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Digital media assignments in undergraduate science education: an evidence-based approach

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Digital media assignments empower students to become co-creators of knowledge rather than passive consumers of content. The Internet explosion and the affordability of digital technologies and devices such as smartphones, tablets and action cameras have created opportunities to use digital media in the classroom. This article aims to present an evidence-based approach to help educators to design, implement and evaluate digital media assignments in the classroom. For this purpose, four theoretical models were tested to inform the design of digital media assignments in undergraduate science education. These models helped to identify the student training in digital media needed, develop effective marking rubrics, and inform the design, implementation and evaluation of digital media assessment tasks. Trials were conducted in Spring 2016 ($n = 458$) and Autumn 2017 ($n = 1329$), respectively. Data collection used a mixed-methods approach, including a qualitative survey, open-ended questions, group contribution data and marks attained. Data analysis showed positive outcomes of the systematic implementation of digital media assignments. In conclusion, students enjoyed the support they received, being creative, working in groups and learning with digital media. To date, this intervention is one of the most comprehensive and practical approaches to digital media assignments in the classroom, which has been undertaken.

Keywords: learner-generated digital media; digital media assignments, multimedia assignments; science education; assessment design

Introduction

Technological tools, in conjunction with digital media, are reshaping social, professional and educational settings. Students in the 21st century need to develop digital media literacies for successful careers, regardless of their discipline (Hobbs 2017; Ohler 2013). In teacher education, digital media provides students with the opportunity to reflect on their practices (Kearney and Schuck 2003). Use of digital media has recently expanded to other disciplines, but a review of relevant literature reveals a lack of theoretical models for its implementation in the classroom and a lack of student-centred approaches (Hoban, Nielsen, and Shepherd 2015; Nielsen, Hoban, and Hyland 2017). The pedagogical approach behind digital media assignments is to

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engage students in active learning and to encourage collaboration which generates an environment conducive to deep learning and reflection (Coulson and Frawley 2017; Pirhonen and Rasi 2016). Additional benefits of using digital media assignments include development of graduate attributes such as communication, time management and planning skills (Frawley *et al*. 2015; Morel and Keahey 2016). When students prepare the storyboards for their digital media assignments, they also exercise research skills such as critical thinking and report writing (Ohler 2009).

Most of the existing research on digital media assignments does not involve a rigorous approach to designing the assessment task, and comparison between studies is difficult because different media types were used, that is digital stories, animations, video or blended media (Reyna and Meier, 2018a). Each of these digital artefacts requires different production skills (Reyna et al., 2018b). One of the most problematic research gaps is the evaluation of student learning with digital media (Hoban, Nielsen, and Shepherd 2015). There are no methodologies for assessing student learning with digital media assignments (Reyna et al., 2018a). Most of the studies use qualitative surveys and interviews and small sample sizes (Reyna and Meier, 2018c). The findings from these surveys have not been linked to, for instance, marks attained for the task. This study aimed to address these issues by incorporating a set of theoretical frameworks to guide the systematic implementation of digital media assignments in undergraduate science education.

Literature review

Theoretical frameworks to inform the design of digital media assignments are rare in the literature. In the discipline of teacher education in Australia, a model was developed for the use of digital video projects in the classroom. The approach included nine stages, teacher strategies and peer learning structures (Kearney and Schuck 2003). This preliminary model informed a later more comprehensive approach for designing digital stories as an assessment tool (Kearney 2009). Although comprehensive, this model is impractical for use outside the teacher education discipline.

An instructional design model for digital media assignments based on the consume, analyse, scaffold, produce and assess (CASPA) model has emerged recently in the literature (Blum and Barger 2018). Using the CASPA model, students need to 'consume' an exemplar of a digital artefact they want to develop. For instance, if they are going to create an audio podcast, they will need to identify good and poor quality podcasts. In the next step, which is 'analyse', students work in groups to deconstruct the digital artefact from the narrative, storytelling and argument. In the next step, the educator 'scaffold' students through the process by helping them to create their storyboards. In the 'produce' stage, students put together the different elements of the digital artefact, and the educator provides feedback for improvement. In the final stage, students 'assess' the effectiveness of the message conveyed with the digital artefact and define if the type of digital artefact was the most appropriate choice. The disadvantages of this model include a lack of pedagogical underpinnings, not considering groupwork and a lack of evaluation. As digital media production in the classroom can be a time-consuming, iterative and resource-intensive process (Musburger and Kindem 2012), not having a groupwork strategy could cause the intervention to fail.

The access, analyse, create, reflect and act (AACRA) model (Hobbs 2017) proposed that the effective creation of digital media artefacts in the classroom requires

'access' exemplars of digital artefacts and 'analyse' how they were built. In the next step, the students should 'create' their digital artefacts using s storyboard approach and receiving feedback from the educator. Then, they 'reflect' on media influences on viewers and finally 'act' using all these literacies in a socially responsible manner. The limitations of this model are that it does not consider groupwork strategies and lacks evaluation. Although digital media assignments in higher education is not a new concept, they are non-traditional assignments; therefore, evaluation is essential to hear student voices to improve the assessment task iteratively.

The CASPA and AACRA models assume students will learn digital media skills by creating digital artefacts. The assumption is problematic as digital media is a discipline and require to be taught formally. For instance, by teaching basic colour theory, layout design, typography, use of images and video techniques, the students will be able to apply the principles when developing their digital media assignments. As a result, the digital artefact will look credible, engaging and will communicate the message to the intended audience.

We developed a set of theoretical models to close these gaps in digital media assignments. The following section presents these models.

The digital media literacies framework

The digital media literacies framework (Reyna et al., 2018b) identifies students' training needs for digital media production in the classroom (Figure 1). This framework helps to define the domains of digital media literacy required to engage in the production of digital media assessments effectively. This framework proposes that the effective creation of a digital artefact has three domains: conceptual, functional and audiovisual. To develop digital media production competence, students need to be trained in each of these domains. The conceptual domain covers the creation of an evidence-based storyboard to inform the development of a digital artefact. The
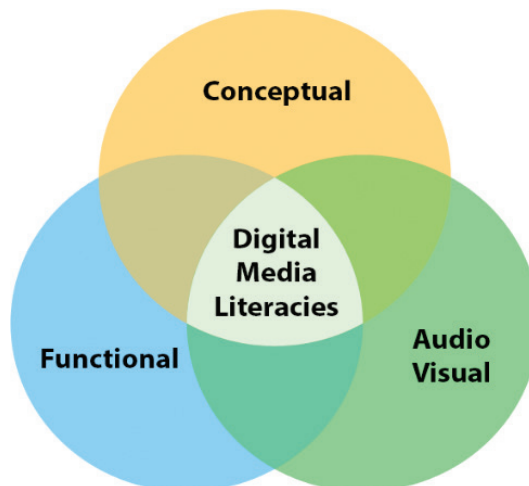

Figure 1. The digital media literacies framework. The skills needed for production of effective digital media which communicate a message effectively to an audience are at the intersection of three domains: conceptual, functional and audiovisual (Reyna et al., 2018b).

storyboard is a document that outlines the content and the sections that will be covered (Carroll 2014). In the discipline of science, the content should be gathered using an evidence-based approach, with students consulting scholarly information such as journal articles and books. The functional domain covers the skills to use different software and applications to create digital media artefacts, that is animation software (Powtoon), image manipulation software (Adobe Photoshop) and video editing software (Movie Maker or iMovie). Lastly, the digital media principles (layout design, colour theory, typography, use of images and video techniques), known as 'the grammar of the 21st century', are covered in the audiovisual domain. Students need to position their skills at the intersection of the domains, shown in the Venn diagram below, to be able to produce compelling digital artefacts. As digital media requires specialised knowledge, this is only achievable with formal training (Arvidsson and Delfanti 2019; Earnshaw 2017; Martin and Zahrndt 2017).

The taxonomy of digital media types

The taxonomy of digital media types (Reyna et al., 2017a) incorporates and extends the digital media literacies framework (Figure 2). The model informs educators' choices about what type of digital media to use for their assessment tasks, and also informs the development of marking rubrics. As an example developing marking rubrics, under communication skills, the rubric could have sections for the conceptual, functional and audiovisual domains to benchmark students against. The educator can then provide targeted feedback to students. From the students' perspective, the taxonomy helps them to see which skills they require to produce their digital media assignments.
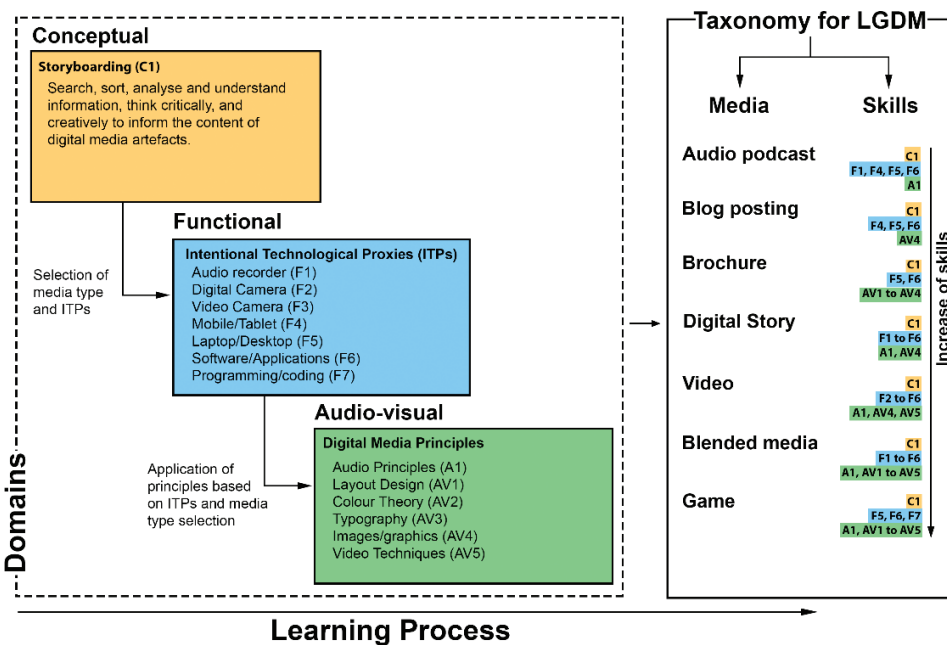

Figure 2. The taxonomy of digital media types for teaching and learning. Each digital media type is linked with the three domains that represent the skills required for the production of a compelling digital artefact.

The digital media principles framework

The third model helps students and academic staff to develop expertise in digital media principles. Evidence from different fields, such as neuroscience (LeDoux 1989, 1992), psychology (Chang, Dooley, and Tuovinen 2002; Smith-Gratto and Fisher 1999), visual design and multimedia learning (Mayer 2008) informed the digital media principles model. The principles include layout design or distribution of design elements on the screen, colour theory, typography and the effective use of fonts (Malamed 2015); contrast, repetition, alignment and proximity (CRAP) principles of graphic design (Williams 2014), and image and video principles (Bowen 2013; Bowen and Thompson 2013; Stockman 2011) (Figure 3). The understanding and application of these principles in the production of digital media artefacts ensures legibility, credibility and effective communication of the message to the audience.
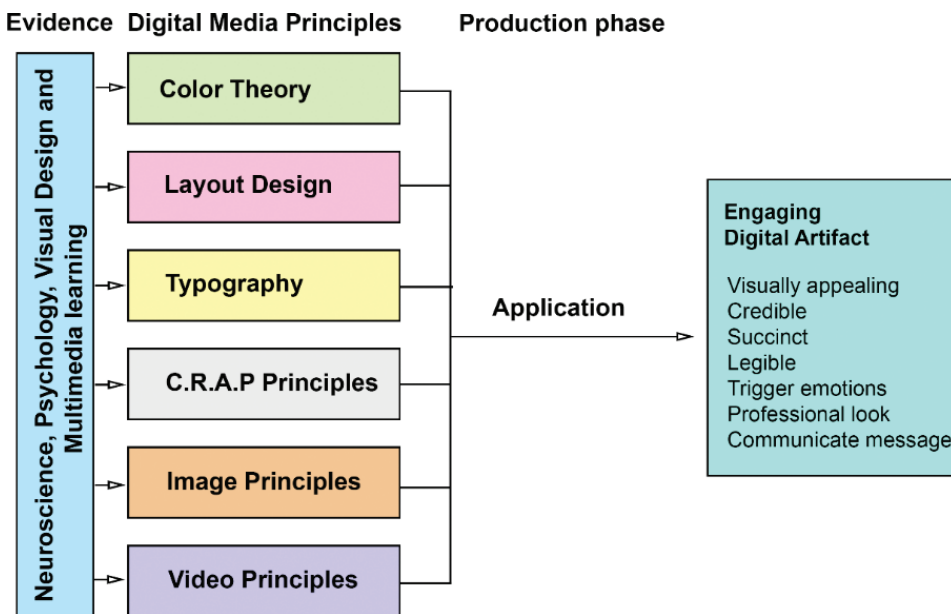

Figure 3. The digital media principles framework for teaching and learning. These principles are the basics of effective communication in the digital space.

The digital media implementation framework

The three frameworks described above (Figures 1–3) complement the digital media implementation framework (Figure 4) (Reyna and Meier, 2018b), especially regarding student training needs and marking schemes. This student-centred practical framework was designed to guide the application of digital media assignments in the classroom. The inner section focuses on what students do with the digital media task and helps them to understand its rationale and the assessment workflow. It contains frequently asked questions to be discussed during classes and tutorials and is reinforced with supporting material available in the learning management system (LMS). The outer section helps academics with digital media task design. It is essential to articulate this model to students in the classroom as they need to 'buy into' the need to learn subject content using digital media.

Figure 4. The digital media implementation framework, showing a systematic approach to the design, implementation and evaluation of digital media assignments in the classroom. The framework is student-centred and addresses possible questions they may have before starting their assessment task. DMP stands for digital media project.

The frameworks presented above (Figures 1–4) were applied in the design of digital media assignments for this study. The research question to be tested was: *What is the impact of a systematic approach using theoretical models to guide digital media assignments in undergraduate science education?*

Materials and methods

Challenges when implementing digital media assignments in higher education are related to how to implement a consistent, reliable and sustainable assessment design, how to train students accurate design of marking rubrics and how to ensure effective group contribution. By using the theoretical models presented in the literature review section, this research aimed to contribute with an evidence-based workflow on digital media assignments implementation. The following sections describe in detail the approach utilised.

Participants

The research was conducted in the Faculty of Science at a metropolitan university in Sydney, Australia. Two case studies were conducted over two sessions: Spring (Sep–Nov 2016) ($n = 458$) (Table 1) and Autumn (Mar–Jun 2017) ($n = 1329$) (Table 2). Subjects who had implemented digital media assignments were chosen to be part of the study. The first case study (Spring 2016) aimed to gauge student perceptions of digital media support received via lectures and online materials, any problems encountered, and what they liked most and least about the digital media task. The second case study focused on evaluating group performance in digital media assignments. In both cases, marks attained for the digital media task were collected to determine if they followed a normal distribution and for use as evidence of student accomplishments. A normal distribution curve is symmetrical on both sides of the mean, and the right side of the centre is a mirror image of the left side. Not obtaining a normal distribution on marks will indicate a detrimental effect of the digital media assignment. The trials used the frameworks described in the literature review (Figures 1–4). Note that some subjects did not have enough available time for face-to-face lectures on digital media and used the online version uploaded into the LMS (captivate interactive module). Geology (Geo) was the only subject run in both Spring and Autumn and therefore was included in both trials. The rest of the subjects were either Spring or Autumn offerings.

Table 1. Subjects who implemented digital media as an assessment tool in the Faculty of Science in Spring 2016 ($N = 458$).

Subject	Year	N	Assessment weight (%)	Delivery mode
Pharmacology 2 (Pharm 2)	2	169	30	Blended
Geology (Geo)	2	101	20	Blended
Animal behaviour and physiology (ABP)	2	106	20	Blended
Evaluating TCM (eTCM)	3	43	20	Blended
Pharmacology and microbiology (PM)	3	39	25	Online
Total		458		

Table 2. Subjects who implemented digital media assignments as an assessment tool at the Faculty of Science in Autumn 2017 ($N = 1329$).

Subject	Year	N	Assessment weight (%)	Delivery mode
Human homeostasis (HH)	1	697	20	Online
Forensic investigations (FI)	2	78	30	Blended
Geology (Geo)	2	103	20	Blended
Pharmacology 1 (Pharm 1)	3	295	15	Blended
Neuroscience (Neuro)	3	323	30	Blended
Molecular nanotechnology (MolNn)	3	50	15	Online
Medical imaging (MedImg)	3	110	30	Blended
Total		1329		

Digital media learning design

In both cases, the implementation used the frameworks previously presented (Figures 1–4). The *digital media literacies framework* guided the design of student training in digital media production covering the three domains (conceptual, functional and audiovisual). The delivery modes for the training were blended and online only. The *taxonomy of digital media types* guided the design of marking rubrics and also the digital media task weighting, according to the media type that students were producing. The *digital media principles framework* provided the topics included in the digital media training lectures, which were delivered face-to-face and online. The topics were layout design, colour theory, typography, use of images and basic video principles. Finally, the *digital media implementation framework* informed the overall learning design of the task and also helped to communicate the assignment rationale to students and subject coordinators (Figure 4).

Survey and open-ended questions

For the Spring 2016 study, a four-point Likert scale survey (strongly disagree, disagree, agree and strongly agree) was administered to participants on a voluntary basis. This survey aimed to gauge student perceptions of the digital media support provided (Table 3). The scale did not include a neutral point, as it would not be useful for data analysis. The survey items were previously validated using factor analysis ($N = 270$), using 'principal components' as extraction method, Kaiser-Meyer-Olkin (KMO) test value was 0.909 and Bartlett's test of sphericity was $p < 0.001$, which allowed us to conclude that there were relationships between the variables.

Open-ended questions (Table 4) were administered to gauge student attitudes to digital media assignments in Spring 2016 and Autumn 2017.

Both surveys (Tables 3 and 4) were developed in 2015 and published previously in a pilot study (Reyna & Meier, 2018c).

Table 3. Survey to gauge student perceptions of support for their digital media assignments in Spring 2016.

	Item	Factor loading
1	The digital media lecture was engaging	0.724
2	I applied concepts from the lecture to the assignment	0.714
3	I used a storyboard to structure my project	0.687
4	I recommend that my peers attend/watch this lecture	0.607
5	I need more training on digital media presentations	0.561

Table 4. Open-ended questions to gauge student attitudes towards digital media assignments in Spring 2016 and Autumn 2017.

Question	Item
1	Did you experience issues with the assignment?
2	What did you like most about the assignment?
3	What did you like least about the assignment?

Group contribution (SPARKPlus)

In Autumn 2017, the second case study aimed to evaluate group performance in digital media assignments. For this purpose, the SPARKPlus student peer-review application was used to ensure fair group contributions from all members (Willey and Gardner 2010). SPARKPlus uses a marking rubric to measure group contribution across all subjects with the following criteria: (1) subject input for the project; (2) punctuality and time commitment; (3) contribution of original ideas; (4) communication skills and working effectively as part of the team and (5) focus on the task and what needs to be done (Reyna et al., 2019). Students used a slider to first grade themselves and then their peers, using the levels of contribution scale: NC = no contribution, WB = well below average, BA = below average, AV = average and AA = above average (Willey and Gardner 2010).

Below each criterion, there was a text box where students could write feedback for their peers. SPARKPlus automatically calculates a rating that identifies groups with collaboration issues. The relative performance factor (RPF) measures the level of contributions to groupwork based on the peer reviews of group members. The final mark for individual students is derived by multiplying the score attained by the group by the student's RPF factor. For instance, if a student gets a group mark of 20, but his/her RPF factor is 0.8, his/her final score will be $20 \times 0.8 = 16$. The SPARKPlus tool is used from the first year in the Faculty of Science, so students were familiar with how it works.

Learning management system logs

LMS logs were collected for the Autumn 2017 cohort only to gauge student engagement with digital media resources online.

Data analysis

This research used a mixed-methods approach (Tashakkori and Teddlie 2010) to data collection and analysis. Survey data, open-ended questions, marks attained, LMS logs and group contribution data were analysed using frequencies and descriptive statistics (SPSS Statistics for Windows Version 24.0, Armonk, NY, USA: IBM Corp.) and open-ended questions were analysed using thematic analysis (NVivo Version 11, QSR International, Melbourne, Australia, 2016). The research used methodological triangulation to provide more credibility to the data sets. For instance, it was expected students to match their attitude towards digital media support with their answers to open-ended questions, group contribution data and marks attained.

Results

Spring 2016 cohort

Thirty-seven per cent of students were males while 63% were females. The age brackets were 18–29 (87%), 30–49 (11%) and 50–64 (2%). Sixty-five per cent of students were high school graduates, 25% already had university degrees and 10% had trade, technical or vocational training. Twenty per cent of the cohort had English as an additional language (EAL) and 80% were native English speakers.

In Spring 2016, a total of five science subjects in the Faculty of Science (three second-year and two third-year) (*n* = 458) implemented digital media assignments (Table 1). The *digital media literacies* and *digital media principles* frameworks guided student training in the three domains discussed previously. Students received training in the conceptual domain to produce storyboards for their DMPs during the first week of the semester, face-to-face or online. Students also received training in the functional domain to learn the basics of video editing and digital media such as layout design, colour theory, typography, use of images and basic video techniques. At the end of the session, 240 students completed an online survey about digital media support (Table 3) (60% response rate) and 89 responded to the open-ended questions (assignment issues, what they liked most and least) (Table 4). A high percentage of students (80% either agreed or strongly agreed) had a positive perception of the digital media support provided (Table 5). Thematic analysis of their answers to the open-ended questions is presented in conjunction with the second case study of Autumn 2017.

Students in both Spring 2016 and Autumn 2017 were expected to apply the content covered during the workshop, face-to-face lecture and online modules to their digital media assignments. The taxonomy helped to develop a generic five-point rubric to gauge student communication skills in their digital media assignments, including high distinction, distinction, credit, pass and fail scores. As each subject was aligned to different learning outcomes, only the part of the rubric which was standard for all subjects is presented in Table 6.

This marking rubric was created in 2016 and recently published in another study on digital media assignments and self-regulation (Reyna et al., 2019).

The *taxonomy of digital media types* also guided the assessment weighting, based on the complexity of the task. Subject coordinators worked with the faculty learning designer to discuss the weighting of the digital media task. Table 7 presents the different media types, their recommended weights as assessment tasks and whether assessments should be individual or group. Extensive consultation with subject coordinators and use of the taxonomy yielded these weightings. Only Pharmacology 1 used blog-posting as an individual assignment (15% assessment weighting). The rest of the subjects chose video.

The *digital media principles framework* guided the topics covered by student training in the audiovisual domain. Students received tuition (blended and online) in layout design, colour theory, typography, use of images and basic video principles (Figure 3).

Table 5. Student perceptions of digital media support when using the digital media literacies and digital media principles frameworks to design teaching materials for the digital media assignment for five science subjects (*N* = 240, 60% sample size), Spring 2016.

Item	Frequencies (%)			
	SD	D	A	SA
The digital media lecture was engaging	0.7	13.8	61.3	24.2
I applied concepts from the lecture to the assignment	1.3	10.4	58.3	30.0
I used a storyboard to structure my project	4.1	22.9	46.3	26.7
I recommend that my peers attend/watch this lecture	1.3	18.3	51.7	28.7
I need more training on digital media presentations	4.1	22.9	46.3	26.7

SD = strongly disagree; D = disagree; A = agree; SA = strongly agree.

Marks were converted to a percentage to run descriptive statistics because each cohort had a different task weighting (Table 8). Comparisons between groups were not possible as there were multiple markers. Marks were essential to confirm that the assessment results followed a normal distribution. A normal distribution confirmed that the assignment was comparable to traditional assessment tasks regarding scores and student performance.

Table 6. A generic example of criteria to design a marking rubric to measure communication skills in digital media assignments. The marking rubrics were created using the frameworks shown in Figures 1 and 2.

Domain	Criteria
Conceptual (Storyboarding)	The goal of the presentation Synthesis of ideas The context of the presentation The structure and flow of the presentation The use of references
Functional (use of software)	Use of software and devices The smoothness of the presentation Absence of image pixelation Transitions and effects used consistently Audio quality
Audiovisual (digital media principles)	Distribution of design elements on-screen Appropriate use of colour scheme Proper use of fonts Using images to convey meaning Video stability and orientation

Table 7. Assessment weights for digital media assignments according to digital media type. The recommended percentages came from consultation with subject coordinators and use of the frameworks (Figures 1–2).

Digital media type	Assessment weight (%)	Group work?
Podcast	10–15	No
Blog-posting	10–15	No
Brochure	15–20	Yes
Digital story/animation	20–25	Yes
Video	25–30	Yes

Table 8. Distribution of grades across the subjects which implemented digital media assignments in Spring 2016.

Subject	N	Min	Max	Mean	Std. Dev.
Pharmacology 2 (Pharm 2)	169	33	96	79	9.25
Geology (Geo)	101	67	100	95	7.51
Animal behaviour and physiology (ABP)	106	53	100	77	14.45
Evaluating TCM (eTCM)	43	70	95	84	7.83
Pharmacology and microbiology (PM)	39	61	97	82	12.48

Autumn 2017 cohort

Twenty per cent of students were male and 80% were female. The age brackets were 18–29 (89%), 30–49 (9%) and 50–64 (2%). Sixty-five per cent of students were high school graduates, 13% already had university degrees, 20% had trade, technical or vocational training, and 2% had postgraduate studies. Forty-seven per cent of the cohort had EAL and 53% were native English speakers.

Groupwork data were collected using the SPARKPlus peer-review application ($n = 1329$). The RPF Factor values showed a normal distribution for all the Autumn 2017 cohorts. Table 9 shows the percentages of students who scored excellent (RPF >1), acceptable (RPF between 0.8 and 1.0) and poor (RPF < 0.8) for group performance. Using one-way ANOVA to compare means between groups and also splitting the data into three groups (first, second and third year) did not reveal statistically significant variations, so it was assumed that group contribution was the same across all Autumn 2017 subjects.

LMS logs were only available for Autumn 2017. Students from all the cohorts participating in the trial showed a high level of engagement with digital media online resources during the teaching period. Seventy to ninety per cent of students visited the folder containing the digital media learning material across the session. The figures include unique visitors only. Resources inside the folder included YouTube videos, online modules (Captivate), PDFs and external links, but the researchers were unable to monitor each of these resources individually. Therefore, it is unknown which resources were more accessible for students in terms of the number of visits and video plays.

As in Spring 2016, student marks were converted to a percentage and were found to follow a normal distribution, suggesting that students did not have difficulties with the digital media assessment task (Table 10).

Table 9. RPF factor distribution in percentages across subjects undertaking digital media assignments in Autumn 2017 in the Faculty of Science – geology (Geo), human homeostasis (HH), forensic investigations (FI), medical imaging (MedImg), molecular nanotechnology (MolNn) and neuroscience (Neuro). One-way ANOVA did not reveal statistically significant variations between subjects.

RPF range	Geo	HH	FI	MedImg	MolNn	Neuro
>1	59.7	46.4	41.6	39.8	39.7	44.9
0.8 – 1.0	34.0	50.5	57.1	58.3	60.0	53.9
<0.8	6.3	3.1	1.3	1.9	2.2	1.2

Table 10. Distribution of marks across the seven subjects that implemented digital media in Autumn 2017 – human homeostasis (HH), geology (Geo), forensic investigations (FI), medical imaging (MedImg), molecular nanotechnology (MolNn), neuroscience (Neuro) and pharmacology 1 (Pharm 1).

Subject	*N*	Min	Max	Mean	Std. Dev.
HH	199	47	100	76.23	11.911
Geo	17	95	100	98.29	2.173
FI	51	64	97	79.78	9.116
MedImg	12	80	100	91.67	7.177
MolNn	13	60	90	77.69	10.127
Neuro	33	60	93	81.85	9.324
Pharm1	22	50	100	78.41	16.503

Table 11. A thematic analysis of open-ended responses from Spring 2016 ($N = 89$) and Autumn 2017 ($N = 243$).

Question	Spring 2016	Autumn 2017
Did you experience issues with the assignment?		
No issues	23	62
Weak skills in digital media production	7	13
Assignment unclear	3	7
Not enough time to complete the assessment task	4	16
What did you like most about the assignment?		
Creativity	16	51
Teamwork	12	36
Learning the subject content	7	21
Different from other assignments	3	42
Fun assignment	5	16
Freedom to use any digital media type	3	8
Learning digital media	9	18
Self-expression	5	15
What did you like least about the assignment?		
Group issues	12	7
Nothing	5	18
Not having digital media production experience	7	12
The digital media assignment was unclear	3	16
Digital media production is time-consuming	7	12
Time constraints to produce the assignment	3	13

Table 12. Student misconceptions about digital media assignments.

No.	Assignment misconceptions
1	I need to appear in the video, and I am not comfortable doing it
2	This assessment is all about creativity, and I am not creative
3	Our group does not own the professional equipment needed to produce quality digital media
4	Groups with tech-savvy members have an advantage
5	This assignment is unfair as it is marking IT skills, not learning
6	This assessment exists because lecturers are too lazy to mark written assignments
7	I will never use digital media in my career
8	I am the only one who can come up with great ideas, and I do not want to share them with others

Thematic analysis of open-ended questions from both Spring 2016 and Autumn 2017 is presented in Table 11. Students in Spring 2016 reported group issues because SPARKPlus was not used to ensure fair contributions by group members. In contrast, the Autumn 2017 cohort did not report group issues in the open-ended questions. In both cohorts, student perceptions of the use of digital media assignments were highly positive. Students did not mention any issues and enjoyed being creative, the team-work, learning the subject content, the difference from other assessment tasks, the fun factor, the chance for self-expression and learning digital media production.

Student misconceptions about digital media assignments were also reflected in a small number of the responses to open-ended questions and the author considers it is essential to present these data (Table 12). Although the misconceptions were not significant, knowing them will allow us in future interventions to address them in the classroom at the beginning of the session to ensure that all students are on board.

Discussion

Data from both trials in Spring 2016 and Autumn 2017 showed an overall positive student experience with digital media assignments. Responses from the survey about support with digital media, marks attained, open-ended questions and group contribution data confirmed this finding. The frequencies of responses shown in Table 5 indicate overwhelming success regarding digital media support for students. These results validated the use of the *digital media literacies framework* to design student training in digital media. As a result, only 20 students (6% of respondents) across Spring 2016 and Autumn 2017 reported weak skills in digital media production for the open-ended question: *Did you have any issues with the digital media assignment?* For the question: *What did you like least about the digital media assignment?*, only 19 students reported inadequate digital media skills (Table 11). Overall, students mentioned enjoying the creativity, teamwork, learning subject content, the difference from other assignments, the fun factor, self-expression and learning digital media production.

These results compare favourably with similar studies, like a study in undergraduate physiotherapy students who created video, which reported that 25% of them had issues with digital media creation and 37% felt stressed by the task (Coulson and Frawley 2017). In that study, the students did not receive any digital media training support, and 48% of students reported issues with understanding the assessment task; while in our study, only 7% did (Table 11). In a cohort of undergraduate pharmacology students who created animations during a 2-h tutorial session, researchers reported that students felt apprehensive, anxious and intimidated (Pearce 2014). Other authors have discussed the need to provide scaffolding on digital media assignments to students (Adams and Blair 2014; Anderson 2013; Fuller and France 2016; Morel and Keahey 2016), but only in the functional domain (software use) and neglecting the conceptual and audiovisual domains covered by the *digital media literacies framework* and the *taxonomy of digital media types*. Restricting student training to the use of software will not fully upskill them to produce digital media effectively. Training should also include storyboarding (conceptual domain) and digital media principles (audiovisual domain). Studies in the United States have pointed out that the issue with technology is fluency in its use (Alexander, Adams, and Cummins 2016). Teaching software skills will not solve the problem, which requires skills at the intersection of the conceptual, functional and audiovisual domains (Figure 1).

The *digital media literacies framework* and the *taxonomy of digital media types* were useful to develop marking rubrics, determine assessment weightings and deciding whether the task should be group or individual. Table 6 shows a generic rubric to score the communication aspect of digital media assignments. Explaining to educators digital media principles such as colour theory, layout design, images, typography and video techniques helped them to design their rubrics and to mark the digital media presentations fairly. Due to the time-consuming, iterative and challenging

nature of digital media production (Musburger and Kindem 2012), allocating the appropriate proportion of total marks to the task is of crucial importance to motivate students to complete the assignment successfully. A relatively high weighting for the assessment task (25%–30% of the total mark) could create a positive environment regarding expectations, task value and beliefs that will affect subsequent behaviour (Wigfield and Eccles 2000).

For the Autumn 2017 cohort, the implementation of SPARKPlus was found to produce excellent group performance (Table 9). Previous research found that students dislike groupwork in other types of assignments, such as written assignments or lab reports (Aggarwal and O'Brien 2008; Taylor 2011). In the case of digital media assignments, it was reported that students had positive experiences working with their peers (Reyna et al., 2017b; Reyna et al., 2016; Reyna and Meier, 2018c). We posit that the reason for this is that digital media production requires different skills such as research, content editing, representation or multimodality, time management and tech savvy. Students likely enjoy groupwork in DMPs because they feel supported by their peers. Reports from other studies highlighted issues with groupwork, possibly due to lack of a mechanism to ensure fair group contributions (Coulson and Frawley 2017; Pearce 2014).

Student engagement with digital media learning resources was high when measured in Autumn 2017. Training materials developed by the learning designer used the digital media principles discussed, such as segmentation, personalisation and image use. Students said in open-ended questions that they found the learning resources accessible and engaging.

Responses from open-ended questions were highly positive, for both Spring 2016 and Autumn 2017, and highlighted that students enjoyed groupwork, creativity and learning digital media. Student misconceptions about the digital media task were also captured (Table 12). While these misconceptions were uncommon in the data, the author thought it necessary to present them. They will be useful for the next iteration of the digital media assignment, for classroom discussion with students to avoid misunderstandings.

Overall, students had positive attitudes to the idea of being a scientist and developing digital media production skills. Other researchers in the digital media field have reported student apprehension, anxiety and negative attitudes to digital media assignments (Coulson and Frawley 2017; Pearce 2014; Pearce and Vanderlelie 2016). That was not the case with the current study, and the author believes this is because of the systematic approach to designing, implementing and evaluating the intervention. Part of our success may be attributed to the student support put in place with lectures, tutorials, online materials and the explanation of the assignment rationale with the *digital media implementation framework* (Figure 4). The quantitative and qualitative data from the current study showed that students had a positive attitude towards digital media support and worked effectively in their groups (according to SPARK-Plus RPF factors). Their marks followed a normal distribution and their responses to open-ended questions were highly positive, thus providing an answer to the research question: *What is the impact of a systematic approach using theoretical models to guide digital media assignments in undergraduate science education?*

The first limitation of the study is that student perceptions of digital media support (Table 3) were collected only in Spring 2016. Ideally, a second dataset in Autumn 2017 could have provided more credibility to the findings. Secondly, the research did not follow students from Spring 2016 to Autumn 2017 and it is unknown if some

students enrolled in Autumn 2017 subjects that used digital media assignments and became more skilled with digital media assignments. Also, how students work in groups in digital media assignments is unknown (e.g. how they distribute tasks, how they work together and how they deal with conflict). Although the SPARKPlus data on group contribution is excellent, the researchers do not know if every team member participated in different tasks such as writing the storyboard, brainstorming the multimodal representation of content or creating the digital media artefact. A follow-up study to understand group dynamics in digital media assignments is essential. Formal data from lecturers and tutors reinforcing the success of digital media intervention is also missing, although one-to-one conversations with them gauged a high level of satisfaction with the digital media task. Survey data and semi-structured interviews with lecturers might add a more holistic view of the value of digital media assignments to them. Lastly, conducting in-depth interviews with students who developed digital media assignments would be useful, to further understand their views on learning scientific concepts using digital media.

There are several implications of this research, such as a practical, evidence-based approach to guide the design, development and evaluation of digital media assignments. The development of a generic marking rubric to gauge communication skills using digital media, assessment weightings with different media types and the articulation of the digital media principles would also contribute to the design, implementation and evaluation of digital media assignments. In a field considered under-theorised, under-researched and in its infancy (Hoban, Nielsen, and Shepherd 2015; Potter and McDougall 2017), the theoretical frameworks used are valuable not only for practitioners but also researchers. Data on group contributions from Autumn 2017 confirmed that it is essential to put in place a mechanism to moderate groupwork in digital media assignments. This was clear when comparing responses to the open-ended question: *What did you like least about the assignment?* between Spring 2016 and Autumn 2017. Students in Spring 2016 highlighted group issues, but the addition of the SPARKPlus application improved group performance in Autumn 2017.

This research developed a website for educators and students which includes guidelines for designing, implementing and evaluating digital media assignments, a list of publications generated by the project, and most critically, training modules on digital media production (www.digitalmediaforlearning.com). The author hopes to develop a community of practice with educators and students using digital media assignments.

Conclusion

The impact of using theoretical frameworks to guide digital media assignments on student attitudes and learning experiences was highly positive, according to the data gathered in this research. Students thought that digital media assignments fostered their creativity and helped them to engage in meaningful learning. They reported enjoying being creative, teamwork, learning the subject content, the difference from other assessment tasks, the fun factor, self-expression and learning digital media production. The main contribution of this article to knowledge about digital media assessments is the proposed guide for educators on how to systematically implement the digital media task. The author hopes that the methodology presented here will be taken up in different disciplines to engage students with their learning, improve

digital media creation and further develop communication skills in the digital space, crucial to 21st-century citizens. The next step of this research project is to study what role self-regulation and motivation play in student learning with digital media assignments, how students work in groups and possibly how they exercise co-regulation when working on their DMPs.

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