




# Digital Explanation as Assessment in University Science

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## Abstract

Assessments in tertiary science subjects typically assess content knowledge, and there is current need to both develop and assess different forms of knowledge and skills, such as communications and digital literacies. A digital explanation is a multimodal artefact created by students to explain science to a specified audience, which is an alternate form of assessment that has potential to develop and assess these other important forms of knowledge and skills. This research draws from perspectives in multimodality, educational semiotics and science education to gain a better understanding of digital explanation as a form of assessment in university science. Data sources include digital artefacts ( $n = 42$ ), task descriptions and rubrics and pre-/post-interviews ( $n = 21$ ) with students who created them as a task in a university science subject. Analysis involved identifying the range of media resources used across the data set, seeking patterns in how multiple resources were used and exploring students' perspectives on the task, including their design decisions. A more detailed look at artefacts from three different science learning contexts illustrates that students base their design decisions on the content knowledge being represented, their technical capabilities to generate them and how to engage the audience. Students enjoy this form of assessment and feel that the tasks allowed them to demonstrate different sorts of capabilities than are normally assessed in their subjects. Recommendations for instructors provide guidance for considering this sort of task in tertiary science contexts.

**Keywords** Assessment · Tertiary science · Representations · Meaning-making · Blended media · Digital explanation · Semiotic resources

## Introduction

Digital technologies offer new possibilities in the assessment space, both in terms of efficiency but also, more importantly, in terms of design (Bennett et al. 2017). In

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science education in particular, where multimodal communication is recognised as a key skill (Jamani 2011; New South Wales Board of Studies 2012; Tang et al. 2014), the growing range of new technologies available for media creation could significantly impact student learning. This paper considers the use of digital explanations as assessment tasks in tertiary science classrooms. We argue for the need to develop a better understanding of the contexts in which these assessment tasks are used, the nature of the digital artefacts or texts and through this, identify some challenges for science education in terms of assessment, pedagogy and students' digital literacies. The paper will provide an overview of the use of digital explanations in tertiary science classrooms and describe the nature and range of artefacts collected in our study before considering students' approaches to the task and decision making in terms of design and construction of the artefacts. We conclude with some implications for their use as assessment tasks in university-level science subjects.

## Assessment

Assessment in university science teaching and learning is a contested space. Traditional forms of assessment, such as examinations, focus on evaluating content knowledge, however, as Stowe and Cooper (2017) rightly note, multiple choice examinations often end up testing content recall at low levels of Bloom's taxonomy, particularly in lower-level undergraduate subjects (Momsen et al. 2013). Furthermore, higher-order skills such as cognitive skills (Zoller 2001), ways of thinking (Stowe and Cooper 2017) and communication are now increasingly prioritised, and assessing these is known to pose significant challenges (cf. Chan 2011; de la Harpe et al. 2009). Laverty et al. (2016) argue that some of these important science literacy skills and knowledge forms, such as proficiency in applying scientific practices, are better assessed through alternate forms of assessment. Further, students typically approach their learning activity based on what they believe will be tested (Momsen et al. 2013) and even take a surface/deep learning approach differentially for different kinds of assessment tasks (Scouller 1998). New assessment forms can therefore provide a significant opportunity to more authentically assess understanding as well as a wider range of skills.

Producing a digital explanation represents an alternative form of task in university science (Hoban et al. 2016a), one that has the potential to *test* a range of content learning and competencies, as well as students' capacities to communicate science understandings. Digital explanations—as artefacts of learning activity—share a common purpose to communicate science content to a particular audience, but gauging their success is not well understood, unlike typical assessment tasks in science such as exams, lab reports or essays (Biggs 1987). The knowledge base applicable to digital explanations or other forms of student-generated media for assessment in disciplinary science is thin (Ng 2015). The current research thus ventures into this new assessment space where student knowledge is represented in a variety of digital forms and for a number of different reasons, one of which is to help someone else understand the content as in a *digital explanation*. Along with the wide variability, the communicative purpose for these student-generated digital artefacts makes it a very different kind of assessment task in university science learning that warrants a research focus to understand it better.

## Digital Explanations

Science is a representationally rich discipline and science students both learn from studying representations and by generating them. Importantly, representations serve both knowledge and communicative purposes because when learners develop their own representations, they *translate* meaning (Prain and Tytler 2012; Prain et al. 2009; Waldrip et al. 2010). A digital explanation thus has the potential for student learning as it involves both researching multiple representations, as well as generating and assembling them to create a coherent product and indeed, early case study work in the area shows learning gains, for example when preservice primary teachers created a *slowmation* (Hoban 2005, 2009; Hoban et al. 2011; Hoban and Nielsen 2013, 2014). To elaborate, in generating a digital explanation, students combine still images, video, slowmation, text-on-screen and narration to create a 3-to-5-min digital product that explains the science to someone else. Students typically draw from a combination of open-source materials, such as still images and YouTube videos (Hoban et al. 2011) to develop the digital explanation. They also create models, take still and video images and include additional features as highlights or explication (Hoban and Nielsen 2010, 2011). Students may also learn content through watching YouTube videos; reading webpages or text-based material, working through a simulation (Stieff and Wilensky 2003; van der Meij and de Jong 2006), developing a scientific model (Gilbert and Boulter 2000; Hubber and Tytler 2013), interpreting a diagram (Cheng and Gilbert 2009) or working through a visualisation (Gilbert 2007) as they plan the digital explanation.

Developing content understanding and using appropriate representational forms are important outcomes for science learners who as scientists need to communicate results or information, to a range of audiences, for a range of purposes. In Australia, the Science Learning and Teaching Academic Standards Statement (Jones et al. 2011) specifies this sort of communicative competence for tertiary science learners, but arguably, tasks to build and assess it need attention. Similarly, the 2017 Horizon Report (Adams-Becker et al. 2017) argues that capabilities in the wider area of digital literacy need improving for all stakeholders in the higher education sector. As an assessment task, having students create a digital artefact is a possible strategy for teaching and assessing digital literacy skills, and producing such artefacts is enabled through the wide range of software programs and digital objects available online.

In an early step in characterising these products, Hoban et al. (2016a) described a range of media forms that students can use to develop digital explanations (Table 1). The term *medium* may be a better descriptor for some of these forms, for example, a podcast (as medium) uses the resources of speech, music and possibly sound effects. Thus, each media form (or medium) offers particular affordances (Gibson 1977).

Because this is a new field, and as part of a wider project, we draw from perspectives in various fields including multimodality and educational semiotics, as well as science education more generally. The focus of our work is a complex multimodal digital artefact or text *created by the learner* for the purpose of assessment. This is a new line of inquiry that requires a new approach to understand how the creator is making meaning. There are implications for learning the science content in the first instance, but also how this may be different from other forms of assessment because the learner makes choices to integrate media resources to represent their ideas (Jones and Issroff 2007) as they create these texts. Little is known about how and why creators combine the possible variety of media resources or how they make meaning as a result of making such products (Rifkin and Hine 2016). In other words, when learners create these

**Table 1** Resources and affordances (adapted from Hoban et al. 2016a)

Resource	Description	Affordances
Podcast	Narration only, like a radio broadcast	Requires ‘active listening’ by ‘viewers’ but is challenging for the creator as the product must ‘paint’ a picture linguistically.
Digital story	Static images played at 10–15 s each; narrated	Static images are displayed for as long as needed to focus the viewer’s attention on salient points.
Animation	Typically generated through specialised software; may include digital objects; played at video speed	Can show changes or processes at macroscopic or microscopic levels that are difficult to see in real life or model in the classroom.
Slowmotion	Slow-motion animation; played at 2 frames-per-second	Illustrates and/or emphasises how elements relate and move in relation to one another.
Video	Fast-moving images, played at 25–32 frames-per-second	Illustrates an actual or real-life example.

digital products as assessment tasks, what are the relationships among the content knowledge to be learned, the processes of learning this material, possible ways to assess the learning and how representing this learning is likely different from other, more traditional assessment types?

To begin our exploration of these digital artefacts as an assessment task, we first present a summary of the contexts in which they are used, including the subjects,<sup>1</sup> the tasks and the rubrics and then consider creators’ perspectives and design decisions. Thus, our aim in this paper is to begin to understand these digital texts from the perspectives of the creators as a means of advancing knowledge about these digital explanations as assessment tasks in science.

## Methods

We have been collecting examples of digital explanations created by tertiary science students as part of a larger research project to understand science learning while generating these products. We gained access to potential participants for this research through subject instructors who use a form of digital explanation as an assessment task in their subjects. We invited instructors among our networks, but also cast the net more widely through a form of snowball sampling (Minichiello et al. 2008) asking those who use such tasks to introduce us to others in their networks who may use similar techniques. All students in these subjects were invited to contribute their tasks to the data set and participate in a voluntary face-to-face interview about their design and creation decisions. We also collected task descriptions and rubrics (where available) for each of the subjects in the sample and interviewed instructors.

The current paper draws on a data set of 42 media files from nutrition/dietetics, pharmacology, biology and preservice science teaching methods both primary and secondary, gathered during the years 2015 and 2016. The data also include interviews with 21 creators, four interviews with subject instructors, subject outlines for each subject and task descriptions and rubrics. Instructors also supplied a marks summary in the form of class mean and marks range. Typically, individual students create these products; however, in one class (nutrition/dietetics), the assessment tasks are created in groups of three or four students. Since these tasks are still

<sup>1</sup> We note that in Australian universities, the term ‘subject’ refers to what might be called a ‘course’ in other contexts. Further, in Australia, ‘course’ typically refers to the degree program, so that subjects make up the program for the degree.

relatively new in the tertiary sector (see for example, Hoban et al. 2016b), sampling for the study aimed to capture a range of products from different science learning contexts. We used convenience sampling for both the samples and interviews and interviewed every willing student or group.

Participants were interviewed in a semi-structured format at points in the creation process (see Appendix 1 for the interview protocols). For example, preservice teachers and pharmacology students were interviewed before they began their work on the task, generally right after the topic was selected, and then again after the task was submitted.

In the initial interviews, questions asked about students' background knowledge of the topic, plans for producing the digital explanation and perspectives on the task. This paper focuses on the follow-up interviews, which were conducted after the task was submitted and explored design choices, intentions in the design and students' processes for learning about the topic in order to produce the explanation. Interviews lasted about 30 min and were transcribed verbatim.

## Analysis Process

Working our way into the data set, we developed a series of tools to capture and summarise salient aspects of the digital artefacts and their creation. The analysis process relevant to this paper is captured in three phases: (1) a *Variety and Quality Rubric* (VQ Rubric), a broad-brush tool to obtain a general overview of the range of digital artefacts with reference to the curriculum and assessment contexts in which they were produced; (2) supported by NVivo, we mapped the resources used in each artefact; and, (3) thematic coding of interviews with creators to gain insights to their design decisions and perspectives on the task.

## Assessing the Assessment Tasks

To produce an overview of the range of resources used, we developed an analysis tool we call the VQ Rubric (Variety and Quality) to summarise key descriptive information for each digital explanation (see example in Appendix 2). The rubric was developed through collective review by the author team, which went through several stages of refinement so as to consistently capture salient details about both the assessment context and the students' digital products. The VQ Rubric identified task details, compositional choices and the range of resources used, which gave an overview of the sample set of digital explanations and provided a high-level means of comparison.

We also evaluated the task criteria to consider the purpose for creating the text, including its communicative purpose, the accuracy of its scientific content and the mark earned. From this information collated in the VQ Rubric data, we prepared a summary spreadsheet for the set of digital explanations, which was the basis for a deeper look at these assessment tasks.

## Mapping the Resources

In order to characterise the resources used in the digital explanations, we reviewed each task multiple times and noted the different resources used: video, slowmotion, animation, still image, narration, music, text-on-screen and external objects. The first two authors did this work together and used NVivo to support the coding work to identify distinct resources. Keeping in mind that the work aimed to characterise the products, the multiple reviews helped

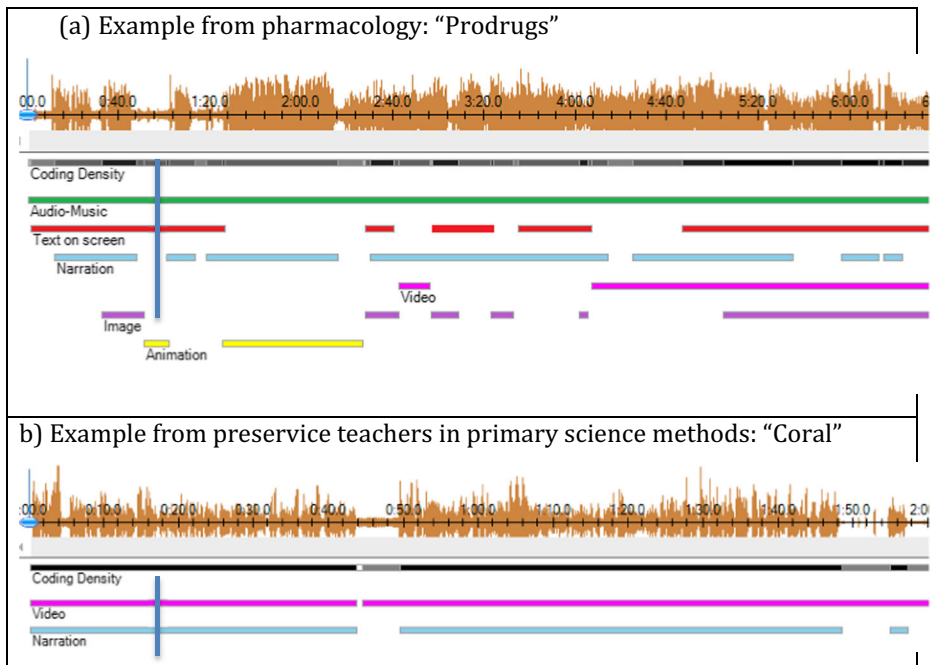
to refine descriptions for each of the resources. We aimed to consistently identify resources as distinct categories on the premise that each resource carries some sort of meaning. For this reason, we have considered *narration* to be a resource because the voiceover narration in digital explanations is used to communicate information, even though it may be used in different ways and can be analysed much more particularly than we have done here (see for example, Knox 2007; Kress et al. 2001; van Leeuwen 2014). To demonstrate the unexpected complexity in this work, we differentiated between *text-on-screen* as added by the science student (and thus, intentional) and text that appeared in imported diagrams or images (coded as *images*). We also added a code for *external object*, which we defined as a digital object that, despite possibly containing one or more resources, was embedded in the digital artefact with minimal or no manipulation by the student. In other words, some of the resources were edited or manipulated and thus represent some aspect of design choice. Table 2 presents the categories of resources and definitions used in the current study.

Following the coding of each digital explanation in the data set for incidence and duration of each resource, we generated a ‘profile’ using features in NVivo. Data illustrations show the range of variability in our identification and characterisation. Figure 1 shows profiles for two such digital explanations: Fig. 1a illustrates “ProDrugs” from a pharmacology student and Fig. 1b illustrates “Teaching Kids about Coral” created by a preservice primary teacher. The colour bars in the profiles illustrate the occurrence and duration of each resource at each instance through the digital explanation. From Fig. 1a, we can see that the creator of ProDrugs used a continuous music soundtrack, narrated nearly continuously through the entire product, used text-on-screen labels extensively and included one short and one longer video, two animated sequences and a number of still images, one of which remained on screen for about 2 min of the overall product that played for 7 min 25 s. In contrast, the creator of the digital explanation in Fig. 1b used two resources only: narration and video. The vertical blue line drawn through each of the displays in Fig. 1 identifies one time point where multiple resources are present.

**Table 2** Categories of resources

Resources	Definition	Example from the data set
Still image	Static image left on screen for longer than 2 seconds	Molecular diagram of ferroquine
Narration	Audio track of voiceover by the blended media creator	Voiceover highlighting red portion of ferroquine molecule
Music	Musical sound track or jingle playing, generally as a background	Folk music playing while map of country shown
Animation	Generally created using specialised software; played at video replay speed so images appear to move, ‘cartoonish’	Animated clip of pokemon character emerging from an egg
Slowmation	Still images uploaded to video production software and played slowly at 2 frames-per-second to give appearance of movement	Sequence of images where frog hops across lily pads on a pond
Video	Fast-moving images give real-life view of phenomenon; may be student-generated or imported	YouTube clip of people dancing
Text on screen	Words used to highlight or label other material	Text label “Tavche Gravche” superimposed on image of the food
External object <sup>a</sup>	Digital object that does not fit in other categories	Inserted clip of a titration simulation

<sup>a</sup>‘External object’ is a category for ‘other’ that we used to identify clips used in the artefact that do not involve any input from the creator and were inserted as-is. If the creator added their own narration to a video clip taken from elsewhere, it would be labelled with ‘narration’ and ‘video’



**Fig. 1** NVivo profiles of two digital explanations

As expected, students used resources in different combinations. Table 3 presents screen shots from the place indicated by the vertical blue line in Fig. 1. The colour bar displays are a simple form of synthesis for reviewing the set of products in this research, providing an overview of the combination of resources chosen by individual creators.



### Thematic Coding of Interviews

To explore the context of creating these digital products as assessment tasks in science subjects, we are interested in how creators make design choices. Thus, discussions of resource use and combinations of multiple resources offer insights to the creator's intentions. Additionally, perceptions and experiences of the task are important because they help us understand the assessment context from the students' point of view.

Interview data were coded inductively by three coders, with the first step of this process involving the identification of emergent codes and the attribution of segments of the interview data to these codes. Open coding involved identifying two general themes; the first related to students' perspectives or experiences of the task whilst the second related to the choices they made in constructing the product. This initial open coding was followed by axial coding for the latter theme, whereby emergent codes were clustered into more specific descriptors. A constant comparison approach (Parry 2004) was adopted by the research team, with members iteratively checking their assignment of segments to each of the codes and refining the definition and focus. Initially, a single-interview transcript was independently coded by each of the researchers who subsequently came together to discuss their coding decisions and from this discussion developed shared codes. Using these shared codes, the researchers then independently coded two further transcripts adding new codes when the need arose. The coding of



**Table 3** Identifying resources in digital explanations

Screen Shot	Resources used in combination	Detail of presentation on-screen
a) 	Animation Text-on-screen Narration	The green circle and purple ellipse move away from each other toward the text labels below in the animation sequence. Static background is black with bubbles. Music runs throughout.
b) (image used with permission) 	Video narration	'Real-life' portrayal through filming with video, in this case, the two characters filmed as live-action speaking into camera.

these subsequent transcripts was used to check for coding consistency, to refine code labels and definitions and to merge and split codes as necessary. During the coding meetings, three axial codes were identified under the broad theme of design choices: representing content knowledge, engaging the audience and technicality. The research team re-checked all previous coding before continuing to code the remaining transcripts. The full set of codes is included in Table 4.

## Results

Task descriptions generally specify content requirements rather than resources to use, which leaves the students to make decisions about what will be represented (and, how) in order to offer an explanation for the viewer. We first present a summary of the resources included by participants across the data set, then move to analysis of interview data to explore the assessment context for student design and creation, with a focus on developing a better understanding of this form of assessment task.



**Table 4** Thematic coding for interview analysis

Open coding	Main theme	Sub-theme	Secondary sub-themes	Example
Design Choices	Technical aspects/issues	Personal Digital Literacy	Ability to use software	“I have used iMovie before. I had to do a digital story about my literacy skills so yeah, I was familiar with that and definitely like I own my own camera and I am familiar with that kind of technology. It wasn't too complex.” EDUCATION
			Experience as a maker	“I have done a few of them at school or university. We did... I don't know if you'd call it... it was probably a literature review, similar, last semester in a genetics subject where we did our own genetics research. We did not have to make a media presentation, we just did a PowerPoint presentation which I suppose is a media but we also had a verbal and physical aspect to it and we did a media presentation.” NUTRITION
			Experience of watching digital media	“There was one video that was directly aimed at what my topic was and all they literally did was have like little Playdough borders lined up and showing the molecule distribution of each of the particles. So that inspired me but I just found it was short so I made sure I separated it, like I added what they had in the video in my own interpretation of it and yeah, put that in my video.” EDUCATION
		Technical/Practical Issues	Accessibility of resources	“I think it was trying to find quality ones rather than photos of food that people had just taken at home. We wanted more professional looking ones just to enhance the quality of the video. It was not too hard. I think the harder thing was finding the videos because that was a bit difficult; trying to find a good video of oil pouring or something like that. The small things that you'd never search for.” NUTRITION
			Software	“Yeah, it did have some templates but it was a bit difficult – I just used still images; I did not use actual video image. A lot of the templates were for if you were to import a video and then you could have like three different videos on the one screen whereas that effect could not be had with a still image because it could not like zoom in on a particular point but it did have different transition effects and text and stuff that could be used but in terms of the templates, I did not really use any of the templates.” EDUCATION
	Representing Content Knowledge		Choice of content	“I had to describe the observable properties of solids, liquids and gases and the reversible or irreversible changes and then I had focused content-wise on physical properties that a student can see so I focused on mass, volume and shape and I looked at yeah, like what shape was the molecule in – was it arranged in a regular pattern or were they all randomly spaced out?” EDUCATION
			Unpacking technicality Connecting abstract and concrete experience	“I just tried to make it as simple as I could while including that terminology.” PHARMACOLOGY “I did not want to do something that the children would never have seen before, even just like I could have used a piece of material but they can probably go away from it knowing like in their

Table 4 (continued)

Open coding	Main theme	Sub-theme	Secondary sub-themes	Example
			Structuring	<p>kitchen they have got a ceramic mug and going to know that “Oh, that’s opaque” and they’d be able to relate to that a bit better.” EDUCATION</p> <p>Yes, it’s similar but it’s just a bit more conversational and added the questions. Now I have got a heading and it’s all about the heading whereas I added a question to relate it to the heading and then talked about that.” PHARAMCOLOGY</p>
	Engagement	Attention to the audience/-engagement	<p>Representational choices</p> <p>Resources used to engage</p>	<p>“If I used words instead of pictures it was just to highlight the word that was the key point of the sentence or the point.” PHARAMCOLOGY</p> <p>“I suppose the audience for the actual presentation in the end was the class. It was the subject cohort which is not an unspecialised audience. So a lot of the decisions I made was just because if you are an unspecialised audience you do not really care about the science behind it. You just want the overview and putting out images people could not relate to very quickly, so it’s not a detailed image, there’s not information image: it’s just more this is a mosquito, that’s a mosquito, so I am saying mosquito here’s a picture of a mosquito.” PHARAMACOLGY</p>
			Needs of the putative viewer	<p>“I really had to simplify the language and if I said a word – because it was for a non-specific audience, non-scientific audience – like a word that I would have just written in my literature review and not explained it in the visual I had to actually explain what that word meant so that the audience would understand what I was talking about.” PHARAMACOLGY</p>
	Assessment context		Task requirements	<p>“We aimed to cover each point that was in the marking criteria. We just split that up into a couple of point each and then we had to research each point we were allocated and that was what we would talk about in the movie as well.” NUTRITION</p>
			Effect of introductory session	<p>“[REMOVED] had shown us some in the lecture so I just had a look at those just to get an idea of...again, I was really focusing on I wanted to make sure I was meeting that criteria with the audience, so I just wanted to have a look and see how other people had done it, found some which were just a bit too simplistic, then found others that were just too over-the-top. So, it just gave me a good gauge of where I should be kind of like be putting mine to make sure I was hitting that target audience.” EDUCATION</p>
			Effect of previous task	<p>“The lit review will probably be a bit different because it’s an actual academic review whereas the presentation, it can be simple so why make it complicated. That’s probably how I’ll approach the task mostly” PHARAMCOLOGY</p>
	Student as maker	Personal factors	Personal learning preferences	<p>“I prefer it when someone gives me a simple explanation; it’s better than an in-depth explanation. If I need an in-depth explanation, give me an in-depth explanation otherwise I’ll be in a situation but if I don’t need it, there’s no point.” PHARAMCOLOGY</p>

Table 4 (continued)

Open coding	Main theme	Sub-theme	Secondary sub-themes	Example
			Availability of Time	“If I had to do that plus the research I do not think it would be as coherent probably because I did not have the time.” PHARMACOLOGY
			Aesthetic preferences - “Looks Cool”	“I think we were just spitting out ideas and we just ended up at MasterChef. We came to the resolution that we did not want to just have images with our voice over talking about Macedonia because it was not very interesting when we watched other people’s ones that were like that. It was not very engaging. It was like oh yeah, that is cool. So, we were like how can we incorporate food and talk about it and suddenly there was MasterChef.” NUTRITION
		Professional Factors	To fit into professional practice	“it’s definitely something I will keep in the back of my mind so when I do become a teacher that I can pull that out and, you know, even if it is with Early Stage 1, you can still make a little tiny movie or something; it does not have to be a crazy concept.” EDUCATION
Open coding	Main theme	Example		
Perspectives	Nature of the task	I am pretty willing to learn how to do it. I am a bit more excited about the freedom that you get with it. It does not seem to be too structured compared to other university assignments. You might have to write out a while essay or report on Macedonian cuisine. It is so much more fun to actually produce a digital media resource.” NUTRITION		
	Role of the maker	“If someone gave me the content and just told me to make a video I would not find it as interesting but because I did all the research myself it was my project from the start to finish it was a bit more interesting because it was making it applicable to making a report that I was – I suppose I am in the final stages of a higher education now, being able to read specialised articles and actually understand them; that was cool.” PHARMACOLOGY		
	Learning opportunities	“I probably prefer a task like this because it’s a bit more of independent learning. A lot of university’s been a little bit spoon-fed so this sort of task...I learn better by researching it and figuring it out myself than just being taught; it because I have to get it, because if I do not, I do not get the marks.” PHARMACOLOGY		
	Preparing for the future	“Good for skills. I guess it depends what you do through. In Dietetics if you were clinical context you probably would not be using a lot of digital media if you were having one on one consultations. Although for a small group facilitation you might have something that you generated and that would be really good or if you are trying to advocate for something at a conference or putting something forward that could be really helpful as well.” NUTRITION		

## Resources Used

Table 5 shows the range of combinations of multiple resources as well as their frequencies across the data set. A total of 98% ( $n = 41$ ) included four or more resources, while 57% ( $n = 24$ ) included five or more resources. Of the remainder, only one example used two or seven resources, and none used three.

Across the data set, the main ‘type’ of digital explanation included the resources of still images and narration with some form of moving media (e.g., animation or video) and most included text on screen (93%). A total of 64% of the digital explanations used animation, while 52% used video and 48% used slowmotion. External objects were present in 14% of the tasks, but not in combination with slowmotion.

Characterising the number and combinations of resources used in producing the digital explanations is a first level of analysis, but tells us little about how and why these choices were made in the university assessment context. To consider these choices, we move to the interview data with a focus on the task context and why particular choices were made.

## Design Choices and Task Contexts

Our set of interviews includes students ( $n = 21$ ) who used four, five or six different resources in their artefacts. Table 6 summarises these data and illustrates the wide variety of digital artefacts in terms of topic, subject, task purpose, intended audience and assessment criteria by detailing three cases, which also act to focus the thematic analysis of design choices. While it would be difficult to call the selected cases *representative*, they do represent variety in terms of *type* of digital artefact across the data set and their analysis provides support for each of the themes developed through the results presentation.

### Pharmacology: Summarise a Technical Literature Review for a Non-specialist Audience

The digital explanation task for the pharmacology subject is related to another assignment where the students prepare a technical literature review that answers a critical question on a contemporary issue in pharmacology (15% of the subject mark). Students choose a topic from a list supplied by the instructor and the task summarises the literature review for a non-expert audience (max. 5 min, worth 5%). An interview explored the instructor’s purpose in assigning this task: to foster students’ capacity to explain science concepts to an audience and to offer students an engaging assessment task. The assessment rubric details categories including *organisation* into a logical sequence with appropriate use of citations (20%); *content* including an introduction, appropriate use of terminology and accurate and relevant material (40%); and *presentation*, which includes technical quality, pace of speaking and a suitable length (40%). The ten digital explanations in our sample from this subject looked quite different, reflecting a range of choices in creation: nine of these used four media forms and eight of these used animation as the fourth resource. Marks for the sample from this class range from 80 to 100% while the whole class ranges from 65 to 100%.

The featured example from this class was created by Paulo who prepared his task to answer the question "Is ferroquine a novel antimalarial?" His digital explanation

**Table 5** Frequencies of combinations of resources used across data set

	2 resources	4 resources	5 resources	6 resources	7 resources
Image	✓	✓	✓	✓	✓
Narration	✓	✓	✓	✓	✓
Text on screen <sup>a</sup>		✓	✓	✓	✓
Additional media forms used		and one of: animation, slowmation or video	and two of: animation, slowmation, video or external objects <sup>b</sup>	and animation, slowmation and video	and animation, slowmation, video, external objects
n	1	16	18	6	1

<sup>a</sup> All but one group used text on screen; slowmation was the fourth media form in this case

<sup>b</sup> Slowmation was not used in combination with external objects

includes animation, still images, narration and text-on-screen. The explanation begins by providing statistics about malaria and issues with current treatment options, and then uses a stylized sketch of a plasmodium cell to explain how Ferroquine works. The illustration was constructed by Paulo from scratch and shows the drug’s hypothesised action in disrupting both the cell membrane and the membrane around the digestive vacuole, killing the parasite and preventing new plasmodium parasites from attaching to red blood cells (see Fig. 2a).

**Nutrition/Dietetics: Describe the Cuisine of an Assigned Country**

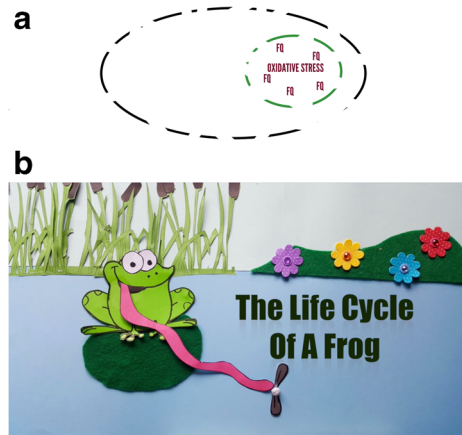
The nutrition/dietetics students were tasked as a group of three or four to produce a *digital media presentation*<sup>2</sup> (max. 4 min; 10% of subject mark) that described the cuisine of an assigned country including information on the country’s geography, food staples and customs around food. The presentation must also outline a typical day of meals and snacks and consider which foods may be problematic in achieving a healthy diet. The students self-select their groups, but countries are assigned by the instructor who uses the task to help students understand more about other cultures, in particular, their food habits and how food features in customs and celebrations. This information is then used for a subsequent task where students consider how to meet the needs of a person from this country who may be in an Australian aged care facility. While this task makes no requirement for particular resources to be used, the students have a short workshop during class time to review possible sources for materials such as downloading from Creative Commons and techniques such as slowmation for illustrating relationships among parts of a concept. Assessment is criteria-based, but no rubric explicitly guides the task. Among the five examples from this class, three used five resources and one each used four or seven. Interestingly, all of the tasks used video in their combinations. Marks in the sample range from 80 to 95%, while the whole class ranges from 70 to 95%.

<sup>2</sup> According to genre theory (Martin and Rose 2008), these artefacts are more accurately described as instances of ‘information reports’.

**Table 6** Task details and case selection summary

	Range in data set	Malaria (pharmacology)	Macedonia (nutrition/dietetics)	Lifecycles (primary teacher science methods)
Purpose of digital media task (from Subject Outline)	varies	Outline the topic of the technical literature review for non-specialist audience, up to 5 mins	Highlight staple foods, geographic influences, food customs, issues for achieving a healthy diet, dietary provisions for aged-care, up to 4 mins.	Explain a concept from an allocated primary level learning outcome to children of that age, 2–3 min
Task purpose (instructor quote)	varies	“If you have got to explain something to somebody it becomes much more powerful.”	“getting students to understand more about other cultures and their food habits.... It’s to help these Nutrition and Dietetics students better understand the multicultural aspects of food and cultural aspects”	“to assess the students’ abilities in putting together a teaching sequence or product. So, in their roles as teachers, they will need to present information, they will need to draw things together”
Indiv or group?	both	individual	Group of 3–4	Individual
Task weighting	5% to 50%	5%	10%	40%
Range of task marks in subj.	50–100%	4.1–5 (65–100%)	8.25–10 (70–95%)	20–37 (50–93%)
Number of resources used in sample for subject	varies	4 (n = 6) 5 (n = 3) 6 (n = 1)	4 (n = 1) 5 (n = 3) 7 (n = 1)	2 (n = 1) 4 (n = 6) 5 (n = 12) 6 (n = 5)

**Fig. 2** **a** Image that Paulo made using a drawing program. **b** Andrea's animated frog



The feature digital artefact was created by a group of four students whose product was about the cuisine of Macedonia. It used five resources: image, narration, text-on-screen, external objects and video. The result is a parody of *MasterChef* where the home cooks (the students) are filmed preparing dishes under the scrutiny of the professional chefs who host the show. The product demonstrates the preparation of several Macedonian dishes while describing the preparation challenges as well as customs associated with the different foods.

### Preservice Primary Teacher Education: Explain Science Content to Children

Preservice teachers in this primary science method subject produce a digital explanation to explain a science concept to children. The preservice teachers choose a topic within an outcome assigned from the NSW K-6 Science & Technology syllabus (NSW BOS 2012). The task specifies a duration of 2–3 min for the explanation, a focus on a small science concept from the assigned syllabus outcome and a presentation suitable for that age/stage of children. Instructors in this subject assign the task specifically to engage preservice primary teachers with science content and expect students to use commonly available technology tools. The preservice teachers create the digital artefact as a stand-alone teaching resource that uses multiple representations. In the rubric, stage appropriateness and design were highlighted, as was the ethical use of sources. Among the examples from preservice teachers, the profiles varied widely, but 96% used four or more resources in the task. Marks in this class range from 50 to 93%.

The featured digital explanation was prepared by Andrea, a primary preservice teacher, whose task explained the life cycle of a frog (see Fig. 2b). She used still images, narration, text-on-screen, animation, video and the requisite 50% slowmotion. In the digital explanation, the frog is the ‘storyteller’ and ‘talks’ to the audience of stage 2 children (years 2–3, aged 7–8), sharing aspects of her life including her habitat, her favourite foods and the general frog life cycle from egg to adult. The slowmotion illustrates the frog moving around her pond by way of explaining the frog life cycle as engaging science content.

### Thematic Analysis

Building from the task contexts and featured products in the previous section, the sections that follow focus on design decisions made by the creators of the digital explanations. Key design



decisions center on representing content knowledge, dealing with technical issues in construction and how the audience was engaged. The Results section concludes with a synthesis of participants' perspectives on digital explanation as an assessment task.

## Representing Content Knowledge

This theme includes an exploration of design decisions relating to the choice of topic, structure of content, how complexity and abstraction were handled and which representations were used to explicitly support the scientific content. Although in each case/subject, the topic was specified, preservice teachers had more flexibility, since they could select a concept from an assigned syllabus outcome. In considering the content focus, Andrea's initial plan was to illustrate a butterfly lifecycle, but this changed because "the more I researched, the more I found that it wasn't suited towards blended media". Andrea made changes to her plan for the task because of the nature of the science content and how this could be illustrated, indicating that there are particular affordances related to representing specific scientific concepts in this format:

I wanted my animations to be more active and in the butterfly, half of it is just in a cocoon so I didn't think I could really show that well in the Slowmotion whereas the lifecycle of a frog, you've got the tadpole growing out its legs, growing out, shortening its tail and I felt like I could really utilise Slowmotion to make that happen.

In terms of organisation, several approaches were used across the data set. In the nutrition case, the organisation of content closely followed the task criteria and the creators simply collected as many resources as possible for later assembly: "It was a very freely spoken script and we just ended up filming a lot of footage; just cooking stuff" (Soo-min, Macedonia). The Pharmacology case, on the other hand, was much more highly structured, with a timed script and PowerPoint-like presentation. The content was arranged such that the complex pharmacological mechanism that was key to answering the assessment question (Is Ferroquine a novel antimalarial?) was carefully built up from the basics of the disease of malaria:

To me ... my main focus [was] why is it not producing resistance ... I had a plan of action ... focus on malaria, then focus on drugs, then focus on Ferroquine and start broad and end up with a conclusion about Ferroquine.

Another important sub-theme within the content knowledge theme was dealing with the characteristics of science knowledge, specifically, abstraction and complexity. As Paulo noted, the digital explanation served a different purpose from the first part of the assessment, the literature review: "The lit review will probably be a bit different because it's an actual academic review whereas the presentation, it can be simpler .... I prefer it when someone gives me a simple explanation." To achieve this, Paulo explicitly omitted the more abstract ideas and simplified those that were more complex: "There's not any of the specific information about specific, I suppose more chemical and pharmacological bits. There are no actual statistics." Others similarly attended to the level of technicality in the presentation because of the non-specialist audience: "I'd probably be a bit more technical if I was talking to actual experts rather than the general public. I think I thought maybe mine was too technical in terms of trying to pitch it to the general public" (Perry, Organometallics). Andrea similarly noted that she was aware of the product being overly complex; however, some complexity was necessary, as she felt that in science, students would need to be aware of the 'terminology' related to life cycles.

Finally, decisions were made in relation to the representations used to support the science content. Different representations were used to achieve different aims, from words (“If I used words instead of pictures it was just to highlight the word that was the key point of the sentence or the point”) to using specific types of images to achieve a purpose (“maybe I’d insert a few real life images and video of frogs and tadpoles just to mix it up a bit and so that they’d be able to see the real life thing”) and also involved more sophisticated combinations of representations (“I did use video. During the tadpole growing, I put a side-by-side of my animation that I cut out with Slowmotion with the video from real life so that they could compare”). Although this student explicitly linked her choice of representational resources to the explication of the scientific content, many students’ representational choices were as much to do with engaging the audience as supporting the content, as will be discussed in a later theme.

### Technical Aspects/Issues in Production

This theme encapsulates how the availability of resources, software characteristics and personal digital literacy (the skills or experience the creator had with the technology) impacted their decisions about the design of the digital resource.

While powerpoint presentations based on written assignments are a common form of assessment in many university classrooms, assignments that require assembling the range of resources described above into a digital artefact are less common. Student creators had a range of prior experience in making digital media and this impacted on the choices they made in creating their assessment product. For example, Ruby learned to use VideoScribe because it has “a variety of pictures and things in there that you can use. You can add text .... and you just pick the objects and put them wherever you want them to go.”

Sometimes, design decisions were made for practical considerations. For example, Paulo, the creator of "Malaria" and an experienced video maker, was very aware of the time-consuming nature of the task:

As I was going through I looked at this as I went [and] I made decisions about what I wanted to show with it, whether it be text, images or if I was not really wanting to make an image for that particular pic because it is too complicated, I just left it blank because of time restraints.

He also made conscious decisions about the aspects of the task in which he would invest time and energy. Knowing that familiarity with construction and video software would streamline the process, he learnt to use new audio software in order to give the finished product a more authentic, documentary-type narration. Similarly, rather than using ready-made digital images, he produced diagrams of the digestive vacuole in Photoshop for Powerpoint slides that could then be embedded in the video file (as in Fig. 2a).

Andrea also brought a good deal of background experience to the task, having had considerable experience with digital media in her preservice primary teacher education course:

Yes, lots. We have had to do a few in this course already. We have done maybe one or two; one for English and one for Geography but before that I loved to make videos and stuff like that so I am pretty knowledgeable about making these kinds of films.

Aesthetic appeal was a high priority for Andrea. Reflecting her Visual Arts background, her final artefact, "Lifecycle", had a "handmade" crafted look, replicating pond life as often depicted in many children's nursery tales. To achieve this, she used Final Cut Pro and Photoshop to produce a slowmotion with several embedded videos—a complex process of integrating resources which required a good deal of care, as well as time:

Oh yep, once I did all the animations and everything, the last thing I did was the audio and the fonts and I overlaid that so that it was relevant to what I was saying and what I was showing in the images.

Not all of the students possessed such skills, however. With respect to the group task (nutrition/dietetics), this sometimes led to an individual group member undertaking much of the work assembling resources because other group members were not as confident about the task. Soo-min referred to a member of her own group (Macedonia) who had the confidence:

She had iMovie and she just said I am happy to put together the movie and we said okay. We sent her all the photos and stuff that we thought would work for our part and then she just put it together and did it really brilliantly.

Reflecting on the students' accounts of such matters provided insight into the nature of the digital environment, with its ready access to multiple resources and into why students' artefacts feature such a range of resources. It also reminded us of the need to proceed with caution when making assumptions about students' digital literacy proficiencies, as these are not *all of a piece* and ie more *traditional* academic skills.

## Engaging the Audience

Under this theme, we consider the creator's explicit attention to engaging the audience. This involves choices about how to organise material or what to show to help the viewer understand the material being presented.

The product featured from nutrition/dietetics looks and feels very much like an episode of MasterChef. In the final interview, Soo-min elaborated design decisions for engaging the audience: "We did not want to just have images with our voiceover talking about Macedonia because it was not very interesting when we watched other people's ones that were like that. It was not very engaging." This was a common theme among all of the samples in this subject. For example, Zaba, who was a member of the Fiji group, was asked during the interview what they had done to engage the audience:

I think because we humanised it. We made it about a person and their story. I think that was our engaging point. I think in the midst of it we did try to use lots of good food pictures so it might grab your interest. I think our strongest point was just making it a man and showing him and telling a story.

This digital artefact about Fiji follows the story of "Mr Telani," from Fiji, who now lives in an aged care facility in Australia. The story traces his background through images and video of cultural events in Fiji illustrating the importance of foods and food customs. So, while making a presentation about the food customs, these groups wanted the product to be interesting visually, suggesting a perception of a wide audience for the product.

However, among the groups in this data set, one [Germany] was explicit in noting that the instructor was the intended audience for the media product:

Moira: We did not know who the audience was ... we just imagined the instructor viewing it.

Harriet: We really wanted to please her.

These comments are interesting because no other groups in this class made such a comment, but then, there was no specified audience in the criteria for this task so it is perhaps not surprising that this group took an instrumental view of task interpretation, in particular, about the audience.

Both preservice teachers and pharmacology students translated scientific content for a non-specialist audience—children in the case of the preservice teachers and other non-specialist scientists in pharmacology, as described by Paulo:

So a lot of the decisions I made was just because if you are an unspecialised audience you don't really care about the science behind it. You just want the overview and putting out images people could relate to very quickly.

The presentation style can also be used to engage the audience. For example, Perry's media product on organometallics featured a role-play where he acted three parts (Scientist, Surgeon General, President) to pitch a grant proposal that included an explanation of possible mechanisms for how several organometallic compounds work to treat diseases and an appeal for more funding to research them. He saw the digital task as a way to put a creative spin on giving a presentation:

I have a tendency to be quite official when I'm giving a presentation ... just to the point and just saying all the information, just having really planned slides, easy to understand sort of thing but I think with this, especially the way that the idea was introduced to us, it just said to me like you can do this funny and you won't get punished for it sort of thing, like go crazy, do whatever, be creative.

Putting a creative spin on the digital presentation was Perry's way to engage the audience.

Preservice teachers have a specific focus on children as the intended audience for the digital explanation. As noted earlier, Andrea had originally selected content to show a butterfly life cycle. However, she wanted active animations within the explanation and felt the butterfly topic did not enable this. She noted, "I wanted it to be entertaining but at the same time, informational and educational." She inserted real-life images and video to

just to mix it up a bit and so they get more experience, rather than just seeing an animation .... if you always show them a model, that's what they're going to think is reality but if you don't compare it to what's reality then they're not going to know the difference.

She used the available resources to show content but with clear attention to the pedagogic purpose for children as the specified audience, which is evident in her design decisions.

Preservice teachers incorporated different design elements to engage the audience. Marc found himself using his *teacher voice*: "I think I've got a little bit of a teacher voice that I put on without really noticing and then there was a female character in there too – I had to do that; it was not brilliant." Jessica sought to include familiar elements to explain the concept of *opaque*:

I didn't want to do something that the children would never have seen before, even just like I could have used a piece of material but they can probably go away from it knowing like in their kitchen they've got a ceramic mug and going to know that 'Oh, that's opaque' and they'd be able to relate to that a bit better.

This sense of realism was also part of others' intentions to engage the audience, for example, Hadara reflected on including an element of realism:

I watched a few YouTube videos of the actual octopus with using its adaptations and I thought that it would be good to include some of that footage because it's more realistic .... I wanted the kids to have a view of what it actually looks like and how it actually moves .... I tried to keep it to the most interesting facts as well so I'd just be like 'Did you know this? It can do this' and then match up with what was on screen and I think being concise in that way but also pinpointing the most interesting, engaging parts would be better for an audience.

## Perspectives

This theme encapsulates creators' perspectives on the digital explanation as an assessment task in the science subject. Sub-themes revolve around student experiences with the task, which are elaborated through selected interview comments.

Students in pharmacology were concerned with producing a high-quality product to maintain their strong marks. This task was, however, quite different from other tasks in the degree and Paulo made a comment in relation to other kinds of tasks:

I probably prefer a task like this because it's a bit more of independent learning. A lot of university's been a little bit spoon-fed so this sort of task ... I learn better by researching it and figuring it out myself than just being taught it because I have to get it, because if I don't, I don't get the marks.

Others in the class reported similar sentiments about independence as learners and the novelty of this task: "It makes me visualise it, like, my learning style is I can read, write very well but that doesn't translate into a video very well so I was forced to think outside of what I'd normally do" (Baxter, Multiple Sclerosis) and "I want to continually learn and develop; I think it's good to have something which is a bit different plus the thing that appeals to me about the digital presentation is that I'm also kind of a very visual learner" (David, TRPV-1 receptors).

In this pharmacology subject, the digital explanation task is worth 5% of the subject mark. Paulo received top marks for his assignment, which is consistent with being a top student in the class. Others commented on the low marks value, "It always seems a little bit silly doing things for five percent" (Ruby, Interleukin), but she was also concerned over the marks earned, "It's all very easy to say five percent doesn't matter, but yes it kind of does sometimes." Ruby went on to describe that even in a small task, the extra effort to earn full marks can make the difference between a Distinction and a High Distinction overall for the subject.

In terms of the assessment context, Paulo commented on the notion of learning communications skills: "if you are trying to teach students effective communication, we did not really get an assessment brief; I did not really know what I was actually meant to be producing." The task specification was quite general: "You will prepare a short digital media presentation outlining the topic of your literature review to a non-specialist audience" and minimal

preparation was provided for students to interpret the task. According to Paulo: “They do try to teach communication skills but a lot of the time they do not mark towards the communication skills, they mark towards the content that is communicated”. Thus, without explicit guidance (in a marking rubric, for example), students are left to guess where to put emphasis and many prioritised science content rather than communication. The rubric for this task did include a degree of detail, but creators must still interpret how much emphasis to give each of the criteria items. Assessing content accuracy seems straightforward; however, more subjective criteria such as *well defined* or *relevant* can also get emphasis in the assessment rubric, which signals to students what they need to attend to in their design choices. Further, marks allocation sets expectations for students to navigate the task.

Participants were generally positive about the task: “I think it’s good. It’s just a different way for the kids to get engaged” (Evelyn, preservice teacher, Solids Liquids Gas) and “I think it’s good, it’s something different. It’s a skill we will be able to use in schools as well” (Marc, preservice teacher, Force). In the final interview, Soo-min found the group context enjoyable:

I think personally I quite enjoyed making it like this. I feel that we actually learned a lot more from a group project point of view than we would have if it was a written assignment. I think with this kind of thing you have to collaborate a lot more and eventually you end up seeing the final product whereas I feel in a lot of group projects you do not .... We have bits all over the place that we have contributed and it feels more collaborative.

Soo-min, as a future nutritionist or dietician, may also see the collaborative nature of the task as possibly more *authentic*, similar to Bartle et al. (2011), who reported that science students felt collaborative tasks were more like how scientists work and health professionals often work as part of a team in institutional settings. The group task did, however, present logistical challenges. Nonetheless, participants from this subject found the task enjoyable and were overwhelmingly positive about it in their interview comments: “I think this is better and more interesting. It is a novelty” (Zaba, Fiji) and “It is refreshing because it is nice to not be so structured” (Elizabeth, Israel). Like Soo-min, most others were also unfamiliar with the type of digital product they were asked to make: “Initially, I guess I looked at it and was just a bit like ‘I don’t know what this is’” (Zaba, Fiji) or “I have had group assignments or group presentations but I have not done anything like this” (Moir, Germany). The novelty of a different form of group assignment gave the group members different opportunity to consider how to communicate the specified content in a digital format. As future professionals, these participants seem aware of the utility of the digital communications skills used in the assessment task.

## Discussion

This research ventures into relatively new assessment territory. We set out to explore the nature of the assessment products, the contexts in which they appeared and what student perceptions were, both in relation to their experiences and their processes in designing the product.

We found that the artefacts exhibited considerable variety in terms of their design, with the assessment contexts contributing significantly to this diversity. For example, the task criteria for the nutrition/dietetics subject lists content items to include in the product, which may

account for the similar organisational structure and style of this set of products as *travelogues*. The assessment context also appeared to shape the interpersonal relationships established within the artefacts. In the nutrition/dietetics artefacts, the students' adoption of a professional communicative style was reflected in their extensive use of video that fostered interpersonal engagement. A similar concern can be seen as shaping the education artefacts, where preservice teachers are tasked to explain the science content to children. The assessment task for a science teacher methods subject has an explicit pedagogic purpose and intent, where the creators must also think about representations that will appeal to children and present them at a suitable development level. In pharmacology meanwhile, the heavy use of image and text can make the digital explanation look like a powerpoint presentation, which could be seen as more *serious*, *scientific* or even authoritative, which could be significant in a setting where academic excellence is highly valued.

Although a large proportion of the products contained image, narration and text on screen, with some including either animation or video, there was no typical *artefact*. The wide range of potential communicative choices open to learners offers opportunities but may also present a challenge. For example, many of the interviews with students demonstrated that across the different contexts, giving them choices of content focus or media forms to include meant the task was highly engaging. This engagement manifested, for example, as an opportunity for students to commit a certain amount of time to the task (Paulo-pharmacology); permission to be creative (Perry-pharmacology); an opportunity for genuinely collaborative work (Soo-min-nutrition); increased relatability of content (Zaba-nutrition); and a growing sense of professional identity (Marc-preservice teacher). Though this variety offers a range of unique opportunities, it also introduces challenges, as creating a successful product depends significantly on the appropriate selection and use of specific resources to suit the particular audience and purpose.

This challenge was apparent when reviewing task rubrics and students' decisions about how to engage the audience. That is, the digital explanations as tasks were loosely expected to develop communication skills in each subject, but it was clear that students could be better supported in this area. For example, in terms of the task rubrics, a communicative requirement was variously represented. In pharmacology, 'attention to audience' was included; in Education, it was 'stage appropriateness' and in nutrition/dietetics, the audience was not specified, but students assumed that the instructor was the main audience. While present to some extent, the criteria for success in demonstrating important communicative skills were not fully developed: a pass grade in Education stated "Satisfactory; stage appropriate in most sections"; the pharmacology assessment rubric had slightly more detail in the expectation that there was a "balance between detail and general overview" and "technical terms were defined."

In the thematic analysis, Paulo (pharmacology) noted that "effective communication" was not necessarily valued (in terms of marking the assessment) or explicitly taught; however, Paulo's techniques in attending to the non-specialist audience were deemed successful; he made decisions such as not including too much detail or information, used labels and carefully structured the scientific content. Andrea (preservice teacher) also discussed the use of specific resources such as complementing stylised animations and models with realistic images and videos to engage the audience and illustrate the science content at a level suitable for children. However, "attention to audience" was not always interpreted in this way, for example, Soo-min (nutrition/dietetics) mentioned that their group's artefact was humorous and freely spoken with lots of footage of themselves in order to be entertaining for the audience. Perry (pharmacology) also noted that communicating to a general audience meant that he could be less scientific and



more creative. Though these techniques might all be appropriate, the ambiguity in what is and is not "technical" and what it means to "attend to the audience" when communicating scientifically is something that could be made more explicit.

Interestingly, analysis of the interviews demonstrated that students did not encounter significant issues with the technology. However, it was clear that the choice of software/program, together with their ability to use a range of digital resources, did introduce certain constraints. Students were sometimes limited in what they could find on the Internet or from what can be constructed using other software programs such as Photoshop or Audacity (either due to skill or time). For example, Paulo (pharmacology) noted that if an image needed for a particular section was too "complicated," he would instead leave the screen blank. Students are also expected to properly reference the material they use, but the area of digital scholarship is new for many students who are used to text-based referencing and may encounter this aspect of digital literacy for the first time when creating a digital explanation. It also opens the possibility of teaching students about ethical use and re-use of open-source materials, an important element of digital literacy.

## Conclusion and Recommendations

In framing this paper, we considered digital explanation as an assessment task in tertiary science learning contexts and sought to characterise students' design decisions and media forms used in creating them. This is part of a larger goal for the wider community in science education to develop and assess a range of skills and knowledges including communication. Alternate forms of assessment such as digital explanation offer such opportunity. Exploring the tasks included developing tools for analysing them but also gathering student perspectives on the task and their design decisions in making the products. This research thus adds to the knowledge base on alternate forms of assessment in tertiary science. We have, however, only scratched the surface of this form of assessment.

Science learners commonly work with a range of representational forms, many that are language-based, even when on-line, where a limited modal range is used to communicate meaning. Communicating science knowledge increasingly involves a range of resources—diagrams, scientific notation, images, etc., which Lemke (1998) highlighted as the multimodal nature of scientific literacy practices. However, for students, managing the range of resources becomes complicated when multiple modes or media forms are combined. When learners are asked to combine various resources into a coherent text to explain sometimes complex scientific knowledge, as in a digital explanation, to be successful, they must realise this knowledge and deliberately assemble these different resources, which is a complex literacy task.

Developing a digital explanation or related form of assessment also means that instructors need a sophisticated understanding of the digital artefacts and how to assess them. In other words, we need a shared awareness that includes ways to talk about a range of texts as meaning making artefacts. When tertiary science students produce such texts, we must consider the assessment context and the nature of assessment practices in tertiary science subjects and universities more generally. Science discipline subjects are content-heavy and typically involve laboratory components; thus, this research has the

potential to inform instructors' decisions about the possibilities of alternate forms of assessment, in particular to assess aspects of digital literacy or communications.

As an alternative form of presentation task, digital explanation puts a press on both students' content knowledge and digital communication skills at the same time. The task can be aligned to a written task or as a stand-alone assignment while generating opportunity for students to be creative in engaging important digital literacy skills. We offer the following recommendations for instructors considering such assignments:

- provide students with choices in creation, e.g. type of media to use (topic of the digital explanation, format of product, hardware/software);
- tailor task criteria for the content area: contemporary issues, analyses of content, reviews;
- assign 20–30% of subject marks: students will feel their effort in production is valued;
- specify an audience other than their peers or the instructor; 'non-expert' is too general;
- specify competencies with digital literacies, e.g. communications, multimodality, creativity;
- to further support students, provide them with models of successful artefacts that meet the task expectations in terms of content and communication.

Media literacy researchers have advice to offer too, such as Reyna et al. (2017) who recently produced a taxonomy to guide task development for digital media creation.

Drawing from science education research literature in representations, we advance the field by asserting that such tasks are beneficial as assessment tasks because they have the potential to foster different forms of engagement with science content and they provide opportunity for teaching science students about how multimodal texts work to communicate science. Students then make design decisions to build meaning through the choice and combinations of semiotic resources that simultaneously focus on representing science knowledge, developing techniques and skills for presenting this information and making specific choices for engaging an audience. We argue that students need to be supported to understand the semiotic potential of multimodal resources and how they combine for different purposes, which can be built into task criteria for such assessment tasks as we have described. Such tasks, however, are also demanding for science educators. Our experience in this research suggests that science educators are up for the challenge.

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## Appendix 1 Semi-structured interview protocols

### Pre-Interview with creators (before topics chosen or construction begun)

What topic did you choose? Why did you choose this topic? Probe.

What do you know about this topic? What do you want to know? Probe.

What are your plans for developing the explanation? learning about the topic? What resources will you use?

What experience do you have making digital media? Digital stories, videos, etc.

What experience do you have of watching digital media? YouTube videos etc.

What is your opinion of the blended media task in this subject? Do you think this will be a useful way to present this topic/answer this question? If so, why, or why not others (essay/ PowerPoint etc.)

Any ideas about what techniques you might use and why?

### **Post-Interview with creators (following construction of blended media)**

How much effort did you put in to the construction process?

Can you describe the process you followed? How much time? Which software packages did you use in the construction of your blended media? Did this limit you in any way?

Did you look at any other examples of blended media? Which? If so, how did they influence your own construction?

Describe the topic now: what have you learned?

Explain the answer to your topic question.

What features have you included so that the audience is engaged?

Do you think your blended media is a good explanation? Why?

Were you able to find the kinds of images that you wanted to use? What happened if you could not?

How would this digital resource have been different if you could produce it professionally?

Ask about modal choices made in the blended media. Why those? Probe:

How/what did each mode make you think about the topic?

Was this a useful way to present this topic/answer this question? If so why? If not, why not? Which would be better?

Were the task criteria detailed enough? What would you add?

What mark did you get on the blended media?

### **Interview with instructors**

What is the nature of the task and its purpose in the subject?

How do you choose topics for the explanations? Are there some that are more appropriate for this task?

Why is it important for the creators to integrate media forms or different forms of representations? If applicable, why is this important for teachers?

How challenging do students find the task?

Do students have a good understanding of an ‘explanation’?

Do you think this is a valuable learning experience for students? In what ways?

How scientifically accurate are the students’ representations?

How is the task set up?

What support do the students get in developing the task?

In terms of assessment, what in particular are you looking for? Are some of these prioritised? (e.g. higher marks value).

## Appendix 2: VQ Rubric (for Variety and Quality of digital explanations)

Date of Review\_Nov27-16\_\_

<b>VARIETY:</b> Title __Malaria__		File Name __Malaria_2015.mp4				
Subject and Year __CHEM350 2015__		Mark earned: 5 out of 5__				
Brief Task Description __short digital media presentation to outline topic of literature review__						
Audience is specified in the task <input type="checkbox"/> no <input checked="" type="checkbox"/> <b>yes</b> (circle one) Audience: __non-specialist audience__ Duration: __04:54__						
<b>Genre and Composition</b>						
Expository: <b>explanation</b> persuasive <input type="checkbox"/> <b>informational</b> filmic/performative (circle one) Other _____						
Range of semiotic resources and composition:						
		>95%	<5%		25%	
Video live action	Slowmotion	Image+narration Digital story	Animation	Voiceover ppt	Text/labels	Other 3 _____
All Verbal		Even Verbal/Visual		All Visual (make mark on continuum)		
Makes use of digital objects/ready-made elements? <input checked="" type="checkbox"/> <b>yes</b> Notables: uses images of drug bottles as drugs named; talks about drug when compound formula displayed, also highlights key portion of molecule; short animation sequence to illustrate evolving response						
Complementarity/coherence/suitability of modes: <b>mostly</b> notables: illustrations are generally simple versions of narrated information						
<b>QUALITY</b>						
<b>Purpose</b>						
Meets purpose stated in task: <input type="checkbox"/> no <input checked="" type="checkbox"/> <b>yes</b> inconsistent (circle one) notables _____						
<b>Attention to audience</b>						
Suitability for specified audience: <input type="checkbox"/> no <input checked="" type="checkbox"/> <b>yes</b> notables: yes, but chemistry of compounds is very high level						
Interesting and engaging: <input type="checkbox"/> no <input checked="" type="checkbox"/> <b>yes</b> inconsistent (circle one) notables: jingling tune in background lightens feel of intense information packaging						
<b>Accuracy</b>						
Accuracy: poor ok <input checked="" type="checkbox"/> <b>good</b> (circle one) notables: most complicated part of presentation moves too fast (oxidative stress, plasmodium lifecycle, resistance mechanism)						
<b>Overall:</b> very careful construction; very engaging; overall nice complementarity of voice and image						

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