and an expression of agreement. The story, argument, or explanation begins with little tension or conflict by connecting the initial facts with ANDs. This allows the presenter or the storyteller to present relevant fundamental information before the testing begins. Other words that fall within the AND category include Also, Likewise, Similarly, As well as, Moreover, etc. BUT connotes denial, contradiction, and negation. It questions the way things are and helps to establish gaps. Other similar phrases or terms that emphasize contradictions include Despite, Nevertheless, In place of, Conversely, Rather, Otherwise, etc. However, given that contradictions such as BUT change the course of the story, it must be used judiciously to retain focus and emphasis. Judicious use of BUT and similar contradictions can impact communication and send the point across. THEREFORE conveys significance. It manifests and indicates a result or effect. It brings a notion of time and sequence, establishing the focus in the context. It helps advance the narrative from one context to another while connecting the two contexts.

Though the ABT framework is minimalistic, authors such as Olson (2019) claim that ABT is an effective framework which can be used for non-scientific storytelling as well as in scientific communication. Olson (2019) claims that one of the most significant research writing in biology, Watson and Crick's (1953) explanation of DNA structure, published in Nature, demonstrates a very good implicit use of the ABT framework. Though only two pages long, the paper is renowned for being powerful and incredibly condensed. Analyzing other exceptional narratives and documents from history for an implicit use of the ABT framework, Olson (2019) claims that Abraham Lincoln's Gettysburg Address and the famed "Star Wars" also follow the ABT structure.

2.2.2 The 9-elements storytelling framework by Anna Clemens

Based on her expertise as a scientist and a science communication consultant to other scientists and researchers, Clemens (2018) proposes a 9-elements storytelling framework for effective scientific writing and storytelling. The nine elements in Clemens' storytelling framework are briefly described in Table 2.

Table 2: Elements in Clemens' 9-elements storytelling framework

Framework elements	Description
Main Theme	The overall motif that a narrative is about. Even though it has numerous short stories, the core topic runs the entire duration of it.
Character	Who will appear in the narrative—both well-known and unfamiliar
Setting	The scene requires background information on the protagonist, which relates to the setting factor
Tension	One or more disputes, challenges, or conflicts may exist. Multiple conflicts may revolve around one main conflict.
Climax	A pivotal moment of high significance when the action peaks, resulting in increased excitement. The moment of truth.
Plot	The organization of the different elements of the story into a combined form
Resolution Element	The clarity comes after the core conflict has been resolved during the climax

Purpose	The reason 'WHY' for which the various elements and actions occur in the story. Thus, each element, action, and detail in the story must be relevant
Chronology	For the plot to make sense, the elements and actions must occur in some order. Typically, the order is setting > tension > action > climax > resolution

Clemens (2018), like others, argues that we have evolved to grasp and recall stories more easily than plain-speaking facts. She emphasizes the human need for active engagement with the presented facts to adequately understand them, which makes storytelling helpful in such situations.

In summary, there is growing interest in the role of storytelling in science, but most of it is focused on science communication. However, to communicate well, one must be able to analyze whether the research work presented or communicated is consistent in its story and the underlying reasoning approach– deductive, inductive, or abductive. Consequently, we can argue that the literature review reveals this gap of inadequate use of storytelling frameworks in assessing the quality of research, as mediated by how it is communicated or presented. Further, the literature review shows no single authoritative storytelling framework. Hence, choosing one or the other framework as the analytical framework is reasonable and possible. The detailed patterns may vary depending on the choice of the framework. Still, it should suffice to identify broad patterns in storytelling as reflected in the analysed research presentation.

3 RESEARCH APPROACH AND METHODS

This research aims to investigate the potential role of storytelling frameworks as analysis tools to assess presented research for consistency in the story and design. The research framework is shown in Figure 1. The research questions investigated in this research are

RQ1: Can we use storytelling frameworks to analyse whether a research work and design, as reflected in how it is reported, is consistent in its story? In other words, can the storytelling-based analysis of research, based on how it is reported or presented, reveal gaps and shortcomings in the research work?

RQ2: Do research presentations judged by reviewers as good research reveal distinct patterns in storytelling elements compared to research with gaps and shortcomings?
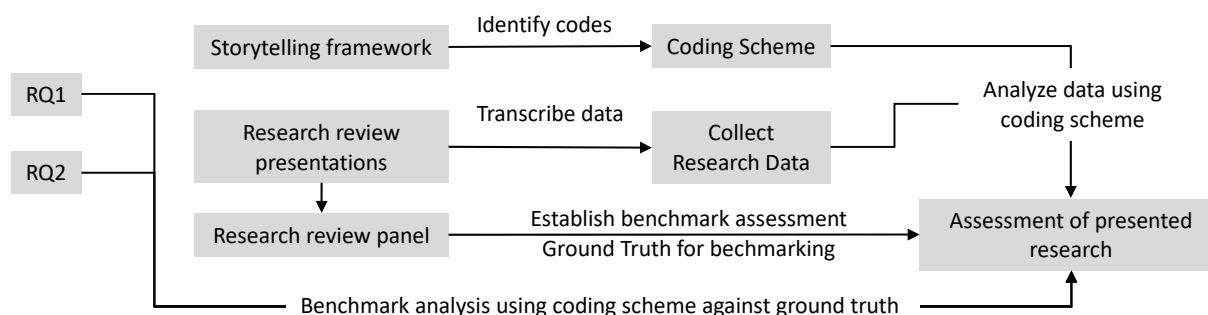

Figure 1: Research Framework and steps

3.1 Data collection

A corpus of data is collected through audio-visual recordings of research presentations made during the Design and Manufacturing Department's annual doctoral research progress review. Altogether thirty-six presentations were recorded, each lasting twenty minutes, including a 5-minute question and answer session. The recorded data is transcribed to get textual data. Thus, each presentation is a separate document or story. Each document or story is analyzed using the two storytelling frameworks to identify the used storytelling elements and patterns therein. It is assumed that research that is judged to be good, based on the review of the presentation, has a more consistent story than others. It is also assumed that patterns in the use of storytelling elements in presentations judged to be good can eventually be used as potential templates or signatures for analyzing and structuring the presented research. The ground truth, whether the presented research is assessed to be good or not, is based on the scores given by the jury. The jury comprises faculty members on the panel conducting the annual research progress review.

This paper is based on the preliminary data analysis from eight out of thirty-six presentations. Three of the eight presentations analysed for this paper were judged to be the top three, while the other five were chosen at random. Thus, it is expected that these two different data sets, the winners versus the others, will show some distinguishable patterns in storytelling elements.

3.2 Data analysis

The transcribed data is imported into QCAmap, a qualitative analysis software that allows data segmentation and protocol analysis using a chosen coding scheme. Two separate coding schemes are used, one each for the ABT framework and the 9-elements framework. Accordingly, there are three codes in the ABT coding scheme and nine codes in the 9-elements coding scheme. It is also important to note that the findings presented in this paper are based on a single-coder analysis, and a cross-coder comparison is still to be done. However, to ensure the acceptability of the preliminary results, random samples from the coded data were evaluated and verified by another person for consistency.

4   RESULTS AND FINDINGS

Table 3 presents the results from the coded data. The numbers in Table 1 correspond to the frequency or the number of times a data segment was found to relate to one or the other storytelling elements. Within the ABT coding scheme, more segments are identified with AND and fewer with BUT and THEREFORE codes. There are no generalizable patterns from a frequency point of view. Presentations D24, judged unanimously by the reviewers as the best-presented research, stand out in the number of THEREFORE codes. All the presentations judged good (D24, D1, D30) demonstrate greater use of THEREFORE code than the other presentations. As noted in the review of the ABT framework, THEREFORE conveys significance. It indicates a result or effect, establishing the focus in the context. It helps advance the narrative from one context to another while connecting the two contexts.

Within the 9-element coding scheme, more segments are found to relate to the setting, followed by tension. Once again, from a frequency point of view, there are no discernible distinct patterns between the presentations deemed good (D24, D1, D30) and the others. However, once again, D24 stands out as the only presentation where CHRONOLOGY code was explicitly identified. As noted in the review of the 9-elements framework, CHRONOLOGY puts the elements and actions in an order that allows the plot to make sense. In addition, D24 also shows greater number of segments associated with PURPOSE code and CLIMAX code. While PURPOSE explains the 'why', CLIMAX emphasises a pivotal moment of high significance or the moment of truth.

Table 3: Number of codes for (1) ABT elements (2) Clemens' 9 elements in each transcript

Framework elements		Document/ Presentation									
		D24	D1	D30	D28	D2	D38	D8	D23		
ABT Framework	And	47	76	74	84	41	85	58	47		
	But	22	12	11	28	8	11	6	7		
	Therefore	77	16	17	14	4	4	12	3		
Clemens' 9-elements framework	Main Theme	23	5	4	13	7	7	5	3		
	Character	8	6	3	10	12	4	10	1		
	Setting	99	77	74	86	18	72	58	37		
	Tension	19	5	13	26	10	12	4	3		
	Climax	12	0	6	5	4	0	3	0		
	Resolution	14	10	9	2	17	4	22	1		
	Purpose	10	2	1	3	3	2	8	1		
	Chronology	2	0	0	0	0	0	0	0		

Figures 2 and 3 show the time-series pattern in the usage and distribution of storytelling elements in the analysed presentations. In D-24, recurrent patterns were observed in the use of ABT elements. The presentation is organised as a series of shorter cycles where the A-B-T elements appear regularly throughout the presentation. The researcher set a premise and properly introduced his research topic.

Both AND and BUT appear at every stage, from the overview to the literature review presentation to the explanation of the experiments, interviews, and a discussion on the barriers faced in the research. Thus, the overall research story is a collection of several sub-stories, each contributing to the larger plot of the research. In addition, across all the three top research presentations, D24, D1, and D30, the ending sequences show a dominant combination of AND and THEREFORE codes, which is not found in the other presentations. Similarly, when assessed from the 9-elements framework perspective, the top three presentations show a combination of RESOLUTION and PURPOSE codes. Once again, D24 stands out in balance across codes throughout the presentation.
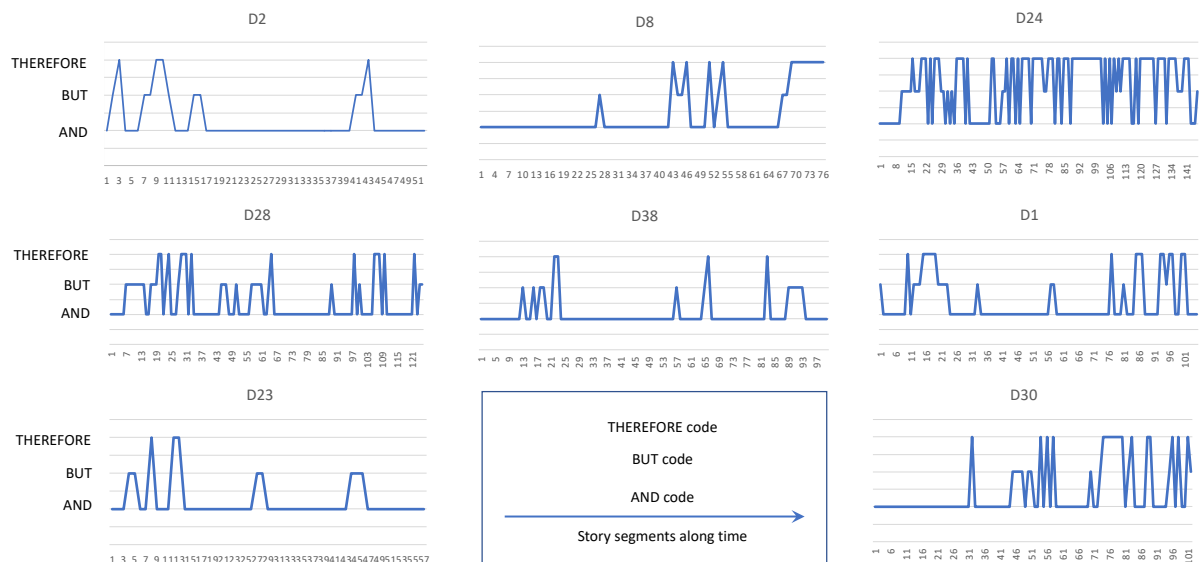

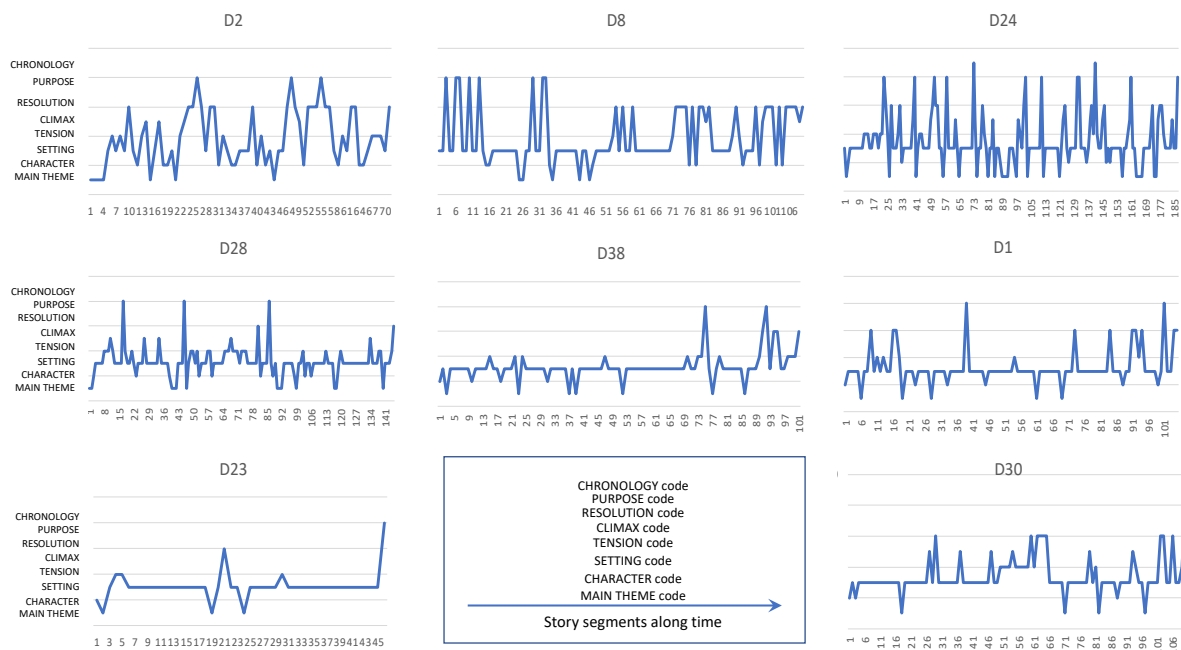Figure 2: Distribution of ABT elements over time in each of the presentations

Figure 3: Distribution of Clemens' 9 elements over time in each of the presentations

5   DISCUSSION AND CONCLUSIONS

The preliminary analysis of the data collected from the research presentations suggests that a coding scheme derived from existing storytelling frameworks can be used to assess the presentations. Though the currently analysed dataset is small, it is notable that the research presentations deemed good by the jury showed distinct patterns in the use of storytelling elements compared to the other presentations, independent of the framework used for the analysis. Thus, even though there are no dominant

storytelling frameworks that stand out in the literature, and even though there are infinite stories to be told because of the diversity and uniqueness of research topics, it appears that it should be possible to identify patterns that differentiate good research presentations from the others.

Concerning the research question RQ1, the findings showed that the presentations that were deemed good showed greater use of the THEREFORE code, possibly allowing better connecting the dots. This suggests that the presentations that raised more questions and were judged low in the ranking were found to have gaps and shortcomings in the story. While an analysis of the gaps and shortcomings has yet to be conducted, it is expected that a review of the questions asked after the presentations, mapped against the dominant codes in the presentations, will reveal and point out the specific gaps and shortcomings.

Concerning the research question RQ2, the findings are more conclusive. The patterns in storytelling elements in presentations deemed good is noticeably different from the other presentations.

In summary, the research findings suggest that it should be possible to use storytelling frameworks to analyse and improve research plans and design. The research presentations that were ranked low typically received more questions about the gaps and shortcomings in the research, suggesting that the research assessment was mediated by how the research was presented. In turn, it can be argued that research reviewers sought to identify what part of the presented research does not make sense and which dots do not connect. Hence, it is proposed and shown that storytelling frameworks can help identify how and where these dots do not connect and where the story does not make sense. While there can be various ways of presenting a convincing research story, findings suggest that the main story can also be a collection of connected small stories following the correct chronological order. It appears that the presentations also need to finish well, with clear reinforcement of the purpose and clear evidence of the resolution of the tension or conflict raised in the research questions or hypotheses.

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