University of Technology Sydney
Faculty of Science

A Systematic Approach to Designing, Implementing and Evaluating Learner-Generated Digital Media Assignments (LGDM) in Undergraduate Science Students and its Effect on Self-Regulation.

A dissertation submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Science Education)

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December 2019

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, ***Jorge Reyna*** declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Science at the University of Technology Sydney. This thesis is wholly my own work unless otherwise reference or acknowledged. Also, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

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Date: 03/28/2019

Acknowledgments

To my supervisor, Associate Professor Peter Meier for allowing me to implement my ideas the support and guidance provided during my candidature.

To Dr Jose Hanham (Western Sydney University) for his guidance, particularly in the first part of my research with the conceptual frameworks proposed.

To Associate Professor Panos Vlachopoulos (Macquarie University) for his initial guidance for designing the research and strategic input during the writing of the papers.

To all the wonderful subject coordinators and tutors who believed in Learner-Generated Digital Media (LGDM) assignments and decided to implement and provide me with an opportunity to try it in their subjects. Special thanks to Associate Professor Kenneth Rodgers, Associate Professor Sara Lal, Dr Ty Lees, Dr Francis Geronimo, Dr Hermily Geronimo, Associate Professor Shari Forbes, Dr Finbarr Horgan, Associate Professor Andrew McDonagh, Dr Mackenzie de la Hunty, Dr Yew Kian Loyeung, and Associate Professor Willa Huston.

To all my fantastic colleagues that I met since 2009 at educational technology conferences. The opportunity to present and receive feedback on my ideas was an amazing learning experience.

To Associate Professor Christine Woodrow (Western Sydney University) for the early intervention, she did make me realise I need it to pack and unpack my thoughts to further understand education.

To my beautiful family Jorge, Carmen, Camucha, and Celeste for being always with me. To my dearest friend Neil Caller (BBTo), Brett (Canga) Todd, Steve Mann, and Joanne Orlando for their constant support.

To all the people that came and gone into my life who taught me a lesson and made me the person I am. To the ones that challenged me and made me think differently.

To the ones that tried hard to put me down as they made me stronger to progress with my ideas.

To Peter the Proofer (Peter Krockenberger) for proofreading of journal papers before submission. His role was copy-editing for grammatical error, misspelling and consistency across journal papers. Peter can be contacted at www.petertheproofer.com.au

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Other publications not included in this thesis

Peer-reviewed industry magazine

Reyna, J (2018). Learners as Co-Creators of Knowledge Using Digital Media. In: Curation vs Creation. *Training & Development* magazine, March 2018 Vol 45 No 1, published by the Australian Institute of Training and Development.

Peer-reviewed conference papers

Reyna, J (2019). A Model to Explore Learning Processes in Learner-Generated Digital Media (LGDM) Assignments. *Exploring New Frontiers in Education.* The 13th annual International Technology, Education and Development Conference, INTED2019, Valencia (Spain), March 11th-13th.

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Abstracts

Reyna, J., Hanham, J., Meier, P., Geronimo, F (2017). Exploring Self-Regulation in Learner-Generated Digital Media (LGDM) Assignments in First Year Science Students. Australian Association for Research in Education (AARE) Conference. Canberra, ACT. Nov 26th – 30th.

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Reyna, J., Hanham, J., Meier, P (2017). Learning workflow using learner-generated digital media (LGDM) assignments. In H. Partridge, K. Davis, & J. Thomas. (Eds.), Me, Us, IT! Proceedings ASCILITE2017: 34th International Conference on Innovation, Practice and Research in the Use of Educational Technologies in Tertiary Education (pp. 57-62).

Reyna, J., Meier, P., Hanham, J., Vachopoulos, P & Rodgers, K (2017). Learner-Generated Digital Media (LGDM) Framework. Poster presented at the 11th annual International Technology, Education and Development Conference, INTED2017**,** Valencia (Spain), March 6th-8th.

Abstract

This study aimed to address the need for a systematic approach to LGDM assignments identified in the literature. The author proposed a set of four theoretical frameworks to design, implement, and evaluate LGDM tasks in science education. The Digital Media Literacies framework informed the development of training materials and marking rubrics. The Taxonomy of Digital Media Types guided the assessment weight and communicated to students and academics of the different media types available according to skills required for their production. The Digital Media Principles framework identified the standards the students and educators need to achieve to communicate effectively in the digital space. The LGDM Implementation framework guided the design, development, implementation and evaluation of digital media assignments in the classroom. A pilot study trialled these frameworks and validated an evaluation survey for LGDM assignments (Spring 2016). The students reported a positive attitude toward digital media for learning, highlighted creativity, teamwork, digital media support, and learning of subject content as the main features of the intervention.

The second part of the dissertation focused on the development of an additional framework to research student learning experience with LGDM assignments. It followed a mixed-methods approach, and the quantitative data section validated a self-regulation questionnaire, suggested to capture LMS logs, marks, and group contribution data. The qualitative part included open-ended questions and student interviews.

The last part of the dissertation included a large trial (n=1,687) across seven science subjects (Autumn, 2017). The aim was to gauge the utility of the theoretical frameworks proposed by answering research questions such as: *are the students self-regulating their learning when LGDM assignment design follows a systematic approach?* and; *how does a systematic approach guided by theoretical frameworks impact the overall student learning experience with LGDM assignments?* The students received LGDM training online and in a blended mode, and both groups showed a high score of self-regulation beliefs, being higher for online learners and female participants. Triangulating

the rest of the data sets found that students had a positive learning experience and answered the research questions proposed.

The contribution of this research has many implications. For practitioners, it offers a set of practical frameworks to guide the design, development and implementation of LGDM assignments. For researchers, the development of the theoretical framework to research the learning experience with LGDM assignments is the starting point to understand further a field considered under-theorised, under-researched and in early stages.

Chapter 1:
Introduction and overview

1.1 Background of the Study

Digital media is now everywhere, affecting almost any possible human activity and social scientists have defined digital media as an agent of transformation of societal practices (Arvidsson & Delfanti, 2019). The digital media explosion via the Internet has dissolved barriers from the content creation perspective and shaped a more ‘democratic’ user participation in the digital space. User Generated Content (UGC) was not achievable with, for instance, the television (Van Dijck, 2009). The Internet and interoperability of Web 2.0 tools enabled user participation as a content producer and curator (O'Reilly, 2009). Users are creating content for self-expression, self-actualisation and the achieving of an online presence (Buckingham, 2013). Some users aim to monetise their participation (Waldron, 2013) and the process of content creation facilitates the active participation and collaboration of users in media production (Borowczak & Burrows, 2016). However, digital media also created many challenges and issues that require attention. The rise of fake news (Lazer et al., 2018), privacy issues (Oh, Byun, & Krishnamoorthy, 2018), and companies exploiting data with lucrative outcomes (Malgieri, 2018) are some examples of these challenges. This seemingly inexorable march of new technology has created a new order in the 21st century. The Internet now offers immersive experiences for everyday users, and social software such as Facebook (West, 2013), Twitter (Weller, Bruns, Burgess, Mahrt, & Puschmann, 2014), Instagram and Vine (Salomon, 2013) have examples on how digital citizens document their everyday activities using digital media. As researchers and students, we have all wittingly or unwittingly become members of this new digital transformation. Digital media production know-how is becoming a ‘desirable’ skill in the 21st-century workforce for all careers (Hobbs, 2017). Consequently, digital media has become an important part of our personal, learning and professional spaces (Arvidsson & Delfanti, 2019).

In the higher education landscape, digital media have been used extensively for content deployment in blended learning environments (Bonk & Graham, 2012; Garrison & Vaughan, 2008) and recently in flipped classrooms (Bergmann & Sams, 2012). Since 2007, Learner-Generated Digital Media (LGDM) assessments became popular in tertiary education. The main purpose was reflective practice in pre-service teachers (Kearney, Pressick-Kilborn, & Maher, 2012), and recently in science disciplines as a pedagogical agent (Nielsen et al., 2018). In other words, LGDM is used as a vehicle for the students to learn the subject content. Educators are optimistic that students will learn to produce effective digital media (Hoban, Nielsen, & Shepherd, 2015), even if they do not receive training on basic digital media production in the classroom. LGDM is incorporated into learning activities with a lack of systematic approaches to design, implementation and evaluation of student learning in the classroom. The New Media Consortium (NMC) Horizon report in the US has highlighted that the issue with technology is no longer ownership, but fluency in its use (Alexander, Adams, & Cummins, 2016). In that regard, the author posits a view that LGDM assignments should have a dual approach, learning the subject content but also developing effective digital media skills. These skills need to be taught in the curricula. Otherwise, students will not develop them.

Recent research in Science Education recognises the need for scientists to communicate their findings using a multimodal approach mediated by digital media (Nielsen, Georgiou, Jones, & Turney, 2018). In that regard, the author's rationale to promote LGDM assignments in Science education aimed to (i) facilitate student learning of complex scientific concepts by a multimodal representation of content using digital media; (ii) develop critical, problem-solving, and research skills while building the storyboard; (iii) student development of digital media literacies with formal training provided; (iv) expose students to teamwork, collaboration and conflict resolution, and; (v) help the students to exercise cross-cultural communication, cultural safety and understanding of diversity mediated by group work.

The first stage of this doctoral project sought to develop, implement and refine practical frameworks for the application of Learner-Generated Digital Media (LGDM) specific to the discipline of Science, but translatable to other disciplines. These models were developed using a naturalistic approach (Salkind, 2010), in which the author combined the knowledge of fifteen years' experience in the digital media industry and ten years' experience as a digital media instructor in the tertiary educational setting. The approach employed the study of previous training material and reflecting on digital media production, attempting to analyse and interpret the phenomena to inform the development of the frameworks. As part of this research, four theoretical frameworks were developed to guide the systematic implementation of LGDM assignments in the classroom. Following digital media creation standards (Arvidsson & Delfanti, 2019; Musburger & Kindem, 2012), visual design principles (Malamed, 2015), video principles (Stockman, 2011), and Gestalt theory (Chang, Dooley, & Tuovinen, 2002), the frameworks were developed using industry standards practices for digital media production workflow. One of the main features of the frameworks is that they are simplified, easy to understand and potentially applicable to LGDM assessments in any discipline. An additional framework included a methodological approach to evaluate LGDM in the classroom. This framework aimed to assess the quality of student learning experience using a mixed-methods approach (Tashakkori & Teddlie, 2010), involving self-regulation and motivational approaches (Zimmerman & Schunk, 2011), and methodological triangulation (Bekhet & Zauszniewski, 2012) drawing data from multiple sources (self-regulation questionnaires, group work, marks, open-ended questions and interviews) to enhance the credibility of the results.

The second stage of this research started in Spring 2016 with the preliminary exploration of the frameworks developed in five science subjects, (n=270). This stage led to the development of a validated evaluation questionnaire for LGDM assignments. A key aspect that emerged from this stage of the research was the notion of using self-regulation theory in conjunction with other datasets to further validate the frameworks. As self-regulation is a high-context dependent construct (Zimmerman, 1998), it was necessary to develop and validate a self-regulation questionnaire for LGDM assignments. Validation took place with a large sample (n=348) using Exploratory and Confirmatory Factor Analysis. A set of six self-regulation subscales were identified as crucial to evaluate LGDM assignments such as Goal Setting, Environment Structuring, Task Strategies, Time Management, Help-seeking from the Internet, and Help-seeking from people. The first 4^{th} subscales were extensively studied before in the literature (Barnard, Lan, To, Paton, & Lai, 2009; Nota, Soresi, & Zimmerman, 2004; Pintrich & Zusho, 2007; Schunk & Zimmerman, 1997; Zimmerman & Schunk, 2011). In the validation process, Help-seeking generated two subscales: from the Internet and People. This is the first time that a study found the differentiation between the two and it could be due to the complexity of the digital media task.

A final stage took place in Autumn 2017, where testing the implementation of LGDM assignments in seven subjects across the first, second and third year at the Faculty of Science was undertaken. The trials had two groups, students who received LGDM training fully online (n=199) and blended learning students (n=149). Self-regulation data collected using the validated online questionnaire was divided into these two groups for further analysis. Statistical analysis included frequencies, descriptive statistics and One-Way Analysis of Variance (ANOVA). For the qualitative data, thematic analysis was used to code student responses. Then, methodological triangulation (Bekhet & Zauszniewski, 2012) was used to evaluate the quality of the student learning experience.

The outcomes of these stages have been published as journal papers and presented in Chapters 2 to 5, and Chapter 6 presents the discussion, conclusions and limitations of the study, including further research needs and recommendations. The thesis contains an additional Chapter containing a couple of papers that can be considered manuals for educators to help systematically implement LGDM assignments in the classroom. The study also included the creation of a website (digitalmediaforlearning.com) for the project to disseminate the research and to make the training content accessible to researchers, practitioners and students. The website has links to the theoretical frameworks developed for the project, journal papers, peer-reviewed conference papers, presentations, videos and training materials, and examples developed by UTS Science students. The author hopes that the promotion of the website will help to establish a community of practitioners in LGDM assignments.

1.2 What is Learner-Generated Digital Media (LGDM?

Learner-Generated Digital Media (LGDM) refers to any digital artefact developed by students to showcase their learning and communicate a message to an audience (peers or the general public) (Reyna, Meier, Geronimo, & Rodgers, 2016). If the process of digital media production is carried out with a systematic approach, it could allow students to learn about the topic by conducting literature research to structure a storyboard. Upon the completion of the storyboard, the students will engage in the process of multiple representations of the content to produce the digital media artefact (Hoban et al., 2015). This second step helps students reinforce what they have learnt from the curation of their information. Researchers believe that enhanced cognition occurs during the process of translating the storyboard into a digital media artefact (Nielsen, Hoban, & Hyland, 2017). Additionally, the self-explanation effect during the production of LGDM can be beneficial for learning (Johnson & Mayer, 2010), as well as the Internalisation effect (Hobbs, 2017). The author will discuss these theoretical underpinnings in more detail in upcoming sections.

Learner-Generated Digital Media (LGDM) emerged more than a decade ago in the field of Education (Crean, 2001; Kearney & Schuck, 2005a; Ludewig, 2001). In this field, the use of LGDM assessments has focused on the reflection of pre-service teaching experiences (Kearney, 2013; Rich & Hannafin, 2009). In contrast, in science disciplines, the focus has been active learning, inquiry and research approaches (Garry Hoban et al., 2015). Extensive examples have been documented in science disciplines. Areas of research include biology (Pirhonen & Rasi, 2016), computer programming (Powell & Robson, 2014; Vasilchenko et al., 2017), health sciences (Pearce & Vanderlelie, 2016), pharmacology (Henriksen, Henriksen, & Thurston, 2016; Nielsen et al., 2017; Reyna et al., 2016), geology (Reyna, Horgan, Ramp, & Meier, 2017), mathematics (Calder, 2012; McLoughlin & Loch, 2012), and engineering (Anuradha & Rengaraj, 2017).

The theoretical underpinnings for learning with LGDM have been discussed in detail within the published papers. However, it should be emphasised that Learner-Generated Digital Media as an assessment tool has the potential to help students to learn the subject content if they are appropriately implemented in the curricula to facilitate group work and collaboration, and to foster effective communication skills in the digital space.

1.3 Advantages of LGDM as an Assessment Tool

Learner- Generated Digital media promotes student reflection, engagement in active learning and fosters creativity and innovation. Learner-generated content has the potential to add value to hands-on experience and peer-driven learning (Berardi & Blundell, 2014). Other benefits of LGDM include the development of graduate qualities such as interpersonal communication, project planning and time management skills (Morel & Keahey, 2016). Additionally, LGDM can help to develop critical thinking, report writing and research skills (Ohler, 2009). Using LGDM assignments can generate new ideas and transform static information into dynamic understanding. By sharing LGDM assignments, students can showcase what they have learnt and contribute to the learning of other students. Sharing digital media projects could result in more engaged learning and promote feelings of being connected to other learners and the wider community, which further motivates students (Hobbs, 2017). When LGDM assignments are designed as group tasks, students are allowed to organise themselves, make decisions, negotiate responsibilities and manage conflict. Group work provides an opportunity for reflection and dialogue between group members (Cohen & Lotan, 2014), and raises awareness of cultural diversity (Van Knippenberg, De Dreu, & Homan, 2004)

From the digital literacies perspective, if students receive training on how to create digital media for their assignments, they will gain skills to be effective multimedia communicators (Hobbs, 2017). Communication skills are essential in any profession, but for science students, multimodal communication has been highlighted as a critical skill (Nielsen et al., 2018). These characteristics make LGDM assignments an authentic task and useful strategy to engage science students in meaningful learning.

1.4 Challenges to Implement LGDM as an Assessment Tool in the Curricula

Research on LGDM in higher education is considered under-theorised and barely sufficient (Hakkarainen, 2009; Potter & McDougall, 2017). Consequently, there is a need for rigorous studies to evaluate their effectiveness in different disciplines (Duffy & Jonassen, 2013; Hoban et al., 2015; Kearney & Schuck, 2005b). The incorporation of LGDM assessments brings the challenge of determining how best to embed them in a science curriculum and how to assess their impact on student learning.

There is little-published research specific to LGDM use in higher educational settings and particularly, in the scientific disciplines. In general, the assessment design has not followed systematic approaches to implement and evaluate the intervention. For example, students do not receive training on how to create digital media, marking rubrics are poorly developed, and evaluations are usually qualitative and portray the view of students that are highly positive about it. Successful integration of any assessment requires consideration of a range of issues such as careful alignment of the assessment with learning outcomes and graduate attributes, minimising inequity in-group/teamwork, and the potential of limiting student participation due to equipment requirements. In addition to the issues arising from traditional assessments, LGDM requires further consideration for successful implementation. For example, students are more familiar with written tasks, so scaffolding to support their undertaking of the LGDM task, as well as their learning, must be well developed. Valid assessment of LGDM may require integration of skills from different disciplines as well as the development of an appropriate marking rubric, and intellectual property and copyright issues need to be considered (Hofer & Swan, 2006; Kearney, 2009).

An issue not identified in the published literature to date is the rise of services like *Fiverr,* commonly called the "micro freelance marketplace". (Lee, Webb, & Ge, 2014). These sites are online communities of graphic designers, videographers, animators and multimedia creators that offer to produce digital media assets at a very low cost (starting from US$50). Students can potentially handle their storyboards to them and pay to create their LGDM assignment. This is not dissimilar to 'pay for assignments' websites and is considered as academic misconduct. To avoid this scenario, educators may need to ask students to provide the construction/building files on a USB or maybe upload it to services such as *MediaFire* (Gaikar, 2012). The long-term solution is to foster ethical practices in university students.

In summary, with the limitations described previously, digital media has been implemented in the classroom as an opportunistic agent (pedagogical) (Buckingham, 2007), and has neglected the importance of teaching digital media principles. Current research in the field still has the same approach, using LGDM to learn the content (Hoban et al., 2015; Morel & Keahey, 2016; Nielsen et al., 2017; Pegrum, Bartle, & Longnecker, 2015). This could be attributed to the 'digital native' myth approach and the notion that students can use technology for learning fluidly.

Another reason could be the lack of understanding from educators outside the media, visual design and filming disciplines of digital media creation (Bader & Lowenthal, 2018). This research project had a student-centred approach and used LGDM as pedagogical agent (learning the content) as well as a digital media agent (learning effective production skills for the generation of digital media artefacts).

1.5 Theoretical underpinnings of LGDM

From the theoretical perspective, there is a lack of a universal definition of digital literacies, with many and significantly different kinds of concepts in the literature (Knobel, 2008). In 2015, an Irish initiative called the All Aboard Project identified over 100 theoretical models on digital literacies. Scholars have used many terms to describe digital literacies such as digital skills (Van Deursen & van Dijk, 2009), digital fluency (Rukantabula & Lukwaro, 2017), digital capabilities (McLoughlin, 2011), and digital competencies (Ilomäki, Paavola, Lakkala, & Kantosalo, 2016). This fact adds another layer of complexity when searching for a commonly agreed definition. Without being able to articulate the meaning of digital literacies, how can we measure our student's digital skills effectively? On the other hand, educators and students outside of media and creative arts courses have no clear understanding of digital media types and what is involved in its effective production (Krumsvik, 2014). This fact has massive implications for LGDM assessment weight, workload, student support and fair marking.

Furthermore, there is a lack of understanding from educators (Bader & Lowenthal, 2018; Spires, Paul, & Kerkhoff, 2018) and students (Alexander, Adams Becker, & Cummins, 2016; McGrew, Breakstone, Ortega, Smith, & Wineburg, 2018) of digital media principles. Layout design, colour theory, typography, use of images, and video principles (Hashimoto & Clayton, 2009; Malamed, 2015; Stockman, 2011; Williams, 2014), need to be taught in the curriculum regardless of the field of study. There is also an assumption that students are 'digital natives' (Prensky, 2001), and capable of producing their assignments without these considerations. It is well established that owning hardware/technology does not make anyone capable of using it (Alexander et al., 2016; Bennett, Maton, & Kervin, 2008). The digital divide is no longer about owning technology but fluency in using it (Alexander et al., 2016). The Internet is inundated with digital media content that fails to engage users due to a lack of understanding of digital media design principles. Digital media principles should be considered the grammar of the 21st century and need to be embedded within educational settings.

These issues raise some questions: are digital media skills being developed in students if the basics of digital media creation are not taught in the curricula? Can digital media training be effectively delivered without a clear definition of digital media literacies? Without a taxonomy of digital media types and skills required, how can assessment tasks be designed? If students do not understand digital media principles, how will they develop effective digital artefacts? Finally, how could academics mark the assignments without an understanding of these digital media principles? The pedagogical approach behind LGDM use is to promote student reflection, engagement in active learning, foster collaboration, creativity (Barra, Aguirre Herrera, Pastor Caño, & Quemada Vives, 2014), and generate an environment for deep learning (Cox, Vasconcelos, & Holdridge, 2010; Hamm & Robertson, 2010). However, how is deep learning happening when LGDM is used as an assessment tool?

Various instructional theories have been postulated to answer some of these questions. For example, the semiotic theory has been used as a theoretical background for LGDM. The triadic model of a semiotic system proposed by Pierce (1931) explains three stages: representation or representamen (a sign that stands for something), referent or object (content being represented), and meaning or interpretant (sense made of the representation or sign) (Hoban et al., 2015). In other words, when the students are given the opportunity to design a digital media artefact about a given topic, they must understand the relationship between the content (storyboard), the construct (the digital media artefact), and the modality (e.g., audio, images, moving text, and so on).

Another construct used to explain student learning with LGDM is the self-explanation effect. It has been studied extensively in multimedia learning and consists of students engaging in explaining themselves (orally or written). Students who used this type of instructional approach performed better at tests in comparison with non-self-explainers (Johnson & Mayer, 2010). It has been postulated that student learning with LGDM may occur via self-explaining the concepts when producing digital media assignments (Hoban & Nielsen, 2013; Hoban, Nielsen, & Carceller, 2010; Hoban et al., 2015). However, the evidence for this is based on case studies and may reflect the view of a small group of students, making it difficult to generalise the findings.

An alternative model for learning with LGDM is called 'Internalisation' which is the process of accepting and consolidating ideas, behaviours and attitudes into our worldview. When students represent information, knowledge, processes, and facts, in a format that makes sense to their audience, it is a form of mastering (Hobbs, 2017).

The attempt to explain how learning happens when using the theories discussed previously (Semiotic, Self-Explanation and Internalisation) are speculative and systematic research has not been undertaken to test these assumptions. It is arguable that qualitative research on its own can elucidate how learning happens when LGDM is used in the curriculum. Finding a sample that represents the student population will be challenging. Studies that have attempted to explain these phenomena have, in most of the cases, recruited small numbers within sub populations of students, and have naturally reported a positive attitude towards learning with digital media.

The lack of systematic evaluation of learning when LGDM is used in the classroom prompted this research to design a novel methodological approach to evaluate learning with digital media. Self-regulation (Zimmerman, Boekarts, Pintrich, & Zeidner, 2000) and motivational factors (Zimmerman, 1990) are crucial for student learning. Self-regulated learners are metacognitively, motivationally and behaviourally active participants in their learning process (Zimmerman, 2002). Using psychometric tools such as the Self-Regulation Learning Questionnaire (SLQ), structured interviews and educator judgements it is possible to measure student self-regulation (Erdogan & Senemoglu, 2016), and therefore, to study the quality of the learning experience and how it can be improved. The LGDM framework developed as part of this study was carefully mapped against self-regulation subscales (goal setting, environment structuring, time management, task strategies, help-seeking, and self-evaluation), and motivational factors (self-efficacy, goal orientations, task value, attributions for failure and anxiety). Psychometric tools were adapted and validated (Exploratory and Confirmatory Factor Analysis) and used to gain an in-depth understanding of student learning using digital media. Furthermore, structured interviews gauged student motivational factors in more detail as these factors are considered the *sine qua non* of self-regulation.

1.6 Frameworks to implement LGDM in the classroom

The All Aboard Project identified over 100 theoretical models on digital literacies. These frameworks are generic to inform what students meant to know about digital technologies. In contrast, the literature on frameworks specific to the application of digital media for learning in the classroom is limited. Most of these frameworks focused on how to design LGDM from a technical aspect (development, pre-production, production, post-production and distribution) with no emphasis on teachers' and learners' roles (Kearney, 2009; Snelson, 2011; Theodosakis, 2001). Professional video-makers and multimedia creators have influenced these models, and they lack pedagogical substance (Hoban et al., 2010).

From the student perspective, as a consumer of digital media for learning, the Digital Artefacts for Learner Engagement (DiAL-e) framework focuses on what the learner does with an artefact rather than giving priority of its subject or discipline content (Burden & Atkinson, 2007). This framework is well-rounded from a pedagogical perspective but fails to engage learners as co-creators of content. In contrast, in teacher education, a model for the good practice of digital video projects was developed and included nine stages, teacher strategies and peer learning structures (Kearney & Schuck, 2005b). Later, a learning design for learner-generated digital stories was proposed based on the previous model (Kearney, 2009). Although this framework is comprehensive, it lacks a practical approach to be used by those outside the discipline of Education. The CASPA model (Consume, Analyse, Scaffold and Produce, and Assess) (Blum & Barger, 2017) is a novel instructional design framework to implement multimedia creation in the classroom. The drawbacks of this model are the lack of pedagogical underpinnings. It does not consider group work and evaluation. A similar model of digital literacies is the AACRA model that includes Access, Analyse, Create, Reflect and Act (Hobbs, 2017). This model fails to identify the skills the students will need to develop to produce digital media assignments. Therefore, this research identified the need to develop and evaluate a simple student-centred framework that combines eight different elements. These elements helped to design the LGDM task and include pedagogies, digital media training, video hosting, marking schema, group contribution, feedback, reflection and evaluation. In contrast to previous models discussed, the LGDM framework considers educators and students.

1.7 Purpose of the study

This study primarily proposed a set of practical and theoretical models to implement Learner-Generated Digital Media (LGDM) in the classroom and investigate its validity by using a mixed-methods approach. Quantitative data were collected using a validated self-regulation LGDM survey designed as a part of this study, LMS logs, student marks, group contribution, open-ended questions, and interviews. Methodological triangulation (Gorissen, Bruggen, & Jochems, 2013) was used to make sense of these data.

1.8 Statement of the problem

Studies using LGDM as an assessment tool in Science education have claimed the advantages of students as co-creator of content in the classroom (Anderson, 2013; Campbell & Cox, 2018; Coulson & Frawley, 2017; Fuller & France, 2016; Graybill, 2016; Garry Hoban et al., 2015; Nielsen et al., 2018; Pearce & Vanderlelie, 2016; Pirhonen & Rasi, 2016; Yeh, 2018). However, none of them has developed a systematic approach that considers rigorous models to design, implement and evaluate the LGDM task about student self-regulation and overall learning experience. Another issue is that LGDM includes a wide range of digital media artefacts from the audio podcast, digital story, animation, and video, mediums that require different sets of skills (Nielsen et al., 2018). Current studies are qualitative and presented the view that may be shared by a few students. In most of the cases, students did not receive training and marking rubrics are inaccurate or non-existent. Although educators evaluate student digital artefacts, it is unknown how this type of assignment is marked by them without an understanding of digital media production workflow and the principles to produce effective digital media content, which would be part of any standard rubric. The unavoidable questions arise, it is fair to ask the students to create a digital artefact as an assessment task without providing them with training? Are educators marking student's work fairly? What type of feedback are educators outside of the creative disciplines providing students on the production of digital media? Are the students developing digital media competencies? These questions can be seen as problematic.

1.9 Aims of This Study

This PhD project was ambitious and innovative with the development of five theoretical models. It amalgamated digital media production know-how and the teaching experience from the author, with psychometric tools (self-regulation) under a mixed-methods approach. The first part of this research was purely theoretical and aimed to develop and refine models to guide the implementation of digital media in the classroom. There are several ways to create frameworks for education (Camp, 2001), for instance following a Grand Theory and using a highly abstract approach in which the formal organisation and arrangement of elements take priority over understanding the social world (Mills, 2000). A second perspective is the use of Middle Range Theory which is the integration of theory with empiric research (Merton, 1973). A third perspective is the use of Substantive Theory which is considered transferable rather than generalisable (Dwivedi, 2009). This approach is opposite to the formal theory that requires validation and generalisable conclusions across multiple studies for sample representativity. The method to formulate the theoretical frameworks in this research used a naturalistic approach (Salkind, 2010), and it was based on the experience of the author creating and teaching digital media a few years before starting the research. In this approach, observation, description and interpretation were used. In other words, the frameworks proposed came up as a result of an iterative process in the natural setting: the classroom, but also in independent digital media projects executed by the author. These LGDM frameworks developed attempted to address the research gaps previously identified by the literature review paper (Chapter 2) and can be summarised as the need for:

- conceptual framework on digital media literacies to inform educators in the design of student training for LGDM assignments
- A taxonomy of digital media types for LGDM assignments to help educators to understand the skills students will require for LGDM creation
- A digital media principles framework to help students to develop effective digital artefacts and educators to design marking rubrics
- A practical LGDM framework to help educators to design student digital media assessment tasks systematically and for students to understand the rationale of the LGDM task.
- A model to evaluate the effectiveness of Learner-Generated Digital Media (LGDM) assignments in science education

The second part of the research evaluated the systematic approach to LGDM assignments using the previously developed frameworks from the perspective of self-regulation and student learning experiences using a mixed-methods methodology. The following research questions postulated were:

- Are students self-regulating their learning when LGDM assignment design follows a systematic approach?
- How does a systematic approach guided by theoretical frameworks impact the overall student learning experience with LGDM assignments?

A range of qualitative and quantitative datasets was required to address the research questions such as student perceptions (student feelings), student assessment performance (marks attained), and student actions (activity tracking inside the LMS) (Phillips, McNaught, & Kennedy, 2012). Evaluating theoretical frameworks in education require that information be assessed from multiple datasets to gather the complete picture (Camp, 2001). Hence, by using a self-regulation approach (validated survey) in conjunction with the rest of the datasets, the student learning experience using LGDM assignments could be better understood. Validating the systematic approach to LGDM will be of benefit for a wide range of educators not only in undergraduate courses but in primary and secondary settings. However, the real contributions of this research are the theoretical frameworks proposed, which may further trigger an inquiry and open a vast opportunity for evaluation and research in the field of LGDM assignments. From the student perspective, the value of the frameworks is that it will ensure they will be prepared for the future as science communicators in the digital space.

1.10 Ethical clearance considerations

Ethical approval from the University of Technology Sydney Human Research Ethics Committee was obtained (UTS HREC ETH16-1060). Upon gaining clearance, the subject coordinators and relevant teaching staff and students were invited to participate. For students, their permission was requested at the beginning of the Spring 2016 and Autumn 2017 sessions by requesting them to sign the consent for an online survey, data collection, and interviews. Students were also informed that any data collected would be properly kept and destroyed under UTS ethical guidelines and rules.

1.11 Limitations

The scope of this study was limited by three primary factors relating to the type of study, sample population, and research questions.

Firstly, while it is possible to generalise the findings of the study, the main objective was to investigate the validity of the theoretical frameworks to guide the systematic implementation of LGDM assignments. The mixed-methods research approach was adopted to accomplish that aim. This type of research is particularly useful in a field that is considered under-theorised, under-researched and in its early stages (Hakkarainen, 2009; Potter & McDougall, 2017). Moreover, when most of the studies have a qualitative flavour using small samples sizes and lack of rigorous methodology, the mixed-methods approach, that utilises data collection instruments including student perceptions, performance and actions (Phillips et al., 2012), can offer thoughtful understandings into how every component works together providing a holistic view of the problem. Methodological triangulation (Bekhet & Zauszniewski, 2012) helped validate self-reported items from the questionnaire and made the study more credible.

Secondly, this research only involved undergraduate science participants rather than other disciplines. The reason why is that in tertiary science education, the LGDM approach has focused on active learning, inquiry and research approaches (Hoban et al., 2015). In contrast, in other disciplines such as Education (pre-service teachers), LGDM has been used as a reflective tool (Kearney, 2013; Kearney et al., 2012; Kearney & Schuck, 2005b). Therefore, it will not be accurate to use and compare in other disciplines within the same study as the purpose of the assessment task differs considerably.

Thirdly, the data collection was conducted in one semester due to the complexity of the research design and the number of different datasets such as online questionnaire, open-ended questions, LMS logs, marks attained, group work contribution data, and interviews. It will be excessive to collect such as rich datasets using a longitudinal approach for a PhD study.

Fourthly, while there are certainly other aspects of the LGDM assessment task, for instance, educator's perspective on LGDM assignments, or group dynamics in LGDM, this study put forward the two research questions previously discussed. The main purpose of study self-regulation in learning settings is to be able to predict student performance; this was out of the scope of this study due to its exploratory nature. As the students worked in groups in 6 of the cohorts that participated in the research, understanding of how they co-regulate to be able to predict their performance may be required. Group work dynamics were out of the scope of this research.

The purpose of this research is was contribute to the seminal work developed in pre-service teachers (Kearney, 2009, 2013) and science education (Hoban et al., 2015; Nielsen et al., 2018; Nielsen, Hoban, & Hyland, 2017) providing a rigorous methodological approach to design, implement and evaluate LGDM assignments in the classroom. The hope here is to promote not only learning the subject content but developing true digital media production skills as it has been identified these are a required graduate attribute for 21st-century professionals (Alexander et al., 2016; Hobbs, 2017). Engaging students with digital media principles and supporting them with digital media production could ensure maximum engagement and impact in their future careers.

1.12 Overview of thesis

This chapter has outlined how technology has reshaped the way people interact and contribute to the digital media explosion on the Internet. LGDM assignments must be placed in the context of these emerging trends and their relationship to the new ways to assess student learning in higher education. A definition of LGDM has been made, explaining its advantages and challenges, covering pre-existing theoretical models, theoretical underpinnings of LGDM, and defining the research questions for the current research. It has also highlighted the process of generating the theoretical frameworks used in this study, the methodology used, and limitations of this study.

Chapter 2 (LGDM in tertiary science disciplines)

This chapter covers a literature review on LGDM in Science education. The literature search used a systematic protocol of identification, screening, filtering, and selection, the crucial steps for information-gathering. LGDM literature was grouped according to media types such as audio podcast, digital story, animation, screencast, and video. Inclusions were tertiary educational settings, student-generated content, and peer-review content. The discussion highlighted the need to develop theoretical models as previously discussed in 1.9 Aims of the study. The literature review generated a journal paper:

Reyna, J., and Meier, PC (2018). Learner-Generated Digital Media (LGDM) as an Assessment Tool in Tertiary Science Education: A Review of Literature. *IAFOR Journal of Education,* 6 (3). https://doi.org/10.22492/ije.6.3.06

Chapter 3 (Theoretical considerations for LGDM assignments and preliminary exploration)

This is a significant chapter including four theoretical frameworks to design, implement and evaluate LGDM in the classroom and an exploratory study of the frameworks in the classroom in Spring 2016. For this purpose, five science subjects across first, second and third-year (N=270) were used to test the first four frameworks developed. Papers published included five:

Reyna, J., Hanham, J., Meier, P (2018). A taxonomy of digital media types for Learner-Generated Digital Media assignments. *E-learning & Digital Media,* Vol. 14(6), pp. 309–322. https://doi.org/10.1177/2042753017752973

Reyna, J., Hanham, J., & Meier, P. C. (2018). A framework for digital media literacies for teaching and learning in higher education. *E-Learning and Digital Media,* Vol 15(4), pp. 176-190. https://doi.org/10.1177/2042753018784952

Reyna, J., Hanham, J., Meier, P (2018). The Internet Explosion, Digital Media Principles and Implications to Communicate Effectively in the Digital Space. *E-learning & Digital Media,* Vol 15, (1), pp. 36 – 52. https://doi.org/10.1177/2042753018754361

Reyna, J., Meier, P (2018). A Practical Model for Implementing Digital Media Assessments in Tertiary Science Education. *American Journal of Educational Research*, 6(1), pp. 27-31. http://pubs.sciepub.com/education/6/1/4/

Reyna, J., and Meier, PC (2018). Using the Learner-Generated Digital Media (LGDM) Framework in Tertiary Science Education: A Pilot Study*. Educ. Sci.* 2018, 8(3), 106, 23p. https://doi.org/10.3390/educsci8030106

Chapter 4 (Materials and methods)

This chapter includes a paper on the methodological framework to data collection and processing for the study. Additionally, a paper with the LGDM questionnaire validation using Exploratory and Confirmatory Factor Analysis. Both papers covered the methods used in this research for data collection, sorting and analysing.

Reyna, J., Hanham, J. & Meier, P. (2018). A Methodological Approach to Evaluate the Effectiveness of Learner-Generated Digital Media (LGDM) Assignments in Science Education. In T. Bastiaens, J. Van Braak, M. Brown, L. Cantoni, M. Castro, R. Christensen, G. Davidson-Shivers, K. DePryck, M. Ebner, M. Fominykh, C.

Fulford, S. Hatzipanagos, G. Knezek, K. Kreijns, G. Marks, E. Sointu, E. Korsgaard Sorensen, J. Viteli, J. Voogt, P. Weber, E. Weippl & O. Zawacki-Richter (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology* (pp. 303-314). Amsterdam, Netherlands: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/184211/.

Reyna, J., Hanham, J., Vlachopoulos, P., & Meier, P. (2019). Using factor analysis to validate a questionnaire to explore self-regulation in learner-generated digital media (LGDM) assignments in science education. *Australasian Journal of Educational Technology*, 35(5), 128-152. https://doi.org/10.14742/ajet.4514

Chapter 5 (Self-regulation in LGDM assignments in science disciplines)
This chapter includes the seminal paper for this research which put together the data collected in Autumn 2017 and performed statistical analysis of self-regulation questionnaire data, LMS logs, marks, SPARKPlus group contribution data, triangulated with the qualitative data from open-ended questions and interviews. All the theoretical frameworks developed for the study (Chapter 3) were used to inform task design, weighting, marking rubrics, student training, group work contribution, and evaluation. This section generated the following journal paper:

Reyna, J., Hanham, J., Vlachopoulos, P., & Meier, P. (2019). A Systematic Approach to Designing, Implementing, and Evaluating Learner-Generated Digital Media (LGDM) Assignments and Its Effect on Self-Regulation in Tertiary Science Education. *Accepted for Research in Science Education.*

Chapter 6 (Discussion, conclusions, limitations and recommendations)
This chapter summarises the main points of this research. It demonstrates how the results have helped to answer the research questions and fill the perceived research gap. Implications and limitations of this study are identified and possible recommendations for future studies proposed.

Chapter 7: Additional paper

This section contains a paper aimed at practitioners to explain digital media principles with practical examples on how to design an accurate marking rubric for LGDM.

Reyna, J. (2019). Theoretical Foundations to Design Learner-Generated Digital Media (LGDM) Assessment Rubrics. In K. Graziano (Ed.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 1380-1389). Las Vegas, NV, United States: Association for the Advancement of Computing in Education (AACE). Retrieved May 8, 2019 from https://www.learntechlib.org/primary/p/207827/.

Chapter 2:
Literature Review

Chapter 2 overview

LGDM in tertiary science disciplines

A review of the general literature in this field suggested that the use of assessment in LGDM is considered under-theorised, under-researched and in embryonic stages (Hakkarainen, 2009; Hoban, Nielsen & Shepherd, 2015; Potter & McDougall, 2017). The introduction of this thesis (Chapter 1) presented and discussed a few theoretical underpinnings used to implement LGDM assessment in the classroom from the discipline of Education, which focuses on the reflective practices of pre-service teachers (Kearney, 2009; Kearney, Pressick-Kilborn, & Maher, 2012). In contrast, in science disciplines, LGDM assignments are used to promote active learning, inquiry, research approaches and communication skills (Coulson & Frawley, 2017; Fernandez et al., 2015; Pearce, 2014; Powell, 2015; Ross, 2015). Consequently, there is a distinctive approach to LGDM assignments between Education and Science disciplines which makes challenging to contextualise their models to Science learning.

At the same time, there is a lack of practical frameworks to implement LGDM assignments across disciplines and across different digital media types that consider educator and student roles. For instance, published reports suggest that alignment with subject learning objectives, student training, marking scheme, group contribution, feedback, and evaluation have not been considered when designing LGDM assignments. One of the glaring omissions from existing frameworks is the need to communicate to students the rationale of LGDM assignments. The literature in educational technology highlighted the importance for the students to buy-into new ways of assessing their learning (Bates, 2015; Collins & Halverson, 2018). Therefore, communication with students is crucial to ensure engagement with the LGDM assessment task.

This chapter focused on the LGDM literature in tertiary Science education presenting the research undertaken in different digital media types such as an audio podcast, digital story, screencast, animation, and video. The literature review followed a systematic approach including identification, screening, filtering, and selection of relevant papers. Mainstream educational databases were consulted, and only LGDM research in tertiary science education from peer-reviewed journal papers, books and peer-reviewed conference papers were examined. Magazines and conference abstracts were excluded. The digital media types included within the literature search terms were an audio podcast, digital story, animation, screencast and video. Digital storytelling, also called digital story was included only when the purpose of the assignment was to develop student research and inquiry rather than showcasing a personal narrative or a particular view of the creator. The terms coined by Hoban (2015) such as ‘Slowmation’ was included in the category of animations and ‘Blended Media’ into the video category. Blogs and wikis were not included in the review as these types of digital media do not promote the multimodal representation of content. Additionally, new technologies such as 360-degree videos, Virtual Reality (VR) and Augmented Reality (AR) were excluded from the review as students are not yet extensively engaging with the production of these digital artefacts in the classroom.

This chapter contains the published paper below that presented and discussed the research gaps in LGDM assignments in tertiary science education:

Reyna, J., and Meier, PC (2018). Learner-Generated Digital Media (LGDM) as an Assessment Tool in Tertiary Science Education: A Review of Literature. *IAFOR Journal of Education,* 6 (3). https://doi.org/10.22492/ije.6.3.06

The paper highlighted in the discussion section the research gaps in the field indicating the need for theoretical frameworks to design, implement and evaluate LGDM assignments systematically. These frameworks included:

1. A conceptual framework on digital media literacies to inform educators in the design of student training for LGDM assignments

2. A taxonomy of digital media types for LGDM assignments to help educators to understand the skills students will require for LGDM creation
3. A digital media principles framework to help students to develop compelling digital artefacts and educators to design marking rubrics
4. A practical LGDM framework to help educators to design student digital media assessment tasks systematically and for students to understand the rationale of the LGDM task.
5. A model to evaluate the effectiveness of Learner-Generated Digital Media (LGDM) assignments in science education

Chapter 3 proposed theoretical frameworks to address research gaps (1-4) to implement LGDM assignments in the classroom systematically. These frameworks were tested in an exploratory study and reported at the end of Chapter 3. Research gap five was addressed with the LGDM evaluation framework proposed in Chapter 4 as a result of the exploratory study.

Certificate of authorship and originality

This paper was published in the Journal of Education from the International Academic Forum (IAFOR). I certify that the work presented in this chapter has not previously been submitted as part of the requirements for a degree. I also certify that I carried the work presented in this paper.

- Jorge Reyna engaged in the literature search, reading the papers and writing the manuscript.
- Peter Krockenberger did the proofread of the manuscript.

Primary Author

Production Note:
Signature removed prior to publication.

Jorge Reyna

03/31/2019

Learner-Generated Digital Media (LGDM) as an Assessment Tool in Tertiary Science Education: A Review of Literature

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Abstract

Learner-Generated Digital Media (LGDM) in tertiary science education focuses on research skills, inquiry, active learning, teamwork, and collaboration. LGDM across disciplines is under-theorised, under-researched, and only in its early development. This paper evaluates the research in the field of LGDM in tertiary science education. The literature review had four stages – identification, screening, filtering, and selection of relevant scholarly research. Results showed that research in the field of LGDM assignments had been done without a systematic approach to designing, implementing, and evaluating the assessment task. Most studies neglected student digital media training and are characterised by a lack of compelling marking rubrics or strategies to ensure efficient groupwork. Studies also lack rigorous methodologies for data capture to evaluate the intervention and they use small sample size cohorts and different digital media types that require different sets of production skills. With the empirical data available, validation of the benefits of LGDM assignments in science education is not possible, and studies have limited scalability. These gaps in the literature create a need to develop theoretical models for the design, implementation, and evaluation of LGDM in the classroom. This paper discusses future research needs in this field and the implications for assessment design.

Keywords: learner-generated digital media, digital media literacies, science education, student-created content, authentic assessments

Learner-Generated Digital Media (LGDM) can be defined as digital artefacts developed by students to showcase their learning (Reyna, Hanham, & Meier, 2018). To date, there is no consensus in regards to naming and LGDM can be called, for example, student-generated digital media, student-created content, user-generated content, multimedia projects, and students as co-creators of content. LGDM include different media types such as podcast, digital story, screencast, animation and video, which adds an extra layer of complexity to a highly atomised field of research. For instance, to conduct a literature review in the field, it was necessary to use a multi-search strategy. The rationale is to use digital media as a vehicle for learning the subject content and developing graduate attributes such as technological skills (Buckingham, 2007), time management (Frawley, Dyson, Tyler, & Wakefield, 2015; Pearce & Vanderlelie, 2016), teamwork and collaboration (Coulson & Frawley, 2017), conflict resolution (Reyna, Horgan, Ramp, & Meier, 2017), and for fostering student engagement and creativity (Coulson & Frawley, 2017; Hoban, Nielsen, & Shepherd, 2015; Pearce, 2014). Research conducted in the last decade in the field of education has described the use of digital media assignments with the main focus on reflective practices for pre-service teachers (Kearney, 2013; Rich & Hannafin, 2009). In contrast, in science disciplines, it can be considered a novel approach focused on the development of research skills, inquiry, and active learning (Hoban et al., 2015). Documented examples include use in biology (Pirhonen & Rasi, 2016), health sciences (Pearce & Vanderlelie, 2016), and pharmacology (Henriksen, Henriksen, & Thurston, 2016; Nielsen, Hoban, & Hyland, 2017; Reyna, Meier, Geronimo, & Rodgers, 2016). Other disciplines where it has been used include computer programming (Powell & Robson, 2014; Vasilchenko et al., 2017), geology (Reyna et al., 2017), mathematics (Calder, 2012; McLoughlin & Loch, 2012), and engineering (Anuradha & Rengaraj, 2017).

LGDM across disciplines in higher education is considered under-researched (Hakkarainen, 2009), under-theorised (Potter & McDougall, 2017), and lacking in practical frameworks to implement it outside the Education discipline (Reyna et al., 2018). There is a lack of rigorous studies evaluating its effectiveness in different disciplines (Duffy & Jonassen, 2013; Hoban et al., 2015; Kearney & Schuck, 2005). This literature review will cover the different approaches trialled to embed LGDM into tertiary science education, and it will critically evaluate the assumptions, theoretical models (if any), and the methodology for evaluating the intervention and its outcomes. Media range from audio podcast (Bartle, 2015), which is considered an elementary form of digital media, to digital story (Rieger et al., 2018), screencast (Yang & Lau, 2018), animation (Wishart, 2017), and video (Hoban et al., 2015; Wishart, 2017). This literature review will also identify research gaps that have an impact on the implementation of digital media assignments in science curricula.

Literature review

Methodology

Research in the field of LGDM is segmented, due to the different names used to describe the intervention such as: (1) digital media for learning (DML); (2) learner-generated content (LGC); (3) student-generated content (SGC); (4) student-generated multimedia (SGM); and (5) learner-generated digital media (LGDM). An additional layer of complexity is the different digital media types, for example, podcast, digital story, screencast, animations, digital video, and so on. This literature research excluded blogs and wikis because, although they are forms of digital media, they do not promote multimodal representation of content like the other digital media types. These types of digital media do not need a storyboard for their production. New forms of digital media such as 360-degree video, Virtual Reality (VR), Augmented Reality (AR), and games also fell outside the scope of the review. A multi-research strategy captured available research in the field of LGDM. The literature review followed a protocol of identification, screening, filtering, and selection, the crucial steps for information-gathering (Figure 1).

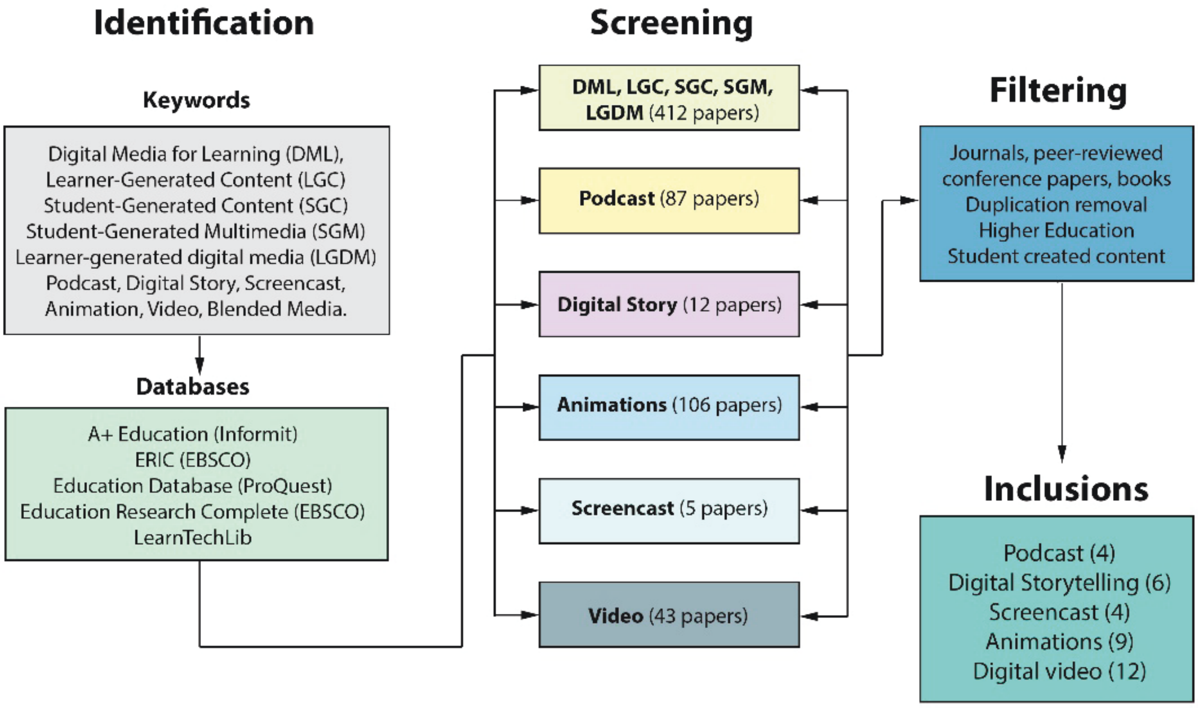

Figure 1. Literature review workflow on LGDM in science education

The keywords presented were used in the process of data gathering across reputable educational databases such as A+ (Informit), ERIC (EBSCO), Education Database (ProQuest), Education Research Complete (EBSCO), and LearnTechLib (AACE). The screening provided all papers that came up with the search. The filtering of papers left only peer-reviewed journals, conference papers, books, and student-created content. Suitable papers were downloaded and imported on EndNote X8, and duplicate papers were removed. Generic keywords such as DML, LGC, SGC, and LGDM in conjunction with 'science education' generated the highest number of results (n=412 papers). In most of the cases, the keywords found papers on using digital media to deliver subject content, for example, DML (n=322 papers), LGC (n=52 papers), SGC (n=36 papers), and LGDM (n=2 papers). In the case of podcast (n=87 papers), only four were on science students creating podcasts. Digital story (n=12 papers) was reduced to six papers, while screencast (n=5) was reduced to four papers. Digital video (n=43 papers) was reduced to eleven papers, and blended media (n=2) to one paper. Blended media papers were added to digital video as in essence; this is a video in the digital media industry. Animation (n=106 papers) was reduced to nine papers (Figure 1). The following sections present research on learner-generated podcast, digital story, screencast, animation, and video.

Learner-generated podcasts

A podcast is an audio file, usually recorded and compressed for online delivery (MP3 format), which can be delivered via web platform and downloaded directly to mobile devices for users to listen to (Geoghegan & Klass, 2008; Reyna et al., 2018). Educators have previously identified the benefits for students of the learner-generated podcast. Students can learn subject content by researching topics and preparing storyboards before recording audio podcasts (Hobbs, 2017). This task helps them to gain a deep understanding of the topic by narrating the content of the podcast (Digiovanni, Schwartz, & Greer, 2009). In the process of designing a podcast, students also develop new skills such as critical thinking (Frydenberg, 2006), teamwork, and collaboration (Lazzari, 2009; McGarr, 2009). It also improves technical skills, gets students motivated (Cane & Cashmore, 2008), encourages the development of reflective learning skills (Forbes, 2015; Lazzari, 2009), transforms the learner from a passive consumer of information into a producer, and enhances student creativity (Struck et al., 2011).

In science education, the available research on podcasting is limited and difficult to compare because of inconsistent approaches to evaluation. Furthermore, it has methodological problems, for example, some studies collected data equal to or less than a semester, used comparatively small undergraduate cohorts of less than 400 (first-year students), or used a qualitative approach via surveys and individual interviews (Fernandez et al., 2015). A qualitative study implemented learner-generated podcasts for a first-year chemistry class (n=350-400), with students allocated to groups of three. The study evaluated students' perceptions, task completion, motivation, and engagement and concluded that the learner-generated podcast led to deep learning of the subject content (Bartle, Longnecker, & Pegrum, 2011). The study used two Likert scale questions: (1) *The podcast activity helped me to get a better understanding of chemistry*; and (2) *The podcast activity was an enjoyable activity*. Two open-ended questions related to the advantages and disadvantages of podcasts for learning were also asked, and analysed using thematic analysis. The survey response rate was 35%. Limitations of the study included insufficient survey items to measure what was claimed (student perceptions, task completion, motivation, and engagement). A continuation of the study with a first-year chemistry class (n=352) (Pegrum et al., 2015) used a quantitative approach and supported the previous study. This study found a significant improvement in marks attained by students who engaged in podcast creation for learning when compared to a previous year cohort. The main limitation of this study was that comparison data was from the previous year when podcasting was not used. Neither study used a theoretical model to design the podcast assessment task, nor was media training offered to students.

In one case, a geography subject used a three-step model that included pre-production, production, and post-production (Kemp, Kotter, Mellor, & Oosthoek, 2009). Pre-production included brainstorming, logical structuring of the topic, and storyboarding. The production stage covered special effects like music and sound, designing the introduction, and recording, editing, and mixing the podcast. The post-production stage required producing a written summary or outline of the podcast and submitting the audio file to iTunes. This model is valuable but did not incorporate relevant aspects of podcast content discussed previously, such as the type of content, length, style, purpose, or the pace and intonation. The model is probably the most complete so far, but it does not have the educator and student role embedded in it. For example, how will this model inform the educator about designing a learner-generated podcast task? How will it inform the student about the assessment task? A continuation of the study a few years later concluded that the task enhanced student learning, competence with technology, creativity, and science communication skills (Kemp, Mellor, Kotter, & Oosthoek, 2012). The evaluation had a qualitative approach using informal discussion with students and the teaching team, and a questionnaire comprising closed and open-ended items. The study used data from 2008 (n=40) and 2010 (n=61) and noted low response rates to the questionnaire. This study used a theoretical model (Kemp et al., 2009) that informed the design of the task and also the creation of a marking rubric. Limitations included the methodology for gathering the data and the small size of the cohorts. Another qualitative study in postgraduate engineering students (in a mathematics subject) adopted an 'action research' approach (planning, action, observation, and reflection) to gauge students' views on learner-generated podcasting. Students appreciated the intervention but found podcast creation to be time-consuming and difficult (Adams & Blair, 2014).

In learner-generated podcast in science education, there is no comprehensive model for its implementation in the classroom which considers content and technical aspects and highlights educator and student roles. Studies are limited because it is a new approach. Most of the existing studies used a qualitative approach to data-gathering and analysis and did not use a framework to design the task. Studies are difficult to compare as they were undertaken in different disciplines and different settings. Most studies did not provide student training for the task. The research on podcasting and student learning in tertiary science education is thus inconclusive.

Learner-generated digital stories

Digital storytelling involves making a 3-5 minute video composed of images and voice-over (Martinelli & Zinicola, 2009). It is an arts-based research method that has the potential to explain complex narratives (Rieger et al., 2018) and to engage the audience and trigger their emotions by creating an unforgettable experience (Reyna et al., 2017). This digital media type can be created using PowerPoint, Movie Maker, iMovie, or similar software (Frazel, 2010; Hussain & Shiratuddin, 2016). Outside science disciplines, digital storytelling has been used to close the gap between facts and understanding, prompt reflection on experiences, embody agency, and assist meaning construction and formation of identity (Chan, Churchill, & Chiu, 2017; Martinelli & Zinicola, 2009; Niemi & Multisilta, 2016; Özüdoğru & Cakir, 2017; Shelton, Warren, & Archambault, 2016). In public health campaigns, digital stories are used to effectively convey complex messages to the general public (Rieger et al., 2018), but digital storytelling in higher education is still under-studied and under-used (Dewi, Savitri, Taufiq, & Khusniati, 2018).

In science disciplines, digital stories have been used to deploy content in blended learning (Molnar, 2018), but rarely used for students to engage in the creation of content. Learner-generated digital stories have the potential to help students in the classroom to learn by translating complex scientific concepts into personal narration. For example, in the process of drafting a storyboard, students have the opportunity to transform information into a simple visual representation (Martinelli & Zinicola, 2009). Regrettably, use of digital stories in science education as an assessment task is infrequent. The reason behind this is that the scientific community does not see digital stories as a rigorous methodology for presenting information (Martinelli & Zinicola, 2009; Schrum, Dalbec, Boyce, & Collini, 2017).

In undergraduate biology (Year 1) and environmental science (Year 2), the digital story has been used in assessment tasks (Ross, 2015). However, the methodology for this research was not straightforward and did not include the analysis of data. Students reported the task of producing the assignment to be time-consuming (+30 hrs). The study used a marking rubric that assessed content, creativity, and language. 'Creativity' seems mismatched with this rubric, which was more concerned with the technical aspects of the task. Outside creative disciplines, how can creativity be measured objectively? The research did not include qualitative or quantitative data. As a result, the study is inconclusive.

A study has reported on the use of digital story in postgraduate science education to improve student communication skills. The framework used was based on the process developed by the

Story Center in 2014 and included seven steps: (1) students see examples; (2) concept check; (3) brainstorming; (4) script and critique; (5) storyboard; (6) production; and (7) exhibition and evaluation. The methodology for the study was unclear, and it used three examples of digital stories developed by students, surveys, and interviews, but the data was not included in the paper. The study concluded that digital stories provided an opportunity for ESL science students to explore digital media and multimodal communication, learn about the subject topic, and improve communication skills (Purser, 2015). Another study with undergraduate (n=8) and postgraduate students (n=4) used the framework described and asked six open-ended questions to evaluate the intervention. Students said that they enjoyed the freedom to create material using their ideas and skills and reported minor technical issues (Martinelli & Zinicola, 2009).

The uses of learner-generated digital stories in science education are in its early stages. Although theoretical frameworks for storytelling have been applied, a methodology for gauging student learning or perception is not comprehensively explained in the literature. The research in this field seems to be more anecdotal than rigorous.

Learner-generated screencasts

Screencasts are recordings of the computer screen, with or without narration, using software such as Camtasia Studio, CamStudio, Macintosh QuickTime, or online applications like Screencast-o-Matic. They have become popular in higher education to develop training materials for students in flipped classroom interventions (Carney, Ormes, & Swanson, 2015; Talbert, 2014). Student-generated screencasts are only a recently emerging trend in higher education, and the literature is scarce. A literature search on student-generated screencasts identified only four papers in science education, exclusively in computer programming subjects. In one study, students were asked to create screencasts as a form of note-taking in tutorials. The trial included two groups, the group of students creating screencasts and the others who did not. The research presented data from four semesters (n=225) and reported only on test scores. Findings suggested that students who created screencasts as note-taking during tutorials achieved better scores than students who used traditional note-taking (Powell, 2015). The limitations of this study included the lack of survey data and interviews and the possibility that students shared their screencasts with their peers.

A second study reported the use of learner-generated screencasts as tests of complement code writing. Previously, students had been asked to provide screenshots for the task (Woods, 2015). This paper’s research methodology is unclear, and it is not known how many students participated in the trial. The author concluded that the screencasts generated by the students helped the instructor to evaluate the assessment task. The intervention was teacher-centred rather than student-centred. The author also mentioned that the screencasts helped students to reflect on code writing. A similar approach was reported as a useful teaching approach in geometry, where students used screencasts for self- and peer-review (Shafer, 2010).

It is questionable whether creating a screencast that may, for example, not require a script can be considered learner-generated content. In contrast, if the task is to create a training video on how to use software or an application, students will need to be familiarised with the tool and learn a storyboard approach. They will also need working knowledge about editing the screencast and about digital media principles like colour schemes and typography, as they are likely to use on-screen text and prompts.

Studies of learner-generated screencasts in tertiary science education are currently rare in the literature, and future studies should consider the pedagogy behind the task. For instance, students learning about an application or software by preparing screencast training material would be an ideal use of screencast. That task would require a storyboard to help students to learn the software. There is a need to undertake studies on learner-generated screencasts that use defined methodologies and large samples to test their effectiveness for student learning.

Learner-generated animations

Animation is a sequence of frames put together to create a sense of motion. Producing animations was a time-consuming task until a decade ago. Designers could spend weeks creating an animated story. The affordability of technology helped to overcome this problem. For example, services such as Pow-toon (Graham, 2015) and GoAnimate (Stratton, Julien, & Schaffer, 2014) allow students to create animations in a short timeframe. This type of animation is called whiteboard animation, and it has been highlighted to communicate concepts online (Türkay, 2016). Online companies are using this approach to showcase their products on social media. In the past, animations were created using Flash Professional and required knowledge of ActionScript coding (Moock & Epstein, 2001). Educators of pre-service teachers coined the term 'slowmation' (slow animation) to refer to a type of student-created animation (Hoban, 2007; Hoban et al., 2015; Jablonski, Hoban, Ransom, & Ward, 2015). New names for existing categories of digital media will only create more atomisation of the LGDM literature and should preferably be avoided.

Constructionist theory, instructional design frameworks, and semiotic theory have all been used to explain learning with animations. For instance, when students prepare an animation to explain a science concept, they clarify, check, and refine their understanding (Hoban, Nielsen, & Carceller, 2010). Although there is no existing framework for implementing learner-generated animations in the classroom, the literature does discuss possible features of such a model, like purpose, timing, orientation, materials, and technology (Hoban & Nielsen, 2013).

With pre-service science teachers, case study design and discourse analysis (n=3) have been used to understand learning through creating a science animation. Research with pre-service teachers found that the process of meaning-making involved in such exercises fostered learning and reinforced the scientific concepts being conveyed. Multimodal representation of content, such as writing, still images, and voice-over, helped them to learn (Hoban & Nielsen, 2013). This research is comprehensive but cannot be generalised to a large cohort of students outside the discipline of education due to its qualitative nature. A study where undergraduate pharmacology students created animations during a two-hour tutorial found that students were anxious (39%), apprehensive (27%), intimidated (26%), lacking time to complete the project (67%), and lacking technical skills (54%) (Pearce, 2014). However, the study reported that students agreed that they had developed problem-solving, critical thinking, oral communication, teamwork, and management skills from the exercise. This research did not use a theoretical model for assignment design, and students did not receive media training. The data presented was gathered from a qualitative survey alone.

There is a lack of extensive studies to reinforce previous findings on the impact of animation in science education. The current affordability and ease of production of whiteboard animations created entirely online opens the possibility of a large-scale study to gauge their effect on learning further.

Learner-generated video

Learner-generated digital video for tertiary science education is the most common form of LGDM represented in the literature. Advantages of student-created digital video in education include the affordability of experiential learning (Coulson & Frawley, 2017), development of graduate attributes (Frawley et al., 2015; Pearce & Vanderlelie, 2016), new ways to represent knowledge (Hobbs, 2017), student engagement (Graybill, 2016), group collaboration (Coulson & Frawley, 2017; Pearce, 2014), project management (Cox, Vasconcelos, & Holdridge, 2010), and the development of technical skills (Morel & Keahey, 2016). Empirical data to validate these advantages are not available in existing research. Studies in the field have a flavour of guesswork, small samples, a qualitative nature, and lack of theoretical models to guide implementation of the assessment task. Moreover, most studies did not provide student training in video production. These drawbacks make it challenging to compare studies.

In a third-year undergraduate course in physiotherapy (n=75), no framework was used to implement the LGDM assessment task, and no training in video production was delivered to students. The results reported were mixed (Coulson & Frawley, 2017). Students reported stress and anxiety from problems related to the time given to complete the assignment, the group work involved, and assignment design issues. The study used a qualitative survey alone to gauge student perceptions and evaluate the intervention. A study in a geography subject followed the same pattern and lacked a framework to implement the assignment. However, it used a six-phase approach for the assessment task: (1) topic selection; (2) thesis statement and information/image gathering; (3) first narrative draft; (4) storyboarding; (5) videography workshop; and (6) viewing of videos on YouTube. Evaluative data was collected from routine institutional student surveys at the end of the semester (Graybill, 2016). The study reported student satisfaction with the assessment task, but issues with groupwork contributions and a lack of technical skills for creating a video.

Another study conducted with postgraduate students in health information management (n=8), using a qualitative survey, claimed that the assessment task developed critical thinking by creating a video that reinforced learning (Morel & Keahey, 2016). The study also suggested the development of project planning, management, and collaboration skills. It highlighted the need for clear assignment instructions and expectations, student training support, and strategies to improve groupwork such as assigning roles and responsibilities. The limitations of the study were its small sample size and the qualitative nature of the data.

Research with fourth-year pharmacy students (n=92) and second-year health sciences students (n=83) across two different institutions, using a qualitative survey, reported that students enjoyed working in teams and the creative nature of the task. They also felt that they developed graduate attributes such as problem-solving, critical thinking, communication skills, and time management (Pearce & Vanderlelie, 2016). However, the study reported that students were anxious (59%) and apprehensive (87%) about the task. Students did not receive video training or any technical assistance, and the assessment task did not use a theoretical framework. Limitations of the study included students undertaking different assessment tasks and being evaluated at different times.

Other studies on learner-generated digital video in science education (biology and geography) have the same limitations described above. These studies have in common small sample sizes, qualitative surveys, and lack of student training in digital media production (Anderson, 2013; Fuller & France, 2016; Pirhonen & Rasi, 2016). They concluded that both students and educators required coaching in video production (Fuller & France, 2016) and that storyboards were essential to master subject content before moving to video production (Pirhonen & Rasi, 2016). As previously suggested in the field of educational technology, it is likely that there are more cases of LGDM implementation in science education that have not been formally evaluated and published (Liu, 2016).

Conclusion

Learner-Generated Digital Media in tertiary science education is currently in its embryonic stages. There is no practical model for implementing LGDM assignments in the classroom which can be applied regardless of the digital media type. The lack of a model means that LGDM as an assessment tool is under-theorised and the lack of coherent methodologies to evaluate the student learning experience means the field is under-researched. However, a deficit in educator knowledge of digital media production workflow and digital media principles adds an extra layer of complexity to using LGDM assignments. The lack of compelling marking rubrics and neglect of student training provides evidence for this claim. These gaps in knowledge could explain the current status of research in the field. Learner-generated digital content, regardless of the type, has been acknowledged to have various advantages for science learning.

There is a great need to develop a practical framework for the design, implementation, and evaluation of LGDM assignments in tertiary science education. Ideally, the framework would be applicable across disciplines and different digital media types such as podcast, animation, digital story, or video. Its purpose would be to guide educators in designing, implementing, and evaluating digital media assignments and to get students to understand the rationale of the assessment task. The framework should be student-centred and should consider digital media training, groupwork contributions, student feedback, reflection, and so on.

Looking at the gaps in the literature, it will be necessary to develop a second model to inform student digital media training which considers conceptual, functional, and audiovisual skills. Conceptual skills developed here are searching for information and producing a storyboard, essential steps for students to understand the content before moving to the digital media production stage. Learning functional skills will ensure that students are capable of using digital media applications and will reduce the anxiety and apprehension reported with LGDM assignments. The digital media principles that apply to the creation of compelling digital media will develop audiovisual skills. Currently, most research on LGDM assignments perpetuates the ‘digital natives’ myth which leads to neglect of student training in digital media. Lack of student training could be due to the limited working knowledge of educators outside the disciplines of visual design, multimedia, film, or digital media about digital media production workflow.

A third model could use a taxonomy of digital media types, based on the skills required to develop the different types of digital media. This framework would inform educators in designing the LGDM task, mark weighting, group size, and comprehensive marking rubrics. From the student perspective, this taxonomy would inform them about the skills and training they need to produce LGDM assignments and to succeed in the assessment task.

Finally, a model is needed to define the minimum audiovisual skills required to produce digital media, for example, the digital media principles for production of compelling digital media artefacts, such as layout design, colour theory, typography, use of images, and basic video techniques. The US literature has highlighted that problems are not related to technology ownership, but fluency in its use (Alexander, Adams Becker, & Cummins, 2016). On the other hand, research papers on LGDM there have reported that students successfully produced quality digital media presentations (Coulson & Frawley, 2017; Pearce & Vanderlelie, 2016). Without an understanding of digital media principles and a good marking rubric, how can we evaluate the quality of LGDM content objectively? Moreover, how can educators fairly mark LGDM assignments if students do not receive formal training in digital media principles? It is therefore essential for educators implementing LGDM assignments to have a sound understanding of digital media production and its principles. LGDM should not be used exclusively as a vehicle for learning content, but also for learning to communicate effectively using digital media. Effective communication in the digital space is a required attribute for 21st-century graduates.

With the creation of the models discussed, it will be possible to apply a systematic approach to designing LGDM assignments for science education. Finally, a methodology for evaluating learning with digital media creation will be required to fill the gap in the literature and validate current assumptions about the benefits of LGDM. This approach should include a validated survey to gauge student attitudes to technology for learning and career development, their understanding of the assignment, their knowledge construction, and open-ended questions. Methodological triangulation of surveys against group dynamics and student marks should provide a sharper picture of the effectiveness of LGDM assignments.

This paper has highlighted the potential of LGDM assignments for science education, but rigorous studies taking systematic approaches to assignment design, implementation, and evaluation are required to validate assumptions.

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Chapter 3:

Theoretical Considerations and Exploratory Study

Chapter 3 overview

Theoretical considerations for LGDM assignments and preliminary exploration

This chapter encompasses five published journal papers. The first four papers are theoretical frameworks that addressed the research gaps discussed in the literature review (Chapter 2). The last paper of the chapter is a preliminary exploration of LGDM assignments using these frameworks. The theoretical frameworks were developed using a naturalistic approach (Salkind, 2010), in which the author combined the knowledge of fifteen-year experience in the digital media industry and ten-year experience as an educational designer in university settings. The approach implied study previous training material developed by the author such as PowerPoint slides in conjunction with digital media creation for several educational projects. The examination of digital media creation included storyboards, representation of content using a multimodal approach and production phase. This training material analysed was based on the literature of visual design (Hashimoto & Clayton, 2009; Malamed, 2015), graphic design (Carter, 2012; Williams, 2014), Gestalt theory (Chang, Dooley, & Tuovinen, 2002), digital media production (Arvidsson & Delfanti, 2019; Earnshaw, 2017; Musburger & Kindem, 2012), video principles (Bowen & Thompson, 2013; Stockman, 2011), visual literacy (Messaris, 1994), and digital literacies (Hobbs, 2017). This combination of multiple disciplines served as the theoretical underpinning of the frameworks. The principles were translated into succinct explanations to ensure that educators and students will understand and apply these key concepts in their LGDM assignments. Papers are presented below in the order of appearance:

Reyna, J., Hanham, J., Meier, P (2018). A taxonomy of digital media types for Learner-Generated Digital Media assignments. *E-learning & Digital Media,* Vol. 14(6), pp. 309–322. https://doi.org/10.1177/2042753017752973

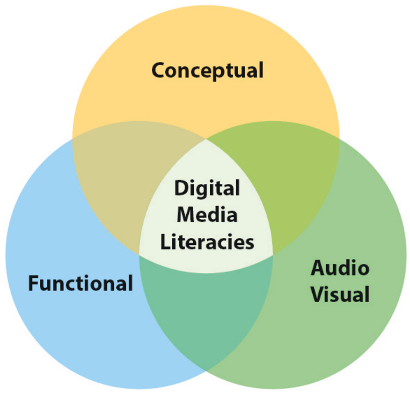
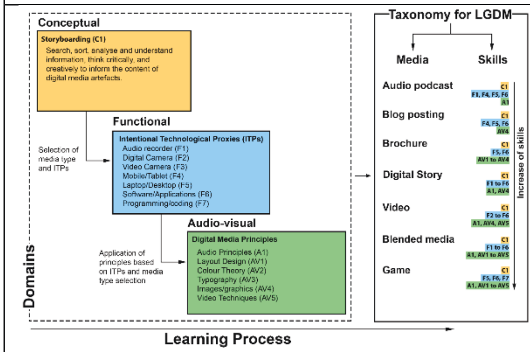
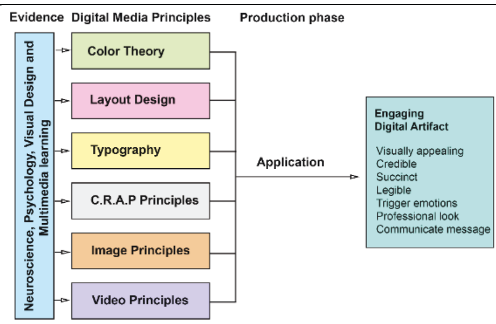
Reyna, J., Hanham, J., & Meier, P. C. (2018). A framework for digital media literacies for teaching and learning in higher education. *E-Learning and Digital Media,* Vol 15(4), pp. 176-190. https://doi.org/10.1177/2042753018784952

Reyna, J., Hanham, J., Meier, P (2018). The Internet Explosion, Digital Media Principles and Implications to Communicate Effectively in the Digital Space. *E-learning & Digital Media,* Vol 15(1), pp. 36 – 52. https://doi.org/10.1177/2042753018754361

Reyna, J., Meier, P (2018). A Practical Model for Implementing Digital Media Assessments in Tertiary Science Education. *American Journal of Educational Research*, 6(1), pp. 27-31. http://pubs.sciepub.com/education/6/1/4/

Reyna, J., and Meier, PC (2018). Using the Learner-Generated Digital Media (LGDM) Framework in Tertiary Science Education: A Pilot Study*. Educ. Sci.* 2018, 8(3), 106, 23p. https://doi.org/10.3390/educsci8030106

A summary of the frameworks and how they informed the design of the LGDM assignment task in this research project is presented below:

<table>
<tr>
<td>
</td>
<td>A framework for digital media literacies for teaching and learning in higher education
The framework identified three domains in the effective creation of LGDM assignments: Conceptual (Storyboard), Functional (use of software), and Audiovisual (digital media principles). The model was used for the developing of training materials in these domains and designing marking rubrics. Additionally, the model served to design the taxonomy of digital media types below.</td>
</tr>
<tr>
<td>
</td>
<td>The taxonomy of digital media types for Learner-Generated Digital Media assignments
The framework presented a workflow of the three domains within the digital media production task and showed the complexity of the different digital artefacts from an audio podcast to the development of a game. This model informed the developing the LGDM task such as assignment weighting, help to decide if the task will be group work or individual, and informed academics and students the digital media production workflow.</td>
</tr>
<tr>
<td>
</td>
<td>The digital media principles framework
The model presents the topics that students need to be trained to produce effective LGDM assignments. It guided the topics where the students need the training to accomplish an effective digital media artefact.</td>
</tr>
</table>

A Practical Model for Implementing Digital Media Assessments in Tertiary Science Education

This LGDM implementation framework helped educators and students to understand the flow of the LGDM assignment. This framework also generated a FAQs sheet for students that followed the questions they had about the LGDM task.

The last paper from this chapter is an exploratory study that put into application all the frameworks presented. The contribution of the paper included the production of a survey, validated by Factor Analysis, to evaluate student attitudes towards digital media for learning. The paper used a mixed-methods approach considering survey data, open-ended questions, group work contribution (SPARKPlus), and marks distribution. Methodological triangulation (Bekhet & Zauszniewski, 2012) was used to analyse and interpret these data. Preliminary data suggested the models were valid tools to support the design, implementation and evaluation of LGDM assignments. Students had a positive attitude towards learning with LGDM, enjoyed group work and creativity and identified the digital media support received as a critical component of their learning experience. The paper proposed a methodological approach that was the starting point of Chapter 4: Materials and methods paper.

Furthermore, the research highlighted the need to use self-regulation to understand student strategies to adapt to learning with LGDM assignments. This notion inspired the idea to use self-regulation in LGDM assignments. The second paper in Materials and Methods chapter proposed and validated the questionnaire on self-regulation for LGDM assignments that was one of the crucial data sets for the core paper of this research in Chapter 5.

Overall, this chapter may seem heavily theoretical; the critical contribution of these papers are the frameworks that are easy to follow when designing LGDM assignments. These frameworks are flexible enough to be adapted to the design of LGDM assignments in different disciplines, and various settings such as primary and secondary education.

Certificate of authorship and originality

This chapter includes five journal papers. The first three papers were published in the E-learning and Digital Media (SAGE Journal) while the fourth paper in the American Journal of Educational Research (SciEP). The last paper was published at the Education Sciences (MDPI Journal). I certify that the work presented in this chapter has not previously been submitted as part of the requirements for a degree. I also certify that I carried most of the work presented in this paper.

- Jorge Reyna wrote most of the first three manuscripts (~95%), and manuscript four and five (100%).
- Peter Meier suggested the split of the original manuscript into three papers as they were three separated frameworks. He also provided feedback for the first manuscript.
- Jose Hanham wrote ~5% of the first three papers
- Peter Krockenberger did the proofread of all manuscripts.

Primary Author

Production Note:
Signature removed prior to publication.

Jorge Reyna

03/31/2019

Article

e-learning and digital media

A framework for digital media literacies for teaching and learning in higher education

E-Learning and Digital Media
2018, Vol. 15(4) 176–190

DOI: 10.1177/2042753018784952
journals.sagepub.com/home/ldm
SAGE

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Abstract
Across a broad range of subjects in higher education institutions, students are required to complete assessment tasks that involve the production of digital artefacts. Examples include podcasts, digital stories, animations, video and blended media. To produce effective digital artefacts, one must be digitally literate. This requires a certain set of technical, audio-visual, behavioural, critical and social skills. In this article, the authors propose a framework that can be used to develop digital media literacies and train students in digital media creation. The framework considers three interdependent domains: conceptual, functional and audio-visual. A series of examples will be provided to illustrate the importance and interdependent nature of these domains. Implications of the framework on student training are discussed.

Keywords
Digital media literacies, learning with digital media, digital media framework, new media, teaching and learning

Introduction

The concept of literacy emerged at the end of the 19th century and referred to the ability to decode and encode text (Ohler, 2009). Overtime, conceptualisations of literacy have

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expanded to include a range of modes including online literacies (De Abreu, 2013), media literacy (Potter, 2013), new media literacy (Ohler, 2013), multimodal literacy(Serafini, 2015) and digital literacy (Buckingham, 2007a). The term *Digital Literacy*, which is well established in academic and public discourse, was first introduced in the 1990s and described as 'the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers' (Gilster, 1997).

There are several modern definitions representing different perspectives on digital literacy. These include functional aspects, such as of operating computers (Buckingham, 2007b), critically reading websites or viewing digital images (O'Brien and Scharber, 2008), as well as definitions that encompass social awareness, critical thinking, and knowledge of digital tools (Hague and Williamson, 2009). From the multiliteracies perspective (Kalantzis and Cope, 2000), literacies cannot be restricted to the acquisition of skills or mastering practices but must consider analysis, evaluation, critical reflection including the impact of the artefact on the community, and the ability to make informed judgments about the role of technology in society and culture. The prevailing view as described in the latest NMC Horizon Project (Alexander et al., 2016) portrays digital literacy as the combination of practical and critical understanding of digital technologies in socio-cultural settings.

The definition advanced in this paper is that digital literacies are the set of technical, audio-visual, behavioural, critical and social skills that enable users to learn, communicate, socialise and contribute in the digital space. Technical skills refer to the use of computers, software and applications to develop digital content (Hashimoto and Clayton, 2009). Audio-visual skills are related to understanding and applying digital media principles that guide the development of digital media artefacts (Malamed, 2015; Stockman, 2011). Behavioural skills are associated with knowing what is acceptable in online communications and Netiquette (Spinks et al., 1999; Strawbridge, 2006). Critical skills are the ability to search, identify, analyse and judge online content for credibility (Hinrichsen and Coombs, 2014; Vaičiūnienė and Mažeikienė, 2017). Finally, social skills are the ability to interact effectively with other online users (Poore, 2011).

Digital literacies are a broad term that is not appropriated for this paper that aims to develop a practical model to help educators and students to produce digital media for learning. Instead, the article uses digital media literacies as a subset of digital literacies. From now, the paper will be focusing on digital media literacies. The proposed framework has been inspired in digital media production workflows commonly used in the industry, for example in graphic design (Lupton and Phillips, 2015), animation (Lasseter, 1987), video (Stockman, 2011) and blended media (Kindem and Musburger, 2012).

Digital media literacies framework

Digital media literacy is critical for the production of effective digital artefacts. Arguably, the effectiveness is contingent upon how well messages are communicated to the intended audience (Carroll, 2014; Hashimoto and Clayton, 2009; Malamed, 2015). This paper proposes a digital media framework to articulate the skills required to produce effective digital media. As an example, a digital media company will be the typical setting of production where digital media is conceptualised, designed, created and deployed online. The digital media literacies framework (DMLF) is composed of three domains: (1) conceptual, (2) functional and (3) audio-visual (Figure 1). Each domain has a set of related skills which must be understood and applied to ensure the production of an effective digital artefact.

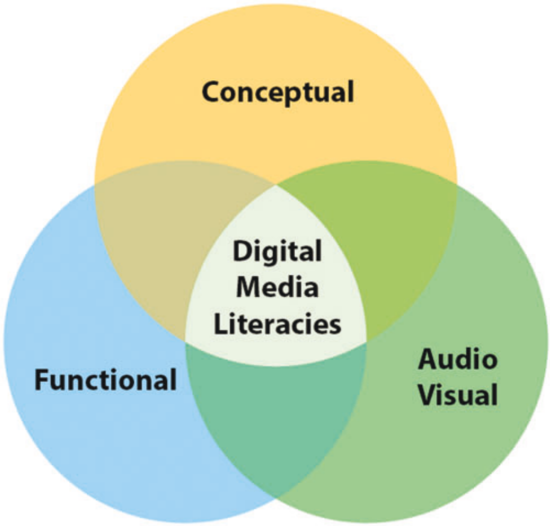

Figure 1. The three domains of digital media literacies from the production perspective.

Conceptual domain

Conceptual skills can be defined as the set of abilities that allow a person to visualise concepts, see patterns, understand abstract ideas, solve problems, formulate processes and understand how systems, programs and ideas interrelate (Carroll, 2014). In the context of digital media production, conceptual skills can be defined as the ability to tailor content to specific types of digital media (Kindem and Musburger, 2012). As an example, to produce an animation about climate change, a student would need to search, analyse and understand relevant topical literature, think creatively and translate the content appropriately to fit the medium.

For the DMLF, the ability to search, sort, analyse and understand information, think critically and creatively to inform the content of digital media artefacts will be labelled the 'conceptual' domain. This conceptual domain is required to be able to adapt content to different types of digital media objects (Masterman and Shuyska, 2012). For example, developing content for an audio podcast is, in essence, different from content for a poster or a video (McLoughlin and Lee, 2007). In an audio podcast, there are no visuals involved. In contrast, in a poster, there is no audio and the visuals and information displayed are crucial as users only have one page of information to engage. For a video, the type and sequence of the shots (long, medium and close-up) and information flow is essential (Stockman, 2011). In sum, the content must be shaped to the type of digital media artefact.

Functional domain

The functional domain is related to the use of computers (Buckingham, 2007a; O'Brien and Scharber, 2008). In a digital media production environment, these skills include audio recording and editing, digital photography, use of image and graphics manipulation software, web authoring tools, animation software, video recording, editing and production, 3D creation and so on. The NMC Horizon Project (Alexander et al., 2016) recommended six

Table 1. Digital tools for media creation (functional domain).

Tools	Adobe Creative Cloud	OpenSource equivalent	Functionality
1	Photoshop	GIMP	Leverage and edit photos/images to convey stories visually
2	Premier Pro	Videopad	Create, edit and publish videos
3	Illustrator	Inkscape	Create vector graphics to share data/content visually
4	InDesign	Scribus	Design pages for reports, poster sessions and ebooks
5	Muse	Webflow	Create code-free, mobile-ready websites
6	Lightroom	Raw Therapee	Edit, organise and share photos at a professional level
7	Soundbooth	Audacity	Audio recording, editing and producing
8	Animate CC	Synfig Studio	Create 2D animations

tools (1–6) from the Adobe Creative Cloud Suite for digital media creation. Table 1 shows these tools (1–6) and two additional tools for audio editing and animation (7, 8) with their OpenSource equivalent software used by the authors of this paper.

Audio-visual domain

There is a vast body of literature on visual literacy, which can be defined as the skills that facilitate a person to understand (read) and use (write) visuals to communicate a message to an audience (Ausburn and Ausburn, 1978b; Hortin, 1980). An analogy between visual literacy and verbal literacy was described that proposed two principles. Visuals are a language to communicate a message and it is expected that a visually literate person should be able to read (decode) and write (encode) visual language (Ausburn and Ausburn, 1978a). From the digital media production perspective, visual literacy is linked to visual design and composition principles. These principles are essential to the production of effective visual communications (Heinich, 1996; Malamed, 2015; Stockman, 2011).

The 'audio-visual' domain is related to applying knowledge of audio and digital media principles to develop effective digital artefacts. The artefacts could be restricted to either the audio, e.g. podcast or visual, e.g. poster elements or combine the two, e.g. video. The audio-visual domain is composed of audio quality, sounds effects and editing, layout design, colour theory, typography and use of images to convey messages (Hashimoto and Clayton, 2009). Visual design principles (Kimball, 2013), video shots, the rule of thirds, transitions and timing are also included in this domain (Stockman, 2011), see Table 2.

Table 2 presents a summary of the basic principles, in a 'prosumer' version of these principles. The term 'prosumer', coined by futurist Alvin Toffler in the 1970s, refers to those users who hover between producer and consumer (Bruns, 2007). In other words, a prosumer is a consumer who has moved beyond using equipments in 'automatic mode' and requires advanced features. In electronics, prosumer equipment is considered to be professional entry level such as digital handycams and Digital Single-Lens Reflex cameras. For example, a standard point-and-shot camera has limited functionality in terms of manual settings, users cannot control aperture, shutter speed, ISO, at the same time, instead, the user need to choose from predetermined settings. A prosumer version will allow the user to control all these settings and offer advanced functionality similar to professional digital cameras such as shooting in RAW format (uncompressed image), bracketing (multiple exposures), High Dynamic Range images, and so on. In the context of the digital media

Table 2. A summary of digital media principles for the audio-visual domain.

Principle	Description
Audio recording	Audio quality, compression, sound effects and editing, producing and deployment
Layout design	How to positioning design elements on the screen, white space, the hierarchy of information for maximum engagement
Colour theory	Effective use of colour to convey a message avoiding a colour clash and maximise readability of content
Typography	Appropriated use of font type and size to increase legibility of the message
Image	Use of images with meaning, to add value to the digital artefact, to trigger emotions of the user
Graphic design principles	Understand and apply visual design principles such as Contrast, Repetition, Alignment and Proximity (CRAP)
Video	Appropriated use of shots (long, medium and close-up shots), the rule of thirds, video transitions and timing, and video framing to avoid Vertical Video Syndrome

literacy framework, it would not be expected that students develop a deep professional level of knowledge, but rather have a 'prosumer' level of understanding of the domain principles that will enhance their creation of digital artefacts beyond the most basic levels. If students were studying digital media, film or visual arts, they will need a professional working knowledge, but outside of these disciplines, for teaching and learning matters, the prosumer level is sufficient.

Some educators may consider the principles outlined in Table 2 as belonging to the functional domain. However, the principles of the audio-visual domain cannot be considered functional for the simple reason that a digital artefact can be developed independently of understanding sound quality and digital media principles. Furthermore, all the domains are interconnected. The separation proposed in this framework was presented for instructional reasons. Ultimately, all of the literacies overlap to some extent. The separate skill sets presented need to be present, to some degree, at the same time to produce effective digital media content.

Application of the framework

The two scenarios presented below illustrate how the framework works and further explains the interdependence between the three domains of digital media literacy.

Scenario 1

A pharmacology student is preparing an assessment task on the medicinal use of cannabis. The assessment task requires the student to produce a brochure to communicate the concept to the general public. The student will need to identify, use, evaluate and think creatively to produce a message that explains the topic and can be suitably presented in a brochure. A storyboard will be required to brainstorm and visualise the ideas (Domain 1, conceptual). The functional part of the task will require the use of relevant software applications (e.g. Adobe Photoshop, Illustrator, InDesign, Microsoft Office Publisher) to create the brochure

(Domain 2, functional). Finally, the student will need to understand and apply visual design principles, such as Contrast, Repetition, Alignment, and Proximity (CRAP) (Kimball, 2013), colour theory, typography and so on (Malamed, 2015) (Domain 3, Visual). Let us assume the student was able to identify the content appropriate for the topic but failed in Domain 1 (conceptual). Even if Domains 2 (functional) and 3 (visual) are present, the content of the brochure will not be suitable for the medium or engage the audience. In other words, the message will not be conveyed effectively. If Domains 1 and 2 are present (conceptual and functional), but the design uses an inappropriate colour scheme, with a lack of contrast between background and text, or hard to read fonts or a chaotic layout, it is unlikely that the end product will engage the audience effectively or be considered credible. Based on this scenario, it is evident that these three domains are interconnected. To complete the task and produce a useful brochure, the requirements of all three domains need to be met.

Scenario 2

A student from psychology is required to explain the self-serving bias theory with computers (Windows vs. Macintosh) using digital video. The student will need to be able to search for evidence-based information and then visualise ideas using a storyboard (Domain 1, conceptual). The functional part of the task will be shooting and editing video (Domain 2, functional). However, the ability to operate a video camera and use a video editing software will not guarantee the end product will be good enough to communicate the message to the audience (Stockman, 2011). The student will need to understand and apply basic video principles during the shooting such as the type of shots, timing, location and so on during the editing process. Also, the student will need to understand and apply video effects such as transitions, titles, background sound effects and music (Domain 3, audio-visual). If the student achieves Domains 1 and 2 only (conceptual and functional), the end product may not engage the audience; it may be too long, confusing or just boring to watch. If Domain 1 is only achieved, in which the content is accurate, but there are no video filming and editing skills (Domain 2, functional), and no audio-visual skills (Domain 3), the video will not be useful to communicate the message appropriately.

To highlight the interdependency of the three digital literacy domains, the two scenarios above can be examined in simple terms of either failing or succeeding to meet the requirements of a domain. Table 3 illustrates how the success or failure in a particular domain may combine to produce eight possible outcomes. It is noteworthy, that a failure in all domains can still result in a digital artefact, but the quality will be compromised. The validation of

Table 3. Digital media literacy domains and digital media creation outcomes.

	Digital media creation task outcomes							
Domain	1	2	3	4	5	6	7	8
1 Conceptual	F	F	F	F	S	S	S	S
2 Functional	S	F	S	F	F	F	S	S
3 Audio-visual	S	S	F	F	S	F	F	S
Outcome	F	F	F	F	F	F	F	S

F: Failure; S: Success.

this table will be presented in the next section using working examples as evidence the domains interdependency.

Each column explains a different scenario for the task with possible combinations of Failure (F) and Success (S) in the three domains discussed. Notice that failing in the functional domain (scenarios 2, 4, 5 and 6) does not necessary mean no artefact is developed. For example, a video can be created from a mobile device and upload it straight to YouTube without any planning and editing. In this case, the three domains will not be fulfilled, and this artefact could become digital media waste or content that fails to engage users. Currently, the Internet is inundated with this type of content and could make searching a process of sorting and discarding information.

In summary, digital media literacies in the context of effective production of digital media are composed of three domains: conceptual, functional and audio-visual. These domains are interconnected and failure of one, two or all could still translate into a digital artefact, but the quality will be undermined. The lack of these domains will result in a product that does not communicate the intention and will not engage the audience.

Working examples to explain the DMLF

As an illustrative example of the interdependencies of the framework domains as noted in Table 3, the authors of this paper have developed a hypothetical poster design about a French Film Festival (Table 4) using the Canva online application (www.canva.com). The possible outcomes (1–8) are explained.

These eight examples illustrate clearly all combinations of the domains in the DMLF and how it mastery can translate into an effective production of digital media artefacts. Similar examples can be developed for other digital media types such as audio podcasts, videos and blended media, but these examples go beyond the scope of this paper.

Discussion

There are a broad range of definitions regarding digital literacies from various discipline perspectives (Vaičiūnienė and Mažeikienė, 2017). This paper defines digital literacies as the set of technical, visual, behavioural, critical and social skills required to use current technologies that enable users to learn, communicate, socialise and contribute in the digital space. The main contribution of this paper is the articulation of the DMLF. This paper explores the DMLF from the production perspective for teaching and learning in higher education. The DMLF is based on three domains: conceptual, functional and audio-visual. The case studies and working example demonstrate the interdependency of the domains which is intrinsically applied to professional digital media production. Designers have this knowledge as second nature and it is honed with years of professional practice in the field (Kimball, 2013). The framework presented in this paper provides a method by which educators can scaffold the learning of digital media literacies for their students.

A graduate capability in digital literacy is required across discipline areas (Martin and Zahrndt, 2017), not just in media and creative disciplines (Alexander et al., 2016). Proficiency in digital media is crucial to developing effective communication skills in the 21st century (Hobbs, 2017; Vasilchenko et al., 2017). As defined within the framework, students must first learn conceptual skills (conceptual domain) applicable to the planning of content for digital media creation. Storyboarding is a good practice used by the digital

Table 4. Working examples of a poster design task using possible outcomes of domains.

Outcome 1

A typical example of conceptual domain failure. Information on the list of movies for the festival is missing; the audience will need to contact the organiser to find out more. The functional domain was achieved: the image compression was appropriate, and the text is clearly readable. The colour scheme is appropriate, there is a good contrast between the title and background, so the visual domain was achieved

Outcome 2

Conceptual and functional domains failed. The conceptual domain failed due to the lack of inclusion of crucial information (list of movies). The functional domain was not achieved as the user did not choose the right image compression, the text looks pixelated, blurry and hard to read. The visual domain was achieved as there is good contrast and an appropriate colour scheme

(continued)

Table 4. Continued.

Outcome 3

An example of the failure of conceptual domain (lack of movie list) and visual domain. The colour scheme used has a lack of contrast, and it is hard to read the information. The functional domain was achieved, the image compression is appropriated. The details of the event cannot be read due to the colour clash

Outcome 4

An example where all domains failed, conceptual (lack of movie list), functional (poor image compression) and visual (lack of colour contrast, poor use of fonts, fonts overlapping graphic)

(continued)

Table 4. Continued.

Outcome 5 	An example where the conceptual domain (list of movies included) and visual domain (good colour scheme) are achieved. However, the functional domain was not achieved: the image exhibits poor compression and is difficult to read
Outcome 6 	An example of the failure of the functional domain (poor image compression) and visual domain (poor colour scheme and font type). The conceptual domain was achieved: the required information is present but hard to read due to the failure of functional and visual domains

(continued)

Table 4. Continued.

Outcome 7

An example of the failure of the visual domain. Conceptual and functional domains were achieved, although the colour scheme and lack of contrast between font and background create a similar effect of poor image compression. If outcome six and seven are printed, the difference will be more evident

Outcome 8

An example of achievement of the three domains, conceptual, functional and visual. The poster has the appropriated information included, the image has been exported with a good compression, and the visual is appropriate (colour scheme and choice of fonts). The poster is easy to the eye and readable video industry (Stockman, 2011), other creative industries such as graphic design and digital media (Hashimoto and Clayton, 2009). Storyboarding skills should be nurtured within university programmes as they help students visualise ideas and ensure their content is sharp, succinct and suitable for the digital media artefact to be developed (Malamed, 2015; Carroll, 2014).

To facilitate the learning of digital media literacies, a division between functional and audio-visual domains was made within the framework. The use of a computer and software (functional domain) does not guarantee the appropriate application of digital media principles (audio-visual domain). The NMC Horizon report about digital literacy assumes that students need to learn the functional domain (Alexander et al., 2016), but appears to have overlooked the audio-visual domain. The emphasis of learning should not be on using the software and applications, but about using it appropriately to communicate a message to an audience. As the affordances of technology continue to improve, digital media literacies have a crucial role in online communication. For this reason, it will be necessary to ensure students have an appropriate level of competency in audio, image and video filming and editing (functional domain). They should be able to integrate their knowledge with the audio-visual domain, employing the digital media principles at a 'prosumer' level. Students no need to be professionally competent but should be able to apply the basic principles of digital media design.

Critical thinking and the ability to critique digital artefacts are also important skills in digital media literacies, which should not be seen merely as 'production standards'. Critical literacy for digital content has two dimensions: internal which allows users to analyse, evaluate and judge digital artefacts both in terms of content and presentation; and external, which is related to exploring social relation bonds in these artefacts (Hinrichsen and Coombs, 2014). This section is out of the scope of the framework that is merely a guide to produce digital media for learning, but the authors recognised the need to foster student critical media literacy via reflection.

Currently, digital media in education is being used in an opportunistic way, as a vehicle of learning or pedagogical agent (Hoban et al., 2015; Nielsen et al., 2017; Pearce and Vanderlelie, 2016). This opportunism may neglect the learning opportunity for students to develop effective digital media skills. This may account for why training in digital media literacies to students outside of the media disciplines is rare. This absence of training may be compounded by several other factors such as the lack of consensus for a definition of digital literacy (Vaičiūnienė and Mažeikienė, 2017), the inaccurate assumption about 'digital natives' postulated in 2001 by Prensky, and the lack of knowledge and skill in digital media of educators (Krumsvik, 2014). This paper envisages that the DMLF will play a crucial role in guiding the development of digital media literacies and assist educators in scaffolding these learning experiences. A balance between content and technology-centred approaches is required to ensure students learn subject content and develop true digital media skills required to successfully work, learn and socialise in the digital age.

The DMLF can help to identify gaps in knowledge and to implement appropriate training for the students. In our institution, the framework is being used to design the delivery of student training in digital media, either face-to-face or online. For example, the digital media principles lecture delivers the essential concepts the students need to understand when creating digital media (audio-visual domain). In contrast, the workshops deliver storyboarding techniques and writing content for digital media projects (conceptual domain). Finally, the computer labs introduce students to basic video shooting techniques and editing (functional domain). Currently, data are being captured to understand student perceptions of digital media for learning using an online survey. This survey has been validated using Factor Analysis and covers constructs such as (1) digital media for learning; (2) digital media for career; (3) digital media support provided and (4) knowledge construction. The development of a standardised digital media literacy quizzes could be a desirable intervention. Educators can measure students understanding of the topic by gathering data at the beginning and end of the semester. Then, by comparison, it can be determined if students gained the desirable skills to produce digital media and the data can be used to improve teaching strategies.

However, in applying the framework, several questions are raised which will need to be addressed by curriculum designers. For example, should the DMLF be incorporated into the curricula across all discipline areas? Do we want the students to develop a good understanding of digital media creation? Where and how this will be taught may depend on the educational setting, e.g. in a tertiary setting, a first-year subject called ‘Applied Digital Media’, where students learn or reinforce conceptual, functional and visual domains could be developed or alternately, such digital media literacies could be taught throughout a curriculum. There also remain a significant number of issues around designing digital media as an assessment tool and evaluate its effectiveness for learning. A promising approach can be considered self-regulation and motivational factors (Schunk and Zimmerman, 2011), and the development of psychometric tools to gauge student learning when digital media is used in the classroom. These issues will be further explored in upcoming papers.

Additionally, it is important to emphasise the development of critical thinking and good digital citizenship skills. These critical skills are essential in the age of fake news. Training in digital media literacies will help future professionals to evaluate digital media, be copyright compliant and develop e-civism, which can be described as representing the virtues and sentiments of a good digital citizen. The digital media framework proposed in this paper could help to identify the training needs of the students and educators for the competent production of effective digital media artefacts to effectively communicate their discipline to a wide audience.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Article

e-learning and digital media

E-Learning and Digital Media
2017, Vol. 14(6) 309–322

DOI: 10.1177/2042753017752973
journals.sagepub.com/home/ldm
SAGE

A taxonomy of digital media types for Learner-Generated Digital Media assignments

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Abstract

The notion of students as co-creators of content in higher education is gaining popularity, with an ever-increasing emphasis on the development of digital media assignments. In a separate paper, the authors introduced the Digital Media Literacies Framework, which is composed of three interrelated domains: (1) conceptual, (2) functional, and (3) audiovisual, each of which defines a set of prosumer principles used to create digital artefacts. This framework fills a gap in the literature and is the first step towards the provision of a systematic approach to designing digital media assignments. This paper expands on the Digital Media Literacies Framework through the incorporation of Technological Proxies and proposes a taxonomy of digital media types to help educators and students to visualise the skills needed to complete Learner-Generated Digital Media assignments. A taxonomy of digital media types is presented considering the conceptual, functional, and audiovisual domains of the Digital Media Literacies Framework. The taxonomy spans a range of Learner-Generated Digital Media assignments, from the creation of an audio podcast to the complexity of blended media or game development. Implications of the taxonomy for teaching and learning in higher education are discussed.

Keywords

Digital media competencies, digital media creation, digital media taxonomy, Learner-Generated Digital Media, teaching and learning, new media, 21st-century skills

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Introduction

Digital competence is a multifaceted concept which encompasses: (i) skills and practices required for using digital technologies in different settings (personal, learning, and professional), (ii) understanding the phenomena of digital technologies from individual and societal perspectives, and (iii) motivations for participating responsibly in the digital world (Ilomäki et al., 2016). Digital competences play a crucial role in current society as evidenced through digital technologies that shape the way we socialise, e.g. through Facebook (Madge et al., 2009) and MeetUp (Sessions, 2010); find job opportunities via LinkedIn (Archambault and Grudin, 2012); share resources via DropBox (Drago et al., 2012); event-following via Twitter (Weller et al., 2014); and collaborate online using Google Drive (Dekeyser and Watson, 2006). These technologies reshaped our everyday life as digital citizens.

In higher education, digital technologies made possible the implementation of Learner-Generated Digital Media (LGDM) assignments. The literature reports LGDM to be beneficial for student learning and developing skills such as teamwork, time management, conflict resolution, and so on (Hoban et al., 2015; Hobbs, 2017; Kearney, 2013; Nielsen et al., 2017). Instructional design models have been used to explain learning with digital media such as the Semiotic Theory (Hoban et al., 2015), the Self-Explanation Principle (Johnson and Mayer, 2010), and the Internalisation Model (Hobbs, 2017). Students gain knowledge by developing storyboards, representing the content using multimodality (audio, images, text, and video), and reinforcing their learning with the digital media production stage. However, it appears that little attention has been directed toward mapping competencies for digital media creation to help educators to implement LGDM assignments. Consequently, there is limited guidance for students as to what skills they will require to complete LGDM assessment tasks.

Educators across disciplines require an understanding of the different media types and the skills involved in its production. This knowledge is necessary due to: (i) effective student workload and marks allocation, (ii) the development of marking rubrics that assess digital media as part of communication skills, (iii) using the LGDM assignment as individual or group according to digital media type, and (iv) scaffold digital media literacies across the curriculum. These considerations are required, as the creation of LGDM can be a time-consuming process. From the students' perspective, understanding the different media types and skills required for production will help them to plan and effectively choose if they can, the right media for their LGDM assignment.

This paper proposes a taxonomy of digital media types for implementation in LGDM assignments. The theoretical foundations are based on the Digital Media Literacy Framework (DMLF) (Reyna et al., 2017) and Technological Proxies (TPs) (Hanham et al., 2014), as discussed further in the next section. The taxonomy begins with a simple task, such as the creation of an audio podcast (Drew, 2017) to more complex tasks such as blended media (Hoban et al., 2015). The taxonomy aims to scaffold learning course content using LGDM in the classroom.

Theoretical foundations

The theoretical framework that underpins the taxonomy of digital media types for LGDM assignments is based on the DMLF and the concept of TPs (Hanham et al., 2014).

The DMLF is based on three domains (conceptual, functional, and audio-visual). The planning stage or storyboard (conceptual domain) is an industry standard practice for the effective production of digital media artefacts (Musburger and Kindem, 2012). The storyboard lays out all the essential elements of a digital artefact such as the script, images, audio effects, video sequences and shots, titles, and transitions (Carroll, 2014; Stockman, 2011). This step is crucial as it allows the designer/s to visualise how the story flows and what gaps may exist (Pallant and Price, 2015). Moreover, a storyboard ensures the information is precise and succinct and can inspire new ideas based on the content (Stockman, 2011). For example, if the task is to produce an audio podcast about respiratory tract infections, quality of content (evidence-based, accurate, and up to date) needs to be curated and prepared for an audio narration. In contrast, if the task is to produce an animation on the topic, the content needs to be prepared to take into consideration how visuals can reinforce the audio narration. For instance, the mechanism of action of viral particles can be explained visually, aided by narration. The animation could show how the virus invades the cells, replicates, and how the immune system responds. A second example, a task for students to produce a blended media presentation on Dabigatran (anticoagulant). As part of their storyboard (conceptual domain according to the DMLF), they had to consider: (i) what is an anticoagulant? (ii) what is the mechanism of action? (iii) what are the risks of taking Dabigatran? (iv) what is the state-of-art of the research on this drug? (v) what is next in the future development of anticoagulants? and (vi) conclusion. The more complex the digital artefact, the more laborious the process of preparing the storyboard. Producing a storyboard for an audio podcast is simple, as there is no need for visuals. In contrast, producing a storyboard for blended media will require creating multiple representations of content, usually a combination of audio, video, animation, images, transitions, and so on (Hoban et al., 2015).

The functional domain is based on the appropriate use of devices, software/applications, and programming/coding to develop digital media artefacts. Devices may include audio recorders, digital cameras, video cameras, mobile/tablets, and laptop/desktop computers. Software and applications include audio editing software (e.g. Audacity), image and graphics manipulation software (e.g. Adobe Photoshop), animation software (e.g. Adobe Animate), and video editing suites (e.g. Adobe Premiere Pro). Programming/coding includes applications to code such as programming text editors (e.g. Komodo Edit).

Finally, the audiovisual domain is related to the digital media principles that govern the production of engaging and credible content. Elements of the audiovisual domain include audio principles, layout design, colour theory, typography, use of images/graphics to convey the message (Hashimoto and Clayton, 2009; Malamed, 2015; Williams, 2014), and video principles such as rule of thirds, shooting techniques, use of tripod, and so on (Stockman, 2011). These domains need to be applied to each level of the taxonomy to produce an engaging and professional digital artefact. For example, an audio podcast will require knowledge on how to record, edit and produce audio, upload, and share on the Internet, e.g. Sound Cloud (Chamberlain et al., 2015). Creation of a blended media artefact, which is a combination of different digital media types such audio, pictures, transitions, video, animated text, or graphics, will require the use of a more extensive set of skills (Starkey, 2007).

A second theoretical construct for the taxonomy of LGDM is the concept of TPs (Hanham et al., 2014). A characteristic of many digital technologies is that they perform important tasks on behalf of the user. Examples of TPs include statistical packages (SPSS, M-Plus), text summarisation tools (Text Compactor, SMMY, Free Summarized), plagiarism software (Turnitin, Quetext), search engines (MEDLINE, Google Scholar), citation manager software (EndNote, RefWorks), and Grammarly (English language writing-enhancement platform). TPs can help students to achieve specific learning goals related to the type of tool, e.g. analysing data using statistical software. A student who use these technologies to perform a task and learn from the process are classified as intentional learners as they consciously control their learning experience (Vosniadou, 2003). In contrast, a non-intentional learner will use the technology as a functional aid without learning new skills in the process to achieve a performance outcome (e.g. saving time or getting high marks). Consequently, Hanham's definition of TPs (Hanham et al., 2014) has two dimensions from the approaches of learning perspective (Prosser and Trigwell, 1999), deep (intentional) and surface learning (non-intentional).

In the production of LGDM assignments, devices (audio recorders, digital cameras, video cameras, mobile phones/tablets, laptop, and desktop computers) and digital media production software often function as TPs. To further extend the concept, it is necessary to discuss how digital versus analogue reshapes that way digital media content is created. In the past, using analogue technologies was more time-consuming and somehow 'lock away' some key aspect of the production process. For instance, before digital cameras, photographers or videographers were not able to see their work on the spot (Buckingham, 2007). With an analogue camera, the photographer needed to go to the darkroom before being able to evaluate and reflect on the images. With the ability to see the picture on the screen with a digital camera, this process became more reflective on the spot. In this case, the digital camera screen acts as a TPs for the users, avoiding the need to go to the darkroom and facilitate the production workflow. Regarding video production, previous generations of video cameras did not have a screen to review the shot and required the camera person to go to a studio to look at the footage. If the videographer was not happy with the lighting, types of shots captured, it will be a need to reschedule the filming. If it were, for example, an event, the videographer would need to work with the limitations of the material captured.

Another example of TPs for digital media can be considered removable memory. In the '90s, the video was recorded on tape (MiniDV) and required to be encoded to the computer, and it took longer. With removable media, the videographer will plug it into the computer and play instantly without the need of encoding. The memory card is performing the task on behalf of the user. If we compare the analogue recording of voice using a tape recorder versus digital recording with a computer, with analogue it was required to record the content several times until it was acceptable. When using computers and an audio editing software such as Audacity, we can continue recording and delete segments not desired and add audio fade in and out and additional sound effects. In other words, the evolution of digital media equipment and tools (software and applications) make them behave more like a TPs.

We posit that digital media equipment and tools in the production of LGDM be Intentional Technological Proxies (ITPs). They become the driver to understand the subject content and not only performing a task on behalf of the user. To further extend this view, in LGDM assignments in Science education, students are given a topic to investigate and produce a storyboard as part of the assignment. Production of digital media in learning settings cannot have a surface approach as students require the planning of production of content based on their topic and storyboard before moving to a multimodal representation of the content using these ITPs. Students will receive feedback from their lecturer on their storyboard content before they engage in the production stage (Reyna et al., 2017). Without a script or storyboard, it will be almost impossible to visualise what content needs to be produced. In other words, in well-designed LGDM assignments, digital media equipment and tools are the vehicles for the students to develop a multimodal representation of content, and with this, learning the course content (Hoban et al., 2015). In everyday settings, digital media production equipment and tools as TPs can have both dimensions discussed before, deep and surface approach (Prosser and Trigwell, 1999), especially if the aim is entertainment or recreation. In contrast, in LGDM assignments, a poorly developed video or blended media will compromise the quality of learning and the marks attained.

To further illustrate ITPs, environmental science students are asked to produce a blended media about 'rip currents'. After producing the storyboard and receiving feedback from the subject expert, students may go to the beach and take pictures of the ocean with a digital camera in different locations. The digital camera will act as ITPs as they can browse the images as many times as possible and learn how to recognise the different types of rip currents. They may remove the storage from the digital camera and plug into a laptop for a large view. These devices (digital camera and laptop) perform a task on behalf of the students, as they do not need to go to a darkroom and process the images. They enable learning and reflection on the spot. For example, if images were not clear enough, they will retake pictures. If they used an analogue camera, the process would be locked-away, as they will need to go to the darkroom or send the negatives for development. Not until they see the printed images, they will not be able to evaluate if they capture the rip currents. They may use an animation software to explain how these rip currents are formed in the ocean. They may record a video footage pretending one of them experienced a rip current. In this example, due to the nature of the task (storyboard had feedback from a subject expert), students used a digital camera, animation software, and video camera as tools to enable deep learning. They need it to visually prove they understood the process of rip currents with the LGDM assignment. This multimodal representation of content will help them to learn the subject content (Hoban et al., 2015). So, these technologies (photography, video, and animation) are ITPs and a vehicle for the students to learn and reflect on the course content.

A second example, pharmacology students are asked to create a blog post suitable for the general public on different topics (study drugs, drugs for abortion, anticoagulants, and antipsychotics). They researched the evidence-based literature on their topics (scientific journals and books), produce a storyboard, and submit for expert feedback. After receiving the feedback, students will move to a multimodal representation of their assigned topics. For example, some students will use animation software (e.g. Powtoon) to represent the pharmacokinetics of the drug in the human body. Before representing the content, students will need to have a clear understanding of the process. While creating the assets for the animation, and representing the knowledge visually, they are reinforcing their learning of the topic, and the animation program becomes an ITP.

A third example, midwifery students were asked to create an informative brochure on the prevention of diabetes suitable for the general public. Like the previous cases, after the storyboard is created, revised by the content expert, and feedback provided, students will move to a visual representation of the information. They will choose a graphic design software (Microsoft Publisher, Adobe Photoshop, and Adobe Illustrator) to create the brochure layout and required graphics. These programs become ITPs, as it will help students to reinforce and reflect on what they learnt. In LGDM assessments, TPs move beyond functionality; their real value is in their capacity to be a vehicle to promote learning by multiple representations of content.

In summary, the theoretical foundations for the taxonomy of digital media types for LGDM assignments are (i) the DMLF and (ii) the ITPs. A close relationship between both constructs will be further extended in the following section.

Taxonomy of digital media types

The primary proposition of this paper is a taxonomy of digital media types for LGDM assignments based on skills required (conceptual, functional, and audiovisual). From a creation of an audio podcast, which relatively eases to produce (Drew, 2017), to the sophistication of blended media or game development. The digital media creation process is a higher order thinking task as students need to design, formulate, create and consider application, implication, and reflection on what they have learnt (Biggs and Collis, 2014). When students engage effectively in a LGDM assignment on any given topic, they should analyse, apply, compare, relate, hypothesise, and reflect on the content (conceptual domain). With the effective use of functional and audio-visual domains, the digital artefact will be effective to communicate the message to the audience.

A summary of the learning workflow using LGDM is presented in Figure 1, featuring the DMLF and ITPs discussed previously, and the proposed taxonomy of digital media types. These theoretical foundations are included in the area delimited by dot lines. The yellow rectangle represents the starting of the task with the conceptual domain (storyboarding). The light blue rectangle represents the functional domain and the ITPs. Finally, the green rectangle represents the audiovisual domain (digital media principles). In the creation of LGDM, students start the task developing a storyboard (conceptual domain), then they

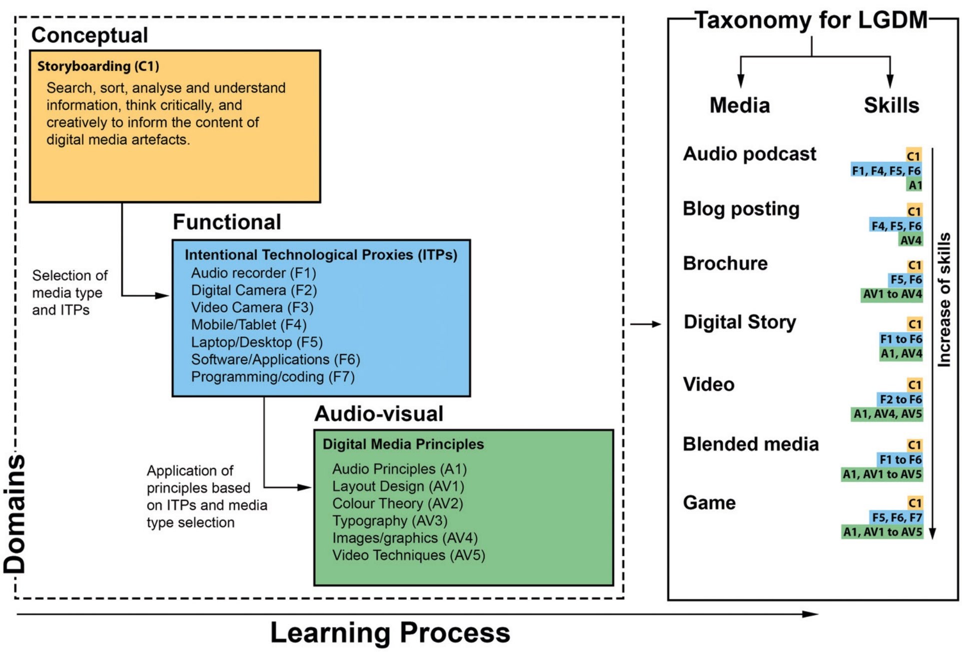

Figure 1. Learning workflow using Learner-Generated Digital Media (LGDM) assignments.

select the media type and the ITPs to be used for the task. In the process of creating the content, they apply the audiovisual domain (digital media principles). The importance of the digital media principles to enhance the message of a digital artefact will be discussed in an upcoming paper. The second section of the workflow (solid line) showcases the taxonomy of digital media types mapped against skills/competencies required in the three different domains. We will extend the concept to the different media types in the following subsections using C1 (conceptual), F1 to F7 (functional), A1 (audio principles), and AV1 to AV5 (audio-visual) from the Figure 1.

Audio podcast

An audio podcast is a recording that can easily create and distributed online. Users can download them into their devices of choice such as mp3 players, tablets, computers, and smartphones (Drew, 2017). The first step to produce an audio podcast will be the creation of content or storyboard (conceptual domain) (C1). Audio podcasts can be produced using a variety of devices from audio recorders (F1) to smartphones, tablets (F4), and laptops/desktop computers (F5) (Geoghegan and Klass, 2008). If using laptop/desktop computer, Audacity software or another application will be required to be installed on PC/Mac to record an audio file (Lunt and Curran, 2010) (functional domain). In this case, the audiovisual domain will be replaced by an audio domain (audio principles) (A1), as there are no visuals involved in an audio podcast. Users can take a simple approach to recording an audio file at once without any editing; it may take few takes. However, if they decide for a more polished product and include background music, sound effects, easy in/out, and so on, they will require the use of audio editing software.

Blog posting

A blog is a platform that allows people to communicate, share, collaborate, and interact online, and it has been used in educational settings for more than 10 years (Angelaina and Jimoyiannis, 2012). The content of the blog post needs to be written (conceptual domain) (C1). Skills such as writing succinctly, chunking information, use conversational language to engage the audience will be required (Felder, 2011). The user will need to access the Internet via mobile/tablet (F4), laptop/desktop (F5), and a software/application (F6) to place the content. Examples of applications for blogging include WordPress (Hedengren, 2012), Wix (Kennedy and Charles, 2009), Weebly (Roe, 2011), and so on (functional domain). Users may embed images/graphics (AV4) to illustrate the post further and decide the font type and size (typography) (AV3) (visual domain). They will not need to program/code in HTML, JavaScript, or any other computer language, as the interfaces are now WYSIWYG (What You See Is What You Get). Although, the ability of coding could enhance the task.

Brochure

In graphic design, a brochure is an informative document that has different types of pamphlets, leaflets, DL flyers, poster, and so on (Williams, 2014). Brochure design as a pedagogical agent has not been explored extensively (Whittingham et al., 2008). In this case, after developing the content for the brochure (conceptual domain) (C1), the student needs to use laptop/desktop computers (F5) and graphics software/application (F6), such as Photoshop or Illustrator (Weinman, 1999), Microsoft Publisher or Word, GIMP (open source)

(Kylander and Kylander, 1999), or any graphic design application (functional domain). Additionally, a basic understanding of visual design principles such as C.R.A.P (Contrast, Repetition, Alignment, and Proximity) (Williams, 2014) is required. Knowledge in layout design (AV1), colour theory (AV2), typography (AV3), and effective use of images/graphics (AV4) will be relevant as well (Malamed, 2015) (visual domain). Applying the visual domain will simplify the message, ensure legibility, and increase audience engagement (Hashimoto and Clayton, 2009; Malamed, 2015; Williams, 2014).

Digital story

The digital story can be defined as a combination of audio narration and still images to communicate an idea or viewpoint (Hoban et al., 2015). A digital story can include background music and sound effects. After developing the content for the digital story (conceptual domain) (C1), the student will need an audio narration file (F1), a set of images or slides (F2), and to match each of these images/slides to explain a concept (Dreon et al., 2011). Stop-motion is an animation technique that manipulates an object so that it appears to move on its own and it is considered in this category as well (Hoban et al., 2015). The student needs to take a sequential set of images and bring them together using a mobile/tablet (F4), laptop/desktop (F5), and software/applications (F6) such as Windows Movie Maker (PC) (Xu et al., 2011), iMovie (Mac) (Kearney and Schuck, 2003) or PowerPoint (Ruffini, 2009). Additionally, there is a wide range of Web 2.0 tools (Solomon and Schrum, 2007) and mobile applications (F6) for this purpose (functional domain). The audiovisual domain will be applied choosing quality images regarding resolution and composition (AV4), music background, and sound effects relevant to the content (A1), thereby triggering emotional reactions in the audience for maximum impact (Malamed, 2015).

Video

A video is a sequence of images to form a moving picture (Stockman, 2011). Video has been extensively studied in the educational context as a way to deploy blended learning materials (Bonk and Graham, 2012; Garrison and Vaughan, 2008). Recently, with the affordability of digital technologies, students are becoming co-creators of content with video assignments (Hoban et al., 2015). A video will require a more complex storyboard to ensure that it is succinct and engages the audience (Pallant and Price, 2015; Stockman, 2011) (conceptual domain) (C1). The operation of a video recording device such as a digital camera (F2), video camera (F3), a mobile/tablet (F4), and laptop/desktop (F5) (functional domain) will be required. Audio recording (A1) may also be required, e.g. special sound effects, deciding the type of shots (long, medium, and close-up shots) (AV4), rules of thirds when framing, use of a tripod, lighting, and so on (AV5) (audiovisual domain). The production or editing phase will require editing software such as Windows Movie Maker, iMovie, Pinnacle Studio, Premiere Pro, Final Cut, and so on (Bowen, 2013) (F6). Producing a video is a more sophisticated task, and students need to 'think-in-shots' (Stockman, 2011), in other words, 'transcode' the ideas from the storyboard (text and drawings) into video shots, and use their creativity to represent the content engagingly.

Blended media

Blended media is a combination of audio narration, sound effects, moving text, images, visual aids, and video (Hoban et al., 2015). For blended media production, a detailed storyboard is required to plan what type of media will be more suitable in each section of the project (conceptual domain) (C1). It requires 3.1 to 3.5, a device to record audio (F1), the video (F3), take pictures (F2), and so on. A mobile/tablet (F4), laptop/desktop (F5), and a combination of software/applications (F6) to create the digital assets such as animation software (Adobe Animate, Blender), 3D software (3DMax, Maya), software to create special effects (After Effects), and software to create music/sound (Reason, GarageBand, and so on). The editing in this task will be time-consuming because different media types will be brought together. It will require audio principles (A1), layout design (AV1), colour theory (AV2), typography (AV3), images/graphics (AV4), and video techniques (AV5) (audiovisual domain). This digital media type leads to a multimodal representation of content, which is highly desirable for learning the content using LGDM (Hoban and Nielsen, 2013).

Game

A game is an online media that is interactive, engaging, and can be played using different devices such as desktop computers, laptops, tablets, and smartphones. To develop a prototype for the game requires conceptual skills and storyboarding (C1). Designing and developing games is probably the most complex task, as it requires knowledge and skills from how to use laptop/desktop computers (F5) and a broad range of software programs (F6) to develop graphics (AV1 to AV4), sounds (A1), animations, and so on. Additionally, proficiency in gaming languages such as C#, Visual Basic, Objective-C, Swift, Python, JavaScript, and so on will be required (Chandler, 2009) (F7). Due to its demands, this task is infrequent and may be relevant to students studying computer science. In this discipline, coding is the main part, and usually, the visuals are less important. Game creation it is more like a multidisciplinary approach as blended media and video production can be.

A summary of the taxonomy of digital media types of LGDM assignments is presented in Table 1. The different classifications are not meant to represent a strict hierarchical structure; they overlap in many ways. Digital media creation is, in general, a collaborative process, a team of people are involved in the workflow. So, these competencies can be shared within a group of individuals. In the discussion section, we will cover the implications of group work for LGDM.

Finally, emerging technologies can enrich the taxonomy, and it may imply new skills/competencies, especially in the functional domain (new devices and applications). For example, 360° videos represent challenges for production, and currently, there are no guidelines on how to create them, how to edit, and so on (Cerejo, 2016). Research on 360° videos for teaching and learning is currently in its infancy (Roche and Gal-Petitfaux, 2017; Yamashita and Taira, 2016). In the past, 3D video showed promising and to revolutionise the way the movie industry operates and prosumers, but after several years, 3D video did not have any impact on movie production. Only a few manufacturers developed 3D-enabled video cameras, and the uptake is being slow. The media explained the reasons why the 3D video did not become massive due to lack of content to watch, gimmicky reputation, the need to wear glasses, and for many people, eye strain (Agnew, 2015). 360° video could suffer the same fate as 3D video; time will tell.

Table 1. A summary of the taxonomy of digital media types for LGDM assignments and their skills required.

Digital media type	Conceptual domain	Functional domain	Audio-visual domain
Audio podcast	Storyboarding (C1)	Audio recording (F1) Mobile/tablet (F4) Laptop/desktop (F5) Software/applications (F6)	Audio principles (A1)
Blog Posting	Storyboarding (C1)	Mobile/tablet (F4) Laptop/desktop (F5) Software/applications (F6)	Images/graphics (AV4)
Brochure	Storyboarding (C1)	Laptop/desktop (F5) Software/applications (F6)	Layout design (AV1) Colour theory (AV2) Typography (AV3) Images/graphics (AV4)
Digital Story	Storyboarding (C1)	Audio recording (F1) Digital camera (F2) Mobile/tablet (F4) Laptop/desktop (F5) Software/applications (F6)	Audio principles (A1) Images/graphics (AV4)
Video	Storyboarding (C1)	Digital camera (F2) Video camera (F3) Mobile/tablet (F4) Laptop/desktop (F5) Software/applications (F6)	Audio principles (A1) Images/graphics (AV4) Video techniques (AV5)
Blended Media	Storyboarding (C1)	Audio recording (F1) Digital camera (F2) Video camera (F3) Mobile/tablet (F4) Laptop/desktop (F5) Software/applications (F6)	Audio principles (A1) Layout design (AV1) Colour theory (AV2) Typography (AV3) Images/graphics (AV4) Video techniques (AV5)
Game	Storyboarding (C1)	Laptop/desktop (F5) Software/applications (F6) Programming/coding (F7)	Audio principles (A1) Layout design (AV1) Colour theory (AV2) Typography (AV3) Images/graphics (AV4) Video techniques (AV5)

Discussion and implications for teaching and learning

This paper proposed a taxonomy of digital media types for LGDM assignments based on the DMLF and skills in three domains: conceptual, functional, and audiovisual. It also links the taxonomy with the use of ITPs within the functional domain of the task. Digital media equipment and applications are ITPs or vehicles for students to represent the content and learn within the process.

From the educator's perspective, the proposed taxonomy will help them to understand the different media types and the skills involved in its production. This knowledge is essential when designing LGDM assignments; educators need to decide how to embed these digital media types in the curricula for first-, second-, and third-year cohorts. In our faculty, first-year students engage in the production of audio podcast and blog postings. Second-year students create brochures and digital stories while third-year cohorts produce video and blended media. This strategy ensures educators can identify the need for training for the students and allows the scaffolding of digital media literacies across the curricula. For this approach to happen, educators require an understanding of the taxonomy proposed. Furthermore, an understanding of the nature of digital media production workflow will help educators to weight the task, whether the assignment is individual or group work according to digital media type. At the Faculty of Science, LGDM assignments for first-year students (podcast and blogging) are designed for individual work and contributes to 15% of the marks. For second-year (brochure and digital story), the assignments are designed for group work and contribute to 20% of the marks. Finally, third-year students (video and blended media) weights 30% of the marks, and it is also a group work.

The proposed taxonomy could also help educators to develop marking rubrics that assess conceptual, functional, and audiovisual domains. The conceptual domain is linked with graduate attributes such as 'An inquiry-oriented approach' and 'Professional skills and its appropriated application'. The functional domain is linked to 'Initiative and innovative ability', and the audiovisual domain (digital media principles) as part of 'Communication skills'.

Digital media creation is a collaborative process, in which a team of people are involved in the workflow. So, these competencies can be shared within a group of individuals. If the LGDM assignment task is group work, there are implications to ensure students contribute to their groups. Peer-review tools such as SPARKPlus to ensure the process is fair to every member of the groups need to be put in place (Willey and Gardner, 2010). A simple way to implement peer review of groups for LGDM can be done using Google Forms. The criteria to evaluate group contribution need to be straightforward such as the above currently implemented in our institution (i) disciplinary/subject input for the project; (ii) punctuality and time commitment; (iii) contribution with original ideas; (iv) communication skills and work effectively as part of the team; and (v) focus on the task and what needs to be done.

From the student perspective, the purposes of the taxonomy are to explain the digital media literacies skills required to produce digital artefacts. The proposed taxonomy will help the students to understand the complexity of a digital media artefact and identify the skills required to complete the task. It will also inform what ITPs (e.g. audio recorder, digital camera, mobile, tablet, and so on) they can use and what digital media principles are applied to the artefact they are creating. Additionally, the taxonomy will reinforce the notion of using LGDM with a dual purpose: learning the subject content (yellow rectangle) and developing digital media literacies (blue and green rectangles) and hopefully further engage students with their subjects. For first-year students, the taxonomy will inform how they will gradually develop competencies in digital media production during their stage at the University. We hope it can help the students to plan their LGDM assignments and succeed in their learning journey.

Additionally, from the faculty/institutional perspective, the taxonomy of digital media types for LGDM assignments can help to design the curricula and to ensure students will *be exposed* to the creation of these different digital media types. It will also prevent students *being enrolled* in several subjects that require complex digital media production during the same semester. As we know, students have competing schedules studying, working, and family commitments. We hope the taxonomy could be a good theoretical foundation to design and implement LGDM as an assessment tool and develop student digital media literacies.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Article

e-learning and digital media

E-Learning and Digital Media
2018, Vol. 15(1) 36–52

DOI: 10.1177/2042753018754361
journals.sagepub.com/home/ldm
SAGE

The Internet explosion, digital media principles and implications to communicate effectively in the digital space

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Abstract
Being literate has traditionally meant being able to read and write using the media of the day. In the 21st century, being literate requires additional skills such as competence with digital media creation. Until recently, those who could afford and use equipment and applications to produce digital media content were typically developers and technicians. With the development of prosumer electronics, in conjunction with the use of mobile devices and tablets, a shift has occurred in the accessibility of these tools, becoming more affordable for the general population. Video sharing services, social software and Web 2.0 applications have made it possible to host a digital media ecosystem on the Internet, and this has led to the proliferation of User-Generated Content. These technological advances have changed how we communicate, socialise and learn. Effective communication using digital media is underpinned by a set of design principles which most students are not likely to be aware. This paper built on two previous papers on the Digital Media Literacy Framework and the Taxonomy of Digital Media types for teaching and learning. It argues the importance of digital media principles to develop effective communication in the digital space. Students now require knowledge of these principles, in conjunction with conceptual and functional skills, for effective communication in the digital space.

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Keywords
Digital media principles, new media literacy, digital media literacies, communication in the digital space, learner-generated digital media

Introduction

Historically, the concept of being literate meant to be able to read and write, speak and listen (Ohler, 2009). It has been argued that conceptualisations of what it means to be a literate need to be extended to reflect the requirements of the digital age (Alexander et al., 2016; Bates, 2016). Digital media creation in the form of audio, graphics, digital story, animation, video, and blended media is a desirable skill for university graduates (Hall et al., 2013; Nix et al., 2012).

The emergence of digital media competency as a desirable skill set is due to several factors. First, the development of prosumer electronics or equipment that hovers between producer and consumer regarding functionality (Bruns, 2007). This equipment (e.g., audio recorders, video cameras, digital SLR/mirrorless cameras), in conjunction with inexpensive software and applications, made digital media production more accessible for inexperienced content creators. Second, the Internet became faster and more ubiquitous with the development and extension of mobile and Wi-Fi networks (Lehr and McKnight, 2003). Additionally, the development of powerful smartphones (since 2007) and tablets (since 2010) (Islam and Want, 2014) contributed to the growth of a digital media ecosystem on the Internet. Online content is increasing at an exponential rate, for example, 300 hours of video is uploaded to YouTube server every minute (Robertson, 2014). All these factors created an opportunity for the users to shift from consumers of digital media to producers (Couldry, 2012).

Several authors have discussed the concept of digital literacies (Bhatt, 2012; Cooper et al., 2013; Ting, 2015), and there is a wide agreement that there are many skills required to be a citizen of the digital age (Hobbs, 2017). The necessary skills encompass technical, audiovisual, behavioural, critical and social components. These skills are now required for all disciplines at different levels. Some careers required professional knowledge, for example, marketing professionals require web design skills, video editing and Search Engine Optimisation. Other careers require digital literacies as soft skills, for example, knowing how to find a YouTube video (Snelson, 2016), use LinkedIn for professional networking (Archambault and Grudin, 2012), or using Google Drive for everyday work (Hall et al., 2013).

This paper focuses on the importance of digital media principles. These principles tend to be taught in specific subject disciplines, namely, media, graphic design, visual design and film. In other disciplines, digital media principles have not been formally incorporated into the curricula. University-aged students are likely to be skilled in digital technology due to having been exposed to technology over the lifetime (Prensky, 2001). Current research suggests that is not necessarily the case (Alexander et al., 2016; Bennett et al., 2008). Importantly, it appears that demographics (gender, race, educational background and socioeconomic status) has a crucial role in digital literacy skills (Hargittai, 2010). Across many subject areas in university settings, there is a reluctance to implement learner-generated digital media (LGDM) as an assessment tool, as many educators are not comfortable creating and evaluating digital media content (Ohler, 2009; Watson and Pecchioni, 2011).

Learning to produce digital media that follows digital media principles is a highly desirable skill for graduates, regardless their discipline (Hobbs, 2017). Effective communication and engagement with the audience in online settings require knowledge and application of these principles in conjunction with critical literacy to be able to understand societal issues and how one's media creations can have an impact on others (Parker, 2013). Digital media literacies, in conjunction with other literacies, could potentially make new graduates better digital citizens (Ilomäki et al., 2016).

This paper aims to discuss the importance of the digital media principles and its implications for learning and teaching.

The digital media explosion on the Internet

This section presents a discussion of technological innovations that dramatically affected the production of digital media artefacts. In the past, digital media creation was a privilege of capital-intensive industries that had access to the tools to create digital media content (Van Dijck, 2009). The cost of equipment and the skills required to produce digital media were a barrier limiting the adopting of digital media by the broad community. The term 'prosumer' emerged in the early 80s in the literature, referring to those users who hover between producer and consumer (Bruns, 2007). An example to illustrate this was the video industry where expensive cameras and video editing machines were required to produce the analogue video. It was not until the early 1980s that the first camcorders were available in the market using magnetic tapes (VCR) and users started to record homemade videos (Lardner, 1987). Users shared the content through lending videotapes to family and friends; no home editing was available at this stage. In the late 1990s, the tapes (VCR, Micro MV, Video8 and Mini DV) were replaced by memory cards, internal storage, and the video workflow became tapeless (Arman, 1999). The use of storage solutions facilitated the easy transfer of media from a camcorder to a computer via USB interface, and users could edit footage using video editing software immediately. Currently, users can create a video using their smartphones and tablets, camcorders that record 4K resolution (Ultra High Definition) (Van Wallendael et al., 2016), DSLR and mirrorless cameras, action cams and recently, 360° video cameras (Qian et al., 2016). This advance in technology has shifted 'some' users from consumers to producers of digital video, resulting in a rapid growth video uploads to video-sharing services such as YouTube (Robertson, 2014).

In the web design field, in the early 1990s, to be able to create a website required an understanding of HTML, JavaScript and CSS coding (Frain, 2012). It also required visual design skills to apply to the website interface. During that decade, creating a website was made from concept/prototype to implementation (Sfetcu, 2014). Now with web-hosting services such as Wix (Kennedy and Charles, 2009) and Weebly (Roe, 2011), which feature a drag-and-drop website builder, users can construct a website within an hour if the content is ready to go. These services have built-in professional templates, contact forms, blogs, interactive photo galleries and so on without the need of coding. The easy-to-use interface of these platforms has resulted in a proliferation of websites offering services and information, thus likely putting an end to the web developing market (Nouvel, 2015). Indeed, there has been a dramatic reduction in the salaries of web designers over the last decade. It can also be explained by supply and demand and more people having web design skills these days (Payscale, 2016).

In the field of motion graphics, to develop an animation took a long time as the designer needed to draw the characters or objects and their movement for at least 12 frames per second and use Flash Professional to bring the animation alive (Ulrich, 2012). Knowledge of ActionScript code was required to produce a smooth animation. This language is straightforward, but it took the time to learn and master the skills (Moock and Epstein, 2001). With the development of mobile devices and tablets, Flash became obsolete in 2012, replaced by HTML5 (Reyna, 2012), due to technical reasons related to touchscreen devices and battery draining. There are now services such as VideoScribe (DeCesare, 2014), PowToon (Graham, 2015) and GoAnimate (Stratton et al., 2014) that allow users to create professional looking animations in comparatively minimal time. This type of animation is called whiteboard animation or whiteboard video (Türkay, 2016).

Currently, there is a broad range of online tools (Web 2.0) to create digital media, some of which are free of charge (Edjudo, 2016). In conjunction with social software such as Facebook, Twitter, Vine, Instagram and video-sharing services, this has resulted in a growth of the digital media ecosystem on the Internet and the rise of User-Generated Media (UGM). Individuals use UGM in three ways: (i) consuming, (ii) participating and (iii) producing (Shao, 2009). There is an economic perspective of UGM; nothing is free on the Internet. Users who develop content, for example, a digital video on YouTube, do not need to pay any membership but contribute to the system by sharing their details at the time of account setup. Consequently, they are monitored for their preferences, and they may see relevant ads and buy items/services online. On the other hand, other users will engage with this video and data will be recorded based on their preferences. Notably, users have no power over data gathering and distribution. Their role as data provider is more important as their role of content creator (Van Dijck, 2009).

Research suggests that only 1% of Internet users create content, 10% interact with the content such as commenting or liking (digital curators) and 89% will just view it (Arthur, 2006; Daugherty et al., 2008). These studies were completed before the widespread use smartphone and tablet technologies, and arguably these percentages are likely to have increased in the 10 years since the studies were published. The claim that the Internet is a participatory space (Kim et al., 2015) is an optimistic view, as participation does not necessarily translate to active contribution in many cases. Furthermore, the digital divide between technology-rich and technology-poor continues (Buckingham, 2007) and it is the inequality nature of the digital age (Selwyn, 2015).

Tertiary educational institutions outside media education are focusing on developing student digital media skills and using the approach 'education through media', in many cases assuming the 'digital native myth.' Examples are the use of LGDM assignments (Blum and Barger, 2017; Hoban et al., 2015; Kearney, 2013; Nielsen et al., 2017). This approach means that no formal training is needed for students. In other words, the students use/using digital media opportunistically as a pedagogical agent. In contrast, media education does not focus solely on developing technical skills but the reflective use of media (Buckingham, 2007).

In summary, the proliferation of prosumer electronics, hardware, software, social media and applications had a massive influence on the 'relative' democratisation of digital media creation on the Internet in the last decade. This is relatively due to the inequitable nature of access to technology (Selwyn, 2015). The proliferation of these tools represents the notion of liquid times, as technologies changed in emphasis from a hardware focus to software-based modernity, creating uncertainty what tomorrow will bring (Bauman, 2013). This technological growth empowered everyday users who have access to technology and tools, motivation, time and some skills to experiment for the first time with digital media creation and sharing on the Internet. The technological evolution is causing the Internet to be a convoluted space with content that is inaccurate, has poor usability and accessibility and fails to engage the audience. Imagine if everyone could write a book and place it into a library, what the experience will be for users to visit a library? The authors believe that education on digital media principles to create engaging content is a required strategy to foster effective communication in the digital space across all careers.

Digital media principles to create engaging content

In a previous paper, the authors proposed the Digital Media Literacies Framework (DMLF) composed by three interdependent domains: (i) Conceptual, (ii) Functional and (iii) Audiovisual (Figure 1) (Reyna et al., 2017a). The planning stage or storyboard (conceptual domain) is an industry standard practice for the effective production of digital media artefacts. The functional domain is based on the appropriate use of devices, software/applications and programming/coding to develop digital media artefacts. In contrast, the audio-visual domain is related to understand and apply the digital media principles in the production of digital artefacts. The DMLF is crucial for planning student training when LGDM is used as an assessment tool in the classroom. For example, the conceptual domain is used in workshops to introduce storyboarding for digital media creation. The functional domain is used to train students in basic video editing techniques during tutorials. Finally, the audio-visual domain (digital media principles) is delivered via face-to-face or online lectures. With knowledge of these three domains, students are prepared to engage in the

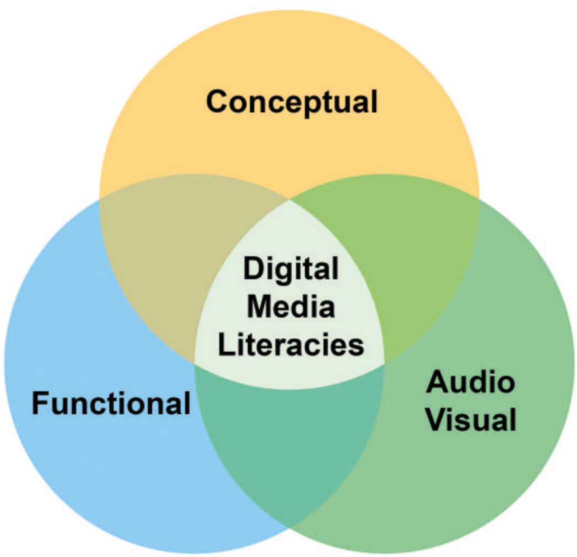

Figure 1. The Digital Media Literacies Framework for teaching and learning.

creation of LGDM assignments. Consequently, LGDM assignments are using with a dual purpose: (i) learning subject content and (ii) developing communication skills using digital media.

Additionally, the authors proposed a second model: the Taxonomy of Digital Media Types for LGDM based on these three domains (Figure 2) (Reyna et al., 2017b). This taxonomy conceptualises the production of LGDM based on skills required and the inclusion of Technological Proxies (Hanham et al., 2014). The proposed taxonomy is being used for educators to understand the complexity of different digital media artefacts, consider LGDM assignment weighting, and find whether individual or group work is appropriate for the task.

The purpose of this section is to explain succinctly the audio-visual (green rectangle, Figure 2) domain comprising the basic design principles that apply to the development of effective digital media artefacts (audio-visual domain). The purpose of the paper is not to discuss examples of these principles, as they can be found elsewhere, but to emphasise their importance in the digital media creation process. The latest NMC Horizon Project mentioned that the digital divide in the USA is not only about access to technology but also a fluency in using it (Alexander et al., 2016). That is why digital media principles are crucial skills to teach to students. This area is supported by evidence in four different disciplines such as neuroscience (LeDoux, 1989, 1992), psychology (Fulks, 1997; Koffka, 2013; Smith-Gratto and Fisher, 1999), visual design (Hashimoto and Clayton, 2009; Malamed, 2015) and multimedia learning principles (Mayer, 2005, 2008; Moreno and Mayer, 2007).

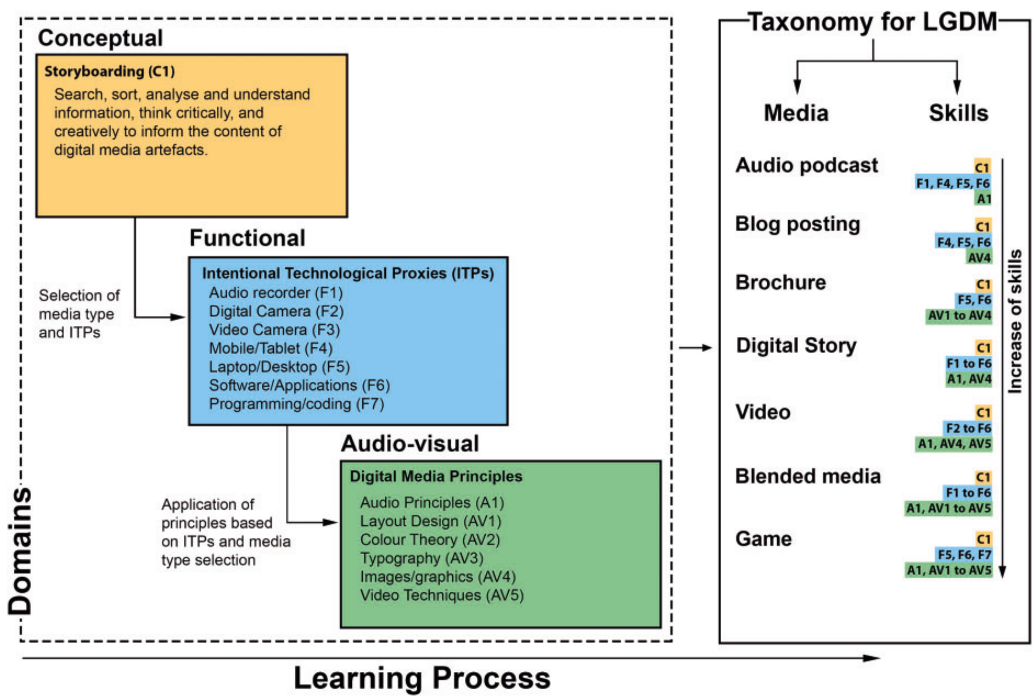

Figure 2. The taxonomy of competencies of digital media types for LGDM.

The evidence behind the digital media principles

In neuroscience, a group of neurones has been found to regulate the amygdala and mediate the reception of visual stimuli from the eye. This response occurs in few milliseconds before the brain interprets that stimuli (LeDoux, 1989, 1992). In other words, the response to visual stimuli is considered to be visceral (Norman, 2004). Therefore, emotion can precede cognition (Damasio, 2000). For instance, an experiment conducted in web design confirmed this fact. Participants in a study identified a website to be credible based on the layout design and colour scheme (visual stimuli). This website was aesthetically appealing, but the content was not accurate. This finding was demonstrated in web design usability tests where users form an opinion on the visual appeal of home pages after a short period of exposure of 50 milliseconds (Buxton, 2005; Fernandes et al., 2003; Lavie and Tractinsky, 2004; Lindgaard et al., 2006).

A psychological approach called Gestalt theory is the foundation for instructional screen design (Koffka, 2013; Smith-Gratto and Fisher, 1999), and it is accepted that its application can improve comprehension and learning (Chang et al., 2002; Dix, 2009). This theory is expressed in laws and explains how design elements on screen need to be organised into fields or structures to achieve effective visual results (Koffka, 2013). Some of these laws include balance/symmetry, continuation, focal point, closure, isomorphic correspondence and so on (Smith, 1988). These laws are similar to the ones used in visual design (Hashimoto and Clayton, 2009; Malamed, 2015). It has been reported that applying these laws in the development of educational material improves educational outcomes from the users' perspective (Chang et al., 2002). This finding is in accordance to what visual designers described before; the visual design has an impact on how people sense information presented, usability, credibility and appreciation for good design (Hashimoto and Clayton, 2009; Malamed, 2015).

The role of visual design in creating engaging digital media artefacts is crucial to communicate a message successfully. The rules that apply to digital media are colour theory, layout design, typography, C.R.A.P principles (Contrast, Repetition, Alignment and Proximity), appropriate use of images and basic video techniques (Hashimoto and Clayton, 2009; Malamed, 2015; Williams, 2014). These digital media principles have a close relationship with multimedia learning principles (Mayer and Moreno, 2002) and can be considered cognitive principles that promote interaction, integration, and understanding of a message. In particular, multimedia learning principles such as spatial proximity principle, the signalling principle and the dual scripting principle can support the user, attract their attention and facilitate information processing and semantic integration of complex material (Mayer, 2008). Visual design helps to create a pleasant environment and facilitate cognitive processes for the user to focus on the message (Galitz, 1992).

Colour theory

There is a body of literature in psychology for the last century that has studied colour reactions as functions of personality and its effects on emotions and behaviour (Valdez and Mehrabian, 1994). Bright colours (blue, red, lime and pink) provoke more positive reactions (e.g., amusement, excitement) than darker colours (black, grey and brown) (Hemphill, 1996). Red colour stimulates athletes to perform better in a competition

(Elliot and Aarts, 2011), stimulates willingness to pay in online auctions (Bagchi and Cheema, 2013) or affects exam performance negatively (Elliot et al., 2007).

Colour schemes have a significant role in the visual design and also in the development of digital artefacts (Hashimoto and Clayton, 2009), and its use should aim to enhance the readability of content (Malamed, 2015). For example, in web design, the role of colour as a salient stimulus will affect the visual appeal of the site (Knutson, 1997). It is important to consider a neutral colour scheme, soft backgrounds with black/grey text rather than bright and highly saturated primary colours (Fernandes et al., 2003). The colour clash occurs when a design contains bright and saturated colours that compete each other creating an unpleasant effect to the eye (Hashimoto and Clayton, 2009). For example, a PowerPoint slide that uses white as background with light yellow text it will be almost unreadable. In contrast, if we replace the background for bright red and the text for electric blue, it will tire the eyes and readers may experience dizziness.

Screen layout

The screen layout refers to how the objects are arranged on the screen to promote attention and engagement. Symmetrical and clean layout achieves balance and stability, and it is highly desirable as it directs the user's focus on the central concepts and ideas (Malamed, 2015). The screen layout is directly linked to multimedia learning principles and cognitive load processing (Clark et al., 2011). Combining this with principles such as coherence, redundancy and segmentation (Mayer and Moreno, 2002) will help users to concentrate more efficiently. By contrast, an asymmetrical layout is likely to have the opposite effect and may distract users' attention to other elements on the screen (Reyna, 2013). It is important to ensure the layout design is clean and easy to follow, avoiding the use of distractive elements or overwhelming patterns. A chaotic layout on a website will make hard to navigate, and the user experience will not be the best. The user may disengage relatively quickly (Buxton, 2005). Screen layout will apply to, for example, a digital presentation such as an animation, screencast, video or blended media, poster or brochure.

The C.R.A.P principles

Principles of graphic design such as C.R.A.P (Contrast, Repetition, Alignment and Proximity) are also considered important when developing posters/brochures that can be distributed online or print (Williams, 2014). Contrast refers to the difference in visual properties that contribute to an object or image being distinguishable from other objects and the background. It can be achieved using, colour, size, shape and position. Repetition is the process of repeating elements across the design to give a unified look. This process will add consistency to the design. Aligning elements in a particular way in a screen design (e.g., PowerPoint slides) creates a hierarchy or visual connection with each other. When these elements are placed randomly, a sense of confusion and chaos is created, which could disengage the audience. Finally, proximity is achieved by grouping similar elements together and creating a relationship between those elements. A typical example can be a website with a complex navigation structure where the designer uses different types of buttons but place them together in submenus. It also provides a focal point and can give the reader an idea of where they should start and finish reading (Hashimoto and Clayton, 2009; Malamed, 2015).

For example, developing a poster that does not follow the C.R.A.P principles may confuse the viewers, and the message may not come across.

Typography

Regarding typography for the screen, it is recommended to use clear font types such as Arial, Courier New, Times New Roman and be consistent in type and size (Friedman and Bryen, 2007). Limiting the use of italic for Latin names only and using bold for emphasising words will make a paragraph more readable. Also, avoid writing in red, as it is tiring for the eyes and can cause dizziness to some students and has been associated with adverse effects on learning (Elliot et al., 2007). Typography is a complex discipline, but the basic understanding can be summarised in using font faces that are easy to read.

Use of images

When using images, illustrations, graphics or icons to produce any digital media, careful thought and consideration are essential. The rationale to use these elements is to make the artefact visually appealing and engage the users/audience with the object. The use of these visual elements must have a purpose (Sfetcu, 2014). Otherwise, it will not give any benefit to the message. In web design, the addition of a visual element on a page just to fill up space has no impact on the visitor (Fernandes et al., 2003). Before using visual elements, consider the benefits of its use, whether it helps the audience to understand a concept, whether the visual element creates appeal and what message the image sends (Malamed, 2015). Effective images and illustrations will tell a story and reinforce the message of a digital media artefact (Kress and Van Leeuwen, 1996).

Video principles

Basic video techniques include how to shoot a video using a tripod, avoid what is called Vertical Video Syndrome, planning the shots (long shot, medium shot and close-up) and the rule of thirds as well as audio manipulation and special effects (Geoghegan and Klass, 2008), the use of text on video, transitions, and shot duration. These basic principles will enhance credibility and engagement of the audience (Stockman, 2011).

In summary, digital media principles such as colour theory, screen layout, typography, C. R.A.P principles, use of image and video framing are required to produce the different types of digital media artefacts effectively. This effectiveness can be measured by user's engagement with the content and understanding of the material. Figure 3 presents a summary of this section. Following these principles for digital media creation will enhance the look and feel of the artefact, user engagement and motivation (Malamed, 2015).

Effective communication in the digital space

Scholars have explored the use of analogies with grammar and filmmaking (Bowen and Thompson, 2013) and grammar and visual design (Kress and Van Leeuwen, 1996). In filmmaking, the grammar of the film refers to a set of principles and visual elements that guide the effective production of movies (Bowen and Thompson, 2013). The film industry applies these commonly accepted rules. Viewers have been trained, implicitly over many decades, to observe, decode and comprehend the different shots used in motion pictures

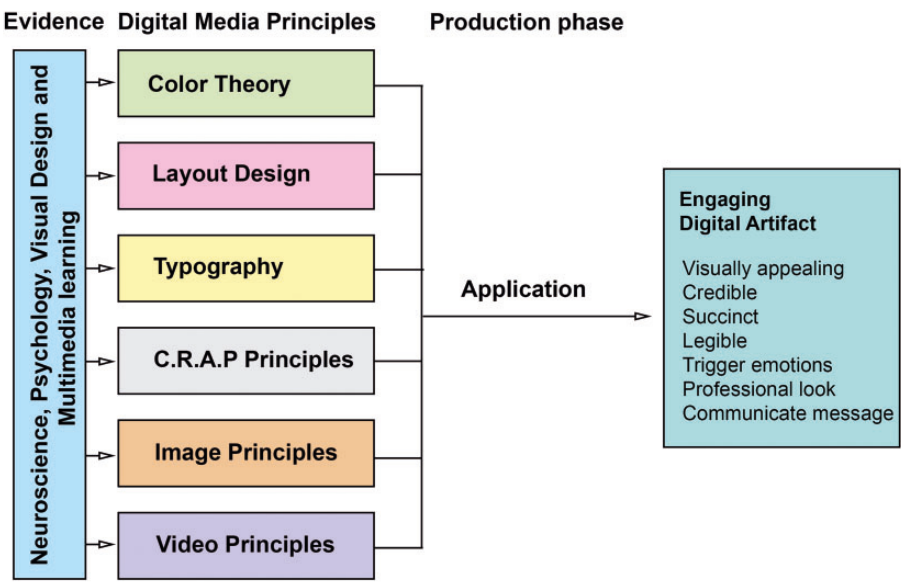

Figure 3. Digital media principles and effective creation of a digital artefact.

creation (Stockman, 2011). For example, in a scene from a movie where two actors are interacting, and it is a close-up scene, the camera will emphasise on the person talking and make the second person look slightly out of focus. The out of focus feature happens naturally with our vision, if we focus on a near object, the background will look slightly out of focus. So, the film is recreating the way the eyes function and create a real effect on the screen. In visual design, the grammar of visual design was proposed by looking at the visual design elements and structures such as colour, perspective, framing and composition. This analogy approach examined how images communicate meaning based on a wide range of everyday examples (Kress and Van Leeuwen, 1996).

This section proposes an analogy between grammar and digital media principles. The rationale to use this analogy is due to not only the measurement of similarities between grammar and digital media principles but the promotion of inquiry, the engagement, and discussion that produces. For an analogy to be effective to explain a concept, it should challenge thinking, and the analogue should be a familiar situation that the audience has been exposed to in the past (Aubusson et al., 2006). In other words, the purpose is not, for example, to compare film shot and the sentence, or the film sequence and the paragraph, but the narrative and representation across digital media principles and grammar. In this case, the analogue is the grammar and the target, the digital media principles.

Grammar is required for effective communication in both formal and informal settings. To illustrate this notion, a poster that has a convoluted layout, different font types and sizes and the colour clash will not communicate the message to the audience; improper grammar can likewise affect the meaning and clarity of an intended message. Not being aware of the digital media principles (audio-visual domain) when developing digital media can cause the audience Emotional and Cognitive Overload (ECO). Symptoms of ECO overload include irritability, pressure and confusion while cognitive overload is perceived as not able to process, handle or cope with a task (Rutkowski and Saunder, 2010). The ECO will be reflected in a lack of engagement with content, and the intended message could fail to reach the audience.

Grammatical errors can include punctuation, misplace of commas, spelling, subject/verb tense and sentence structure. In the case of digital media creation, poor choice of the font, text over a busy background, poor colour scheme, busy design layout and misuse of images can limit the way users engage and understand the information (Hashimoto and Clayton, 2009; Malamed, 2015; Williams, 2014).

When grammar rules are applied, it makes written content easy to understand and more engaging for the reader. If the flow of a paragraph gets interrupted by a poor sentence construction, spelling mistake or 'unusual' word, the idea will not be communicated properly. A video developed that does not consider, for example, shots (smallest unit of visual information captured by a video camera) and length, use of overwhelming transitions, distractors on screen and so on can result in outcomes like those associated with the poorly written text. The cognitive load is audio visual, and the brain can be easily overloaded (Mayer and Moreno, 2002). Reading text written using appropriate grammar structure will not have issues with cognitive load unless the text is written using fonts that are hard to read, or has complex graphics or bright colours with the lack of contrast between fonts and background. Usually, print books and articles have standard layouts and fonts.

Grammatical inconsistencies can make powerful slogans less effective. This issue can be observed in digital media artefacts, for example, an interactive poster (infographic) that has a poor colour scheme and layout design will not lead the eyes of the person to engage and try to understand the message. Another example, a website with poor navigation and bad choice of fonts and colour scheme will not convey credibility; visitors will be reluctant to put their credit card details to buy a product or service. In the case of video, a talking head video vignette that runs an hour long and has been recorded vertically (Vertical Video Syndrome) with distractive transitions and poorly designed graphics regarding layout design and colour will not convey professionalism and credibility. Users will not engage with this artefact.

In summary, digital media principles are as important as grammar rules, and they are necessary for everyday situations, clarity of meaning and intent for communicating in the digital space. Moreover, understanding digital media principles will not be enough to communicate in the digital world; it will require good use of grammar. The production of effective digital media artefacts is guided by a storyboard that needs to practice proper grammar such as be written succinctly, use a conversational style, use precise and plain terms, list items, keep sentences and paragraphs short, chunk information and so on (Carroll, 2014; Felder, 2011).

Discussion and implications for learning and teaching

The digital media explosion on the Internet due to the rise of prosumer electronics, Wi-Fi availability, ubiquitous devices, software and applications contributed to the growth and development of the digital media ecosystem on the Internet. The privilege of capital-intensive industries that had access to the tools to create digital media content shifted to include users who can afford these prosumer technologies. In this regard, a 'relative' democratisation of the digital media production has been observed since last decade which continues to shape the Internet towards a participatory culture (Van Dijck, 2009). This phenomenon empowered User-Generated Content on the Internet. Users with no digital media expertise are creating digital media content and uploading on the Internet. In many cases, the content fails to engage the audience due to poor quality. Examples of this can be Vertical Video on YouTube channels, blogs using fonts that are difficult to read or websites with complex navigation and poor colour scheme. We are leaving this unattended, and we can see the results with the massive amount of online content that is inaccurate, has issues with usability, accessibility and credibility due to poor understanding of digital media principles. Fostering digital media principles in a new generation of professionals could alleviate this growing issue. As we discussed previously, these principles to create engaging content are linked to different disciplines: neuroscience, psychology, visual design and multimedia learning principles. This paper discussed its importance in the creation of effective digital artefacts. The analogy of these principles with grammar was discussed not as an absolute match, for example, shot with the sentence, but as a way to generate an inquiry. Grammar and digital media principles work together to help to establish a clear communication in the digital space.

As educators, it is essential to ensure the students not only learn how to write reports, assignments, monograph and so on. They need to know how to communicate effectively in the digital space, regardless of their discipline of study. LGDM assignments should be used as pedagogical and digital media agent. We should aim to teach the digital media principles and to scaffold student digital media learning during their stage at the university. Currently, we think about the tools to produce digital content but not the principles. The lack of understanding of digital principles is evident in the latest NMC Horizon Project Report that discussed the tools for digital literacy (Alexander et al., 2016) and did not mention the theoretical foundations that govern the development of effective digital artefacts. Additionally, the Visual Literacy Standards in Higher Education (Hattwig et al., 2013) focused on the use of images and neglected other visual elements such as layout design, colour, theory, typography, C.R.A.P (Contrast, Repetition, Alignment and Proximity) principles and video techniques. Communicating using digital media implies not only functional knowledge on the application and tools to produce the content but also audio-visual skills. If we do not teach students how to communicate with the digital media principles, how can we expect them to communicate effectively in the digital space?

Conclusions

It is not about being able to create content online anymore; it is about effective communication to engage the audience in the digital space. This paper contributes to the body of knowledge by presenting the basic digital media principles for effective digital media production. Grammar is one set of rules to talk and write which is bimodal. In contrast, digital media principles are a wide range of rules that lay on, in most of the cases, multimodality. Students now are pushed to learn additional skills; it is not enough anymore to be able to write, read and speak, but they need skills in audio, imaging, animation, and video creation. Grammar works in synergism with digital media principles; without good grammar, effective digital media artefacts cannot be developed. In the digital age, grammar and digital media principles are closely related. In an ideal scenario, they should coexist in a 'symbiotic' relationship.

As educators, we need to foster digital media skills in our students. We need to teach or train students not only on using the software or tools available but also the principles behind to communicate effectively using digital media. We acknowledge most educators outside of the media and design courses that do not have the skills to teach these principles. We are currently working on guidelines for the effective practice to produce digital media content for educators and students. Hopefully, these guidelines will engage both educators and students in LGDM assignments.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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A Practical Model for Implementing Digital Media Assessments in Tertiary Science Education

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Abstract Learner-Generated Digital Media (LGDM) has been incorporated as a learning tool to assess students in Higher Education over the last decade. There are models developed for video making in the classroom that considers technical know-how, pedagogies or a combination of both. However, there is the absence of a student-centred, practical framework to inform academics and students on the implementation of digital presentations as an assessment tool in the curricula. This conceptual paper proposes a new framework to assist with the design, implementation and evaluation of LGDM as assessment tools. The framework considers the following elements: (1) pedagogy; (2) student training; (3) hosting of videos; (4) marking schemes; (5) group contribution; (6) feedback; (7) reflection, and; (8) evaluation. The purpose of this paper is to outline the basic elements of the framework and provide practical implementation strategies that academics from any discipline could apply to their classrooms.

Keywords: *learner-generated digital media, digital story, video as an assessment tool, digital media, digital media literacies, blended media, students as co-creators*

Cite This Article: Jorge Reyna, and Peter Meier, "A Practical Model for Implementing Digital Media Assessments in Tertiary Science Education." *American Journal of Educational Research*, vol. 6, no. 1 (2018): 27-31. doi: 10.12691/education-6-1-4.

1. Introduction

Learner-Generated Digital Media (LGDM) emerged more than a decade ago in the field of education [1,2,3]. In this field, the use of LGDM assessments has focused on the reflection of pre-service teaching experiences [4,5]. In contrast, in science disciplines, the focus has been active learning, inquiry and research approaches [6]. Extensive examples have been documented in science disciplines. Areas of research include biology [7], computer programming [8,9], health sciences [10], pharmacology [11,12,13], geology [14], mathematics [15,16], and engineering [17]. Currently, LGDM is gaining momentum in the higher education landscape [18,19]. The increased use of digital media as an assessment tool has been possible due to the proliferation of digital applications [20], and electronic devices such as smartphones, tablets, video cameras, and the like. [21,22].

The pedagogical approach to LGDM use is to promote student reflection, engagement in active learning, collaboration, creativity [23], and generate an environment for deep learning [18,24]. Learner-generated content has the potential to add value to hands-on experience and peer-driven learning [25]. Other benefits of LGDM include the development of graduate qualities such as interpersonal communication, project planning and time management skills [26], critical thinking, report writing, research skills and digital literacies [27]. Nevertheless, research on LGDM in higher education is considered under-theorised and barely sufficient [28,29]. Thus, there is a need for rigorous studies to evaluate the effectiveness of LDGM in different disciplines [1,6,30].

The literature on frameworks specific for the application of LGDM in the classroom is limited. Most of these frameworks focused on how to design, implement and evaluate LGDM from the technical aspects (development, pre-production, production, post-production and distribution) with no emphasis on teachers' and learners' roles [31,32,33]. Professional video-makers and multimedia creators have influenced these models, and they lack pedagogical substance [34].

From the student perspective, as a consumer of digital media for learning, the DiAL-e framework focus on what the learner does with an artefact rather than giving priority of its subject or discipline content [35]. This framework is well-rounded in pedagogies but fails to engage learners as co-creators of content.

In contrast, in teacher education, a model for the good practice of digital video projects was developed and included nine stages, teacher strategies and peer learning structures [1]. Later, a learning design for learner-generated digital stories was proposed based on the previous model [31]. Although this framework is very comprehensive, it lacks a practical approach to be used by those outside the discipline of Education. The CASPA model (Consume, Analyse, Scaffold and Produce, and Assess)[36] is a novel instructional design framework to implement multimedia creation in the classroom. The drawbacks of this model are the lack of pedagogical underpinnings. It does not consider student training and support on the task, group work or evaluation. A similar model of digital literacies is the AACRA model that includes Acess, Analyse, Create, Reflect and Act [37]. This model fails to identify the skills the students will need to develop to produce digital media assignments.

Consequently, this paper aims to introduce a practical, theoretical framework to guide the implementation of digital presentations as assessment tools in tertiary science learning. This paper will explore and outline the development and implementation strategies of the framework.

2. The LGDM Framework

The LGDM framework has eight elements starting from pedagogy and ending the cycle with an evaluation to inform future improvements (Figure 1). These elements were developed based on a gap assessment of previous models of digital media as an assessment tool [5,31,33,34]. For academics, the framework acts as a conduit between theory and good practice. From the student's perspective, the framework informs why they need to learn using digital media and how the assessment task has been structured. As a student-centred framework, communicating this information is vital to ensure students buy into the task and have clear expectations of what will be required from them. Consequently, each element of the LGDM Framework explained below, links to a key question that students will need to understand before undertaking a digital media assessment. When designing digital assessment tasks, it is vital that these key questions are addressed.

Figure 1. The Learner-Generated Digital Media (LGDM) Framework. DMP stands for Digital Media Project.

2.1. Pedagogy

This element will address the student's question: *Why I need to learn this way?* While the framework begins with pedagogy as a separate element, it of the remaining seven elements. The separation here has been made for instructional proposes.

The student-centred pedagogies that drive LGDM assignments should include active learning approaches, students working in small groups and 'learning-by-doing'. Relevant theories involve Problem-Based Learning [38]; Collaborative Learning [39], Cooperative Learning [40], Peer-Assisted Learning [41], and Case Studies [42]. These pedagogies can be used to design LGDM assessment tasks that engage students with technology in developing research skills, collaborative organisational skills, and problem-solving [43]. When designing LGDM assessments, it is important to ensure that subject learning objectives are aligned with graduate attributes. For example, at our institution, digital media assignments are aligned with Graduate Attribute 6: Communication skills.

2.2. Student Training

This element will address the student's question: How do I create a digital media project? Digital media support for students is essential. Training on how to create effective digital presentations needs to be planned and delivered. The suggested topics to be covered include (1) digital presentation types; (2) layout design; (3) colour theory; (4) typography; (5) use of images; (6) audio recording; (7) video quality and resolution; (8) video framing and shots; (9) storyboarding, and; (10) tools available to produce digital presentations [44]. At our institution, we have developed hands-on workshops for students to brainstorm their ideas with their peers and instructors. A crucial element at this stage is student feedback provided from the content perspective and digital media perspective. In our faculty, the learning designer undertakes the role of digital media educator and supports the students with the technical parts of the task. Additionally, online student resources have been developed that cover (1) welcome to digital presentations video; (2) Frequent Asked Questions on LGDM assignments; (3) interactive lecture on digital presentations; (4) example storyboard; (5) past student projects; (6) marking rubric for the assessment task; (7) interactive lecture on storyboarding, and; (8) additional resources such as tools to create digital presentations.

2.3. Hosting of Video

This element will address the student's question: *Where do I upload my digital media project?* The video hosting service should be determined before designing the assessments. Appropriate attention will need to be paid to privacy, ethics and issues such as intellectual property in line with each institution's policies. However, as a guiding principle, Learner-Generated Digital Media artefacts should be accessible to all the students as it will foster discussion and consideration of ideas. The use of Web 2.0 tools to host videos such as YouTube and Vimeo can be taken into consideration [32,45]. Creating a classroom account in those services and sharing the details with the students will be well suited. Students should be able to see each group's work and comment if necessary. Qualitative research has reported that an "awareness of audience" enriches the process of LGDM creation with students reporting high levels of accomplishment and ownership in digital media assignments [5]. At our institution, there is an emphasis on work integrated learning. Consequently, during digital media training for the students, the learning designer explains how they could use their digital presentations for their portfolios. A digital artefact can showcase student's creativity, ability to work in groups and as part of a team, and communication in the digital space and digital media skills; all essential skills identified as desirable by employers.

2.4. Marking Scheme

This element will address the student's question: *How is our digital media project going to be marked?* When designing an assessment structure, it is important to determine the weighting of the LGDM activity since preparation of digital media projects can be time-consuming [31]. It is recommended to have at least 20% of the total subject mark devoted to this assignment [11]. Additionally, the use of marking rubrics is highly encouraged as it will help the students focus on the important elements of the task and will make the marking process more objective if several tutors/instructors are involved in the process [46]. As students ideally receive training in digital media principles, the assignment should mark the application of these principles in addition to grading content. The exemplary marking rubric used in our institution has, under the communication skills graduate attribute, a criterion for the application of digital media principles such as layout design, colour theory, typography, use of images and basic video techniques such as framing, use of tripod and type of shots.

2.5. Group Contribution

This element will address the student's question: How do you ensure that everyone contributes to the digital media project? Mechanisms to ensure all group members are contributing to the project need to be implemented. The best approach, in this case, is self and peer-assessment [47,48]. A contribution to group work rubric should be developed, and a peer review application used to allow students to rate each other's contribution to the project. Using such a tool helps to identify free riders and non-contributors. In our institution, SPARKPlus is used to moderate group work [14]. Other tools such Google Forms or even paper-based systems can be used. Our faculty developed a simple group contribution rubric inside the SPARKPlus application. This rubric includes (1) disciplinary/subject input for the project; (2) punctuality and time commitment; (3) contribution with original ideas; (4) communication skills and work effectively as part of the team; (5) focus on the task and what needs to be done. Students will go ahead self and peer review with a sliding bar that contains a scale from well below average, below average, average, above average and well above average. Additionally, the students need to input comments on why they give that mark to their peers. This qualitative data is useful when conflicts between group members occur. When explaining to the students SPARKPlus at the beginning of the semester, group issues are less than 10% in the digital media projects [14].

2.6. Feedback

This element will address the student's question: *How are we going with the digital media project?* When implementing learning designs that use innovative ways to assess students, it is critical to provide targeted, specific and timely feedback. The purpose of feedback aims to reduce discrepancies between understanding and performance in relation to a goal [49]. In the case of digital media projects, students need early feedback on the storyboard at the start of the process, and then, on the digital media approach and tools, they plan to use. Later, feedback on the draft is critical to reinforce student's learning of the content and digital media principles. These levels of feedback will allow students to produce an effective digital artefact and minimise task related anxiety [10].

2.7. Student Reflection

This element will address the student's question: *How was the learning experience developing a digital media project?* Research has shown that student's perceptions of the benefits of educational technology can be diminished. Not until analysing the data and comparing performance, can we elucidate the benefits of the intervention [50]. Adding a reflection task after the assignment will help the students to rethink if they have gained additional knowledge by engaging in the development of a digital media project. This task can be implemented using a reflective journal inside the Learning Management System and by asking the students questions such as: what do you feel you learned from this task? How could you use the skills you developed? This reflective task could be built into a marking structure, designed for extra credit or simply noted as a required threshold activity.

2.8. Evaluation

This element will address the student's question: *What could be improved on the assignment?* Evaluation is an important part of any educational intervention. The purpose of the evaluation is to produce data that will help to improve the assignment in the next iteration. The process involves (1) identifying the activity/task; (2) developing questions (for students and tutors); (3) determining the sources of data; (4) collection and analysis; (5) making the adjustments required, and; (6) starting a new iteration in the following semester. Sources of data can be teacher reflection, student's perceptions (via surveys, interviews and focus groups), student's assessment performance (grades attained) and student actions (group contribution) (Phillips & Gilding, 2002). Most institutions will have formalised systems for gathering student feedback, but it is important that feedback also is gained from instructors who implemented the tasks. When collecting such data, consideration should also be given to whether these data will contribute to any research publications. The final step of this process is perhaps the most important as data is often gathered but then not used to review pedagogical practices effectively. At our institution, we have implemented specific quality control processes to ensure teaching practices are regularly reviewed. These processes include an online survey for students to capture their learning experience using digital media.

3. Conclusion

This paper has outlined some shortcomings in existing models that look at the development of Learner-Generated Digital Media as an assessment tools. These include the complexity of teacher educator's models and the lack of practical application outside the field of Education. To address these gaps, educational researchers at our institution have proposed a new model: the LGDM Framework. This model is a student-centred framework with eight clear elements underpinned by active learning pedagogies. The central theme focuses on student engagement and how academics can design LDGM assessments that are meaningful to students and help ensure a development of desired student graduate outcomes. In subsequent papers, the authors will explore the implementation of the framework and present data that validates the underlying approaches.

For additional information about Learner-Generated Digital Media visit www.digitalmediaforlearning.org.

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education sciences

Article

Using the Learner-Generated Digital Media (LGDM) Framework in Tertiary Science Education: A Pilot Study

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Abstract: Learner-Generated Digital Media (LGDM) has become prevalent in higher education. Frameworks have been developed for video-making in the classroom that consider technical requirements, pedagogies, and the combination of both. However, missing is a practical model to guide academics and students on the implementation of LGDM assignments. This research aims to test a model to design, implement, and evaluate LGDM as an assessment tool. The model was built based on research gaps and it considers the following elements: (1) pedagogy, (2) student training, (3) hosting of videos, (4) marking schemes, (5) group contribution, (6) feedback, (7) reflection, and (8) evaluation. For this purpose, five science subjects (N = 270) were used to test the model as a guide to implementing LGDM assignments. Data was gathered using a validated 33-step questionnaire instrument. Additionally, group contributions were received using the SPARKPlus peer review application, and marks attained were gathered. Methodological triangulation of the datasets suggested that students have a positive attitude toward LGDM for science learning. Students enjoyed the group work and creativity, and they identified digital media support as a critical component of their learning experience. Preliminary data support using the LGDM framework to design digital media assignments for science education.

Keywords: Learner-generated digital media; video as an assessment tool; digital media; digital media literacies; blended media; digital media as an assessment tool

1. Introduction

Learner-Generated Digital Media (LGDM) can be defined as a digital artefact developed by students to learn the subject content [1]. This approach emerged in the field of education more than a decade ago [2–4]. Currently, it is gaining momentum in the higher education landscape [5–7]. Using digital media as an assessment tool has been made possible by the wide availability of digital applications [8] and electronic devices such as smartphones, tablets, video cameras, and so on [9,10]. These new technological tools create opportunities for new approaches to curriculum and pedagogies in the classroom [11–13].

The pedagogical approach behind LGDM use is the promotion of student reflection, engagement in active learning, fostering of collaboration and creativity [14], and the creation of an environment for deep learning [15,16]. Learner-generated content has the potential to add value to hands-on experience and peer-driven learning [17]. Other benefits of LGDM include the development of graduate attributes such as interpersonal communication skills, project planning and time management skills [18], critical thinking, report writing, research skills, and digital literacy [19]. Nevertheless, research on LGDM in higher education is considered to be in the embryonic stage [20–22]. Thus, there is a need for rigorous studies using large student samples to evaluate the effectiveness of LGDM in different disciplines [2,6,22,23].

The authors reviewed the research in LGDM using educational databases including Education Research Complete, ERIC (EBSCO), Education Database (ProQuest), A+ Education (Informit), and LearnTechLib. A research gap was identified in the literature: the need for a practical model linking pedagogy and technology to guide academics and students on the implementation of digital media assignments. Consequently, the aims of this research paper are (1) to use the LGDM framework to guide the implementation of digital presentations as assessment tools in tertiary learning and (2) to explore student perceptions about the use of Learner-Generated Digital Media (LGDM) assignments for learning scientific concepts.

2. Literature Review

Research conducted in the last decade in the field of education has described the use of digital media assignments. The main focus has been on reflective practices for pre-service teachers [24,25]. In contrast, in science disciplines, digital media assignments are a novel approach focusing on the development of research skills, inquiry, and active learning [22]. The affordability of new technology allowed digital media assignments to spread the repertoire of the traditional assignments such as writing a lab report, a scientific abstract, a literature review, and so on. Examples of digital media assignments have been documented in life sciences such as biology [26], health sciences [27], and pharmacology [28–30]. Other disciplines using digital media assignments include computer programming [31,32], geology [33], mathematics [34,35], and engineering [36]. There are challenges to designing digital media assignments in the science discipline due to the lack of systematic approaches and theoretical models to guide the implementation in the classroom. Additionally, educators outside the field of visual design, multimedia, filming, and digital media do not have a basic understanding of digital media production workflow and digital media principles.

Learning mediated by digital media assignments has not been rigorously explored. The semiotic theory described by Hoban et al. (2015), the self-explanation principle [37], and the internalisation principle [38] have been theorised as mediating learning when creating digital media assignments. When creating LGDM assignments, learning takes place in three different steps—preparing, representing, and reinforcing. When students prepare by searching for subject content to build their storyboards, they learn about the topic [26,39]. Representing occurs when they look at their scripts and think in a multimodal way to present the content [26,40,41]. Finally, reinforcing takes place during the digital media production task, which is iterative and time-consuming [42]. For example, creating an animation to explain a biochemical reaction will require students to prepare their storyboards [43]. Students will need to engage in reading and understanding the material before they can summarise it for the script. The next step will be to think about the best way to represent the reaction, whether it be a whiteboard animation [44], slowmation [45], or PowerPoint animation [46]. The final step will be to play and refine their animations until they run smoothly, which will reinforce student learning [47].

Existing models to guide the design and implementation of digital media assignments in the classroom focus on technical aspects such as development, pre-production, production, post-production, and distribution. In these technology-driven models, there is no emphasis on teachers' and learners' roles [25,40]. These models have been heavily influenced by professional video-makers and they lack pedagogical substance [43]. In teacher education, a nine-stage model that includes teacher strategies and peer-learning structures [2] has been proposed. Later, a learning design for learner-generated digital stories was proposed based on the previous model [25]. Although this framework is very comprehensive, it has been contextualised for teacher education, and extrapolation to other disciplines can be difficult. The CASPA model (Consume, Analyse, Scaffold, Produce, and Assess) [5] is a novel instructional design framework for implementing multimedia creation in the classroom. A recent study used the ICSDR model (Identify, Conceptualise and Connect, Storyboard, Develop, Review, Reflect, and Revise) to inform the use of LGDM in the classroom [6].

However, none of these models considered, for example, communicating to students the assessment task rationale, training the students in digital media principles, using an accurate marking rubric, ensuring healthy groupwork, or evaluating the intervention. Therefore, we identified that a simple model combining pedagogies, digital media training, video hosting, marking schemes, group contribution assessment, feedback, reflection, and evaluation was required to implement digital media assignments outside of the Education discipline. This paper uses the Learner-Generated Digital Media (LGDM) Framework [48] for the design of digital media as an assessment tool. This model is flexible enough to be applied to any digital media type, including a podcast, digital story, animation, video, and blended media. The LGDM Framework is student-centred because it helps students to understand the benefits of learning using digital media and guides them in how the digital assignment is structured. From the educator's perspective, the LGDM Framework could be an excellent approach for designing digital media assignments in the classroom.

3. The LGDM Implementation Framework

The LGDM model has eight elements, starting with pedagogy and ending with an evaluation to inform future improvements (Figure 1). These elements were chosen based on previous models of digital media as an assessment tool and identified research gaps in the literature. Aspects of the LGDM Framework are explained above and linked to a set of questions which students need to understand before undertaking the digital media assessment. From the academic perspective, the model blends theory and good practice. From the student's viewpoint, the model informs them about the benefits of learning using digital media and about how the assessment task is structured. Communicating this information is crucial to ensure that students will buy into the task and to set clear expectations of the requirements for success in the assessment task.

Figure 1. The Learner-Generated Digital Media (LGDM) framework. DMP stands for Digital Media Project.

3.1. Pedagogy

The starting point of LGDM assignments is the pedagogic and instructional strategies. Most of the research in the field of LGDM is guesswork and does not rest on a solid educational foundation. In other words, educators improvise digital media assignments without taking into consideration that the starting point is the pedagogical approach, for example, students working together using Active Learning [49], Problem-Based Learning [50], Collaborative Learning [51], Cooperative Learning [52], and Peer-Assisted Learning [53]. The objective is for students to engage with the subject content and use the technology as a vehicle for learning. When developing LGDM assessments, it is also essential to align the subject learning objectives with graduate attributes and with the digital media tasks the students will undertake [54,55].

3.2. Student Training

Storyboard creation, digital media principles, and production technique training have in most cases been neglected in LGDM research. Several studies in different disciplines did not consider student training and support [5,6,15,25,27,56]. The assumption is always that students know more than educators regarding technology because they own it and use it more in everyday life [22]. However, the literature reported student apprehension, anxiety, and poor digital media skills in LGDM assignments [27,57,58]. The issue with technology in first world countries is not ownership or access, but fluency in its use [12,59]. Our framework identified digital media support for students as essential. For this purpose, training on how to create compelling digital presentations needs to be planned and delivered to students. The Digital Media Literacies Framework (DMLF) [1] is used to train students in the conceptual domain (storyboard), functional domain (software), and audiovisual domain (digital media principles). Intellectual property and copyright issues must also be considered in training to ensure that students understand their importance and application to their digital media projects.

3.3. Hosting and Distribution

Research has described the importance of audience awareness to get students motivated about LGDM assignments [2,26,38]. The prospect of creating LGDM content that can help the learning of students elsewhere gives students a sense of agency and students reported high levels of accomplishment and ownership from digital media assignments [25]. Hosting video on open platforms such as YouTube and Vimeo [60,61] can also promote student agency and accomplishment. Using an open platform to upload the LGDM assignments can provide student access even after they finish their studies, so that they can showcase their assignments as evidence of teamwork, digital media skills, and achievement of graduate attributes highly regarded in the workforce [26,55]. Nevertheless, some higher education institutions are moving to closed video platforms such as Kaltura. Uploading LGDM assignments to open platforms is a vital feature of student-created digital media.

3.4. Marking Schemes

Digital media production is time-consuming [62], iterative [63], and resource-intensive [64], with variations depending on the media type [65]. For example, creating an audio podcast is less onerous than creating a digital story or video. Educators need to have a good understanding of the complexity of different digital media types before designing LGDM assignments. The Taxonomy of Digital Media Types Framework is used [65] to guide assignment design and weighting. For example, for a video group assignment, it is recommended that it be worth at least 20% of the total subject mark [28]. Finally, the development of marking rubrics that consider communication in the digital space is crucial to ensure that the effort students put into their assignments is recognised.

3.5. Group Contribution

Digital media production is teamwork by nature. It is unrealistic to ask students to produce, for example, video individually. Some media types, such as an audio podcast or blog posting, could be developed individually because they are less complicated. A mechanism needs to be implemented to ensure groupwork is optimal and that all group members contribute to their projects. The best approach, in this case, is self and peer-assessment [66,67]. Development of a marking rubric for contributions to group work will be necessary, as well as a peer-review application allowing students to rate each other's contributions to the project. SPARKPlus is an example of a group work moderation application that provides feedback and quantitative ratings for group contributors [33]. The use of other tools, such as Google Forms or even paper-based forms in small classrooms, could substitute for online peer-review tools.

3.6. Feedback

Feedback on LGDM assignments is crucial from two perspectives: content and digital media production. Students need to feel supported, and this has a positive effect on their engagement with the task. As theorised previously, the purpose of feedback is to reduce discrepancies between understanding, performance, and the goal [68]. Students will need feedback on the storyboard structure early in the semester. Week 2–3 is preferable. Then, they will need feedback on the digital media tools they are planning to use. It is ideal to provide feedback on students' prototypes two to three weeks before assignment submission. This level of feedback will allow students to produce a useful digital artefact and minimise anxiety about the LGDM task [27,58].

3.7. Student Reflection

Research has shown that when students do not reflect on a learning task using technology, they do not see the value of it [69]. Adding a reflective task after the assignment will help the students to rethink if they have gained additional knowledge by engaging in the digital media project. This can be implemented by using a reflective journal inside the Learning Management System and by asking students questions in the classroom such as "What do you feel you learned from this task?" and "How could you use the skills you developed?"

3.8. Evaluation

Evaluation is an integral part of any educational intervention. The purpose of the evaluation is to produce data that will help to improve the LGDM assignment in the next iteration. The process of evaluation involves (1) identifying the activity/task, (2) developing questions (for students and tutors), (3) determining the sources of data, (4) collection and analysis, (5) making the adjustments required, and (6) starting again. Sources of data can be teacher reflections, student perceptions (via surveys, interviews, and focus groups), student assessment performance (grade attained), and student action (group contribution) (Phillips & Gilding, 2002).

4. Materials and Methods

This research project used a mixed-methods approach [70]. A 33-step online questionnaire (28 Likert scales and five open-ended questions) was used to gather data. The questionnaire items were validated using factor analysis [71]. Factor analysis is a statistical methodology that allows the researcher to test the hypothesis that there is a relationship between observed variables and their underlying latent constructs. The research also collected group contribution data (SPARKPlus) and grades attained. Methodological triangulation [72] of datasets was performed to confirm student perceptions of LGDM as an assessment tool. Questionnaire data were analysed using IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, USA: IBM Corp., and open-ended questions were analysed using NVivo (Version 11, QSR International, Melbourne, Australia, 2016).

4.1. Selection of Subjects

The study was conducted during Spring 2016 and included five Science subjects (Table 1).

The Faculty's learning designer liaised with subject coordinators to adopt authentic assessments for the University's strategic implementation of blended learning. LGDM assignments are considered authentic because (1) students need to research to write their storyboards, (2) they require teamwork and applied problem-solving and communication skills, and (3) they reflect tasks that students will face in their professional life as scientists—for example, showcasing research using digital media to communicate to the scientific community or to attract funding. Subject coordinators from ten subject areas were presented with the LGDM framework and had the process to design the assessment task explained to them. Five of them decided to implement the task and be part of the pilot study.

Table 1. Subjects which implemented LGDM as an assessment tool in the Faculty of Science in 2016. B = Blended, O = Online.

Subject	Yr	N	Sample Size (%)	Digital Media Type	Assessment Weight	Mode of Instruction
Pharmacology 2	2	169	98 (58%)	Digital story, video, blended media	30%	B
Geological Processes	2	101	73 (72%)	Digital story, video, blended media	10%	B
Animal Behaviour and Physiology	2	106	34 (31%)	Digital story, video, blended media	10%	B
Evaluating TCM: Theory, Practice and Research	3	43	35 (81%)	Digital story, video, blended media	20%	B
Introductory Pharmacology and Microbiology	3	39	34 (87%)	Brochure, poster design	25%	O
TOTAL		458	274 (60%)			

4.2. LGDM Assessment Design

Design, implementation, and evaluation of the digital media assignments was done using the LGDM Framework. Pedagogy was the starting point of the design process. Active learning and small group work were the drivers of the assignment. Constructive alignment ensured that the digital media task addressed the subject learning objectives and the Faculty of Science's graduate attributes—for example, (1) Disciplinary knowledge and its appropriate application, (2) An inquiry-oriented approach, (3) Professional skills and their appropriate application, and (4) Communication skills.

Student training was carefully designed and delivered via a face-to-face lecture on "Basic Digital Media Principles to Communicate Science". The lecture followed the Digital Media Literacies Framework (DMLF) and addressed the conceptual, functional, and audiovisual domains [65]. The conceptual domain was addressed by introducing principles of storyboarding, while the functional domain was covered with a general explanation of how video editing works in Movie Maker (Windows platform) and iMovie (Macintosh). The audiovisual domain was addressed using the Digital Media Principles Framework [73]. This section of the lecture covered concepts such as layout design, colour theory, typography, use of images, and basic video principles. A workshop on storyboarding for digital media creation was also delivered to the students. In this session, students were able to apply the conceptual domain discussed in the classroom and develop a preliminary structure for their storyboards. Online resources on digital media creation were embedded inside the Learning Management System (LMS) to further support students with the LGDM assignment. For the subject Introductory Pharmacology and Microbiology, an interactive module on "Visual Design Principles to Communicate Science" was deployed inside the LMS. This subject had a different type of digital media task, creating a poster/brochure, and did not have time to allocate to a lecture and workshop.

Video hosting was on YouTube, as our institution supports it. Individual YouTube accounts for each subject were created, and instructions were developed for students on how to upload their videos to the subject channel. Video-sharing services were considered the best for students to upload their LGDM assignments to and also watch videos created by their peers. This also helps tutors to mark the videos quickly, as they are all in one place.

The project developed a comprehensive marking rubric for each of the subjects. The rubrics aligned with the subject learning objectives and graduate attributes. The intervention used the SPARKPlus application, a peer-review tool, to ensure strong group contributions. SPARKPlus helped students to focus on the task and contribute to their groups. A basic marking rubric for group work was designed and used 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.

Students developed a structure for their storyboards during the workshops and feedback was provided by the subject coordinator and the learner designer during weeks 1 and 2 of the semester. Students also had access to a page in the LMS that contained the following sections: (1) a "welcome to LGDM assignments" video, (2) an interactive lecture on digital presentations/brochure design, (3) frequently asked questions on digital media assignments, (4) examples of LGDM developed in previous years, (5) the marking rubric, and (6) instructions on how to upload digital presentations to YouTube channels.

Toward the end of the semester, when students had completed their digital media projects, they were prompted to reflect about their experience in the classroom. Students discussed with their peers the importance of using digital media to learn and communicate science. This data was not captured for the research, as it would require observational studies, video or audio recordings, and further analysis. Finally, in the last two weeks of the semester, students were asked via announcements to participate in the online questionnaire.

4.3. Data Gathering and Questionnaire Design

Student attitudes toward LGDM for learning were captured with an online questionnaire (33-step questionnaire, Likert scale) that considered demographics, digital media support, attitude toward technology, understanding of the assignment, knowledge construction, and open-ended questions (Table 2). Factor analysis was performed to validate the questionnaire items.

Table 2. Students' online questionnaire on attitude toward digital media for learning.

Category	Item
Demographics	1. Gender 2. Age 3. Education 4. English as an additional language (EAL)
Digital media support	5. I found the digital presentation lecture engaging. 6. I applied concepts from the lecture to my assignment. 7. I need a better understanding of digital presentation principles. 8. I will recommend that my peers attend this lecture. 9. I used a storyboard to structure my project. 10. Overall, the technical support to complete my project was good.
Attitude towards technology	11. I Enjoy using technology for personal/recreational matters. 12. I am confident using technology for personal/recreational matters. 13. I have a positive attitude towards technology for recreational matters. 14. I enjoy using technology for learning. 15. I am confident using technology for learning. 16. I have a positive attitude towards technology for learning.
Understanding of the assignment	17. I believe instructions on the assignment were clearly provided. 18. The timeframe to complete the project was good. 19. I understand the importance of communicating concepts/ideas in the digital world. 20. Overall, I was happy about the digital media presentation assignment.
Knowledge construction	21. I believe using digital presentations helped me to understand the topic. 22. The digital presentation assignment helped me to develop critical thinking skills. 23. The digital presentation assignment helped me to develop communication skills. 24. The digital presentation helped me to work as a part of a team. 25. The digital presentation helped me to exercise my creativity. 26. I believe digital presentations are a good way to assess students' understanding of a topic. 27. I will encourage academics to use similar assignments in other subjects. 28. I believe I learnt additional skills by doing this assignment.
Open-ended Questions	29. Did you experience any issue with the assignment? 30. What did you like most about the assignment? 31. What did you like least about the assignment? 32. Do you have any feedback on how to improve this assignment? 33. Is there anything that you would like to say that has not been covered in the previous questions? If so, please feel free to provide additional feedback in the space below:

Data from the online questionnaire were analysed using frequencies and descriptive statistics and combined for the five subjects, as there were no significant statistical differences between the subjects. The software IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp., was used to analyse the data. For the open-ended questions (Q29–Q33), thematic analysis was used to find the categories, and open-ended question responses from all subjects were consolidated using NVivo (Version 11, QSR International, 2016). SPARKPlus results for group contribution and grades attained were analysed using descriptive statistics. Data were interpreted using methodological triangulation [72].

5. Results

5.1. Demographics

The overall sample was 62.8% female and 37.2% male. Most participants were in the age bracket of 18–29 (87.2%), with 30–49 (11.3%) and 50–64 (1.5%). Sixty-five percent were high school graduates, and 24% already had a university degree. Twenty percent of participants had English as an Additional Language (EAL). Table 3 presents the detailed demographic characteristics of participants.

Table 3. Demographic characteristics of participants in the LGDM assignment for five Science subjects (N = 274).

Characteristic	N	%
Gender		
Male	102	37.2
Female	172	62.8
Age bracket		
18–29	239	87.2
30–49	31	11.3
50–64	4	1.5
Level of education		
High school graduate	179	65.3
Some college	15	5.5
College graduate	5	1.8
University degree	66	24.1
Trade/technical/vocational training	9	3.3
English as an Additional Language (EAL)		
Yes	55	20.1
No	219	79.1

5.2. Questionnaire Validation Using Factor Analysis

Factor analysis (FA) (N = 270) was performed to verify the factor structure of the questionnaire items. The online questionnaire aimed to gauge (1) digital media support, (2) attitude toward technology, (3) understanding of the assignment, and (4) knowledge construction. The extraction method used was 'principal components'. The Kaiser-Meyer-Olkin (KMO) Test for Sampling Adequacy was calculated at 0.909, which indicated that the sample size was suitable. Bartlett's Test of Sphericity was calculated as $p < 0.001$, which allowed us to conclude that there were relationships between the variables. Table 4 presents the loading factors for the questionnaire items tested. Items 10 (Overall, the technical support to complete my project was good), 20 (Overall, I was happy about the digital media presentation assignment), and 24 (The digital presentation helped me to work as a part of a team) had low loading factors and were withdrawn from the analysis.

Table 4. Standardised solutions by Factor Analysis to measure questionnaire construction.

Item	Factor			
	Digital Media Support	Attitude Toward Technology	Understanding the Assignment	Knowledge Construction
5	0.724			
6	0.714			
9	0.687			
8	0.607			
7	0.561			
13		0.874		
12		0.855		
15		0.851		
14		0.823		
16		0.823		
11		0.809		
18			0.742	
17			0.682	
19			0.561	
26				0.833
27				0.817
28				0.784
22				0.762
21				0.749
23				0.744
25				0.681

5.3. Attitude toward Technology

This section of the questionnaire had six items measuring the use of technology for personal or recreational matters and learning. Ninety-one percent of participants agreed that they enjoy using technology for personal/recreational matters, 85% were confident using technology for that purpose, and 93% had a positive attitude toward technology for personal/recreational matters. Similar results were observed when participants were asked about enjoying technology for learning (93%), their confidence in using technology for learning (85%) and having a positive attitude toward technology for learning (93%). Table 5 summarises the frequencies of student responses. Figure 2 is a visual representation of the data.

Table 5. Student attitude toward technology in the LGDM assignment, for five Science subjects (N = 274).

Question	Frequencies			
	SD	D	A	SA
I enjoy using technology for personal/recreational matters.	2 (0.7%)	24 (8.8%)	107 (39.1%)	141 (51.5%)
I am confident using technology for personal/recreational matters.	2 (0.7%)	40 (14.6%)	116 (42.3%)	116 (42.3%)
I have a positive attitude towards technology for recreational matters.	1 (0.4%)	19 (6.9%)	124 (45.3%)	130 (47.4%)
I enjoy using technology for learning.	2 (0.7%)	16 (5.8%)	136 (49.6%)	120 (43.8%)
I am confident using technology for learning.	-	41 (15%)	122 (44.5%)	111 (40.5%)
I have a positive attitude towards technology for learning.	-	20 (7.3%)	129 (47.1%)	125 (45.6%)

SD = Strongly Disagree; **D** = Disagree; **A** = Agree; **SA** = Strongly Agree.

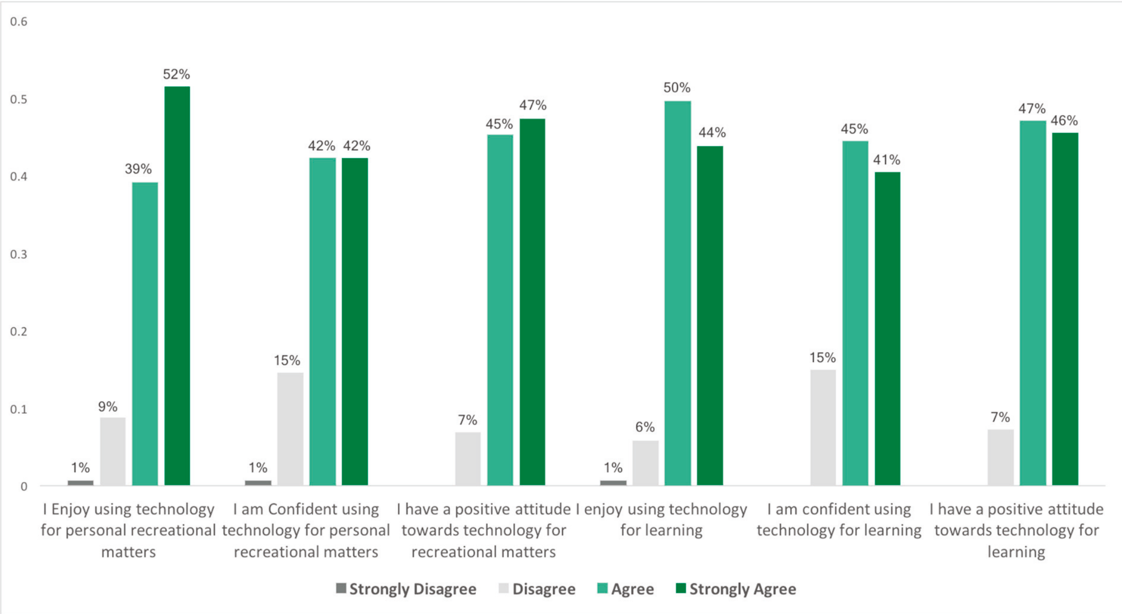

Figure 2. Student attitude toward technology in the LGDM assignment for five Science subjects (N = 274).

5.4. Digital Media Support

This data does not include the subject Introductory Pharmacology and Microbiology (N =34), as the delivery of the training for this subject was entirely online. Instead, we recorded module completion rates by looking at the Learning Management System (LMS) logs at the end of the semester. Eighty-two percent of students completed the interactive modules, but their questionnaire did not contain digital media support questions. Additionally, records from the LMS were gathered to track student activity within the supporting material in the digital media tab. Data showed extensive engagement with the support content for the LDGM assignment.

Eighty-six percent of participants found the digital presentation lecture engaging, while 88% applied concepts from the lecture to their assignments, including storyboarding (73%). Eighty percent of students thought they would recommend the digital media lecture to their peers. Finally, 73% of participants believed they needed a better understanding of digital presentation principles (Table 6, Figure 3).

Table 6. Student perceptions of digital media support in the LGDM assignment for five Science subjects (N = 240).

Question	Frequencies			
	SD	**D**	**A**	**SA**
I found the digital presentation lecture engaging.	2 (0.7%)	33 (13.8%)	147 (61.3%)	58 (24.2%)
I applied concepts from the lecture to my assignment.	3 (1.3%)	25 (10.4%)	140 (58.3%)	72 (30.0%)
I used a storyboard to structure my project.	10 (4.1%)	55 (22.9%)	111 (46.3%)	64 (26.7%)
I will recommend that my peers attend this lecture.	3 (1.3%)	44 (18.3%)	124 (51.7%)	69 (28.7%)
I need a better understanding of digital presentation principles.	10 (4.1%)	55 (22.9%)	111 (46.3%)	64 (26.7%)

SD = Strongly Disagree; **D** = Disagree; **A** = Agree; **SA** = Strongly Agree.

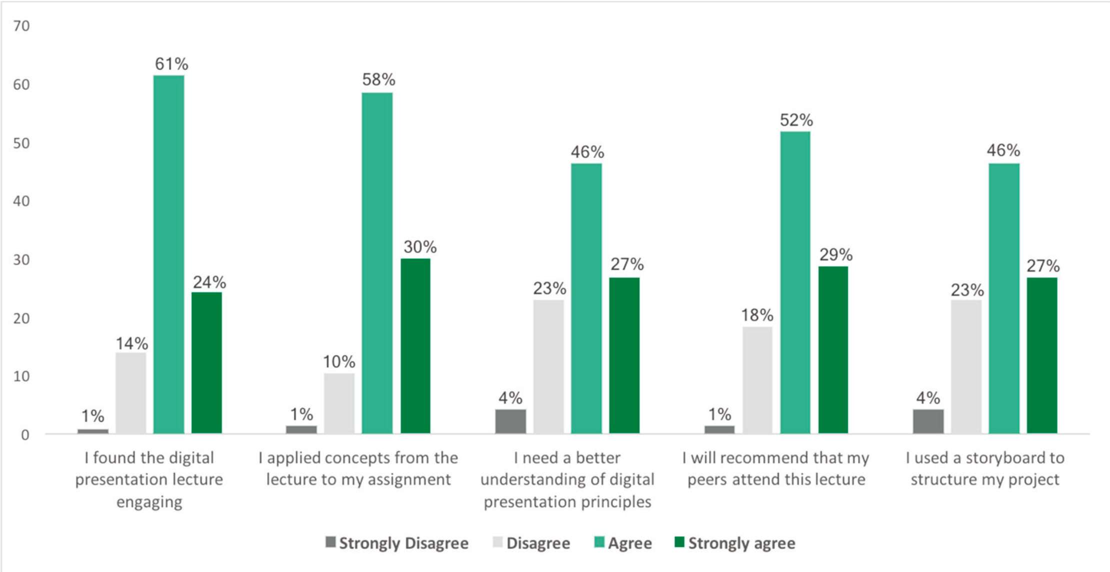

Figure 3. Student perceptions of digital media support in the LGDM assignment for five Science subjects (N = 240).

5.5. Understanding the Assignment

Eighty-five percent of participants thought the instructions for the digital media assignment were clear, while 91% thought the timeframe to complete the assignment was good. Ninety-seven percent of participants understood the importance of communicating concepts/ideas in the digital world (Table 7, Figure 4).

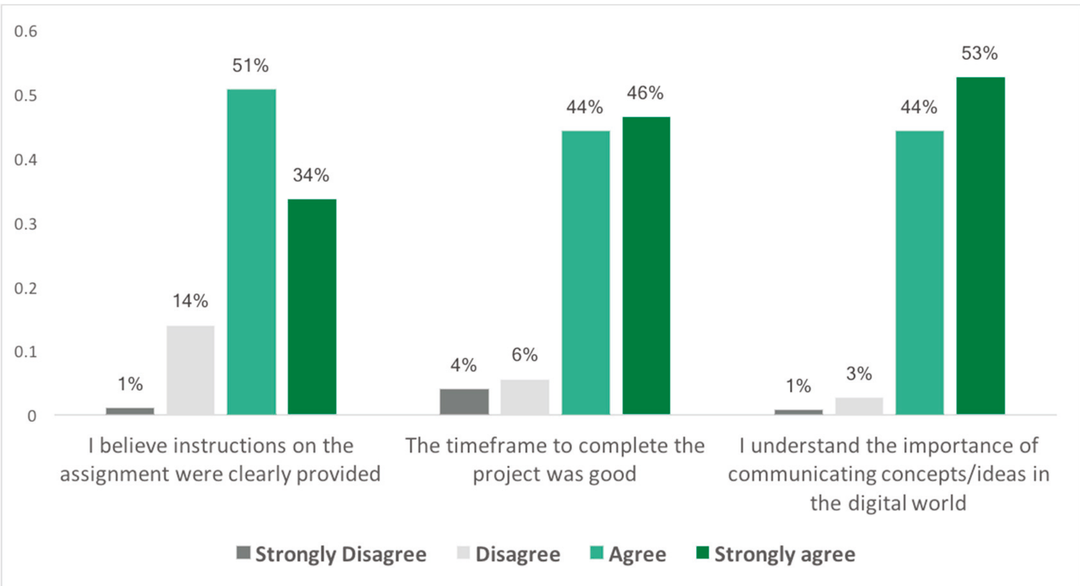

Figure 4. Student understanding of the LGDM assignment instructions, timeframe, and importance for five Science subjects (N = 274).

Table 7. Student understanding of the LGDM assignment instructions, timeframe, and importance for five Science subjects (N = 274).

Question	Frequencies			
	SD	D	A	SA
I believe instructions on the assignment were clearly provided.	5 (1.8%)	38 (13.9%)	39 (50.7%)	92 (33.6%)
The timeframe to complete the project was good.	11 (4%)	15 (5.5%)	121 (44.2%)	127 (46.4%)
I understand the importance of communicating concepts/ideas in the digital world.	2 (0.7%)	7 (2.6%)	121 (44.2%)	144 (52.6%)

5.6. Knowledge Construction

Of the participants, 82% thought the digital presentation assignment helped them to understand the topic, develop critical thinking skills (75%), develop communication skills (86%), exercise creativity (90%), and learn additional skills (83%). Seventy-five percent of students thought digital presentations were an excellent way to assess students' understanding of the topic. Seventy-six percent of students would encourage academics to use similar assignments in other subjects (Table 8, Figure 5).

Table 8. Student perceptions of knowledge construction in the LGDM assignment for five Science subjects (N = 274).

Question	Frequencies			
	SD	D	A	SA
I believe using digital presentations helped me to understand the topic.	8 (2.9%)	41 (15%)	134 (48.9%)	91 (33.2%)
The digital presentation assignment helped me to develop critical thinking skills.	8 (2.9%)	60 (21.9%)	134 (48.9%)	72 (26.3%)
The digital presentation assignment helped me to develop communication skills.	10 (3.6%)	28 (10.2%)	137 (50%)	99 (36.1%)
The digital presentation helped me to exercise my creativity.	4 (1.5%)	23 (8.4%)	127 (46.4%)	120 (43.8%)
I believe digital presentations are a good way to assess students' understanding of a topic.	20 (7.3%)	49 (17.9%)	117 (42.7%)	88 (32.1%)
I will encourage academics to use similar assignments in other subjects.	17 (6.2%)	48 (17.5%)	124 (45.3%)	85 (31%)
I believe I learnt additional skills by doing this assignment.	14 (5.1%)	34 (12.4%)	125 (45.6%)	101 (36.9%)

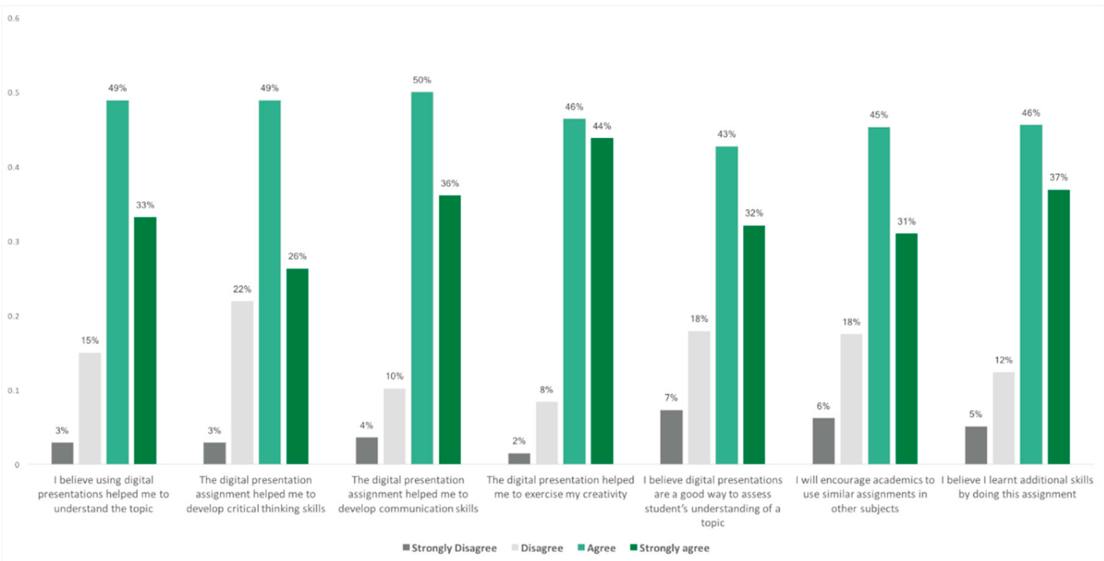

Figure 5. Student perceptions of knowledge construction in the LGDM assignment for five Science subjects (N = 274).

5.7. Open-Ended Questions

Responses to open-ended questions (Q29–Q33) were analysed using thematic analysis (NVivo 11), coded, and classified. For the first open-ended question Q29, (Did you experience any issue with the assignment?) we received 163 responses (60%). Table 9 presents the frequencies of student responses.

Table 9. Categories derived from thematic analysis of open-ended Q29.

Theme	Frequency	%
No issues	110	68
Inadequate skills in digital media creation	20	12
Not understanding the assignment	11	7
Short time to complete the assignment	10	6
Other	12	7

For the second open-ended question (Q30 What did you like most about the assignment?), we received 169 responses (62%). Table 10 presents the frequencies of student responses.

Table 10. Categories derived from thematic analysis of open-ended Q30.

Theme	Frequency	%
Creativity	47	28
Teamwork	38	23
Learning digital media	35	21
Learning subject content	16	10
Different to other assignments	16	10
Self-expression	10	6
Other	7	2

Quotes from students are presented below:

Student 1

"To be able to be creative rather than just another boring report assignment. It was also a fun way to present information and learn about the content. Sufficient time was also given to complete the assignment which was great!"

"I like that there were a few topics that had current cultural/social relevance, e.g., study drugs in universities, abortion drugs, cannabis issues, etc. Would be great to see if all the topics could have some real world social relevance to things happening currently in society and being addressed in the media".

Student 2

"The most enjoyable aspect was definitely the group work (which is rare). It was simply fun to come up with ideas on how to include a joke or how to present a particular point. It's rare that we as students get such enjoyable and fun assignments at this late point in the degree. A much-needed breath of fresh air".

Student 3

"The entire concept was brilliant. At first, I was somewhat skeptical about how useful such an approach would be in learning about a topic. However, I found that by essentially forcing students to break down the general concepts of a given topic for ease of explanation for those of a non-science background, it made understanding the more complex components much easier to not just learn, but actually remember. This was particularly helpful for the final exam in that it made study that much easier, with an incredibly solid foundation on at least one area of study".

For the third open-ended question (Q31 What did you like least about the assignment?), we received 143 responses (52%). Table 11 presents the frequencies of student responses.

Table 11. Categories derived from thematic analysis of responses to open-ended Q31.

Theme	Frequency	%
Nothing	46	32
Group issues	32	22
Inadequate digital media skills	20	14
Understanding the assignment	14	10
Time-consuming	13	9
Not enough time to produce the assignment	5	4
Other	13	9

Quotes from students are presented below:

Student 4

"Group work is always a challenge in that it is hard to know how each individual works and different styles and ways people work".

Student 5

"Groups of four is too big. The assignment should be in pairs so that people learn better. Often groups of four end up affording at least one student to be slacking off".

Student 6

"The effort and time you have to put into making a 5-min video is a lot, you have to make a script, figure out where and when you're going to film (if you're filming), edit etc. It's a lot of time that goes into it. And when there are a lot of other subjects' projects going on at the same time, it's a hard thing to do. With all that effort put in the amount it was worth for the subject was very small, and it seemed like a lot of wasted time".

For the fourth open-ended question (Q32 Do you have any feedback on how to improve this assignment?), we received 129 responses (47%). Table 12 presents the frequencies of student responses.

Table 12. Categories derived from thematic analysis of responses to open-ended Q32.

Theme	Frequency	%
No feedback	48	37
Additional software training	31	24
More assignment instructions	12	9
Small group size	6	5
Start task earlier in the semester	7	5
Equipment available to students	5	4
Ability to choose group members	5	4
More topics to choose from	5	4
Other	10	8

Quotes from students are presented below:

Student 7:

"No, it seemed extremely fluid and was easy to understand what was needed to be done, the assignment allowed students to take control of their learning which I believed got us to be more engaged and keen to produce a good piece of work. It helped in my case in particular that I was quite interested in the topic chosen".

Student 8:

"It was the best assignment I have done throughout my whole university degree and believe other subjects should take a similar approach to learning".

Student 9:

"I think that allowing the students to focus on the social issues associated with drug use and prescription results in a much greater level of critical thinking on the issues. It is too easy to ask a student to present how

a drug functions. Asking ethical questions, the answers to which aren't clear-cut or can be found with a simple google search, ensures a greater level of engagement".

For the last open-ended question (Q33 Is there anything that you would like to say that has not been covered in the previous questions?), we received 55 responses (20%). Table 13 presents the frequencies of student responses.

Table 13. Categories derived from thematic analysis of responses to open-ended Q33.

Theme	Frequency	%
Positive comments about assignment	30	55
No comment	18	32
Other	7	13

Quotes from students are presented below:

Student 10

"Really great assessment, again speaking personally, not having any group troubles meant that this assignment was a breeze and a pleasure to complete (something that I would not have seen myself saying about a pharmacology assignment!)".

Student 11

"Both the subject coordinator and the digital media person were excellent; they showed a genuine interest in the education of their students".

Student 12

"I strongly support the idea to use digital media for some part of course studies or assignments. Skills on using technologies are important skills for students when they seek employment or develop their own business".

5.8. Group Contribution Data

Group contribution data was captured using the SPARKPlus application for three subjects—Geological Processes, Introductory Pharmacology & Microbiology, and Pharmacology 2. The two other subjects had some technical issues implementing the application, and there was missing data. The Relative Performance Factor (RPF) is a measure of the degree of contribution to group work. This factor is calculated from a peer review of group members. Table 14 presents descriptive statistics for the three subjects. Table 15 shows the percentages of students who had optimum, acceptable, or poor performance. Only 6.3%, 7.5%, and 3% of students had a poor contribution level for the subjects Geological Processes, Introductory Pharmacology & Microbiology, and Pharmacology 2, respectively.

Table 14. Descriptive statistics for the RPF—SPARKPlus group contribution.

Subject	N	Min	Max	Mean	S. D	Variance
Geological Processes	96	0.19	1.18	0.99	0.14	0.019
Introductory Pharmacology & Microbiology	40	0.60	1.12	0.99	0.11	0.012
Pharmacology 2	167	0.29	1.15	0.99	0.09	0.007
Total	**303**					

Table 15. Group contribution ranking from three subjects which used the SPARKPlus application to moderate marks.

Contribution Level (%)	Geological Processes	Introductory Pharmacology & Microbiology	Pharmacology 2
Optimum (RPF > 1.0)	60.0	62.5	49.1
Acceptable (RPF = 0.8–1.0)	33.7	30.0	47.9
Poor (RPF < 0.8)	6.3	7.5	3.0

5.9. Grades Attained

Grades were corrected, using the RPF factor, for students who had RPF < 0.8. For example, if a student had an RPF = 0.6, the assessment task was 30 marks, and the group got 25 marks, the final mark would be 25 × 0.6 = 15 marks. The marks were converted to percentages to see how students performed across the different subjects (Table 16). Grade comparison was not possible, as every subject had slightly different rubrics, different learning objectives for the digital media assignment, and various different markers. The marks data were used to triangulate questionnaire responses. The majority of students thought they learnt from the assessment task, as shown by the findings on the knowledge construction data from the questionnaire (Table 8, Graph 4). Table 16 shows that this was the case for most students by displaying the means and standard deviations of marks attained.

Table 16. Mark distribution across the five subjects which implemented LGDM. As the assignment weighting varies across the five subjects, marks were converted to a percentage.

Subject	N	Min	Max	Mean	S. D
Pharmacology 2	169	33	96	79	9.25
Geological Processes	101	67	100	95	7.51
Animal Behaviour and Physiology	106	53	100	77	14.45
Evaluating TCM: Theory, Practice & Research	43	70	95	84	7.83
Introductory Pharmacology and Microbiology	39	61	97	82	12.48
Total	**458**				

6. Discussion

This study is one of the first which has used a comprehensive and practical framework to systematically approach the design, implementation, and evaluation of LGDM assignments. Previous studies did not use frameworks to guide the implementation of LGDM assignments [27,58,74,75]. Other studies used semiotic theory to conceptualise learning with digital media, but included no model to guide the task design, implementation, and evaluation [29,39,76,77]. However, most of these studies are restricted to qualitative surveys and open-ended questions [15,25,27,56] or purely qualitative comments from interviews [43,78]. While students' perspectives provide a valuable dataset in educational research, they cannot be relied on solely to evaluate an intervention. Along with small sample size (from 3 to 79 students), the lack of standardised evaluation approaches and the qualitative nature of these investigations make comparisons between the current study and previous studies problematic. Also, different media types used in LGDM require different production skills, whether they be audio podcast, digital story, animation, screencast, or video [65], adding an extra layer of complexity when comparing studies.

The demographics of participants in this study showed a high percentage of females (63%) from 18 to 29 years old (87%) and high school graduated (65%). They had a positive attitude toward technology for personal/recreational use and for learning (Table 5). Their gender, age, and socioeconomic status could influence their perceptions [79–81]. These results could reflect student exposure to the use of technology for learning at high school, giving them a positive attitude to the LGDM assignment. With the current data, we cannot elucidate if this was the case. Focus groups and individual interviews would be of value.

Triangulating the data from the questionnaire items, the open-ended questions, the group contribution data, and the grades attained indicated that the use of the LGDM Framework enhanced the student learning experience with digital media assignments. Current literature in science education has found similar results, using qualitative surveys and interviews [82–84]. Overall, student attitude toward digital media support was highly positive. Seventy-three percent of students used a storyboard to inform their digital media projects. Storyboards are essential to ensure the production of a quality digital artefact [85] but also to develop conceptual skills for digital media production [38,65,86].

These digital media skills have been highlighted as desirable graduate attributes across all disciplines in the 21st century [54,87,88]. Nevertheless, in LGDM assignments the primary benefit of producing a storyboard is to learn the subject content. Producing a storyboard requires students to search for information, think critically, and summarise their findings, and this is the first step of learning through digital media production [65]. Seventy-three percent of students thought they needed a better understanding of digital media principles. This finding was confirmed by responses to open-ended Q31, where 20 students (14%) said they had poor digital media skills, and to Q32, where 31 students (24%) said they needed additional software training and 12 students (9%) said they needed additional instructions for the assessment. Understanding digital media principles from a one-hour lecture can be overwhelming, and students need post-lecture online activities to reinforce the concepts covered, for example, an annotated online video to highlight the digital media principles applied. Tools such as Kaltura can be used for this purpose. These findings open opportunities to further engage students in additional training during the semester and maybe run digital media drop-in clinics.

Research on LGDM assignments does not often include providing digital media support to students [29,76,77]. There are problems with assessing students on a skill that is not formally taught and relying on the myth of 'digital natives' that postulated that young students who grew up in the digital age are fluent with the use of technology. This notion has been disproved in the literature [89]. Current research in the field of digital literacy has identified that the issue with technology is not ownership or access, but fluency of use [59]. Research has pointed to the need for student support with LGDM assignments [27,54,58]. In this regard, the LGDM Framework offers extensive support to students in acquiring digital media production skills like storyboarding and includes training on software and digital media principles.

An important aspect missing in the current literature on LGDM assignments is the opinions of students on the adequacy of the digital media assignment instructions. In this study, a high percentage of students seemed to understand the assignment (Table 7, Graph 3), although open-ended question Q29 showed that 11 students (7%), and Q31 showed that 14 students, (10%) had issues understanding the assignment. Perhaps those students did not come to the lectures or visit the digital media resources. Communicating the task well is essential because it has been reported that students can become anxious about digital media assignments [57,58,90,91]. Explaining the assignment at the beginning of the semester using the LGDM Framework (Figure 1) and providing early feedback on storyboards from the content and digital media perspectives seem to have a positive impact on students' engagement. None of the responses to the qualitative questions (Q29 to Q33) showed the student task anxiety described in other previous studies [27,55,57,58]. Ninety-seven percent of students understood the importance of communicating concepts/ideas in the digital world. This figure is crucial, as this understanding could act as a factor motivating students to self-regulate their learning using LGDM assignments. Motivational factors such as self-efficacy, goal orientation, task value, attribution for failure, and anxiety are considered in educational psychology the sine qua non of self-regulation processes [92].

Students' attitudes toward LGDM and knowledge construction were highly positive (Table 8, Graphic 4). These findings were confirmed by Q30, where students reported positive attitudes about LGDM regarding creativity (28%), development of teamwork (23%), learning of subject content (10%), and learning about digital media (21%) (Table 10). For the last open-ended question, Q33, 55% of students gave positive comments on LGDM, reinforcing these findings. Creativity was a feature of LGDM reported approvingly by students previously [27,57], as was teamwork [58]. Learning of subject content [26,78,93] and learning about digital media [58] were also highlighted as attractive by previous research. Triangulating the data from this study with the marks attained by participants, it seems that students had an overall positive learning experience using LGDM as an assessment tool. The data available on group contributions (SPARKPlus) (Tables 14 and 15) showed students had positive group work experiences. On average, 94% of students had a healthy groupwork experience. These findings are reinforced by the responses to open-ended question Q30, where twenty-three percent of students said they enjoyed the teamwork. These results are similar to results previously reported for LGDM in science education [27–58], but those studies only used qualitative responses to open-ended questions. The present study is the first to gather group contribution data from the whole cohort of students by using the SPARKPlus peer-review application in LGDM assignments. We postulated that, due to the nature of digital media projects where group members have different roles, students bring different skills complementing each other to the project. A focus group would be required to elucidate if this is the case. Responses to Q31 (What did you like least about the digital media assignment?) contradict these findings, as 22% of students' responses to the survey mentioned group issues. Students who perceived they did not perform well in groups or did not like the idea to work in groups could contribute to this figure. It could also be the case that students receive good SPARKPlus feedback from their peers, but somehow, they felt unsatisfied. Analysing these responses further, three themes were found. Communicating ideas with the group, members' availability, and group conflicts were the issues highlighted by students. Students that contributed to this figure with the open-ended question could be the ones who did not perform well in groups or who were not satisfied with it. Educators often ask students to work in groups, but training on how to work in groups effectively is usually overlooked. A video of 'how to' tips on working in groups could provide support to students in the future.

This study had several limitations which minimise the generalisability of its findings. First, the sample only included science students from a single institution. Future research should consider using large cohorts from a wide range of disciplines and university settings to provide more generalisable findings. Second, the study did not use interviews and focus groups to gain an in-depth understanding of students' attitudes toward LGDM assignments. Third, it would be ideal to compare cohorts of students who developed LGDM assignments using the LGDM Framework with those who did not, to elucidate if there are differences. However, such research would be challenging to design and implement because it could potentially disadvantage some students. Finally, interviews with academics on their perceptions of the validity of the LGDM framework would add an all-around perspective to the results.

The next step in this project is to map the LGDM Framework against self-regulation subscales [94] and measure how students adapt to learning with LGDM assignments. Because LGDM assignments require a high level of autonomy [38] and are time-consuming [63], iterative, and resource-intensive processes [64], self-regulation could be a useful theoretical model for further research in the field [95,96]. Understanding how students self-regulate their learning with LGDM would allow educators to help students acquire and master the necessary skills [95,96] and increase the personalisation of the learning experience [97]. Investigating the self-regulated learning processes of LGDM could lead to future research exploring group work dynamics and co-regulation. It is required to understand self-regulation first as in group work students bring these skills that will affect the group dynamics and therefore how they co-regulate with their peers.

With the affordability of digital technologies and new assessment tools, the challenge now is how to embed them in curricula and how to evaluate their impact on student learning and performance. Higher education institutions should be encouraged to adopt a systematic approach to introducing LGDM assignments. The LGDM Framework offers educators the opportunity to align digital media tasks to learning outcomes and graduate attributes, to plan student training on digital media principles and production, to ensure effective teamwork, to develop rubrics for evaluation, and so on. From the learner's perspective, LGDM assignments require further consideration for successful implementation. For example, 50% of students have never produced a video for assessment purposes [27], and they are more familiar with written tasks. Student training and scaffolding in storyboarding, digital media principles, and digital media production is essential to support them when undertaking the assessment task and learning experience. The LGDM Framework has been designed as a student-centred approach to engaging students with their learning while also developing digital media literacy. Also, considering intellectual property and copyright issues in the student training about LGDM assignments [61,98] will help foster ethical behaviour in the digital space. Further studies across different disciplines and university settings to further develop the LGDM framework would be highly desirable.

7. Conclusions

Methodological triangulation of the datasets shows evidence that the LGDM Framework helped students to learn using digital media by communicating the assessment design, scaffolding their learning experience, putting in place a mechanism to ensure effective group work, and providing them with relevant feedback. The present study is the first to use a systematic approach to LGDM assignments that included communicating the task to students, formal student training, mechanisms to ensure group contribution, and evaluation of the learning experience. Academics can use the validated survey developed for this study to improve their LGDM assignments. In conclusion, students have a generally positive attitude toward LGDM as an assessment tool. Students highlighted creativity, teamwork, digital media support, learning of subject content, and self-expression as the main features of the assessment.

Author Contributions: Conceptualization, J.R.; Formal analysis, J.R.; Investigation, J.R.; Methodology, J.R.; Supervision, P.M.; Validation, J.R.; Writing—original draft, J.R.; Writing—review & editing, J.R. and P.M.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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Chapter 4:
Materials and Methods

Chapter 4 overview

Materials and Methods

As a result of the pilot study conducted (Chapter 3, paper 5), the first paper for this chapter proposed a methodological approach to evaluate LGDM assignments in the discipline of science, which could also be adopted in other disciplines. The approach fulfilled an identified need within the field, for an effective method to evaluate LGDM assignments. Current approaches to evaluate LGDM assignments are qualitative and may portray the view of students who have positive experiences. The evaluation framework in this study is a holistic approach that uses a mixed-methods (Tashakkori & Teddlie, 2010) to systematically evaluate student learning experience when LGDM is designed following the theoretical frameworks discussed in Chapter 3. The quantitative component proposed the use of a self-regulation questionnaire, marks attained and SPARKPlus group contribution data. The qualitative component used open-ended questions to gauge student attitude towards LGDM assignment, individual interviews based in motivational constructs such as self-efficacy (Pintrich & Zusho, 2007), attribution for failure (Licht & Dweck, 1984), task value (Pintrich, 2004), and anxiety (Zimmerman, 1989). All data were brought together by using methodological triangulation (Bekhet & Zauszniewski, 2012) to validate the student responses due to the nature of the self-reported questionnaire. This framework was used to guide the paper in Chapter 5.

The second paper explored the validity and reliability of the self-regulation questionnaire designed to study self-regulation processes when students engage in the production of LGDM assignments. This was also a recommendation raised on the pilot study (Chapter 3, paper 5). The subscales used were informed by previous research (Barnard, Lan, To, Paton, & Lai, 2009; Nota, Soresi, & Zimmerman, 2004; Pintrich & Zusho, 2007; Schunk & Zimmerman, 1997; Zimmerman & Schunk, 2011). As self-regulation processes are highly context-dependent (Zimmerman, 1998; Zimmerman & Tsikalas, 2005), using previous questionnaires may be invalid for blended or online settings due to the dramatic differences between both environments and possibly the student profiles (Barnard-Brak, Paton, & Lan, 2010; Barnard et al., 2009). Exploratory and Confirmatory Factor Analysis was consequently used to validate the subscales and items of the questionnaire created for this study. A total of six subscales such as Time Management, Goal Setting, Environment Structuring, Task Strategies, Help-Seeking from People, and Help-Seeking from the Internet were validated. Overall 28 items passed the validation within these subscales.

Both instruments, the evaluation instrument and validated self-regulation questionnaire, in conjunction with the theoretical frameworks presented in Chapter 3, were used to test the following research questions for this project in Chapter 5:

1. Are students self-regulating their learning when LGDM assignment design follow a systematic approach?
2. How does a systematic approach guided by theoretical frameworks impact the overall student learning experience with LGDM assignments?

Papers are presented below in the order of appearance:

Reyna, J., Hanham, J. & Meier, P. (2018). A Methodological Approach to Evaluate the Effectiveness of Learner-Generated Digital Media (LGDM) Assignments in Science Education. In T. Bastiaens, J. Van Braak, M. Brown, L. Cantoni, M. Castro, R. Christensen, G. Davidson-Shivers, K. DePryck, M. Ebner, M. Fominykh, C. Fulford, S. Hatzipanagos, G. Knezek, K. Kreijns, G. Marks, E. Sointu, E. Korsgaard Sorensen, J. Viteli, J. Voogt, P. Weber, E. Weippl & O. Zawacki-Richter (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology* (pp. 303-314). Amsterdam, Netherlands: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/184211/.

Reyna, J., Hanham, J., Vlachopoulos, P., & Meier, P. (2019). Using factor analysis to validate a questionnaire to explore self-regulation in learner-generated digital media (LGDM) assignments in science education. *Australasian Journal of Educational Technology*, 35(5), 128-152. https://doi.org/10.14742/ajet.4514

Certificate of authorship and originality

This chapter includes a peer-reviewed conference paper for EdMedia from the American Association for Computers in Education (AACE) and a journal paper published at the Australasian Journal of Educational Technology (AJET). I certify that the work presented in this chapter has not previously been submitted as part of the requirements for a degree. I also certify that I carried most of the work presented in this paper.

- Jorge Reyna wrote most of the first manuscript (~95%), and the second manuscript entirely (100%)
- Jose Hanham wrote ~5% of the first manuscript and provided feedback to address changes requested for the second paper
- Peter Meier and Panos Vachoupolus provided feedback on the concept before writing the papers.
- Peter Krockenberger did the proofread of all manuscripts.

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03/31/2019

A Methodological Approach to Evaluate the Effectiveness of Learner-Generated Digital Media (LGDM) Assignments in Science Education.

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Abstract: Learner-Generated Digital Media (LGDM) has been an essential part of teaching, learning and assessment practices in Higher Education for more than a decade. Nevertheless, the field is still considered under-theorised, under-researched and in its infancy. Research studies of LGDM have been mainly qualitative, and implementations of LGDM have rarely been underpinned with systematic approaches that take into account factors such as the training needs of students and appropriate rubrics. Empirical findings from research on LDGM have tended to have limited generalisability, due to the majority of studies drawing on relatively small sample sizes. This paper aims to propose a framework, using a longitudinal, mixed-methods approach to examine changes in students' self-regulation processes overtime and their relationships with individual and group performance on LDGM assignments in a range of science-based subjects. We also intend to capture group contribution data, Learner Management System (LMS) logs and marks attained with the LGDM task. The qualitative components will include open-ended questions, individual structured interviews and focus groups. Methodological triangulation will be used to evaluate the student learning experience with LGDM assignments. The framework appears to be one of the first systematic approaches in the literature to evaluate LGDM as an assessment tool in higher education. Work in progress and research needs are presented.

Introduction

Learner-Generated Digital Media as an assessment tool arose in Higher Education more than a decade ago as a reflective tool in teacher education. For example, students have been asked to construct a digital story illustrating their learning experiences after completing a school practicum (Kearney & Schuck, 2003, 2005; Ludewig, 2001; Rich & Hannafin, 2009; Theodosakis, 2001). In the science disciplines, approaches to LDGM have focused on active learning, developing inquiry and research skills (Hoban, Nielsen, & Shepherd, 2015). Studies of LGDM have been in the life sciences such as biology (Pirhonen & Rasi, 2016), health (Pearce & Vanderlelie, 2016), pharmacology (Henriksen, Henriksen, & Thurston, 2016; Nielsen, Hoban, & Hyland, 2017; Reyna, Meier, Geronimo, & Rodgers, 2016), and geology (Reyna, Horgan, Ramp, & Meier, 2017). Additionally, LGDM has been reported in other areas such as computer sciences (L. Powell & Robson, 2014; Vasilchenko, Green, Qarabash, Preston, Bartindale, & Balaam, 2017), mathematics (Calder, 2012; McLoughlin & Loch, 2012), and engineering (Anuradha & Rengaraj, 2017).

Scholars have posited that LDGM can promote student reflection, engagement in active learning and foster creativity and innovation (Hoban et al., 2015; Nielsen et al., 2017). Moreover, learner-generated content is believed to have the potential to add value to hands-on experience and peer-driven learning (Berardi & Blundell, 2014). Other possible benefits of LGDM include the development of graduate qualities such as interpersonal communication, project planning and time management skills (Morel & Keahey, 2016). Additionally, LGDM may help to develop critical thinking, report writing and research skills (Ohler, 2009). Using digital media assignments can generate new ideas and transform static information into dynamic understanding (Hobbs, 2017). When LGDM assignments are designed as group tasks, students are given the opportunity to organise themselves, make decisions, negotiate tasks and manage conflict.

The theoretical frameworks used in LGDM assignments include semiotic theory (Hoban et al., 2015), self-explanation (Johnson & Mayer, 2010), and recently the internalisation effect (Hobbs, 2017). Several variables in these models, for example, self-explanations, are thought to mediate learning with digital media. In general, when students create a storyboard for digital media, they need to engage in researching their topics and curating the content, which should be evidence-based. When the storyboard is finalised, they will discuss and brainstorm with their peers regarding the mediums with which to represent their topics, for example, images, text, animations, video, and so on. When students move to the building phase of their LGDM assignments, key concepts acquired in previous steps will be reinforced in this phase of the assignment. For example, if students are required to produce an animation of a chemical reaction, they will continuously have the concept in their minds while using the digital tools to complete the task. They will need to play the animation many times to correct possible glitches, and to improve it.

LGDM as an assessment tool is under-theorised and under-researched. Theoretical frameworks have been formulated taking into account technical know-how and instructional principles such as the CASPA Model (Consume, Analyse, Scaffold, Produce and Assess) (Blum & Barger, 2017), or the AACRA model (Acess, Analyse, Create, Reflect and Act) (Hobbs, 2017). There are also models that include pedagogies such as the nine stages, teacher strategies and peer learning structures (Kearney et al., 2005), and the learning design model for digital stories (Kearney, 2009). Those frameworks have been contextualised for the discipline of education and due to their intricacies, are arguably not readily applicable to other disciplines such as Science. Additionally, there is a gap on the literature regarding how to evaluate LGDM assignments in the classroom. This research presents a novel theoretical framework to evaluate learning when LGDM is used as an assessment tool in Science Education. The framework can be extrapolated to other disciplines.

Literature review

Digital media as a vehicle of learning has been used since the explosion of Web 2.0 Tools (Bower, Hedberg, & Kuswara, 2010; O'Reilly, 2009; Solomon & Schrum, 2007). Initially, tertiary educational institutions used wikis and blogs (Boulos, Maramba, & Wheeler, 2006; J. Williams & Jacobs, 2004), and recently, more rich forms of digital media such as video and blended media (Hoban et al., 2015). The technology evolution characterised by the proliferation of smartphones, tablets and prosumer electronics such as video cameras, digital cameras, action cams, and so on, made this possible (Reyna, Hanham, & Meier, 2018). Currently, there appears to be no consensus on how to define digital media for learning. To illustrate, numerous labels have been used to describe digital media for learning including, learner-generated video, student-generated video, multimedia generated content, screencast, digital presentations, new media, and Learner-Generated Digital Media (LGDM). Digital media for learning can be considered a highly atomised field of research. The scope of this research considered the following media types: animation, screencast, multimedia, video and blended media.

LGDM approaches in most of the cases are guesswork and rarely based on valid theoretical frameworks. For example, many of the studies have been predicated on the myth of *digital natives* (Prensky, 2001) and have neglected the need to teach students the digital media principles such as layout design, colour theory, typography, use of images and basic video techniques. These skills are considered part of the grammar of the 21st century (Reyna et al., 2018). Many educators outside the discipline of creative arts, digital media, visual design and related disciplines are unlikely to have an understanding of these principles and therefore tend to lack the necessary knowledge and skills to effectively teach their students about these principles (Malamed, 2015). Limited knowledge of digital media principles is problematic in some respects, including the design of appropriate marking rubrics and identifying student training needs in digital media.

Table 1 below presents a summary of studies in digital media for learning. Studies in the field of LGDM have largely been qualitatively consisting of case studies, qualitative survey evaluation, in-depth interviews and analysis of digital media produced by students. While qualitative data is crucial to have an in-depth understanding of a situation, is not scalable to large cohorts of students.

Table 1: Summary of LGDM studies up to date.

Author	Discipline	N	Framework	Media type	Methodology	Outcome
(Cox, Vasconcelos, & Holdridge, 2010)	Information and knowledge management	19	Ivers and Barron's (2006) model Decide-Design-Develop-Evaluate	Video	Survey + open-ended questions	The students seemed engaged, copyright and group issues
(Greene & Crespi, 2012)	Marketing & accounting	73	No framework	Video	Survey + open-ended question	Deeper learning; more engaging learning; more active learning; experiential learning; more personal involvement
(Anderson, 2013)	Human geography	?	No framework	Video	Qualitative comments	Experiential and active learning
(Hoban & Nielsen, 2013)	Preservice science teachers	3	Semiotics (Peirce, 1931)	Slowmation	Qualitative comments	Learning occurs by multiple representations of content and social interaction
(Kearney, 2013)	Preservice primary teachers	33	Digital Story Framework by Kearney 2011	Video	Survey, open-ended questions, focus groups	Enhanced students understanding of teaching with technology
(Pearce, 2014)	Pharmacy	92	No framework	Animation, video, blended media	Survey, open-ended question.	The multimedia product effectively engaged students in the understanding and skill development.
(L. M. Powell, 2015)	Computing	255	No framework	Screencast	Assessment scores and final mark	Screencast improved test scores
(Braun, 2017)	Medical imaging	51	No framework	Digital presentations	Survey and marks attained.	Study compares online vs face-to-face presentations
(Coulson & Frawley, 2017)	Physiotherapy	79	No framework	Multimedia	Survey, open-ended questions	Students liked group work and collaboration but need support on the task.
(Georgiou, Nielsen,	Science	2	Semantic density	Multimedia	Analysis of artefacts	Inconclusive

Doran, Turney, & Jones, 2017)						
(Nielsen et al., 2017)	Pharmacolog y	3	Semiotic theory, Peirce, 1931	Blended media	Interviews and analysis of artefacts	Development of communication skills via multimodal explanation
(Campbell & Cox, 2018)	Education, Postgraduate course	10	ICSDR Framework to create digital video	Video	Surveys, online group discussion, storyboards and video analysis	Authentic and personalised learner experience, academic content and skills gained

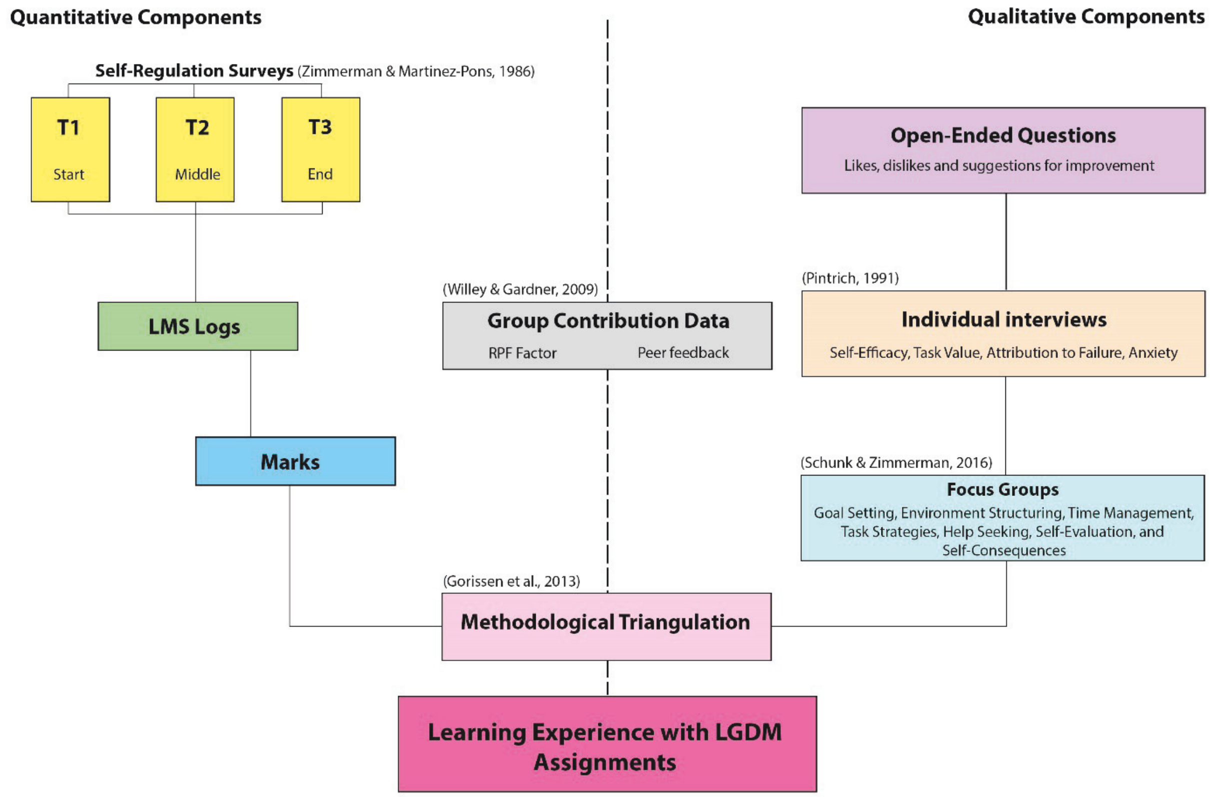
From table 1, it is evident that methodological approaches to evaluate LGDM are still in the embryonic stages of development. Most studies used qualitative methods, with very few based on sound theoretical frameworks to guide the implementation of digital media assignments.

The purpose of this paper is to formulate a framework to evaluate LGDM using self-regulation. Self-regulation processes can be defined as the thoughts and actions that students plan and implement to achieve a learning goal (Zimmerman, 2002). Research suggests that self-regulation is associated with improved student performance and achievement (Azevedo & Cromley, 2004), depth of student thinking (Jenson, 2011), and students' focus on their learning processes (Ottenhoff, 2011). Self-regulation involves a learner being able to monitor the learning process and to identify and implement strategies to succeed (Miller, 2015). In LGDM assignments, learners are active participants in the learning process, and self-regulation has an important role to ensure learners engage with the development of their evidence-based content (Storyboard) to produce a digital media artefact. Later on, when the storyboard is finalised, learners will move to a multimodal representation of content using images, audio, text, video, and so on. Finally, the digital media production phase will also depend on self-regulation processes due to the nature of the task, being time-consuming and iterative. Self-regulation has been used as powerful theoretical concepts to study student learning and achievements.

The framework

The framework to evaluate learning with LGDM assignments (Figure 1) was developed using a mixed-methods approach (Tashakkori & Teddlie, 2010). The methodology is a combination of quantitative and qualitative data to gain an in-depth understanding of a situation.

Figure 1: A framework to evaluate the effectiveness of Learner-Generated Digital Media (LGDM) Assignments in Science education.



Quantitative components of the framework

Survey instruments: Part of the quantitative section of the framework uses a psychometric component, (surveys represented in yellow rectangles, Figure 1). Psychometric tools aim to measure skills and knowledge, abilities, attitudes, personality traits and educational achievement (Schunk & Zimmerman, 2011). The questionnaire subscales on self-regulation (Table 2) were based on previous research (Wolters, Pintrich, & Karabenick, 2005; Zimmerman & Pons, 1986). The items from this survey were chosen and adapted because of their generality, and internal reliability scores from a validated self-regulation survey for blended learning (Barnard, Lan, To, Paton, & Lai, 2009). Additionally, constructs such as digital media for learning, digital media for a career, assignment motivation, assignment ownership, and marks were developed specifically for this study. The items were measured on a 4-point Likert scale: 1 Strongly Disagree, 2 Disagree, 3 Agree, and 4 Strongly Agree. As additional constructs were added, there is a need to validate the survey items. For this purpose, a multivariate statistical approach, Exploratory and Confirmatory Factor Analyses procedure will be used (B. Williams, Onsman, & Brown, 2010). Exploratory Factor Analysis (EFA) is used when the researcher has no expectations of the number of constructs to be measured by the questionnaire (Costello & Osborne, 2005). The primary objective is to reduce a large number of variables into a smaller set of factors. This process ensures that there is a relationship between variables and latent constructs. In contrast, Confirmatory Factor Analysis (CFA) is used by the researcher to test previously verified factor structures, for example, those factors identified using an EFA and then tested with a separate sample with a CFA. Both, EFA and CFA help to refine a proposed theory (Harrington, 2009).

Based on the self-regulation subscales and survey items presented in Table 2, data will be gathered at three-time points during the semester: for T1 (Week 2), T2 (Week 6), and T3 (Week 10).

Table 2: Questions on digital media for learning, digital media for a career, assignment motivation, assignment ownership and self-regulation. Questions to be asked at T1, T2 and T3.

Subscale	Survey Item
Digital media for learning (DML)	1. I learn about the subject content while creating digital media 2. Learning the subject content using digital media is good 3. Digital media helped me to learn the subject content 4. I enjoy learning the subject content using digital media
Digital media for career (DMC)	5. Digital media skills are important for my career 6. I will apply digital media skills in my future career 7. Having digital media skills is an advantage for my career 8. Digital media skills are needed now regardless the career you are in
Marking scheme - Motivation/ mark driven (MM)	9. I am driven by marks 10. If the assignment is not worth too many marks, I will put less effort on it 11. I will perform the best I can no matter how many marks the assignment is worth 12. I am driven by learning rather than marks
Video hosting and distribution - Motivation/ownership (MO)	13. I feel a high sense of accomplishment when producing a digital media assignment 14. Sharing a digital media assignment online makes me feel a high level of accomplishment 15. I would like to produce a digital media assignment that I can be proud of
Student Training - Task strategies (TS)	16. I take notes from the digital media lecture to be more prepared for the task 17. I take notes from the digital media workshop to be more prepared for the task 18. I visit the digital media resources inside the LMS 19. I visit additional resources online about digital media
Goal Setting (GS)	20. I set standards for my assignments 21. I set goals to help me manage time for my assignment 22. I set short-term goals when preparing my digital media assignment 23. I set long-term goals when preparing my digital media assignment
Environment Structuring (ES)	24. I choose the location where I work on my digital media assignment to avoid distraction 25. I find a comfortable place to work on my digital media assignment 26. I know where I can work most efficiently for my digital media assignment 27. I choose a time with few distractions for working for my digital media assignment
Time Management (TM)	28. I allocate extra study work time for my digital media assignment 29. I schedule regular times a week to work on my digital media assignment 30. I helped manage my time efficiently, so I was not rushing around to finish at the last minute 31. I follow my planned schedule for completing the digital media project
Help-seeking (HS)	32. I find people who are knowledgeable in subject content so that I can ask them for help 33. I share the difficulties I am having with the digital media assignment with my classmates

	34. I am persistent in getting help for my assignment from the instructor 35. I seek help on the Internet about my assignment topic 36. I seek help on the Internet about digital media creation
Self-Evaluation (SE)	37. I ask myself questions about the assignment material when preparing the digital media assignment 38. I check with my classmates to find out how I am doing in my assignment 39. I check with my classmates to find out what I am learning that is different from what they are learning 40. I reflect on what I have learnt on my assignment

Group contribution data: As LGDM projects are mostly group work due to the workload involved to develop digital artefacts. The SPARKPlus application will be used to ensure equity in group contribution. This application is a student peer review tool that identifies free riders and non-contributors in group work (Willey & Gardner, 2010). A group contribution rubric was designed for subjects using LGDM assignments (Table 5). The SPARKPlus application allows academics to upload student groups using an Excel file extension. Students will be granted access to SPARKPlus towards the end of the semester. The system used a slider with a scale such as NC = No Contribution, WB = Well Below Average, BA = Below Average, AV = Average, and AA = Above Average. SPARKPlus generates a RPF factor which is a coefficient that measures group contribution. If a student has an RPF >1 indicates an excellent contribution to the group, between 0.8 and 1, good contribution and under 0.8 can indicate group issues. When students review their peers, they need to justify the rating they gave to them and provide feedback inside SPARKPlus. The feedback will generate a rich source of qualitative data. That is the reason why SPARKPlus tool sits in the middle of the framework (Figure 1, grey rectangle).

Table 3: Group contribution rubric for LGDM assignments using SPARKPlus student peer-review application

Item	Description
1	Disciplinary/subject input for the project
2	Punctuality and time commitment
3	Contribution to original ideas
4	Communication skills and work effectively as part of the team
5	Focus on the task and what needs to be done

LMS Logs: Students undertaking the LGDM assignment need to have access to a section inside the LMS called “Digital Media Resources’. The folder will contain: (1) welcome to digital media presentations video; (2) the digital media principles interactive lecture; (3) Frequent-Asked Questions on LGDM assignments; (4) example of a storyboard for digital media creation; (5) samples of digital media artefacts developed by students in previous years, and; (6) a marking rubric for the assignment. The resources need to be trackable to measure student engagement with the material and logs will be downloaded from the LMS at the end of the semester.

Marks attained: Student marks for subjects using LGDM assignments are important data, linked to the learning experience using digital media for learning. If the comparison between different cohorts is required, these marks should be converted to percentages as different subjects will have different weights for the LGDM assignment. Gathering student marks are essential to evaluate educational interventions (Phillips, McNaught, & Kennedy, 2012).

Qualitative components

The qualitative section of the framework includes a comprehensive set of demographic questions to be asked to students at the beginning of T1 (Table 4). Open ended-questions will be gathered at the end of T3 (Table 5). Individual structured interviews to gauge motivational factors (Table 6) (Pintrich, 1991), and focus groups questions on self-regulation (Table 7)(Schunk et al., 2011) will be gathered towards the end of the semester.

Table 4: Demographic questions to be asked at the beginning of T1.

Item	Question
1	What is your student number?
2	What is your gender?
3	What is your age?
4	Is English your first language?
5	What is the highest level of education you have completed?
6	In what degree, you are currently enrolled?
7	What is your year of study?
8	Are you the first member of the family to come to university?
9	What is your employment status?
10	Are you a local or international student?
11	What is your postcode?
12	What devices do you own?

Table 5: Open-ended question to be asked to students at the end of T3.

Item	Question
1	What did you like about the digital media assignment?
2	What did you like less about the digital media assignment?
3	Do you have any suggestion on how it can be improved?
4	Do you have any additional comment?

Table 6: Individual interview questions based on the motivational theory

Category	Reference	Question
Self-Efficacy	A positive relationship has been established between self-efficacy and self-regulation (Pintrich & Zusho, 2007).	Did you feel you have the knowledge and skills to complete the digital media project?
Task Value	Students who attach a high value to the task will use deeper cognitive and metacognitive strategies for learning (Pintrich, 2004).	How did you find the digital media project usefulness for your learning and development of skills?
Attribution for failure	Students who rate uncontrollable factors (luck, ability and task difficulty) as their reason for failure or success does not have learning tendencies (Licht & Dweck, 1984).	Did you feel there were uncontrollable factors beyond your knowledge that could affect the outcome of your digital media project?
Anxiety	Can affect negatively self-regulated learning undermining cognitive and metacognitive learning processes (Zimmerman, 1989).	Did you feel anxious about the digital media project?

Table 7: Focus groups questions to understand self-regulation further when LGDM is used as an assessment tool.

Category	Questions
Goal setting	What were your study goals for the digital media project? What have you done to achieve your goals? Would you define your goals to be: learning-oriented or performance-based goals?
Environment structuring	How did you focus attention on the digital media project?
Time management	How did you distribute your time during the week/semester to work on the digital media project?

Task strategies	How did you learn the skills required to create the digital media project?
Help-seeking	How did you seek for help for the completion of the digital media project?
Self-evaluation	From 1 to 5 (1=poor and 5=excellent) how would you rate your performance on the digital media project? What are the reasons for your current performance? What would you do to improve your performance on the digital media project?
Self-consequences	Did you achieve your goals on the digital media project? How do you feel about it?

Methodological triangulation: When a research study is based on one source of data and one method to analyse, it can distort the reality being investigated (Cohen, Manion, & Morrison, 2002). The distortion can occur for example by errors in the interpretation of the survey questions by the respondents or changes in their attitudes (Sieber, 1973). Accuracy in results can be increased by using multiple data collection techniques and multiple analysis within a study to answer research questions. This approach is known as methodological triangulation (between-method) (Gorissen, Bruggen, & Jochems, 2013). The proposed framework will use this technique to increase the credibility of the data and to gain an in-depth understanding of learning with LGDM assignments. It is important to know what students had to say, but it is crucial to link their comments to their actions. For example, if students indicate that they agree on a survey item that they often use the online resources for the LGDM assignment, and the LMS logs show the same pattern, this will give more creditability to the study.

Work in Progress

This research gathered data from seven Science student cohorts (Year 1 to 3, n=1,687) during Autumn semester in 2017 following the proposed Framework. For the self-regulation surveys, students were asked to complete them at three points in time during the semester for T1 (Week 2), T2 (Week 6) and T3 (Week 10). The full participant sample was split in two. Exploratory Factor Analysis was employed with T1 and T2 + T3 with half the sample to identify factor structures. Factors were extracted using the Principal Axis Factoring procedure. The criteria used to determine the number of factors to extract were eigenvalues greater than one, scree test, and most importantly, theoretical interpretability. The self-regulation factors remained the same for the T1 and T2+T3. Confirmatory Factor Analysis was used with T1 and T2 + T3 with the other half of sample, to test the validity of those factor structures identified in the EFA. Parameter estimates (i.e. factor loadings, modification indices, error variances) and a combination of fit indices (e.g., RMSEA, CFI) were examined when assessing confirmatory factor (measurement) models. So far, thirty-two out of forty self-regulation items were validated. Survey data is currently analysed using descriptive statistics, paired sample T-Test, ANOVA, correlation and regression. The results will be linked to the rest of the datasets (LMS logs, marks, SPARKPlus data, and qualitative datasets) using methodological triangulation. Future publications will cover the findings and validate the proposed framework.

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Using factor analysis to validate a questionnaire to explore self-regulation in learner-generated digital media (LGDM) assignments in science education

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This research is a validation study of a survey instrument to assess student self-regulation which aims to fill a methodological gap by capturing self-regulation processes while completing learner-generated digital media (LGDM) assignments. For this purpose, the study developed and validated a self-regulation learning questionnaire. Data were gathered from seven science subjects (Years 1 to 3, *n* = 341) which used LGDM assignments during Semester 1, 2017. Students were asked to complete a 40-item online questionnaire. The questionnaire was administered at three times during the semester (Weeks 2, 6, and 10). Exploratory factor analysis was used to identify factor structures, followed by confirmatory factor analysis to test the validity of the constructs defined by exploratory factor analysis. Analysis of the data revealed a ten-factor structure – six concerning self-regulation, two concerning student attitudes towards LGDM assignments, one concerning assignment ownership, and one concerning assignment motivation. The variables empirically verified in this study have important practical implications, as they could provide educators with the direction in which to target interventions to improve learners' experiences with LDGM. The study findings also contribute to the field by providing scholars with a validated research instrument that can be used in future studies.

Introduction

Learner-generated digital media (LGDM) refers to digital artefacts developed by students as an assessment task which communicates a message to an audience, such as their peers or the general public (Reyna, Meier, Geronimo, & Rodgers, 2016). It has been used for the last decade in higher education as a vehicle of reflection for pre-service teachers (Hoban, Nielsen, & Shepherd, 2015; Kearney, 2009, 2013; Kearney & Schuck, 2005). In other disciplines, such as marketing and accounting (Greene & Crespi, 2012), human geography (Anderson, 2013a), pharmacy (Pearce, 2014; Pearce & Vanderlelie, 2016), computing (Powell & Robson, 2014), medical imaging (Braun, 2017), and physiotherapy (Coulson & Frawley, 2017), LGDM has focused on teaching subject content. Nonetheless, examination of the literature suggests that LGDM is in its embryonic stages and is under-researched and under-theorised (Campbell & Cox, 2018; Hakkarainen, 2009; Hoban et al., 2015; Potter & McDougall, 2017).

The main issue with LGDM assignments is the lack of a practical model for designing, implementing, and evaluating the assessment task in the classroom. Many studies on LGDM do not rely on a framework to approach assessment design (Anderson, 2013a; Braun, 2017; Coulson & Frawley, 2017; Greene & Crespi, 2012; Pearce & Vanderlelie, 2016; Powell & Robson, 2014). Other studies use frameworks contextualised within the discipline of education (Kearney, 2009, 2013), and it is unclear how well these frameworks extrapolate to other subjects, such as sciences. Finally, some studies use semiotic theory (Hoban & Nielsen, 2013; Nielsen, Hoban, & Hyland, 2017), semantic density theory (Georgiou, Nielsen, Doran, Turney, & Jones, 2017), and instructional design models (Cox, Vasconcelos, & Holdridge, 2010), but these approaches often overlook the need for student training to develop digital media production skills.

From the evaluation perspective, typical problems with LGDM research are the small sample sizes used in studies and the qualitative nature of methods to evaluate the intervention. Many LGDM researchers have used qualitative surveys and open-ended questions (Cox et al., 2010; Greene & Crespi, 2012; Kearney, 2013; Pearce & Vanderlelie, 2016), analysis of surveys and marks attained (Braun, 2017), or purely qualitative comments from interviews (Anderson, 2013b; Hoban & Nielsen, 2013). The surveys reported in the research literature often have not been previously validated to ensure correlation between the questions asked and the constructs under study. While qualitative data provides some valuable insights into student perceptions, its results cannot be generalised to the classroom. Along with small sample size and lack of a standardised evaluation model, the qualitative nature of these investigations makes comparisons between studies problematic. Additionally, different media types used in LGDM – such as audio podcast, digital story, animation, or video – require different production skills, adding an extra layer of complexity when comparing studies.

This research used a comprehensive model, the LGDM implementation framework (Reyna & Meier, 2018), as a theoretical underpinning to guide the systematic design of the LGDM task. Previous studies have used the LGDM framework in science education (Reyna, Hanham, & Meier, 2018c; Reyna, Horgan, Ramp, & Meier, 2017; Reyna et al., 2016). Elements of the framework include pedagogies, student training, video hosting, marking scheme, group work, feedback, reflection, and evaluation. Mapping of these elements against self-regulation subscales sought to capture the dynamic nature of students' self-regulation while completing LGDM assignments.

The goals of the research were to explore and validate the psychometric properties of a survey instrument designed to measure self-regulation where the LGDM implementation framework had been used to guide assignment design and implementation in science subjects. Additionally, the study included measurements of student attitudes towards the use of digital media creation for learning, use of digital media in their careers, and assignment motivation and ownership.

Literature review

Self-regulation is a psychological construct defined as judgements, feelings, and activities that are planned and implemented to achieve personal goals (Zimmerman, 2002) and that are essential for succeeding in academic, professional, and personal life. From the lens of social cognitive theory, self-regulation is a mixture of personal, behavioural, and environmental processes that interact (Bandura, 1991). There is research evidence suggesting that self-regulation is related to student academic performance and achievement (Azevedo & Cromley, 2004; Broadbent & Poon, 2015; Richardson, Abraham, & Bond, 2012), as well as to the depth of student thinking (Jenson, 2011). There is also evidence to suggest that strategies employed by students to self-regulate their learning (Barnard-Brak, Paton, & Lan, 2010), as well as the frequency with which they use those strategies, may vary (Dörrenbächer & Perels, 2016).

A self-regulated student can monitor his or her learning and identify and implement strategies to succeed (Miller, 2015). Self-regulation learning strategies are important in traditional classrooms (Cleary & Zimmerman, 2012; Inan, Yukselturk, Kurucay, & Flores, 2017) and in blended learning contexts (Zhu, Au, & Yates, 2016), and they are particularly critical in online learning environments (Azevedo & Cromley, 2004; Inan et al., 2017; Yukselturk & Bulut, 2007). The autonomous nature of online learning and the fact that instructors may have difficulty facilitating learning activities due to the lack of face-to-face interaction means that students need to be self-regulated learners to succeed (Artino & Stephens, 2009; Barnard, Lan, To, Paton, & Lai, 2009; Broadbent, 2017). Also, previous research has highlighted that self-regulated learning strategies are more frequent in online settings (Kuo, Walker, Schroder, & Belland, 2014).

A set of subscales has been described in the literature which measures self-regulation learning and is used to guide development of questionnaire items (self-regulation learning questionnaires). These subscales have been extensively reviewed (Barnard, Lan, To, Paton, & Lai, 2009; Nota, Soresi, & Zimmerman, 2004; Pintrich & Zusho, 2007; Schunk & Zimmerman, 1997; Zimmerman & Schunk, 2011) (Table 1).

Table 1
Self-regulation subscales for learning

Subscale	Description
Environment structuring (ES)	Learners need to structure their physical learning environment (e.g., home, library, or elsewhere) to avoid disruptions (Zimmerman, 1995).
Goal setting (GS)	Learners need to set their goals and orientation towards their studies (Pintrich, Smith, Garcia, & McKeachie, 1991).
Time management (TM)	Refers to effective time allocation when completing a task or activity (Dabbagh & Kitsantas, 2004). Learners need to schedule, plan, and manage their study time (Chen, 2002).
Task strategies (TS)	Describes student approaches to learning tasks, such as note-taking and preparation of questions to ask educators (Zimmerman, 2002).
Help-seeking (HS)	Considered a social component of self-regulation (Hodges, 2005), this is defined as the learner's ability to seek academic help (e.g., from peers, instructors) in an adaptive manner and to promote their learning (Lynch & Dembo, 2004).
Self-evaluation (SE)	Defined as the learner's capacity to monitor and evaluate personal effectiveness concerning specific learning tasks (Winne & Hadwin, 1998).
Self-consequences	Refers to what learners regard as reward or punishment for success or failure in a learning task (Nota et al., 2004).

Identifying self-regulation learning skills is crucial. They are learnable skills, and educators can help students to acquire and master them (Azevedo & Cromley, 2004; Dabbagh & Kitsantas, 2004). For LGDM assignments, students need to research their topics (storyboarding) and review online training materials about producing digital media. As such, we propose that there is a component of self-regulated learning relating to searching for information and a component relating to learning digital media production. In LGDM assignments, students must develop a high level of autonomy to complete the task successfully. Only a few studies on LGDM have reported providing formal student training (face-to-face or blended) in digital media production (Reyna, Horgan, et al., 2017; Reyna et al., 2016). In many the cases, students needed to seek digital media production training materials online (e.g., YouTube.com, Lynda.com). When students plan their LGDM assessment tasks with their groups and engage in planning, scheduling meetings, seeking help, developing task strategies, and so forth, they will need to use self-regulation learning strategies. Digital media production has been characterised as time-consuming, iterative, and resource-intensive (Musburger & Kindem, 2012; Sørensen & Levinsen, 2014) and it requires self-regulation skills to accomplish. We posit that LGDM assignments require a high degree of student self-regulation learning skills. Therefore, this research uses the self-regulation model linked to the LGDM implementation framework to guide the evaluation of LGDM assignments.

Materials and methods

Theoretical framework

The LGDM framework was used to design and implement the assignment (Reyna & Meier, 2018). This framework has eight components to guide the implementation of digital media assignments in the classroom (see Figure 1). The framework was refined and validated in previous studies in scientific disciplines such as pharmacology (Reyna et al., 2016) and geological processes (Reyna, Horgan et al., 2017). Mapping of the elements of the LGDM framework against self-regulation subscales and other constructs was done before the design of the questionnaire (Table 2). As the LGDM framework informed the assignment design, implementation, and evaluation, the mapping was necessary to link the different elements of the framework.

Figure 1. The LGDM implementation framework

Table 2
The LGDM framework mapped against self-regulation subscales and additional constructs

Element	Subscales
Pedagogy	Digital media for learning and career**
Student training	Task strategies*
Video hosting and distribution	Assignment ownership**
Marking scheme	Assignment motivation**
Group work	Goal setting*
	Environment structuring*
	Time management*
Feedback	Help-seeking*
Reflection	Self-evaluation*
Evaluation	Self-evaluation*

Note. *Indicates self-regulation scales. **Indicates additional constructs.

The rationale for the inclusion of additional constructs in the questionnaire was informed by research in the field of self-regulation and motivation in LGDM assignments. According to the literature, motivation is the sine qua non of self-regulation processes (Dunnigan, 2018; Pintrich et al., 1991; Zimmerman, 1989; Zimmerman & Schunk, 2011). For instance, self-efficacy, attribution to failure, task value, and anxiety affect self-regulation strategies (Bandura, 1986; Elliot & Harackiewicz, 1994; Pintrich & Zusho, 2007; Zimmerman, 2000). Studies have suggested that attitudes determine how students perceive situations, how they feel about them, and how they behave in those situations (Ajzen, 1996; Fazio & Roskos-Ewoldsen, 2005). In the current literature on LGDM assignments, it appears that there are no validated surveys available to measure student attitudes towards LGDM for learning and career. Student attitudes towards digital media for learning and career were considered in this study to be an essential construct to establish the relationship of motivation with self-regulation processes.

The authors postulated a link between assignment ownership, video hosting, and the presentation component. Research in the field of LGDM with pre-service teachers suggests that students are motivated to produce their digital media projects by the sense of having an audience (Kearney, 2013; Kearney & Schuck, 2005). Students work harder to achieve a better outcome in digital media projects when they know, for instance, that the YouTube community will see their content (Hobbs, 2017; Van Dijck, 2009a). This sense of an audience boosts student agency and satisfaction in contributing to the learning experience of other students around the world (Hoban et al., 2015; Hobbs, 2017). A possible relationship between assignment motivation and the marking scheme emerged from the previous research. If the student's perception of task value is low, it will affect the effort they are willing to put into their project (Reyna & Meier, 2018) and could therefore affect their ability to self-regulate.

It is common in the literature on self-regulation to link survey questions with motivational features such as *self-efficacy* or *task value*. For instance, a study conducted by Wang, Shannon, and Ross (2013) measured personal characteristics, technology self-efficacy, and self-regulation beliefs to understand academic outcomes and satisfaction levels. Similar studies using mixed scales are available in the literature. For instance, Agustiani, Cahyad, and Musa (2016) studied how self-regulation can influence academic outcomes in online courses using a mixed scale including self-regulation, motivation, task value, and self-efficacy. Lynch and Dembo (2004) conducted a study to investigate self-regulation as a predictor of academic success in a blended learning course using self-regulation subscales, verbal ability, and self-efficacy for learning and performance. Another study, conducted by McClain (2015), used a mixed scale including self-regulated learning levels and a self-monitoring instrument to gauge academic achievement in an online post-secondary developmental mathematics course.

The self-regulation learning questionnaire for LGDM assignments

This questionnaire is part of a framework to evaluate the effectiveness of the learning experience when using LGDM assignments in the classroom (Reyna, Hanham, & Meier, 2018b). The framework was developed using a mixed-methods approach (Tashakkori & Teddlie, 2010) and has quantitative (surveys, marks, learning management system (LMS) logs) and qualitative components (open-ended questions, interviews, focus groups). Part of the quantitative section of the framework uses a questionnaire to measure self-regulated learning and additional constructs such as student attitudes towards digital media for learning, digital media for careers, and assignment motivation and ownership (see Table 2).

Self-regulation is highly context-dependent (Zimmerman, 1998; Zimmerman & Tsikalas, 2005), and research has found that in traditional face-to-face settings learners use different self-regulation strategies than when they are operating in online settings (Broadbent, 2017). Although comparisons of self-regulation in traditional versus online settings are scarce in the literature (Barnard-Brak et al., 2010), one of the reasons for the difference in self-regulation from traditional settings could be the social context offering opportunities to support self-regulation (Zimmerman, 2000). For instance, effective feedback from instructors and peers in the classroom could support self-efficacy and help learners deal with feelings like anxiety and fear (Hadwin, Oshige, Gress, & Winne, 2010). These motivational factors are the sine qua non of self-regulation processes (Pintrich & Zusho, 2007). In contrast, autonomy is a characteristic of online environments, and self-regulation learning strategies have been highlighted as a crucial component of student learning and achievement online (Barak, Hussein-Farraj, & Dori, 2016; Dabbagh & Kitsantas, 2004; Kocdar, Karadeniz, Bozkurt, & Buyuk, 2018). In online settings, learners need to be more independent and self-directed than in traditional settings. Online activities are open regarding time, pace, and content, which means that self-regulation learning skills such as time management are required (Barak et al., 2016; Barnard et al., 2009; Bergamin, Ziska, Werlen, & Siegenthaler, 2012; Garrison, 2000; Kauffman, 2004). Students lacking self-regulation learning skills may misconceive the autonomy of the learning environment and underperform (Barnard et al., 2009). On the other hand, online learning environments could support self-regulation learning skills by providing opportunities for self-monitoring, peer interaction, and mastering learning (Barnard et al., 2009; Cho & Heron, 2015). For instance, research has found that online students use self-regulation strategies more often than blended students, except for peer-learning and help-seeking (Broadbent, 2017). However, self-regulation in online settings has not received the same attention as self-regulation in traditional face-to-face settings (Barnard, Paton, & Lan, 2008). This research gap presented challenges when developing the self-regulation questionnaire for the present study.

Reviewing the literature on self-regulation learning scales for traditional modes of delivery (Brown, Miller, & Lawendowski, 1999; Pintrich et al., 1991; Weinstein & Palmer, 2002), we found the scales to be unsuitable for online learning, as also reported recently by Kocdar et al. (2018). A validated instrument such as the motivated strategies for learning questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1993), which measures self-regulation in traditional learning environments, may be invalid in online settings, as argued by Barnard et al. (2009). Due to the differences reported between self-regulation in traditional face-to-face learning and in online learning, the questionnaire subscales and items on self-regulation learning for the current study were adapted from the online self-regulation questionnaire (Barnard et al., 2009; Barnard-Brak et al., 2010) (see Appendix A). Items from this survey were chosen and adapted because of their generality and internal reliability scores. Due to the diversity of the survey items, the statements were rewritten to replace “online learning” with “digital media assignment” to reflect the task that the students would undertake during the semester (i.e., “I allocate extra time for my online courses” was changed to “I allocate extra time for my digital media assignment”). Questionnaire items were developed using a four-point Likert scale – 1 *strongly disagree*, 2 *disagree*, 3 *agree*, and 4 *strongly agree*. The authors did not include a middle point (neutral), to avoid indecisive data (Busch, 1993). The objective was to study self-regulation and neutral responses were of limited utility. A similar approach was used in a recent study on developing self-regulation in self-paced open and distance learning environments that used a five-point Likert scale including *slightly agree* as a middle point (Kocdar et al., 2018). Appendix B presents the subscales and survey items for self-regulation learning and the additional constructs.

Participants

Our research was conducted at a metropolitan university in Sydney, Australia, during Semester 1, 2017. Science students (n = 1656) from seven subjects which had implemented LGDM assignments in years 1 to 3 were asked to complete a questionnaire (Table 3) at three times during the semester: T1 (Week 2); T2 (Week 6); and T3 (Week 10). Three datapoints were used to ensure student self-regulation learning strategies could be tracked across the semester.

Table 3
Science subject cohorts which implemented LGDM assignments in Semester 1, 2017, and participated in the questionnaire validation study

Subject	**Year**	**LGDM assignment weight (%)**	**Delivery mode**	***N***
Health and Homeostasis 1	1	20	O	697
Investigation of Human remains	2	30	B	78
Geological processes	2	20	B	103
Pharmacology 1	3	15	B	295
Neuroscience	3	30	B	323
Molecular Nanotechnology	3	10	O	50
Medical imaging	3	30	B	110
Total				**1656**

Note. O = Online delivery, B = Blended delivery.

Students were sent a link via email and asked to participate in the survey on a voluntary basis in Weeks 2, 6, and 10. The questionnaire was designed inside the LMS, and participant data were identified to ascertain patterns of students’ self-regulation learning. This research had full ethics approval (ETH16-1060). Data were gathered from the Grade Centre as comma-separated values (CSV) for each point of time, cleaned, and processed into one file containing entries for only those students who responded to all of T1, T2, and T3.

LGDM task design

The LGDM assignment task design followed a systematic approach. The following frameworks were used to inform the creation of the assessment task:

- the digital media literacies framework (Reyna et al., 2018c);
- the taxonomy of digital media types (Reyna, Hanham, & Meier, 2017);
- the digital media principles framework (Reyna, Hanham, & Meier, 2018a); and
- the LGDM implementation framework (Reyna & Meier, 2018).

The digital media literacies framework was used to plan, design, and implement face-to-face and online student training. This model has three domains: conceptual, functional, and audiovisual. Students received training on storyboarding for digital media (conceptual), essential use of video editing software (functional) and, finally, audiovisual aspects of producing effective digital media. The taxonomy of digital media types (Reyna et al., 2017) was used to explain to students the skills required for the digital media type they chose for their assignments. The digital media principles framework (Reyna et al., 2018a) guided the audiovisual training (layout design, colour theory, typography, use of images, and basic video techniques). The LGDM implementation framework (Reyna & Meier, 2018) guided academics and students to understand the assignment workflow. The weightings of the tasks ranged from 10% to 30%. The delivery mode of the digital media training was blended for five subjects and online for two subjects (Table 3).

Exploratory and confirmatory factor analysis

Because the self-regulation questionnaire was adapted from a previous study (Barnard et al., 2009) and additional constructs were added, there was a need to validate the constructs and questionnaire items. For this purpose, a multivariate statistical approach, exploratory and confirmatory factor analysis, was used (Williams, Onsman, & Brown, 2010). This statistical approach is used to interpret self-reporting questionnaires in educational psychology and health interventions (Thompson, 2004). Exploratory factor analysis (EFA) is used when the researcher has no prediction of the number of constructs to be measured (Costello & Osborne, 2005). The primary objective is to reduce many variables to a smaller set of factors. This process tests whether there is a relationship between variables and latent constructs (O'Rourke, Psych, & Hatcher, 2013). Confirmatory factor analysis (CFA) is used by researchers to propose a priori factor structures based on theory and preliminary analyses like EFAs, and it provides validity evidence for the scales used in the questionnaire. Both EFA and CFA help to refine a proposed theory (Harrington, 2009).

Questionnaire validation

Data collected during the semester for T1 (Week 2), T2 (Week 6), and T3 (Week 10) were used to run EFAs and CFAs to identify factor structures and assess the reliability of the constructs. The sample was split in half as follows:

- split data in half for T1;
- split data in half for T2 + T3;
- run EFA for the first half of T1 data;
- run EFA for the first half of T2 + T3 data; (e) run CFA for the second half of T1 data; and
- run CFA for the second half of T2 + T3 data.

The reason that the data were analysed as described was that T2 and T3 contained co-regulation questions for a second study which are beyond the scope of this paper (Figure 2). Therefore, it was necessary to check if the same results would be generated if co-regulation factors were included. The results were similar, so the same questions were combined to form factors.

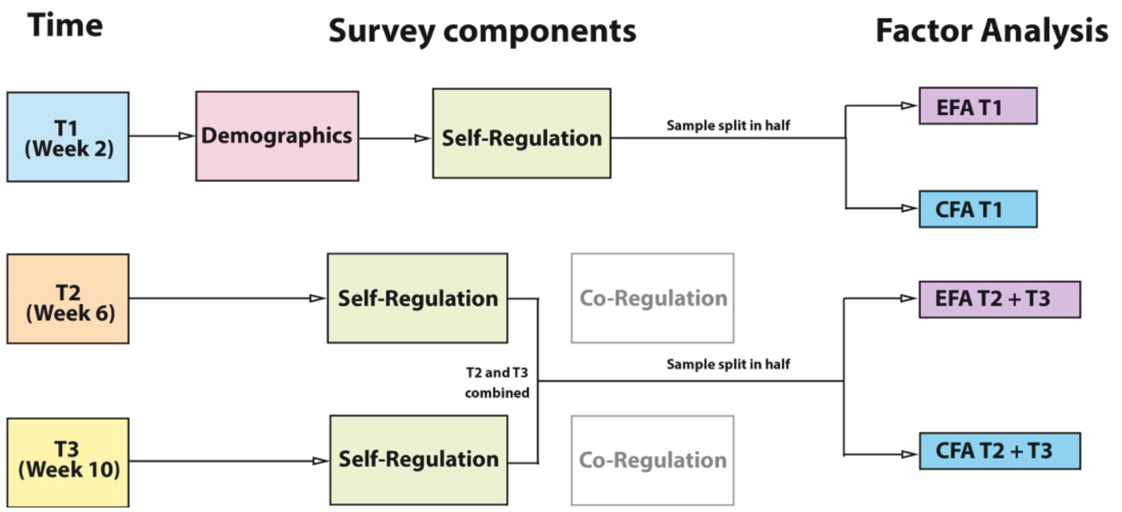

Figure 2. Sample split for EFA and CFA. EFA T1 was similar to EFA T2 + T3, and CFA T1 was similar to CFA T2 + T3 ($n = 341$).

The data were analysed using SPSS (version 24.0). Factors were extracted using principal axis factoring (Henson & Roberts, 2006). The criteria to determine the number of factors to extract were Kaiser's criteria (eigenvalues > 1 rule) (Kaiser, 1960), the scree test (Cattell, 1966), the cumulative percentage of variance extracted (Horn, 1965), and most importantly, theoretical interpretability (Williams et al., 2010). The rotational method varimax was used to maximise high item loadings and minimise low item loadings to produce a simplified solution (Thompson, 2004). Parameter estimates (i.e., factor loadings, modification indices, error variances) and a combination of fit indices (e.g., root mean square error of approximation [RMSEA], CFI) were examined when assessing confirmatory factor (measurement) models.

Results

Questionnaire completions

Twenty percent of participants were male and 80% were female. Regarding the ages of the participants, 91% were between 19 and 29, 6% were between 30 and 39, and 3% were 40 and over. Fifty-three percent of the students were native English speakers and 47% were ESL students. For T1, T2, and T3 surveys, 955, 697, and 626 students responded, respectively. There was a decrease in responses towards the end of the semester. This pattern was expected as students were finalising assignments and preparing for exams. For the factor analyses, data were cleaned and only included students who completed all of T1, T2, and T3, which ensured data consistency. Table 4 presents completion rates of T1 + T2 + T3 for each subject.

Table 4
Science subject cohort response rates for T1 + T2 + T3 questionnaires in Semester 1, 2017

Subject	Year	*N*	Responses	%
Health and Homeostasis 1	1	697	199	29
Investigation of Human Remains	2	78	48	62
Geological Processes	2	103	17	17
Pharmacology 1	3	295	22	8
Neuroscience	3	323	30	9
Molecular Nanotechnology	3	50	13	26
Medical Imaging	3	110	12	11
Total		**1656**	**341**	

EFA

The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used to determine if the data were suitable for factor analysis. Bartlett's test demonstrated significance, as the KMO was higher than 0.50 (Table 5).

Table 5
Assessing the suitability of data for EFA

KMO of sampling adequacy		.906
Bartlett's test of sphericity	Approx. Chi-square	8343.152
	df	780
	Sig.	.000

As seen in Table 5, the KMO coefficient and Bartlett's test value for the 40 items passed the reliability test, at 0.906 and 0.000 respectively. The KMO coefficient showed that the sample size was close to perfect, and Bartlett's test indicated that the data set was suitable for EFA. Principal axis factoring was the method used for factor extraction. The scree test suggested taking ten factors, the second elbow on the plot. Looking at the total variance extracted by each factor, the ten factors made sense (Figure 3). Figure 3 shows that the break point happened after the tenth factor, when the factor eigenvalue dropped below 1.

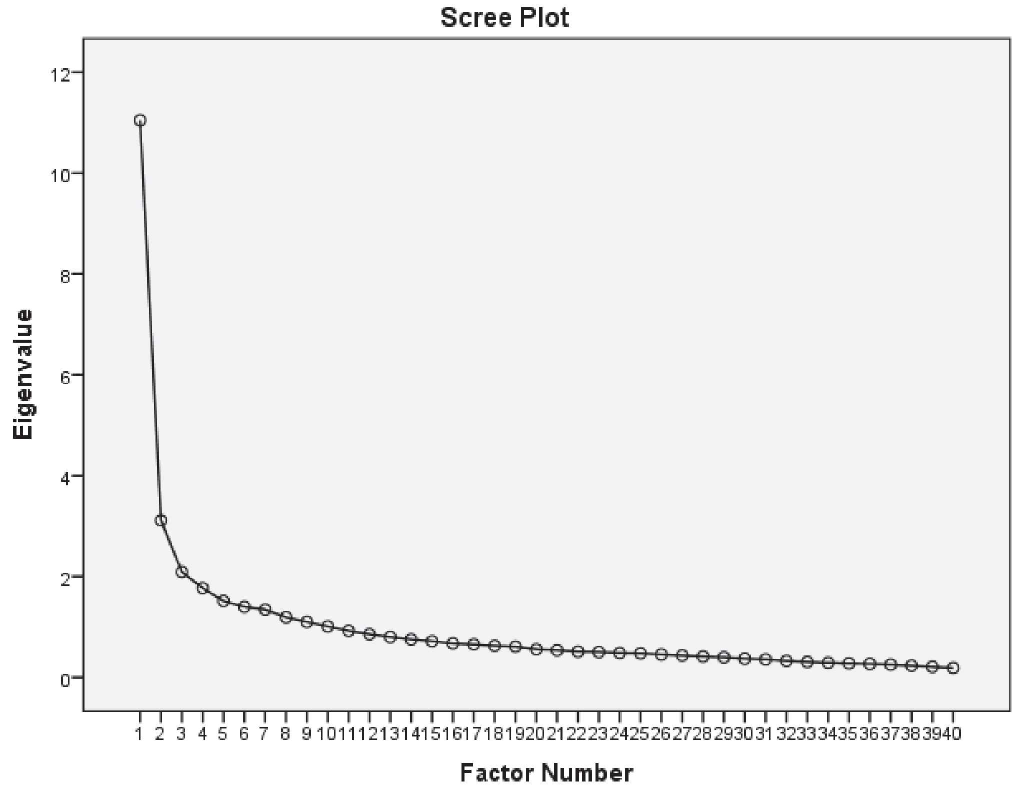

Figure 3. Factor eigenvalue by factor number

Table 6 shows that a ten-factorial structure explained 63.929% of the total variance. The ten factors are presented in Table 7.

Table 6
Factor eigenvalues and variances

Component		**Initial eigenvalues**	
	Total	**% of variance**	**Cumulative%**
1	11.047	27.618	27.618
2	3.112	7.780	35.398
3	2.089	5.223	40.621
4	1.771	4.428	45.049
5	1.513	3.783	48.832
6	1.399	3.496	52.328
7	1.342	3.356	55.684
8	1.190	2.974	58.658
9	1.099	2.747	61.405
10	1.010	2.524	63.929

To make the axes fit the data better, varimax rotation was used. Factors whose questions exactly matched the previous set groupings were labelled with their original names, but those whose questions were a mixture of groupings were given a different name. For example, help-seeking generated two different factors: help-seeking from people and help-seeking from the Internet. The summary is presented in Table 7.

Table 7
Factors extracted by EFA for T1

Factor	Factor name	Description
1	DMC	Digital media for career
2	HSP*	Help-seeking from people*
3	ES*	Environment structuring*
4	GS*	Goal setting*
5	TM*	Time management*
6	DML	Digital media for learning
7	TS*	Task strategies*
8	AO	Assignment ownership
9	HSI*	Help-seeking from the Internet*
10	AM	Assignment motivation

Note. *Denotes self-regulation items.

Of the 40 items, eight had very small loadings for all factors (five self-regulation items and three items in other constructs), so they were not included in any factor. The questions with no grouping are presented in Table 8.

Table 8
Items with small loadings on all factors that were discarded from the data

No.	Item
23	I set long-term goals (e.g., across semester) when preparing my digital media assignment.*
40	I reflect on what I have learnt on my assignment.*
28	I allocate extra time for my digital media assignment.*
19	I visit additional resources online about digital media.*
15	I would like to produce a digital media assignment that I can be proud of.
12	I am driven by learning rather than marks.
9	I am driven by marks.
37	I ask myself questions about the assignment material when preparing the digital media assignment.*

Note. *Denotes self-regulation items.

For the model fit measures, the minimum discrepancy/degrees of freedom (CMIN/DF) ratio was low at 1.875, which is a good value, but the *p* value was significant, indicating a poor fit (Table 9). However, the sample size is large, so the probability that any fit would have a non-significant *p* value is very low. The comparative fit index (CFI) is acceptable at 0.945, as is the parsimonious comparative fit index (PCFI) at 0.798 (Table 10). The PCLOSE is acceptable at 0.995, as is the RMSEA at 0.043 (Table 11). The values were in the range of the standard fit criteria (Schermelleh-Engel, Moosbrugger, & Müller, 2003) (Table 12). Therefore, the model fit is acceptable.

Table 9
Model fit measures (CMIN)

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	141	785.670	419	.000	1.875
Saturated model	560	.000	0		
Independence model	64	7102.771	496	.000	14.320

Table 10
Baseline comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.889	.869	.945	.934	.945
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Table 11
RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.043	.038	.047	.995
Independence model	.167	.164	.171	.000

Table 12
Standard fit criteria for CFA

Measures	The best values	Acceptable values
RMSEA	From .00 to .05	From .05 to .08
SRMR	From .00 to .05	From .05 to .10
GFI	From .95 to 1.00	From .90 to .95
AGFI	From .90 to 1.00	From .85 to .90
CFI	From .95 to 1.00	From .90 to .95
RFI	From .90 to 1.00	From .85 to .90

EFA was determined, applied, measured and assessed separately for T1 and T2 + T3, because in T1 students were not asked the co-regulation questions that were part of another study. This was done to verify if the grouping of questions under self-regulation factors would differ when co-regulation questions were included. The self-regulation factors and additional constructs remained the same for EFA conducted on T1 and on T2 + T3. Only data which includes T1 has been included.

CFA

Appendix C shows the loading per factor for the self-regulation subscales and additional constructs. The CMIN/DF ratio was relatively low at 2.525, but the *p* value was significant, indicating a poor fit (Table 13). However, as above, the large sample size minimises the chances of getting a non-significant *p* value. The CFI and the PCFI values are within the threshold at 0.934 and 0.805, respectively (Table 14). The PCLOSE is acceptable at 0.851 (> 0.5), as is the RMSEA at 0.049 (< 0.05) (Table 15). These values were in the range of the standard fit criteria (Schermelleh-Engel et al., 2003) (Table 12). Thus, it can be concluded that overall the model fit is acceptable. For T2 + T3, CFA gave similar results.

Table 13
Model fit measures (CMIN)

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	166	1449.461	574	.000	2.525
Saturated model	740	.000	0		
Independence model	74	13949.244	666	.000	20.945

Table 14
Baseline comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.896	.879	.935	.924	.934
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Table 15
RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.048	.045	.051	.851
Independence model	.174	.171	.176	.000

Discussion

This research paper is the first attempt to develop and validate a self-regulation learning questionnaire to be used in LGDM assignments. A ten-factor structure was identified by EFA. Six factors corresponded to self-regulation learning (goal setting, environment structuring, time management, task strategies, help-seeking from people, and help-seeking from the Internet). Notably, help-seeking generated two factors not previously reported in the literature (help-seeking from people and help-seeking from the Internet). Other studies have identified additional self-regulation learning factors, for example, self-study strategies (Kocdar et al., 2018). Following CFA, comparison of the values obtained for RMSEA, SRMR, CFI, and RFI against the best values/acceptable values (Schermelleh-Engel et al., 2003) confirmed the six-factor structure of the self-regulation learning skills scale and additional constructs. The remaining four factors identified were student attitudes towards LGDM assignments (digital media for learning, digital media for career) and assignment motivation and ownership. These additional factors were included in the scale to reflect that motivation is the sine qua non of self-regulation processes (Dunnigan, 2018; Pintrich et al., 1991; Zimmerman, 1989; Zimmerman & Schunk, 2011).

Task strategies describes student approaches to learning tasks, such as note-taking, and preparation of questions to ask educators (Zimmerman, 2002). In the context of digital media, task strategies are crucial because students will need to engage with digital media resources inside the LMS and master relevant software to produce their assignments. Previous research in LGDM suggests that students feel overwhelmed by the task when they don't receive any support from educators (Coulson & Frawley, 2017; Pearce, 2014; Pearce & Vanderlelie, 2016). For task strategies, one of the self-regulation learning subscales, three out of four items were validated. The item not validated was "I visit additional resources online about digital media." This was possibly because digital media resources were developed and provided inside the LMS, and so students did not need to look for additional material. The original validated survey (Barnard et al., 2009) used to build the section which included this subscale also included two questions that could not be adapted to the LGDM task: "I prepare my questions before joining the chat room and discussion" and "I work extra problems in my online courses in addition to the assigned ones to master the course content." Nevertheless, the number of items for TS is in the range suggested by previous studies (2 or 3 items per factor), so it can give a meaningful interpretation of the construct (Henson & Roberts, 2006; Isaac & Michael, 1995).

Students need to set their goals and orientation towards their studies (Pintrich et al., 1991). For goal setting, three items out of four were validated. The item that was not validated was "I set long-term goals (e.g., across semester) when preparing my digital media assignment", which is probably due to the LGDM assignment being a single semester task. The meaning of "long-term" can be a year or more, and the subject only lasted 12 weeks. Students may have responded to the item inconsistently, and this may explain why this item failed to be validated. For environment structuring, all four items were validated by factor analysis. In the case of time management, three out of four items were validated. The item "I allocate extra time for my digital media assignment" was not validated.

Interestingly, after EFA items for help-seeking (items 32–36) and self-evaluation (items 37–40), formed two different factors that were labelled as help-seeking from people (items 32–34 and items 38 & 39) and help-seeking from the Internet (items 35 & 36). Two items under self-evaluation were not validated – "I ask myself questions about the assignment material when preparing the digital media assignment" and "I reflect on what I have learnt on my assignment". The self-evaluation factor was thus deleted from the questionnaire (see Table 3). This sort of result is expected when validating questionnaires using factor analysis, as not all measurement items capture the underlying constructs effectively or consistently (Williams et al., 2010). Moreover, a recent study found that self-evaluation was not a significant factor for explaining student achievement and satisfaction in an entirely online course (Inan et al., 2017). Contrarily, other authors have described self-evaluation as an essential skill for students to be successful in online learning courses (Barnard et al., 2008; Dabbagh & Kitsantas, 2004).

As emphasised previously, self-regulation is highly context-dependent (Schunk & Zimmerman, 2011). In the present study, all students were taught in blended mode, but the training for the LGDM assignment was delivered entirely online for two cohorts (n = 212) and in blended mode for five cohorts (n = 129). This approach could distort validation results. A recent study has described how online and blended learners varied in their self-regulation strategies. Online learners use self-regulation learning strategies more often than blended learners, except for peer learning and help-seeking, which are employed more often by blended learning students (Broadbent, 2017).

The digital media for learning and digital media for career items were validated by EFA and CFA. This means that these items are representative for evaluating student attitudes towards LGDM for their career and attitudes towards technology for learning subject content. Attitudes determine how students perceive situations, how they feel about them, and how they behave (Ajzen, 1996; Fazio & Roskos-Ewoldsen, 2005). Understanding these additional constructs could help to establish their relationship with self-regulation processes.

For assignment motivation, factor analysis only validated two items out of four. The items not validated were “I am driven by marks” and “I am driven by learning rather than marks.” Assignment motivation can also affect self-regulation processes. In the psychology literature, *task value* refers to perceptions of interest, usefulness, importance, and costs of a task (Meece, Blumenfeld, & Hoyle, 1988). Students who attach a high value to the task are likely to use deeper cognitive and metacognitive strategies for learning (Pintrich, 2004). Previous research suggests that if the LGDM task has a low weighting in total marks (10%–15% of the total mark), students are likely to apply less effort to the assignment (Reyna & Meier, 2018). Due to the often time-consuming, iterative, and laborious nature of digital media production (Musburger & Kindem, 2012), allocating the appropriate proportion of total marks to the task is of crucial importance to motivate students to successfully complete the assignment. 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 & Eccles, 2000). Furthermore, the taxonomy of digital media types (Reyna et al., 2017) could be a valuable tool for educators new to digital media assignments. This model could help them to decide on assignment weighting according to digital media type, avoiding unfairness and improving student motivation by increasing task value.

For assignment ownership, factor analysis validated two out of three items. The item not validated was “I would like to produce a digital media assignment that I can be proud of it.” The number of items under each of these factors is in the range suggested by previous studies (2 or 3 items per factor), so these items can give a meaningful interpretation, similarly to task strategies, discussed above. It has been reported in the literature that the sense of an audience (e.g., the LGDM assignment is uploaded onto YouTube) can motivate students to put greater effort into their projects (Kearney, Pressick-Kilborn, & Maher, 2012; Kearney & Schuck, 2005). However, there may also be other drivers of motivation in LGDM assignments, such as the need for self-expression and creativity (Van Dijck, 2009; Van Dijk & Lazonder, 2016).

Conclusion

Preliminary validation of questionnaire items indicated that our model is fit for evaluating self-regulation learning subscales such as goal setting, environment structuring, time management, task strategies, help-seeking from people, and help-seeking from the Internet in LGDM assignments. Items from additional constructs such as attitude towards digital media for learning and career, assignment motivation, and assignment ownership items were also validated. The present study is one of the first to develop and validate a self-regulation learning questionnaire for LGDM assignments. This validated questionnaire will help educators develop strategies to enable students to acquire or improve self-regulation learning in LGDM assignments.

Implications of the study

There are some implications which flow from the findings of this study. Based on the data, students employed a number of self-regulation strategies, specifically environmental structuring, goal setting, time management, help-seeking from people, help-seeking from the Internet, and also task strategies related to note-taking and accessing digital resources within the LMS. The verification of these strategies in the context of student experience of LDGM has practical implications. Environmental structuring (Kocdar et al., 2018; Su, Zheng, Liang, & Tsai, 2018; Zimmerman, 2008) has been identified in a range of contexts as an important self-regulation strategy. In this study, environmental structuring focused on students choosing times and locations in which to work on their digital media assignments. The exercise of personal control (Lee & Brand, 2010) is an important mechanism in environmental structuring. Educators can provide students with some direction on how to organise and structure their environments to minimise distractions. This may include advice about putting mobile phones on silent, locating distraction-free learning spaces, and identifying times during the week when distractions are likely to be minimal. Educators can also assist students with goal setting. For example, throughout the time period for an LDGM assignment, teachers could provide students with milestones on a weekly or fortnightly basis. Early in the semester (Week 2 or 3), the group should submit a draft storyboard via the Turnitin application. The inclusion of milestones will provide students with the opportunity to get timely feedback (Carless & Boud, 2018; Hattie & Timperley, 2007) and to apply feedback to improve the quality of their LDGM assignments. Furthermore, regular milestones can facilitate effective time management practices. Educators could also assist students with time management through the use of tools within the LMS (e.g., the calendar tool with alerts) or by using cloud services such as Google Drive to work collaboratively on their storyboards on a weekly basis without the need to meet face-to-face.

Educators can also assist students with help-seeking (Karabenick & Gonida, 2018). In this study, students sought help from others, as well as from the Internet. Regarding help-seeking from others, teachers can nurture learning environments in which students feel safe and empowered to ask for help from their peers. This may be achieved through group-building activities (Mittelmeier, Rienties, Tempelaar, & Whitelock, 2018) and instruction in active listening techniques (Weger, Castle, & Emmett, 2010). Regarding help-seeking from the Internet, educators can curate resources relevant to LDGM, such as resources on how to develop storyboards, video production techniques, and copyright-free materials. Curation of resources will help students focus their efforts and minimise the workload and associated stress and anxiety reported for LGDM assignments (Coulson & Frawley, 2017; Pearce & Vanderlelie, 2016). Self-regulation strategies related to note-taking can also be enhanced through educator intervention. According to Hattie, Biggs, and Purdie (1996), students need to understand the purpose of note-taking and the conditions in which they will be required to apply the knowledge acquired from note-taking. When providing students with learning materials for their LDGM, educators can include study questions to guide students as they work through the materials.

The findings of this research may also have implications concerning the design of LGDM assignments according to learners' self-regulation skills. For instance, the science curriculum could be redesigned to include LGDM as a vehicle of learning, but also as an approach to developing communication skills in the digital space. Digital media skills are crucial for 21st century professionals regardless of their discipline (Alexander, Adams, & Cummins, 2016; Hobbs, 2017). First-year students could be introduced to simple ways to create LGDM, such as audio podcast, while second-year students could produce digital stories. In the third year, students could engage in the production of more sophisticated forms of digital media like video and blended media. Using this approach, first-year students could complete the Digital Media for Learning and Career items to gauge their attitudes towards LGDM and inform communication about why it is essential to learn through LGDM assignments.

Similarly, the self-regulation subscales described here (goal setting, time management, environment structuring, help-seeking from people, and help-seeking from the Internet) could be used for second- and third-year students and their scores compared to identify specific areas needing improvement. Also, aggregate scores could be used to set student profiles and inform group allocation at the beginning of the semester. The questionnaire can be completed within a relatively short timeframe (10–15 minutes) using tools like Google Forms, and a summary of student responses could be visualised within the classroom time frame. By using these scales in the classroom, educators can design activities which support student self-regulation learning processes. Researchers can also use the questionnaire instrument in conjunction with, for example, interviews and focus groups to get a deeper understanding of self-regulatory processes in LGDM assignments. Understanding self-regulation in LGDM assignments will also be an advantage in studying group interactions like co-regulation to provide better group experiences for students.

The next stage of our research will try to understand how students can use self-regulation learning strategies in LGDM assignments to enhance their performance and success. Analysis of data from the validated self-regulation questionnaire is currently in progress, using multivariate techniques including structural equations and multilevel modelling. Qualitative data collected via open-ended questions, individual interviews, and focus groups will help to get an in-depth understanding of self-regulation learning processes when using LGDM assignments in the classroom.

There are several limitations of the current study. Firstly, it used a four-point scale rather than a five-point or seven-point scale and did not capture students with truly neutral responses to the questionnaire. Notwithstanding this, several studies (e.g., Adelson & McCoach, 2010; Chang, 1994) have found very few differences between the results of data obtained from four-point scales and the results of data captured from five-point scales. Secondly, because we tested constructs from the LDGM framework, we did not measure other variables such as self-efficacy, which is considered a motivational factor that works together with self-regulatory processes and which could provide additional explanatory power. A third limitation is that the data comes from students enrolled in blended learning courses, but the training for the LGDM assignment was in two modes – online and blended. As previously discussed, online learners use self-regulation strategies more often than blended learners do. Another limitation of the study is that data were gathered from cohorts of undergraduate students studying only science subjects. Future research should explore the extent to which findings from this research are generalisable to other program areas and institutions.

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Please cite as: Reyna, J., Hanham, J., Vlachopoulos, P., & Meier, P. (2019). Using factor analysis to validate a questionnaire to explore self-regulation in learner-generated digital media (LGDM) assignments in science education. *Australasian Journal of Educational Technology, 35*(5), 128-152. https://doi.org/10.14742/ajet.4514

Appendix A

Table
Measuring self-regulation in online and blended learning environments (Barnard et al., 2009, pp. 5 & 6)

Subscale	Item
Goal setting	I set standards for my assignments in online courses. I set short-term (daily or weekly) goals as well as long-term goals (monthly or for the semester). I keep a high standard for my learning in my online courses. I set goals to help me manage studying time for my online courses. I don't compromise the quality of my work because it is online.
Environment structuring	I choose the location where I study to avoid too much distraction. I find a comfortable place to study. I know where I can study most efficiently for online courses. I choose a time with few distractions for studying for my online courses.
Task strategies	I try to take more thorough notes for my online courses because notes are even more important for learning online than in a regular classroom. I read aloud instructional materials posted online to fight against distractions. I prepare my questions before joining in the chat room and discussion. I work extra problems in my online courses in addition to the assigned ones to master the course content.
Time management	I allocate extra studying time for my online courses because I know it is time-demanding. I try to schedule time everyday or every week to study for my online courses, and I observe the schedule. Although we don't have to attend daily classes, I still try to distribute my studying time evenly across days.
Help-seeking	I find someone who is knowledgeable in course content so that I can consult with him or her when I need help. I share my problems with my classmates online so we know what we are struggling with and how to solve our problems. If needed, I try to meet my classmates face-to-face. I am persistent in getting help from the instructor through email.
Self-evaluation	I summarise my learning in online courses to examine my understanding of what I have learned. I ask myself a lot of questions about the course material when studying for an online course. I communicate with my classmates to find out how I am doing in my online classes. I communicate with my classmates to find out what I am learning that is different from what they are learning.

Appendix B

Table
Questions on digital media for learning, digital media for a career, assignment motivation, assignment ownership and self-regulation

Subscale	Item
Digital media for learning (DML)	1. I learn about the subject content while creating digital media.
	2. Learning the subject content using digital media is good.
	3. Digital media helped me to learn the subject content.
	4. I enjoy learning the subject content using digital media.
Digital media for a career (DMC)	5. Digital media skills are important for my career.
	6. I will apply digital media skills in my future career.
	7. Having digital media skills is an advantage for my career.
	8. Digital media skills are needed now regardless the career you are in.
Assignment motivation (AM)	9. I am driven by marks.
	10. If the assignment is not worth too many marks I will put less effort into it.
	11. I will perform the best I can no matter how many marks the assignment is worth.
	12. I am driven by learning rather than marks.
Assignment ownership (AO)	13. I feel a high sense of accomplishment when producing a digital media assignment.
	14. Sharing a digital media assignment online makes me feel a high level of accomplishment.
	15. I would like to produce a digital media assignment that I can be proud of.
Task strategies (TS)*	16. I take notes from the digital media lecture to be more prepared for the task.
	17. I take notes from the digital media workshop to be more prepared for the task.
	18. I visit the digital media resources inside the learning management system.
	19. I visit additional resources online about digital media.
Goal setting (GS)*	20. I set standards for my assignments.
	21. I set goals to help me manage time for my assignment.
	22. I set short-term goals when preparing my digital media assignment.
	23. I set long-term goals when preparing my digital media assignment.
Environment structuring (ES)*	24. I choose the location where I work on my digital media assignment to avoid distraction.
	25. I find a comfortable place to work on my digital media assignment.
	26. I know where I can work most efficiently for my digital media assignment.
	27. I choose a time with few distractions for working for my digital media assignment.
Time management (TM)*	28. I allocate extra time for my digital media assignment.
	29. I schedule regular times a week to work on my digital media assignment.
	30. I helped managed my time efficiently, so I was not rushing around to finish at the last minute.
	31. I follow my planned schedule for completing the digital media project.
Help-seeking (HS)*	32. I find people who are knowledgeable in subject content so that I can ask them for help.
	33. I share the difficulties I am having with the digital media assignment with my classmates.
	34. I am persistent in getting help for my assignment from the instructor
	35. I seek help on the Internet about my assignment topic.
	36. I seek help on the Internet about digital media creation.

Self-evaluation (SE)*	37. I ask myself questions about the assignment material when preparing the digital media assignment.
	38. I check with my classmates to find out how I am doing in my assignment.
	39. I check with my classmates to find out what I am learning that is different from what they are learning.
	40. I reflect on what I have learnt on my assignment.

Note. *Denotes self-regulation.

Appendix C

Table
Standardised solutions by CFA for the ten-factor model

	Factor									
Item	**DML**	**DMC**	**AM**	**AO**	**TS**	**GS**	**ES**	**TM**	**HSP**	**HSI**
3	.82									
4	.75									
2	.66									
1	.56									
8		.85								
5		.84								
6		.82								
7		.65								
11			.85							
10			.82							
13				.84						
14				.82						
16					.90					
17					.86					
18					.57					
22						.82				
20						.76				
21						.64				
26							.73			
27							.70			
24							.70			
25							.60			
31								.82		
30								.78		
29								.72		
38									.82	
39									.72	
33									.71	
32									.63	
34									.56	
36										.84
35										.78

Note. The first four factors correspond to other constructs and the last six factors to self-regulation subscales.

Chapter 5:
A Systematic Approach to LGDM Assignments and Its Effect on Self-Regulation

Chapter 5 overview

A Systematic Approach to LGDM assignments and its effect on Self-Regulation

This PhD research started with the review of literature relevant to LGDM in tertiary education with an emphasis in the Science discipline. The author identified five different gaps in the systematic implementation of LGDM assignments (Chapter 2). Based on these gaps, in Chapter 3, the author developed four theoretical models to design, implement and evaluate LGDM assignments (papers 1-4) and tested them on a pilot study (paper 5). The pilot study identified the need to develop an additional framework to evaluate LGDM in the classroom. It also raised the need to validate further the proposed frameworks using a self-regulation approach. Due to the nature of LGDM assignments to be considered two tasks in one (content creation and digital media artefact production), the author considered self-regulation as an appropriate theoretical construct to measure student learning experience with LGDM assignments. Chapter 4, paper 1 proposed the evaluation framework and a questionnaire to measure self-regulation in LGDM assignments (paper 2).

The final step of this research was to utilise all the frameworks developed, and the self-regulation validated survey in conjunction to LMS logs, marks attained, open-ended questions, interviews, and group contribution data to gauge student learning experience with LGDM in Science education. The objective of the paper in this chapter was to test the following research questions:

1. Are students self-regulating their learning when LGDM assignment design follow a systematic approach?
2. How does a systematic approach guided by theoretical frameworks impact the overall student learning experience with LGDM assignments?

For this purpose, the frameworks developed in Chapter 3 informed the LGDM intervention. First, the Digital Media Literacies Framework (Chapter 3, paper 1) was chosen to guide student training needs in digital media production. This framework helped to define the elements of digital media literacies required to engage in the production of LGDM assessments effectively. This framework proposed that the effective creation of a digital media artefact has three domains: conceptual, functional, and audiovisual. The conceptual domain relates to research for evidence-based information and the creation of a storyboard. The functional domain represents the development of skills for the use of software and applications, i.e., video editing software, animation software, and so on. Finally, the audiovisual domain covered digital media principles or the grammar of the 21st century. These domains need to be mastered to produce an engaging digital artefact.

The second framework used was the Taxonomy of Digital Media Types (Chapter 3, paper 2), and helped academics to decide what type of media they could use for their assessment tasks but also informed the development of marking rubrics. The third framework helped students to understand and apply digital media principles to the production of their LGDM assignments (Chapter 3, paper 3). This framework guided student training in layout design, colour theory, typography, C.R.A.P principles (Contrast, Repetition, Alignment, and Proximity), image and video principles.

The three previous frameworks described above complemented the LGDM Implementation Framework (Chapter 3, paper 4). This student-centred practical framework was designed to assist in the implementation of LGDM as an assessment tool in the classroom. It considered pedagogies, student training, video hosting, marking scheme, group contribution, feedback, reflection and evaluation.

Finally, the methodological approach to evaluate the effectiveness of Learner-Generated Digital Media (LGDM) framework (Chapter 4, paper 1) informed data gathering and analysis.

To address the research questions presented, a population of 348 science students undertaking a LGDM task were split into two groups according to LGDM training delivery mode: Online (n=199) and Blended (n=149). The validated self-regulation questionnaire for LGDM developed in Chapter 4 was trialled at three-time intervals during Autumn 2017 session: T1 (week 2), T2 (week 6) and T3 (week 10). Additional data include LMS logs on student activity within the LGDM folder, marks attained, group work contribution data (SPARKPlus), open-ended questions, and interviews to gauge student motivation to complete the LGDM assessment task. The evaluation framework (Chapter 4, paper 1) guided the methodological triangulation of data to assess the student's learning experience.

Overall results found that the systematic implementation of LGDM assignments following the frameworks described had a positive effect on student self-regulation beliefs for both, online and blended cohorts. The self-regulation data was confirmed with the results for group work contribution, marks attained, open-ended questions and interviews. The paper discussed the limitations of the data sample and highlights some strategies that can be used to improve teaching and learning with LGDM assignments in the discipline of science. The following paper presents the findings of the chapter:

Reyna, J., Hanham, J., Vlachoupolus, P., & Meier, Peter (2019). A Systematic Approach to Designing, Implementing, and Evaluating Learner-Generated Digital Media (LGDM) Assignments and Its Effect on Self-Regulation in Tertiary Science Education. Accepted for publication, Research in Science Education.

Certificate of authorship and originality

This chapter include a peer-reviewed journal paper accepted for Research in Science Education (Springer Journal). I certify that the work presented in this chapter has not previously been submitted as part of the requirements for a degree. I also certify that I carried most of the work presented in this paper.

- Jorge Reyna wrote the entire manuscript
- Peter Meier, Jose Hanham and Panos Vachoupolus provided feedback on the concept before writing the paper.
- Peter Krockenberger did the proofread of the manuscript.

Primary Author

Production Note:
Signature removed prior to publication.

Jorge Reyna

03/31/2019

Research in Science Education
https://doi.org/10.1007/s11165-019-09885-x

A Systematic Approach to Designing, Implementing, and Evaluating Learner-Generated Digital Media (LGDM) Assignments and Its Effect on Self-regulation in Tertiary Science Education

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Published online: 30 August 2019

Abstract
This study explored the self-regulation strategies and learning experiences of undergraduate science students completing Learner-Generated Digital Media (LGDM) assignments that had been implemented using a theory-driven, systematic approach. The rationale for using LGDM in science education is to facilitate student learning of complex scientific concepts through the multimodal representation of content using digital media. The study was conducted in seven science subjects from first to third year in Autumn 2017, using a sample of 348 undergraduate science students attending a university located in Sydney, Australia. All the participants were enrolled in subjects that required them to communicate complex scientific concepts using digital media. Training on LGDM was conducted online ($n = 199$) and in blended mode ($n = 149$). The study used a mixed-methods approach with a validated self-regulation questionnaire, LMS logs, assessment scores, group contribution data, open-ended questions, and interviews. Online students were more likely than blended students to report using self-regulation strategies for goal setting, time management, task strategies, and help-seeking. Data triangulation revealed that participation in LGDM assignments was perceived by students to contribute to their science content knowledge, provide them with digital media skills, and nurture their capacity for working in groups. The findings of this study have implications for how LGDM is deployed in science education.

Keywords Learner-generated digital media · Digital media assignments · Multimedia assignments · Self-regulation · Science education

Introduction

Digital technologies are reshaping the way people learn, socialise, and communicate. Evidence of this change can be seen with the rise of platforms such as Facebook (Manzi et al. 2018),

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Twitter (Weller et al. 2014), Instagram (Salomon 2013), and LinkedIn (Cho and Lam 2017). Educators have identified the need for twenty-first-century professionals to be competent in communicating in the digital space (Alexander et al. 2016; Hobbs 2017b; Shen et al. 2018). Providing students with digital media assignments is seen as an essential strategy for enhancing digital communication skills (Alexander et al. 2016; Hobbs 2017a; Potter and McDougall 2017). In science education, the promotion of digital media assignments has the following aims: (i) facilitate student learning of complex scientific concepts via multimodal representation of content using digital media; (ii) develop critical, problem-solving, and research skills while building the storyboard; (iv) develop digital media literacies; (v) expose students to teamwork, collaboration, and conflict resolution; (vi) help students to exercise cross-cultural communication, cultural sensitivity, and understanding of diversity (Coulson and Frawley 2017; Jablonski et al. 2015; Nielsen et al. 2018; Pearce and Vanderlelie 2016a).

The term Learner-Generated Digital Media (LGDM) refers to any digital media artefact developed by students to showcase their learning (e.g. podcast, digital story, animation, or video) (Reyna et al. 2016). Early use of LGDM was in teacher education courses; LGDM was used as a reflective tool (Kearney 2013; Kearney and Schuck 2005; Rich and Hannafin 2009). In science education, there has been a different focus, with an emphasis on active learning, inquiry, and research approaches (Hoban et al. 2015). Areas of research on LGDM include biology (Pirhonen and Rasi 2017), computer programming (Powell and Robson 2014; Vasilchenko et al. 2017), health sciences (Pearce and Vanderlelie 2016b), pharmacology (Henriksen et al. 2016; Nielsen et al. 2017; Reyna et al. 2016), geology (Reyna et al. 2017b), mathematics (Calder 2012; McLoughlin and Loch 2012), and engineering (Anuradha and Rengaraj 2017). These studies represent early attempts to explore LGDM in the classroom. There is an emerging consensus on the need for rigorous approaches to be adopted in evaluation studies of LGDM in educational settings (Hoban et al. 2015; Pirhonen and Rasi 2017; Potter and McDougall 2017).

According to the literature, the design, implementation, and evaluation of Learner-Generated Digital Media have tended not to follow a theory-driven, systematic approach (Hoban et al. 2015), meaning that the intervention did not follow a plan or use theoretical models to inform the assessment task design. Key elements that have been missing in the design of LGDM in educational settings include the training of students in digital media creation, identification of appropriate digital media types, linking the task with learning objectives, and the development of appropriate marking rubrics (Reyna et al. 2016). Failure to consider these elements can result in a range of negative outcomes for students. As an example, if the digital media training needs of students are not taken into consideration, this may lead to student apprehension and anxiety (Coulson 2017; Pearce 2014). With regard to the implementation of LGDM, it is essential to communicate the requirements and expected outcomes of the task to students, including how the assessment task is designed and the reasons why they need to learn how to use digital media. These elements may help promote student engagement and understanding of the value of the learning task (Phillips et al. 2012). Evaluation means collecting data to assess and improve the student experience. Evaluation can capture the skills that students have acquired, including digital media skills, knowledge construction, attitudes towards digital media for learning, understanding of the assessment task, and open-ended comments.

It has been suggested (Buckingham 2007) that digital media assignments have been implemented in the classroom as an opportunistic pedagogical agent, with the expectation that students will develop digital media production skills without formal training and support from educators. Digital media as a discipline has principles and practices that cannot be mastered without formal training (Arvidsson and Delfanti 2019; Martin and Zahrndt 2017; Reyna et al. 2018a, b, c). Therefore, expecting students to learn digital media production by engaging in LGDM assignments without training is misguided.

LGDM is considered under-theorised and under-researched (Hoban et al. 2015; Potter and McDougall 2017). Frameworks to implement LGDM in the classroom come from either the technological or the pedagogical perspective; the roles of educators and students are unclear. Scholars have proposed several models of good practice for video in the classroom. A comprehensive nine-stage model was developed by Kearney and Schuck (2005) which focused on teaching strategies and peer learning structures. A limitation of the model is that it is difficult to contextualise in other disciplines. Later, a learning design model for digital stories was proposed based on the previous model (Kearney 2009). Recent attempts to develop a framework for multimedia production in the classroom include the CASPA Model (Consume, Analyse, Scaffold, Produce, and Assess) (Blum and Barger 2018), and the AACRA (Access, Analyse, Create, Reflect, and Act) (Hobbs 2017a) model, which are useful frameworks to guide the implementation of digital media. However, there is still a need for models that consider student group dynamics, training, marking rubrics, and evaluation of student experiences.

To date, the research field has been dominated by qualitative methodologies, which have provided in-depth insights into the lived experiences of small cohorts of students working on LGDM assignments (Hoban et al. 2015). These studies have been essential for unpacking some of the complexities associated with the implementation of LGDM. Nevertheless, there is a need for studies that employ designs that allow for a more holistic understanding of the nature of Learner-Generated Digital Media in science subjects. Mixed-methods designs represent such an approach, because they involve the collection, and often the triangulation, of various sources of quantitative and qualitative data.

Educators outside of the creative disciplines (visual design, digital media, graphic design, and film) face challenges in designing, implementing, and evaluating LGDM assignments (Bader and Lowenthal 2018). These challenges are related to a lack of understanding of digital media production workflows and principles, such as storyboarding, colour theory, layout design, typography, and video editing applications (Reyna et al. 2018a, b, c). For these reasons, it is common to see in the LGDM literature that digital media training has been neglected. It is essential to develop a systematic approach to LGDM in the classroom that identifies student training needs for digital media creation. With that approach, students will not only learn the subject content, but also develop practical digital media communication skills.

Literature Review

Self-regulation

In educational contexts, self-regulation covers the judgements, feelings, thoughts, actions, and strategies involved in achieving a learning goal (Zimmerman 2002). From the perspective of social learning theory, self-regulation is a complex interaction of cognitive, metacognitive, behavioural, and environmental processes (Bandura and Walters 1977). Several studies have found that self-regulation is associated with motivation, academic performance, achievement (Azevedo and Cromley 2004), and depth of student thinking (Jenson 2011). Studies have also shown that self-regulation can help students to focus on the learning process (Ottenhoff 2011) and promote the acquisition of reflective and responsible competence (Sluijsmans et al. 2002).

Self-regulation is a critical factor in higher education online courses (Agustiani et al. 2016; Bailey et al. 2015; Hodges 2008; Pardo et al. 2016), in part because educators are not physically present (McMahon and Oliver 2001) and students need to be self-directed. Self-regulation is also vital in blended learning environments (Barnard et al. 2009; Broadbent 2017; Kenney and Newcombe 2018). These modes of learning require high levels of motivation, self-efficacy, and persistence for success (Edwards 2018; Kaufmann and Buckner 2018; Vanslambrouck et al. 2018). Students in online and blended environments need to be actively engaged leaders of their learning processes, so self-regulation has an essential role in ensuring they will engage with online resources and succeed in their learning. Self-regulated students monitor their learning and can identify and implement the strategies required to succeed (Miller 2015).

Self-regulation processes are highly context-dependent (Zimmerman 1998; Zimmerman and Tsikalas 2005). For instance, a survey instrument that is valid for traditional settings may be invalid for online settings due to the dramatic differences between the delivery modes and the student profiles (Barnard-Brak et al. 2010; Barnard et al. 2009). Online learners need to be more independent and self-directed than blended or face-to-face learners (Barak et al. 2016; Kocdar et al. 2018). Online activities are open regarding time, pace, and content, which means that strategies such as time management and environmental structuring are required (Barak et al. 2016; Barnard et al. 2009; Broadbent 2017). Only in the past decade has a self-regulation questionnaire for online and blended learning been validated (Barnard et al. 2009). In the literature, comparisons between students in these two settings are rare, and it is an area of research that needs attention to inform course design to maximise student performance. From the limited research, it appears that online learners use self-regulation strategies more often than blended learning students do (Broadbent 2017).

Self-regulation is multidimensional, with a set of subscales used to measure the different dimensions of self-regulation. These subscales have been reviewed extensively (Barnard et al. 2009; Nota et al. 2004; Pintrich and Zusho 2007; Schunk and Zimmerman 1997; Zimmerman and Schunk 2011). One dimension of self-regulation, *environment structuring*, refers to strategies students use to organise their physical environment at home or elsewhere so that distractions are minimised (Zimmerman 1995). *Goal setting* is considered a critical dimension of self-regulatory learning and refers to learners' goals for their studies (Pintrich 1991). *Time management* is a dimension of self-regulation that includes scheduling, planning, and managing one's study time (Chen 2002). *Task strategies* refer to the student's methods of learning, such as note-taking or preparing questions before classes or discussion forums (Zimmerman 2002). Finally, *help-seeking* refers to pursuing academic help to promote learning (Lynch and Dembo 2004).

Previous research has highlighted the need to investigate self-regulation to better understand how students undertake digital media assignments (Reyna and Meier 2018b). The authors posited that digital media for learning requires the development of a high level of self-regulation and autonomy to complete tasks successfully. Students lacking self-regulation skills may not be able to handle the autonomy of the learning tasks and may not complete them successfully (Barnard et al. 2009).

There are several aspects involved in the production of LGDM digital media assignments—producing the content, planning a multimodal representation, and building the digital media artefact. Students need to set up a goal for the project, research a given topic, and write a storyboard. To do this, students need to control their environment to avoid distractions (e.g. put mobile phones on silent) and they need to develop task strategies (e.g. note-taking in classes or tutorials). Then, they have to review the training material on digital media production, using task strategies, time management skills, and possibly help-seeking from the Internet or resources such as YouTube videos. Students need to monitor their activities and time to ensure they deliver their LGDM by the due date. An important, and arguably overlooked, aspect is motivation. The learning curve to acquire digital media production skills is generally slow due to its time-consuming, iterative, and resource-intensive nature (Arvidsson and Delfanti 2019; Musburger and Kindem 2012; Sørensen and Levinsen 2014). Students need to be motivated to achieve a good result for their digital media project. Motivation is considered the sine qua non of self-regulation processes. Constructs such as self-efficacy (Pintrich and Zusho 2007), task value (Pintrich 2004), attribution to failure (Licht and Dweck 1984), and anxiety (Zimmerman 1989) have a direct effect on self-regulation.

Theoretical Frameworks to Design LGDM Assignments

A practical workflow, flexible enough to apply to any digital media type across all disciplines, has been identified as necessary for implementing LGDM assignments systematically (Reyna and Meier 2018a, b). Previous research by the authors developed a set of five frameworks to design LGDM assignments for tertiary science students which were transferable to other disciplines. Descriptions of these frameworks are provided below.

The Digital Media Literacies Framework

This framework defines the elements of digital media literacy required for the production of LGDM assessments in educational settings. The Digital Media Literacies Framework (DMLF) proposes that the creation of a digital artefact has three domains—conceptual, functional, and audiovisual. The conceptual domain relates to research to find evidence-based information and the creation of a storyboard. The functional domain represents the development of skills for the use of software and applications, for example, video editing software, animation software, and so on. Finally, the audiovisual domain covers digital media principles, ‘the grammar of the 21st century’. All these domains need to be mastered to produce an engaging digital artefact (Reyna et al. 2017a).

The Taxonomy of Digital Media Types

The second framework is the Taxonomy of Digital Media Types, which incorporates and further extends the DMLF. The framework classifies the different digital media types according to the complexity of the production skills required to create digital media artefacts, ranging from the development of an audio podcast to a blended media artefact—a video containing animations, images, and motion graphics. It also helps academics to decide what type of media to use for their assessment tasks and it informs the development of marking rubrics. For example, under communication skills, the marking rubric for the LGDM task could have three sections—the conceptual, functional, and audiovisual domains (Reyna et al. 2017a).

The Digital Media Principles Framework

This model can be used to educate students and academic staff about digital media principles and how these principles can be applied in the production of LGDM assignments. Its development was informed by research in neuroscience, psychology, visual design, and multimedia learning. The digital media principles articulated in the model include layout design, colour theory, typography, C.R.A.P principles (contrast, repetition, alignment, and proximity), image use, and video principles. The application of these principles is important for the creation of engaging digital media artefacts (Reyna et al. 2018a).

The LGDM Implementation Framework

The three frameworks described above complement the LGDM Implementation Framework. This framework contains eight elements that guide the implementation of LGDM assignments in the classroom—pedagogy, student training, video hosting, marking scheme, group collaboration, feedback, reflection, and evaluation. It includes FAQs discussed in the classroom and is scaffolded with supporting material available in the learning management system (LMS) (Reyna and Meier 2018a, b).

A Framework to Evaluate Learning Through LGDM Assignments

This framework uses a longitudinal, mixed-methods approach to examine changes in students' self-regulation processes over time and their relationship with individual and group performance in LGDM assignments. It captures group contribution data, learner management system (LMS) logs, and marks attained for the LGDM task. The qualitative components include open-ended questions, individual structured interviews, and focus groups. Methodological triangulation is used to evaluate the student learning experience in LGDM assignments (Reyna et al. 2018c).

This research aimed to test the validity of these frameworks through the lens of self-regulation. Research questions were (i) are students self-regulating their learning when LGDM assignment design follows a systematic approach?; and (ii) how does a systematic approach guided by theoretical frameworks impact the overall student learning experience with LGDM assignments?

Materials and Methods

The study used a mixed-methods approach (Tashakkori and Teddlie 2010), where quantitative and qualitative data were analysed using methodological triangulation to support the findings (Bekhet and Zauszniewski 2012). The study had full ethics clearance from the university (UTS HREC ETH16-1060).

Participants

The research was conducted in the Autumn session, March to June 2017, at the Faculty of Science in a metropolitan university in Sydney, Australia. The study was based on a total sample of 1687 students distributed across seven subjects across first year (Health and

Homeostasis, $n = 697$), second year (Investigation of Human Remains, $n = 78$; Geological Processes, $n = 103$), and third year (Pharmacology 1, $n = 295$; Neuroscience, $n = 323$; Molecular Nanotechnology, $n = 50$; Medical Imaging, $n = 110$) which had implemented LGDM assignments. In all the cohorts, students were able to choose their preferred digital media type out of digital story, animation, or video because the theoretical models used applied across all of them. The mode of delivery for all cohorts was blended mode, i.e. face-to-face lectures in the classroom complemented by self-paced online activities. For LGDM training, two methods of delivery were used: online, where the students completed the instruction inside the learning management system; and blended, where students had a face-to-face lecture and engaged in revision with online materials. Both these models were required because one subject could not allocate face-to-face lectures due to timetable constraints.

The participants completed a self-regulation questionnaire at three time-points during the session—T1 (week 2), T2 (week 6), and T3 (week 10). The collection of demographic data took place at the end of T1 (gender, age, education, and English as an additional language). Additionally, at the end of T3, answers to open-ended questions were collected to capture student views on the LGDM task. These questions were (i) what did you like about the digital media assignment?; (ii) what did you like less about the digital media assignment?; and (iii) do you have any suggestions on how it can be improved? All students, except for one subject (Pharmacology 1), were allocated to groups to work on their LGDM assignments. Pharmacology 1 was the only group that created blogs; the other subjects created videos.

Task Learning Design

Learner-Generated Digital Media (LGDM) assignment design, implementation, and evaluation followed a systematic approach, using five previously developed frameworks. Figure 1 presents a workflow and explains the frameworks and how they were used in the current study. The first four frameworks were validated in a pilot study that found that students had a positive attitude towards the training and support in LGDM creation provided during the session (equivalent to the old term 'semester'). The training was designed using the Digital Media Literacies Framework, the Taxonomy of Digital Media Types, and the Digital Media Principles Framework. The LGDM implementation framework was also validated by student attitudes towards the LGDM assessment's design (Reyna and Meier 2018b). The last framework to evaluate learning with LGDM assignments was recommended in the previous study and trialled in this research. All of these models can be used for any digital media artefact, as they are flexible enough for use with audio podcast, infographic, animation, brochure design, website, blog, or video.

Self-regulation Questionnaire

A previously developed and validated twenty-item self-regulation questionnaire about LGDM assignments was used for the quantitative data collection (Reyna et al. 2019). The subscales included Task Strategies (TS), Goal Setting (GS), Environment Structuring (ES), Time Management (TM), Help-Seeking from People (HSP), and Help-Seeking from the Internet (HSI). The questionnaire used a four-point scale from 1 to 4 (strongly disagree, disagree, agree, and strongly agree). The self-regulation subscales were mapped against the LGDM Implementation framework (see Fig. 1, green rectangles). Student Training was aligned with Task

Strategies and Group Work was aligned with Goal Setting. Environment Structuring and Time Management and Feedback were aligned with Help-Seeking (Fig. 1, green rectangles).

Marking Rubric

All subjects used a standard rubric structure to measure communication skills in LGDM assignments, but weightings ranged from 20 to 30% of the total assignment score. The rubric comprised three sections, which were informed by the Digital Media Literacies Framework (Reyna and Meier 2018a, b) and the Taxonomy of Digital Media (Reyna

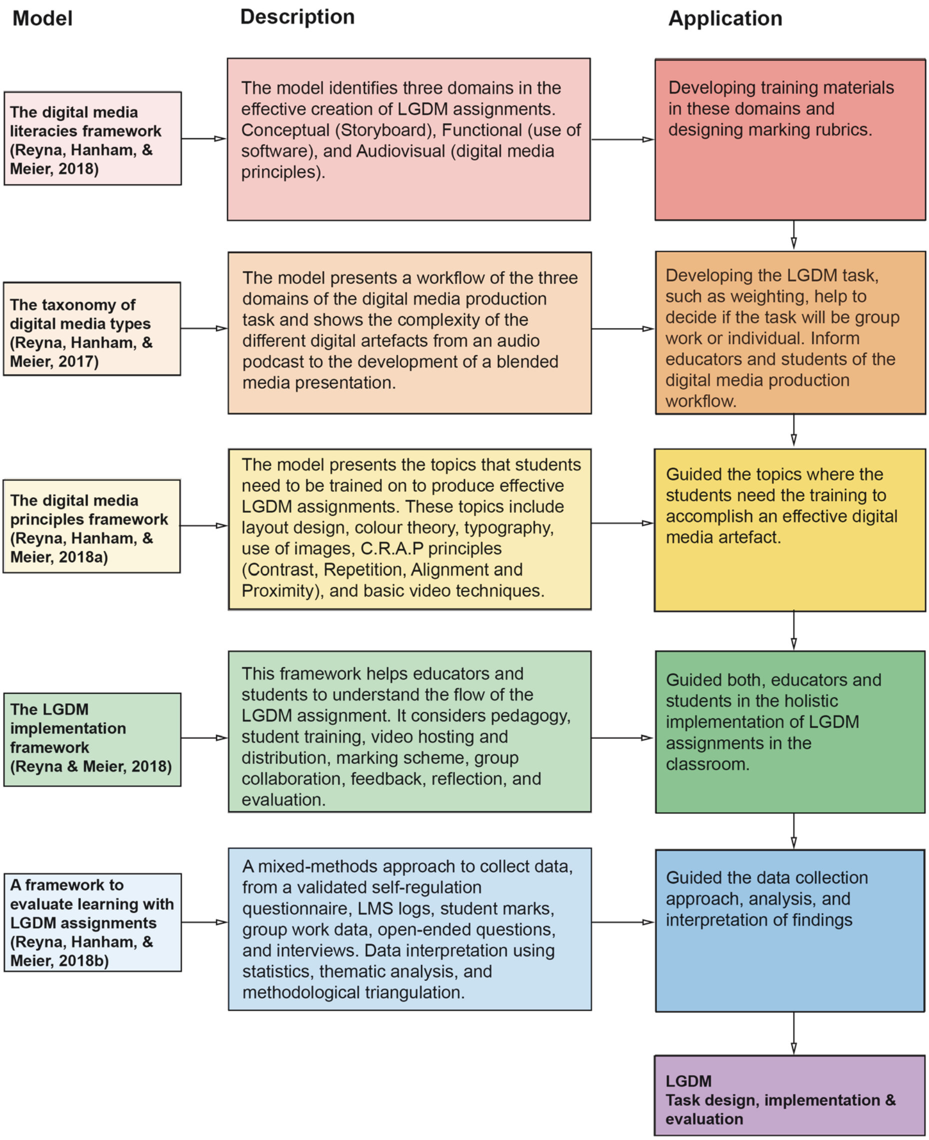

Fig. 1 Theoretical frameworks that informed the learning design of the LGDM assessment task

et al. 2017a). The conceptual domain included the goal of the presentation, synthesis of ideas, context, structure, flow, and use of references. The functional domain included the choice of software and device(s), smoothness of the presentation, no image pixellation, consistent use of transitions and effects, and audio quality. Finally, the audiovisual section of the rubric evaluated the application of the digital media principles (layout design, colour theory, C.R.A.P principles, typography, images, and video techniques). Also, the weighting for the content was different for each subject, measuring different learning outcomes and graduate attributes such as disciplinary knowledge, inquiry-oriented approaches, and professional skills.

Group Contribution Data

The SPARKPlus student peer-review tool was used to capture student perceptions of group member contributions. Inside the SPARKPlus application, a marking rubric to measure effective group contribution was designed and used across all subjects with the following criteria: (i) subject input for the project; (ii) punctuality and time commitment; (ii) contribution of original ideas; (iv) communication skills and working effectively as part of the team; and (v) focus on the task and what needs to be done. The students were given a sliding scale to grade themselves and then their peers, the 'levels of contribution' scale. The scale had five levels of contribution: well below average (0–20%); below average (20–40%); average (40–60%); above average (60–80%); and well above average (80–100%). Additionally, students needed to provide feedback to their peers. Due to the large number of datasets in this research, the feedback was not used for this paper.

The SPARKPlus application automatically calculated a rating that identified unbalanced groups. The relative performance factor (RPF) is a measure of the degree of contribution to group work. This factor was calculated from a peer review of group members. The final mark for individual students was calculated by multiplying the group's mark by the student RPF factor. For instance, if a student got a group mark of 30, but his/her RPF factor was 0.7, his/her final mark was $30 \times 0.7 = 21$. Levels of contribution inside SPARKPlus for LGDM projects can be measured in three categories: Poor RPF < 0.8; acceptable 0.8 to 1.0; and excellent > 1.0 (Reyna et al. 2016).

LMS Logs

Learning management system (LMS) logs measuring student engagement with LGDM training materials were collected for T1 (week 2), T2 (week 6), and T3 (week 10). Unique visitors to the digital media files resources folder were recorded and converted to a percentage relative to the cohort size to give an estimate of the number of visits. The resources included a welcome video, FAQs about LGDM assignments, a module on digital media presentations, an example of a storyboard, links to previous LGDM assignments, and a marking rubric.

Marks Attained

Marks were collected for all the groups and converted into percentages to evaluate whether they followed a normal distribution. Using marks alone as a measure of academic performance can be inconsistent and unreliable (Phillips et al. 2012). Marks do not always truly reflect achievements, due to possible subjective biases in the marking process (Dunnigan 2018). This may apply especially to this task because it requires marking of digital media and tutors may not have experience in marking LGDM assignments. The marks were triangulated with the other datasets.

Interviews

Twenty-eight interviews with four open-ended questions were conducted with students from the different cohorts to gauge their motivation to complete the LGDM assessment task. The first question (*Did you feel you have the knowledge and skills to complete the LGDM project?*) gauged self-perceptions of confidence, which have been found in previous research to be associated with self-regulation (Pintrich and Zusho 2007). The second question (*How did you find the LGDM project's usefulness for your learning and development of skills?*) measured task value, as students who attach a high value to an assignment generally use more in-depth cognitive and metacognitive strategies for learning (Pintrich 2004). The third question (*Did you feel there were uncontrollable factors beyond your knowledge that could affect the outcome of your LGDM project?*) measured attribution to failure, as students who rate uncontrollable factors such as luck, ability, or task difficulty as their reason for failure or success do not exhibit learning tendencies (Licht and Dweck 1984). The last question (*Did you feel anxious about the LGDM project?*) gauged levels of anxiety, as it can negatively affect self-regulated learning by undermining cognitive and metacognitive learning processes (Zimmerman 1989).

Analysis of Data

Survey data on self-regulation beliefs were divided into two groups, students who received LGDM training online ($n = 199$) vs blended ($n = 149$). The available literature suggests that students who receive LGDM training online use self-regulation strategies differently to those who receive training in a blended learning mode (Barnard et al. 2009; Broadbent 2017; Kocdar et al. 2018). Taking this into account, we did not aggregate the data or analyse them together. Quantitative data (questionnaire data, LMS logs, marks, and group contribution scores) were analysed using frequencies, descriptive statistics, and one-way ANOVA. The software used to analyse the data was IBM SPSS Statistics for Windows, Version 24.0. For qualitative data (open-ended questions and interviews), thematic analysis with NVivo, Version 11, was used to find categories. Data were interpreted using methodological triangulation, which links qualitative and quantitative data to make sense of the results (Gorissen et al. 2013).

Results

Demographic characteristics of participants showed a ratio of 79% females to 21% males, of ages 17–28 (89%), 29–40 (9%), and 41–51 (2%). Sixty-five percent were high school graduates, 10% were college graduates, 10% were trade/technical/vocational graduates, 13% had university degrees, and 2% were postgraduate students. Forty-seven percent of students had English as an additional language and 53% were English native speakers.

Overall Self-regulation

The final sample for the self-regulation questionnaire comprised students who responded at all three time-points (T1, T2, and T3). Out of 1687 students, 348 responded to the self-regulation questionnaire (21% response rate). Comparisons between cohorts were not possible due to sample size variability (Table 1). This sample was divided into online ($n = 199$) and blended ($n = 149$). The students who 'strongly disagreed' and 'disagreed' were considered as having non-self-regulated beliefs, while students who 'agreed' and 'strongly agreed' were regarded as having self-regulated beliefs. Of students who received online training in LGDM, 87% had self-regulation beliefs, while 13% did not have self-regulation beliefs. Of students who received blended training in LGDM, 82% had self-regulation beliefs, while 18% did not have self-regulation beliefs. Overall descriptive statistics on self-regulation were calculated (Table 2) at T1, T2, and T3.

To assess whether there were statistical differences between the mean values for self-regulation in the subscales for online and blended delivery, one-way analysis of variance (ANOVA) was used. Students who received LGDM training online exhibited significantly higher scores for self-regulation beliefs in the following subscales at the times studied:

T1 (week 2): Task Strategies ($F = 8.492$, $P = 0.004$); Goal Setting ($F = 5.535$, $P = 0.019$); and Time Management ($F = 24.389$, $P = 0$). T2 (week 6): Task Strategies ($F = 4.278$, $P = 0.039$); Time Management ($F = 13.687$, $P = 0$); and Help-Seeking from People ($F = 11.261$, $P = 0.001$). T3 (week 10): Time Management ($F = 5.734$, $P = 0.017$); and Help-Seeking from People ($F = 6.090$, $P = 0.014$) (Table 3).

To assess the differences between self-regulation items in the subscales for online and blended delivery of LGDM training for T1, T2, and T3, one-way analysis of variance (ANOVA) was used. Table 4 presents the statistically significant items.

Self-regulation and Gender

Regarding overall self-regulation for students who received LGDM online training, there was a statistically significant gender difference, with females at T2 scoring higher for self-regulation beliefs than males ($F = 4.660$, $P = 0.011$). In contrast, no statistically significant difference by gender was found in overall self-regulation for students who received blended training for T1, T2, and T3 ($F = 4.10$, $P = 0.664$; $F = 5.45$, $P = 0.581$; $F = 2.047$, $P = 0.133$, respectively).

Table 1 Science subject cohorts that implemented LGDM assignments in Autumn 2017 and responded to the questionnaire at T1, T2, and T3

Subject	*N*	Year	Delivery mode
Health and Homeostasis 1	199	1	Online
Investigation of Human Remains	52	2	Blended
Geological Processes	17	2	Blended
Pharmacology 1	22	3	Blended
Neuroscience	33	3	Blended
Molecular Nanotechnology	13	3	Blended
Medical Imaging	12	3	Blended
Total	348		

Table 2 Descriptive statistics for overall self-regulation for online ($n = 199$) and blended ($n = 149$) modes of delivery

		N	Mean	Median	Mode	SD
Self-regulation T1	Online	199	3.107	3.002	3.00	.351
	Blended	149	3.002	2.967	2.95	.329
Self-regulation T2	Online	198	3.025	3.000	3.00	.395
	Blended	149	2.911	2.912	3.00	.337
Self-regulation T3	Online	199	3.042	2.967	3.00	.329
	Blended	148	2.947	2.912	3.00	.444

To further analyse the results, one-way ANOVA was conducted for the items in each self-regulation subscale, for both online and blended groups. Females in online settings scored higher for self-regulation beliefs at T2 than males in Environment Structuring (*I choose a time with few distractions for working for my digital media assignment*) ($F = 3.657$, $P = 0.027$) and Time Management (*I schedule regular times each week to work on my digital media assignment*) ($F = 3.732$, $P = 0.026$). Additionally, females scored higher at T3 for Help-Seeking from People (*I share the difficulties I am having with the digital media assignment with my classmates*) ($F = 4.162$, $P = 0.017$) (Table 5).

Females in blended mode scored higher for self-regulation beliefs in Task Strategies at T1 and T3 (*I take notes from the digital media workshop to be more prepared for the task; I visit the digital media resources inside the LMS*), T1 ($F = 3.330$, $P = 0.039$; $F = 3.432$, $P = 0.035$), and T3 ($F = 5.896$, $P = 0.003$; $F = 3.818$, $P = 0.024$). Females also scored higher at T3 for Environment Structuring (*I choose a time with few distractions for working for my digital*

Table 3 One-way ANOVA for the effects of online and blended modes of delivery (LGDM training) on self-regulation subscales for T1, T2, and T3

Variable mean	Online		Blended			
	M	SD	M	SD	F	Sig.
T1 (week 2)						
Task Strategies	3.196	.431	3.049	.507	*8.492*	*.004*
Goal Setting	3.107	.467	2.981	.530	*5.535*	*.019*
Environment Structuring	3.081	.459	3.030	.499	.978	.323
Time Management	3.034	.529	2.749	.533	*24.389*	*.000*
Help-Seeking People	3.025	.415	2.934	.492	3.482	.063
Help-Seeking Internet	3.196	.430	3.269	.606	1.703	.193
T2 (week 6)						
Task Strategies	2.969	.509	2.848	.586	*4.278*	*.039*
Goal Setting	3.000	.507	2.935	.515	1.373	.242
Environment Structuring	3.049	.491	2.988	.476	1.363	.244
Time Management	2.931	.541	2.703	.603	*13.687*	*.000*
Help-Seeking People	2.994	.443	2.837	.415	*11.261*	*.001*
Help-Seeking Internet	3.182	.514	3.155	.494	.231	.631
T3 (week 10)						
Task Strategies	2.969	.609	2.851	.642	3.071	.081
Goal Setting	3.055	.532	3.003	.586	.741	.390
Environment Structuring	3.076	.523	3.027	.512	.749	.387
Time Management	3.010	.569	2.858	.604	*5.734*	*.017*
Help-Seeking People	2.991	.478	2.858	.516	*6.090*	*.014*
Help-Seeking Internet	3.189	.543	3.085	.632	2.746	.098

*Statistically significant difference: $p<0.05$

Table 4 One-way analysis of variance for the effects of online and blended modes of delivery on self-regulation subscales for T1, T2, and T3. Data only included items that had statistical significance

Item	Online		Blended			
	M	SD	M	SD	F	Sig.
Task Strategies T1						
I take notes from the digital media lecture to be more prepared for the task.	3.260	.537	3.09	.557	*8.738*	*.003*
I visit the digital media resources inside the LMS.	3.140	.562	2.91	.716	*10.732*	*.001*
Goal Setting T1						
I set goals to help me manage my time for engaging with my digital media assignment.	3.180	.519	3.01	.612	*7.856*	*.005*
Time Management T1						
I schedule regular times each week to work on my digital media assignment.	2.940	.582	2.62	.654	*23.341*	*.000*
I manage my time efficiently, so I am not rushing around to finish at the last minute.	3.100	.661	2.91	.681	*7.209*	*.008*
I follow my planned schedule for completing the digital media project.	3.060	.589	2.720	.607	*27.394*	*.000*
Task Strategies T2						
I visit the digital media resources inside the LMS.	3.030	.638	2.740	.061	*14.757*	*.000*
Help-Seeking People T2						
I find people who are knowledgeable in subject content so that I can ask them for help.	2.970	.618	2.800	.682	*6.441*	*.012*
I share the difficulties I am having with the digital media assignment with my classmates.	3.090	.546	2.910	.546	*9.108*	*.003*
I check with my classmates to find out how I am doing on my assignment.	3.070	.575	2.890	.585	*7.661*	*.006*
I check with my classmates to find out what I am learning that is different from what they are learning.	3.03	.597	2.82	.636	*9.529*	*.002*
Time Management T3						
I schedule regular times each week to work on my digital media assignment.	2.930	.647	2.750	.775	*5.847*	*.016*
I follow my planned schedule for completing the digital media project.	3.060	.589	2.880	.669	*4.679*	*.031*
Help-Seeking People T3						
I find people who are knowledgeable in subject content so that I can ask them for help.	2.970	.634	2.840	.639	*3.902*	*.049*
I share the difficulties I am having with the digital media assignment with my classmates.	3.060	.601	2.890	.653	*6.222*	*.013*
I check with my classmates to find out what I am learning that is different from what they are learning.	3.040	.582	2.86	.728	*5.903*	*.016*

*Statistically significant difference: $p<0.05$

media assignment) ($F = 3.894$, $P = 0.023$) and Help-Seeking from People (*I share the difficulties I am having with the digital media assignment with my classmates; I check with my classmates to find out what I am learning that is different from what they are learning*) ($F = 4.829$, $P = 0.009$; $F = 3.456$, $P = 0.034$, respectively) (Table 6).

Males who received blended training exhibited statistically significantly higher self-regulation belief scores at T1 and T2 than females for Help-Seeking from People, in the item: *I check with my classmates to find out what I am learning that is different from what they are learning* (T1: $F = 5.137$, $P = 0.007$; T2: $F = 4.527$, $P = 0.012$) (Table 5).

These results may not be representative, due to the large population of females in the current study. Overall population of females was 89% ($n = 272$) and males 11% ($n = 71$). For

Table 5 One-way ANOVA for the effects of gender on self-regulation subscales at T1, T2, and T3 of students who received LGDM training online. Data only included items with statistical significance

Item	Female ($N=174$)		Male ($N=21$)			
	M	SD	M	SD	F	Sig.
Environment Structuring T2						
I choose a time with few distractions for working for my digital media assignment.	3.01	.594	2.71	.644	*3.675*	*.027*
Time Management T2						
I schedule regular times each week to work on my digital media assignment.	2.82	.625	2.52	.814	*3.732*	*.026*
Help-seeking People T3						
I share the difficulties I am having with the digital media assignment with my classmates.	3.09	.568	2.76	.768	*4.162*	*.017*

*Statistically significant difference: $p<0.05$

the online group, the percentage of females was 89% ($n=174$) and males 11% ($n=21$) and for the blended group, females were 66% ($n=98$) and males 34% ($n=50$). It has been suggested that there is a difference between males and females in self-regulation strategies (Niemivirta 1997; Wolters 1999). This could affect the results and will be examined in the "Discussion" section.

Table 6 One-way ANOVA for the effects of gender on self-regulation subscales at T1, T2, and T3 for students who received LGDM training in blended mode. Data only included items with statistical significance

Item	Female ($N=98$)		Male ($N=50$)			
	M	SD	M	SD	F	Sig.
Task Strategies T1						
I take notes from the digital media workshop to be more prepared for the task.	3.22	.508	3.00	.495	*3.330*	*.039*
I visit the digital media resources inside the LMS.	3.02	.718	2.70	.278	*3.432*	*.035*
Help-Seeking People T1						
I check with my classmates to find out what I am learning that is different from what they are learning.	2.82	.737	3.02	.589	*5.137*	*.007*
Help-seeking People T2						
I check with my classmates to find out what I am learning that is different from what they are learning.	2.81	.651	2.88	.558	*4.527*	*.012*
Task Strategies T3						
I take notes from the digital media lecture to be more prepared for the task.	3.02	.707	2.60	.700	*5.896*	*.003*
I visit the digital media resources inside the LMS.	2.86	.750	2.70	.678	*3.818*	*.024*
Environment Structuring T3						
I choose a time with few distractions for working for my digital media assignment.	3.05	.569	2.82	.629	*3.894*	*.023*
Help-seeking People T3						
I share the difficulties I am having with the digital media assignment with my classmates.	2.94	.662	2.84	.584	*4.829*	*.009*
I check with my classmates to find out what I am learning that is different from what they are learning.	2.86	.720	2.70	.678	*3.456*	*.034*

*Statistically significant difference: $p<0.05$

LMS Logs

The LMS logged unique visitors to the LGDM resources folder of training material for students. These resources included a 'welcome' video, an online module on digital presentations, a PDF of FAQs, an example of a storyboard, and links to examples of LGDM projects from Spring 2016. Due to the limitations of the LMS, it was not possible to track student visits to each of these resource items. In T1 (week 2), 70 and 53% of students visited the LGDM resources, while 79 and 58% visited in T2 (week 6), and 77 and 67% in T3 (week 10), for online and blended modes, respectively.

Marks Attained

Marks could not be compared because there were different markers and different rubrics aligned with different subject learning objectives. The data had a normal distribution. The marks were also analysed per subject, and all subjects had normal distributions for both online and blended cohorts.

Group Contribution (RPF Factor—SPARKPlus)

One-way ANOVA showed no significant differences between RPF factors for the online and blended groups ($F = 0.25$, $P = 0.875$). In both groups, a normal distribution of RPF factors was observed. The mean for RPF < 0.8 was 2.6%, for RPF 0.8–1.0 was 51.3%, and for RPF > 1 was 46.1% across all subjects. RPF factor data were also divided into years (first, second, and third) and one-way ANOVA was run, but no statistical differences were found ($F = 0.120$, $P = 0.887$). Table 7 shows the RPF range: Excellent (> 1.0); acceptable (0.8–1.0); and poor (< 0.8).

Open-ended Questions

A total of 442, 297, and 250 responses were received from students for questions (1) what did you like about the digital media assignment?; (2) what did you like less about the digital media assignment?; and (3) do you have any suggestions on how it can be improved?

In some cases, a single student answer was coded into a few themes. For instance, a student might say that they enjoyed learning digital media, the creativity aspect, and the group work experience. Responses from the online and blended groups were coded separately (Tables 8, 9, and 10).

Table 7 RPF factor distribution by percentage across subjects undertaking the LGDM assignment in 2017 in the Faculty of Science

RPF range	Geo	HH1	IHR	MI	MN	Neu
> 1 (excellent)	59.7	46.4	41.6	39.8	39.7	44.9
0.8–1.0 (acceptable)	34.0	50.5	57.1	58.3	60.0	53.9
< 0.8 (poor)	6.3	3.1	1.3	1.9	2.2	1.2

Interview Data

Did You Feel You Had the Knowledge and Skills at the Time You Started the Digital Media Project?

Three themes emerged in the responses to this question. *Inexperience with Digital Media* was a prominent theme, where most of the interviewees indicated that they had limited or no previous experience with digital media production. *Help-seeking* was a theme which reflected the strategies interviewees used to acquire skills relevant to accomplishing the LGDM task. These included accessing resources on the learning management system (e.g. digital media resources folder), searching the Internet, and help-seeking from peers in their group and those who had completed the assessment task in previous sessions. *Group support* was a theme which referred to the importance of the social and instrumental support that working together with peers in groups provided to students. Social support was about positive social reinforcement, for instance, encouragement and motivation of group members as they worked on the assignment. Instrumental support referred to group members assisting with technical aspects of the assignment, such as video editing.

In What Ways Did You Find the Digital Media Project Useful for Your Learning and Development of Skills?

Three themes emerged in the responses to this question. *Acquisition of digital media skills* was a prominent theme and reflected interviewees' belief that the process of undertaking the digital media assignment equipped them with digital media skills that they did not previously possess. Notably, most of the interviewees did not mention the

Table 8 Student 'likes' about the Learner-Generated Digital Media (LGDM) assignment

What did you like about the digital media assignment?	*N*	
	Online	Blended
Learning digital media	43	33
Group work	37	30
Creativity	39	21
The learning experience	41	17
Fun assignment	27	8
Different assignment	23	10
Helped me to learn subject content via digital media creation	22	7
Interesting assignment	13	11
Using digital media for learning	14	7
The social aspect of the assignment	9	9
Learning the subject content	10	6
Making the digital media artefact	8	7
The satisfaction after digital media creation	8	6
Developing communication skills with technology	7	5
Everything	6	5
Development of critical thinking	9	4
Improving time management	7	7
Development of organisational skills	7	4

Table 9 What students 'liked less' about the Learner-Generated Digital Media (LGDM) assignment

What did you like less about the digital media assignment?	*N*	
	Online	Blended
Time-consuming	52	20
Time to organise the assignment with the group	21	19
Difficult for students with no digital media skills	16	19
Positive comments	13	12
Assignment unclear	15	3
Nothing	12	5
Groups too large	3	14
The time to learn digital media skills	8	7
Everyone cannot contribute equally	10	6
Not being digitally savvy	9	6
Challenging	5	4
Not being creative	7	4
Not relevant to my degree	6	4
Working together as a group	5	4

specific skills gained (e.g. video production), but talked about acquiring digital skills in a more general sense. *Acquisition of collaborative learning skills* was another theme, referring to the skills students developed through the experience of working in groups, including skills related to collaborative problem-solving and conflict management. *Enhancement of learning through digital media* was a theme, referring to how digital media functioned as a tool for learning. For example, researching information online and then producing a storyboard helped to consolidate and structure knowledge. Also, translating the storyboard using multimodality (e.g. transforming concepts into a role play or creating an animation to explain a process) was identified by interviewees as a benefit of using digital media for learning. *Digital media as a distraction* was a theme mentioned by a couple of students who believed that digital media was not useful for their learning. When we looked at the cohorts which these participants belonged to, they were ones in which the assessment task was worth only 10% of the total mark.

Table 10 Student suggestions to improve the Learner-Generated Digital Media (LGDM) assignment

Do you have any suggestions on how it can be improved?	*N*	
	Online	Blended
No, is good	51	30
Additional training on creating video	43	10
Smaller groups	0	23
More clear instructions	20	2
Video to be longer	9	10
Individual assignments	7	7
Do not do it	2	8
Show video examples in the classroom	6	4
Students to choose their groups	3	7
University to provide software to edit video	3	4
Teach more about copyright	3	2

Did You Feel There Were Uncontrollable Factors Beyond Your Knowledge That Could Affect the Outcome of Your Digital Media Project?

The interviewees mentioned several potential uncontrollable factors, including availability of fellow group members, cost of digital media applications, deadlines for the assignment, and not all group members having social media accounts. Although these were identified as potential uncontrollable factors, most of the participants believed that these obstacles could be overcome. Indeed, most of the interviewees suggested that they were able to exercise a high level of control over most aspects of the LGDM assignment (e.g. assigning roles, choosing the digital media type, scheduling and attending meetings, learning different software and applications, and so on) and submitting the LGDM assignment on time.

Did You Feel Anxious About the Digital Media Project?

Most of the interviewees indicated that they were not anxious about the LGDM task, despite most of them having limited or no previous experience with digital media production. Notwithstanding this, there were three themes associated with anxiety: *anxiety as a motivator*; *choice-induced anxiety;* and *assignment-induced anxiety*. *Anxiety as a motivator*: interviewees acknowledged that they felt anxious about the assignment, though this anxiety was viewed as a motivator to ensure that they completed their part of the task on time. *Assignment-induced anxiety:* interviewees felt anxious in the initial phase of the assignment, due to having limited or no knowledge of how to put together a digital media project. *Choice-induced anxiety*: some interviewees felt anxious due to the vast range of digital media choices available to them and were unsure about which digital media products were most suitable for their projects.

Discussion

Digital media production is inherently complex, time-consuming, iterative, and resource-intensive (Arvidsson and Delfanti 2019; Musburger and Kindem 2012). LGDM tasks require students to engage in goal setting, task strategies, environmental structuring, and help-seeking, which are all dimensions of self-regulation (Reyna et al. 2019). To date, implementation of LGDM across several disciplines, including science, has not adopted a systematic approach guided by theoretical frameworks (Reyna and Meier 2018a, b). Several streams of data collected for this study strongly suggest that students engaged in self-regulation strategies when undertaking LGDM assignments which had been implemented using a theory-driven, systematic approach. The data from the study show that students are reporting the use of various self-regulation strategies during the LGDM assignment, thus providing an answer to the first research question: Are students self-regulating their learning when LGDM assignment design follows a systematic approach?

The quantitative survey data showed that the majority of participants who received training online or in blended mode exhibited high scores for various dimensions of self-regulation. Notably, participants who received training online had higher scores for self-regulation strategies than did those students who received training in blended mode. This was evident for time management, task strategies, help-seeking from people, and goal setting. The results of this study align with a previous study by Broadbent (2017), which found that online students used self-regulation strategies more often than blended learning students did, with the exception of help-seeking. In the Broadbent (2017) study, blended learning students were less likely to engage in help-seeking than online students; however, as noted in the study, neither blended nor online students engaged in help-seeking very often. In this study, there is an emphasis on group work, which was not evident in the Broadbent study and may explain the different results concerning help-seeking. In this study, the absence of an instructor for the online students is likely to have compelled them to seek help from fellow group members and the Internet more often than the blended students, who had access to an instructor, did.

Further evidence of differences between online and blended learning students emerged from analysing LMS logs. The LMS logs provided information regarding the number of unique visitors per day to the digital media resources folder in the LMS. Based on the logs, at every time interval, more online students accessed the digital media resources folder than did blended learning students. This result is likely a reflection of the fact that online students did not have face-to-face lectures and workshops, and therefore had to rely more heavily on the online resources (Wells and Blincoe 2015). Triangulating these two datasets was important. Reliance on a single source of data, such as questionnaires, can have limitations because of self-reporting biases (Johnson and Morgan 2016). In this study, the self-reported data suggesting that online students engage more often in self-regulation strategies than blended learning students appeared to be supported by the data from LMS logs. This result is consistent with previous research which showed that online students use learning resources more than blended students do (Wells and Blincoe 2015).

Regarding gender, there were differences between females and males in terms of scores on various dimensions of self-regulation. Differences between females and males in self-regulation strategies have been reported in previous research (Bidjerano 2005; Zimmerman and Martinez-Pons 1990). At various time intervals, female online students scored higher than males for task strategies, environment structuring, and help-seeking from people. In the blended mode, females scored higher than males for environment structuring and time management, but not for help-seeking from people. The finding that females report a greater propensity for time management and environmental structuring accords with previous research (Bidjerano 2005; Zimmerman and Martinez-Pons 1990). Interestingly, males taught in blended mode scored higher than females for self-regulation beliefs in help-seeking from people. It is important to note that the literature on gender differences regarding self-regulation strategies is inconclusive (Pintrich and Zusho 2007). As an example, one study found that females tend to use help-seeking strategies more than males do (Virtanen and Nevgi 2010), while another study found no statistically significant difference for help-seeking between males and females (Bidjerano 2005).

Group contribution data had a normal distribution and no statistically significant difference was found between the two groups, online and blended. For the majority of groups in the study, the contributions of group members, as measured by RPF Factors in SparkPlus, ranged from acceptable (51.3%) to excellent (46%). The RPF data aligns with the open-ended responses concerning what the participants liked most about the digital media assignment, with group work being highly rated by the participants. This also resonates with the interview theme, *group support*, which reflected the perceived importance of social and instrumental support that working in groups provided to students. Notwithstanding this, some data from the open-ended responses and the interviews—specifically from Neuroscience, where there were 6–8 students per group—suggested that the groups were too large and requested smaller size groups. It has been suggested that four students is the optimum group size to achieve higher satisfaction in knowledge acquisition, learning performance, and skill development, particularly in oral presentation, paper writing, and problem-solving (Chou and Chang 2018). Previous research suggests that, as group size increases, group performance decreases due to factors like ‘social loafing’ (Kooloos et al. 2011; Suzuki et al. 2018). An interesting finding is that, although interviewees from the Neuroscience cohort reported that their groups were too large, group contribution measures captured through SPARKPlus found that the Neuroscience groups had relatively high RPF scores, suggesting healthy group contributions.

There were consistencies between the open-ended question data and the interview data. This was evident in several respects. In the open-ended responses, *learning digital media* was the most frequently cited aspect of the LGDM assignment that students liked. This aligned with the interview theme, *acquisition of digital media skills*, which reflected interviewees’ belief that undertaking the LGDM assignment gave them digital media skills. It is important to reiterate that many of the participants indicated that, before taking the LGDM, they had limited or no knowledge of how to produce the digital media product for their assignment.

Another common thread between the open-ended responses and the interview themes was *learning through digital media*. Learning the subject content through digital media creation was cited, mostly by online students, as one of the critical aspects that students liked. Enhancement of learning through digital media was a theme from the interviews. The different phases of preparing a LGDM assignment, including storyboarding, transforming the content using a multimodal approach (e.g. converting the text into an animation or role play), and producing a digital media artefact, likely required students to engage in a variety of cognitive processes that enhanced their learning. These are likely to include cognitive restructuring (Webb and Mastergeorge 2003), self-explanation (Johnson and Mayer 2010), and meaning-making (Hoban et al. 2015).

Regarding the logistic difficulties of working with others in a group, there was a common thread between the open-ended responses and the interview themes. Interviewees highlighted that availability of group members was a potential uncontrollable factor. In the open-ended responses, finding times to organise the assignment with their group was frequently rated as one of the aspects that participants disliked about the LGDM assignment. Logistical issues such as availability of group members and finding times to meet have also appeared in previous research as negative aspects of working in groups (Pauli et al. 2008). Although not mentioned in the interviews, in the open-ended responses, the time-consuming nature of the LGDM was the most frequently cited aspect that students liked least. The time-consuming nature of digital media production has been identified in previous research as a factor related to student anxiety and apprehension about LGDM assignments (Anderson 2013; Coulson and Frawley 2017; Pearce and Vanderlelie 2016b).

The discussion in the preceding paragraphs has provided insights which address the second and final research question: (2) How does a systematic approach guided by theoretical frameworks impact the overall student learning experience with LGDM assignments? The implementation of LGDM was beneficial for most students in the study, facilitating the advancement of their scientific discipline knowledge, digital media skills, and skills for working in groups. It is also worth noting that the marks for the LGDM followed a normal distribution, which suggests that the theoretically driven implementation of LGDM likely did not have a detrimental impact on student achievement.

Conclusion

The purpose of the current study was to explore the validity of a novel systematic approach using practical frameworks to design, implement, and evaluate LGDM assignments in science subjects. Before discussing the implications of this research, it is essential to acknowledge the limitations of the study. First, the datasets included both online and blended learning students for the LGDM task. In practical terms, all students were in blended mode, although the training for the LGDM assessment task was given in both online and blended mode. Although the data were analysed separately, the online students were undertaking first-year subjects, while the blended students were taking second- and third-year subjects. Splitting the blended learning sample into subject cohorts was not appropriate due to reduction of the sample size. Second, the sample mainly comprised females (79%), so the differences found between females and males regarding self-regulation strategies need to be interpreted with caution. Third, we did not directly capture how students interacted with each other, either online or in the blended mode, as they worked on the tasks. This issue was beyond the scope of this research, but it would be useful in future research to understand student roles in their groups and map this against self-regulation processes. Fourth, all participants were from a single higher education institution. To increase the generalisability of the research, future studies should involve participants from a broader range of randomly sampled universities. Fifth, the fact that there was no control group for comparison is also a limitation. Using a control group may be ethically problematic because it could potentially disadvantage some students.

Notwithstanding these limitations, this study has several important implications. Researchers and practitioners now have a set of frameworks to guide the systematic design, implementation, and evaluation of LGDM in the discipline of science. This is a significant contribution because the deployment of LGDM in science, and other disciplines, has so far been done without using empirically tested theoretical frameworks. Educators implementing LGDM now have an evidence-based workflow to guide them. It is important to emphasise that these theoretical frameworks are flexible and can be adapted to different contexts. Educators may not always need to use all the frameworks together. As an example, an educator might already have implemented LGDM assignments, but not included a training component to train students in digital media skills. That educator could draw on the Digital Media Principles Framework (see box 3 of Fig. 1) (Reyna et al. 2018a, b, c) as a resource to guide student training, e.g. layout design, colour theory, typography, use of images. As another example, if educators or students are unsure of which digital medium to choose for the LGDM assessment task, they can consult the Framework for Digital Media Types (see box 2 in Fig. 1) (Reyna et al. 2017a). Another implication of this study concerns the evaluation of students' self-evaluation strategies as they work in groups on LGDM assignments. Self-regulation is an important component of student motivation and self-directed learning. Researchers and practitioners now have a validated tool to measure different dimensions of self-regulation. A survey could be deployed at a particular time-point (e.g. week 1, week 3 etc.), which could provide educators with insights into aspects of self-regulation, for example, goal setting or time management, that might need to be strategically targeted for improvement. For instance, groups in which members are having difficulties with time management could be identified through the survey and then assisted by an educator who could employ scaffolding strategies to improve time management skills in relation to the task.

Current research in science education identifies the need to develop a better understanding of the context in which LGDM assessments are used, the pedagogy behind them, and the learning processes involved (Nielsen et al. 2018). The various data sources used in this study confirmed that many students use self-regulation strategies when engaging in LGDM assignments. Scientific concepts can be challenging to understand and apply (Gurel et al. 2015; Tümay 2016). This could be due to the limited capacity of short-term memory and cognitive overload (Clark et al. 2011). When students self-regulate their learning using LGDM assignments, they are likely to be better able to learn the content through storyboard creation, represent the content through meaning-making, and reinforce their content knowledge through digital media production (Reyna 2019). These processes are likely to promote content retention in long-term memory and result in a higher-quality learning experience (Hoban et al. 2015).

Government agencies responsible for education (e.g. the NSW Department of Education, Australia: BOS 2012) have recognised the need for scientists to be able to use multimodal approaches to communicate. Based on the data from this research, LGDM assignments guided by a systematic, theory-driven approach may enhance students' communication skills in the digital space (Jamani 2011; Tang et al. 2014).

Reflectively, this research is not claiming that LGDM assignments will improve the quality of student learning, because providing the evidence for that claim would be methodologically challenging. The view of the authors is that science education should be relevant to the times we live in. Digital media is integrated into all systems of information and knowledge production, interacting with almost every human activity. It offers transformative power to change society and facilitate the active participation of users in media production underpinned by collaborative processes. Digital media provides to its users the opportunity to express creativity and agency. New scientists, as twenty-first-century citizens, need fluent digital media production skills and the best way to develop these skills is with a systematic approach to LGDM assignments. Guesswork with LGDM will not guarantee student development of practical digital media production skills. The author hopes that the systematic approach to LGDM assignments in the science discipline explored in this research will inspire the new generation of science educators to foster digital media principles and effective production of digital artefacts. Science educators have a social responsibility to ensure that new science graduates are equipped with effective communication skills in the digital space.

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Chapter 6:
Discussion, conclusions, limitations and recommendations

6. Discussion

This chapter summarises the contribution of this research to the body of knowledge in the design, implementation and evaluation of LGDM assignments in Science education. Each of the papers that comprise this thesis have already discussed the findings, limitations and recommendations. The purpose of this chapter is to review the discussion in the previous journal papers from Chapters 2 (Literature review), Chapter 3 (theoretical considerations for LGDM assignments and preliminary exploration) and Chapter 4 (Materials and methods) and link to the results of the last paper in Chapter 5 (self-regulation in LGDM assignments).

6.1 The need to develop models for digital media literacies for teaching and learning

Digital literacies have been discussed extensively in the literature, and there is no consensus on what it means to be digitally literate. Definitions of digital literacies include online literacy (De Abreu, 2013), multimodal literacy (Serafini, 2015), new media literacy (Ohler, 2009), computer literacy (Tsai, Wang, & Hsu, 2018), media literacy (Hobbs, 2018), and Internet literacy (Stodt et al., 2018). The definition that the author used in this research is that digital literacies are a set of technical, audio-visual, behavioural, critical and social skills that allow users to learn, communicate and socialise in the digital space (Chapter 3, paper 1). As "digital literacies" is a wide concept, for purposes of this research, the definition was narrowed to mean digital media literacies for teaching and learning, that is, the skills required to produce effective Learner-Generated Digital Media (LGDM) assignments.

The New Media Consortium (NMC) Horizon report in the US mentioned that the issues with technology are not ownership anymore but fluency in its use (Alexander, Adams, & Cummins, 2016). Although the frameworks proposed in the NMC Horizon report does not mention the audiovisual skills required to produce effective digital media artefacts, this set of skills is essential in the production of LGDM assignments. At the same time, a gap was identified whereby educators do not train or support their students in the production principles of their digital media assignments. Current use of LGDM assignments in the Science curricula follows an opportunistic approach, what Buckingham (2007) called, digital media as a pedagogical agent. Somehow it is expected that students will learn digital media creation with the LGDM task by engaging with the task. One of the bases of this assumption is that students are ‘digital natives’ (Prensky, 2001) and have the ‘instinctive ability’ to produce digital media. This shallow approach to learning with LGDM assignments is related to the lack of understanding of digital media production workflow. The literature review in Chapter 2 discussed in detail these research gaps and identified the need for theoretical frameworks to lead the design, implementation and evaluation of LGDM assignments.

The Science education literature highlighted the need for scientists to communicate using a multimodal approach with technology (Wendy Nielsen, Georgiou, Jones, & Turney, 2018). However, the literature did not discuss the need for educators to understand multimodal communication and basic principles of digital media production (Chapter 2, paper 1). Educators are the ones who should foster effective communication in the digital space. Without an understanding from educators, how could students learn to use digital media to communicate science concepts effectively to a massive audience? How can educators mark LGDM assignments fairly?

Researchers outside the Science discipline have discussed the need for students to have digital media production skills regardless of their disciplines (Alexander et al., 2016; Hobbs, 2017). Recent research has suggested that digital media skills could help users to recognise fake images online and has been highlighted as a starting point to identify fake news (Shen et al., 2018; Watson, 2018). Consequently, to help develop these digital skills for science students, the starting point of this research was to adopt a student-centred approach by providing training in digital media production to both students and educators. Chapter 3, paper 3 discussed the basic digital media principles that are considered the grammar of the 21st century. The author identified the minimum standards of these principles for students and educators to produce digital content, which can be considered as the prosumer level (a user that hovers between producer and consumer of digital media). The digital media industry has grown as fast, and the principles applied in commercial visual design and graphic design are applied now to the production of online content (Musburger & Kindem, 2012). However, students and educators outside the creative arts disciplines do not have a comprehensive understanding of these principles. Therefore, the digital media principles framework proposed in this research (Chapter 3, paper 3) should provide the required skills for students to communicate science in the digital space.

There is no training material available that deals with digital media principles at a prosumer level; therefore, paper 3 can be considered one of the first attempts to address this need in the literature.

The lack of understanding from educators of digital media production caused the research field of LGDM assignments to be under-theorised, under-researched and barely sufficient (Hakkarainen, 2009; Potter & McDougall, 2017). Educators outside of the creative disciplines implemented LGDM without following a systematic approach (Anderson, 2013b; Braun, 2017; Coulson & Frawley, 2017; Greene & Crespi, 2012; Pearce & Vanderlelie, 2016; Powell & Robson, 2014). In the literature relating to LGDM assignments, researchers did not consider student training (Kearney, Pressick-Kilborn, & Maher, 2012; W Nielsen, Hoban, & Hyland, 2017), there is a lack of accurate marking rubrics (Hoban, Nielsen, & Shepherd, 2015), a lack of strategies to ensure effective group work (Coulson & Frawley, 2017; Pearce, 2014), and the lack of a systematic approach to evaluate LGDM assignments (Anderson, 2013b; Cox, Vasconcelos, & Holdridge, 2010; Georgiou, Nielsen, Doran, Turney, & Jones, 2017; Hoban & Nielsen, 2013). Other issues include excessive student workload as video projects are carried out individually, causing students to be reluctant and stressed with the assessment task (Anderson, 2013b; Coulson & Frawley, 2017; Pearce, 2014). Additionally, it has been described that many educators are using LGDM assignments without evaluating and formally reporting any of the interventions (Liu, 2016).

The discipline of Education (pre-service teachers) were the pioneers in implementing LGDM assignments (Kearney et al., 2012; Kearney & Schuck, 2003, 2005). Their approach focused on reflective practices of teaching experiences. In contrast, in the discipline of Science, the method was to foster active learning, research and inquiry as to the primary pedagogical approaches (Hoban et al., 2015). There was an emphasis on developing graduate attributes (Frawley, Dyson, Tyler, & Wakefield, 2015) which included more recently, the ability to communicate using multimodal approaches online (Wendy Nielsen et al., 2018). Nowadays, scientists are required, for example, to produce a summary of an experiment for electronic journal submission (e.g., JoVE), or to showcase a project initiative to attract funding.

Based on the literature review of LGDM in tertiary (Chapter 1, Introduction) and science education (Chapter 2), the digital media types are classified into the audio podcast, digital story, animation, and video. The research undertaken has a common pattern: a lack of theoretical frameworks to inform LGDM task design, the absence of student training, a lack of marking rubrics and poor evaluation methodologies.

Therefore, the first research gap identified was the need for a model to guide student training on LGDM creation (Chapter 3, paper 1 and 3). The next gap was a model to inform educators and students on the different digital media types, their complexity and skills required for production (Chapter 3, paper 2). The third gap was a framework to summarise audiovisual principles into a 'Prosumer' level (the user that hovers between professional and consumer) (Bruns, 2009), to inform the effective production of LGDM artefacts (Chapter 3, paper 3). Then, a practical model to design, implement and evaluate LGDM assignments in the classroom (Chapter 3, paper 4). Finally, an empirical model to inform evaluation and research in the field of LGDM assignments (Chapter 4, paper 1).

6.2 Theoretical frameworks developed to inform LGDM assignments

As digital literacies are still 'blurry' concepts influenced by the discipline (e.g., social, technological, functional), a simple model to guide student training on digital media literacies was required. The author used a naturalistic approach (Salkind, 2010) combining knowledge from the digital media industry and previously developed learning materials. The content from previous learning materials was divided into three domains to create the Digital Media Literacies framework (Figure 1, see appendix). The conceptual domain defined as the skills required to gather evidence-based information and translate into a storyboard. Storyboard is the digital media industry standard to produce a digital artefact (Musburger & Kindem, 2012). Then, the functional domain defined by the basic video editing skills that are valid across any software or application (Chapter 3, paper 1). Finally, the audiovisual domain dealing with digital media principles such as layout design, colour theory, typography, use of images and basic video techniques. This framework guided all the training (online and face-to-face) the students received during this research project. For instance, the lectures focused on digital media principles while the workshops/tutorials on storyboarding and video editing (Chapter 3, paper 3). The exploratory study (Chapter 3, paper 5), showed that students had a positive attitude towards the support provided with the LGDM task (86%), they applied the concepts from the lecture into their LGDM assignments (88%), they used storyboards (73%), and they were willing to receive additional training (73%). These results were highly favourable and validated the digital media literacies framework to inform student training needs.

The taxonomy of digital media types (Chapter 3, paper 2) was created as an aid for educators and students to identify different digital media types and the skills required for its production, including a guide for assessment weight and marking rubric design. The taxonomy is one of the first attempts to classify digital media for teaching and learning purposes. It informs the LGDM assessment task weight and, whether it should be an individual or group task. Due to the nature of digital media creation, which is time-consuming, iterative and resource-intensive (Arvidsson & Delfanti, 2019; Musburger & Kindem, 2012), asking a student to produce a video or animation will be justifiable only in a digital media course. The learning outcome, in that case, will be highly weighted on the production of the artefact and less on the content. In the context of Science education, LGDM assignments are meant to cover subject learning objectives that are usually related to research and inquiry-based approaches (Nielsen et al., 2017). Therefore, LGDM assignments can take advantage to develop graduate attributes such as the ability to work in groups, conflict resolution, time management, and an understanding of diversity (Coulson & Frawley, 2017; Hoban et al., 2015; Pearce & Vanderlelie, 2016; J Reyna, Meier, Geronimo, & Rodgers, 2016). The Taxonomy could become a valuable tool to scaffold digital media learning across the curricula. For instance, first-year students could engage in the production of audio podcast and brochure or posters, second-year students in the production of digital story and animation while third-year students in the production of the video.

The digital media principles framework from Chapter 3, paper 3 (Figure 3, see appendix), articulates for the first time in the literature, the basic principles at a prosumer level to apply in the production of LGDM assignments. The model incorporated different disciplines such as visual design (Hashimoto & Clayton, 2009; Malamed, 2015), psychology (D. Chang, Dooley, & Tuovinen, 2002), graphic design (R. Williams, 2014), the image principles (Kress & Van Leeuwen, 1996), and video principles (Stockman, 2011). The model is well-rounded and based in common practices in the disciplines previously mentioned. The value of the digital media principles framework is that it not only identifies the prosumer level of knowledge to produce effective digital media but simplifies complex concepts to help educators and students to learn and apply the principles. The framework led student training and helped to develop the criteria for the marking rubric under communication skills (Table 1, see appendix).

The LGDM implementation framework is the key to design, implement and evaluate digital media assignments (Chapter 3, paper 4). It is a comprehensive framework that considers pedagogies, student training, video hosting, marking schema, group contribution, feedback, reflection and evaluation. Frameworks developed for teacher education are comprehensive but are difficult to contextualise outside the discipline of education (Kearney, 2009; Kearney et al., 2012). Additional models were technology-centred without emphasising educators and student roles (Barnett, 2006; Theodosakis, 2001). Contemporary models to guide the implementation of LGDM assignments did not consider core components such as pedagogies, marking schema, group contribution, feedback, reflection and evaluation, for example the CASPA model (Consume, Analyse, Scaffold, Produce and Assess) (Blum & Barger, 2018). The AACRA model (Access, Analyse, Create, Reflect and Act) incorporated reflection but failed to define pedagogies and student training, marking schema, group contribution, feedback and evaluation (Hobbs, 2017). Therefore, to date, the LGDM framework is the most comprehensive model to implement digital media assignments in the classroom, has a holistic approach and is flexible enough to be used across disciplines. It's universality and logical workflow allows educators and students to easily understand the rationale behind learning with LGDM assignments. The LGDM implementation framework has been adopted for use in marketing (Notre Dame University), education (Western Sydney University), biology (Macquarie University), and medicine (University of Melbourne) in Australian universities. Implementation in nursing education at the University of Stavanger (Norway) and teacher education at the Complutense University of Madrid (Spain) is currently taking place. These collaborations may form the basis of future multi-side studies.

The exploratory paper (Chapter 3, paper 5) aimed to test the incorporation of the frameworks to inform the systematic implementation of LGDM assignments and to develop an evaluative strategy for LGDM assignments currently missing in the literature. This paper developed a questionnaire to evaluate LGDM in the classrooms, and was validated using Factor Analysis (Williams, Onsman, & Brown, 2010) to assess the constructs and reliability of the items. The questionnaire validated a 4-factor structure: digital media support, attitude toward technology, understanding of the assignment, and knowledge construction (Table 2, see appendix). The preliminary finding of the paper was the basis of the first paper in Chapter 4 on evaluating the effectiveness of LGDM assignments. This paper offers for the first time a comprehensive mixed-method approach (Tashakkori & Teddlie, 2010) to researching the student learning experience with LGDM assignments (Figure 5, see appendix). The framework is another contribution to the under-theorised, under-researched LGDM assignments research topic (Hakkarainen, 2009; Potter & McDougall, 2017).

Additionally, the exploratory paper (Chapter 3, paper 5) identified the next step in the research, which was the mapping of the LGDM implementation framework against self-regulation subscales to study how students adapt to learn with LGDM assignments. The second paper on Chapter 4 proposed and validated a self-regulation questionnaire for LGDM assignments and discussed the implications for teaching and learning. This paper validated the following self-regulation subscales: Goal Setting, Environment Structuring, Time Management, Help-Seeking from People and Help-Seeking from the Internet (Table 3, see appendix). Most of these subscales were an adaptation from self-regulation for online and blended learning settings (Barnard, Lan, To, Paton, & Lai, 2009). Interestingly, Help-Seeking generated two different subscales, from people and the Internet. Each subscale validated items to measure self-regulation beliefs. It was challenging to find the subscales and adapt the items as most of the research in self-regulation has been done in traditional classrooms and the subscales used were not 'transferable' to the LGDM setting (Barnard, Paton, & Lan, 2008; Broadbent, 2017). Hence, the validating of the self- regulation questionnaires in this study was a crucial step to collect meaningful self- regulation data, which as identified by (Zimmerman 1998) is context-dependent.

6.3 Self-regulation and LGDM assignments

Digital media production has a slow learning curve, it is a time-consuming process, iterative, and resource-intensive (Arvidsson & Delfanti, 2019; Musburger & Kindem, 2012; Sørensen & Levinsen, 2014). Consequently, self-regulation theory was applied for the study of student adaptation to LGDM assignments. As discussed in Chapter 4, paper 2, digital media production can be considered two tasks in one, from the content perspective and the digital media production perspective. It is a task that requires autonomy to be achieved. For instance, to produce LGDM assignments, students need to set up a goal for their projects, research their topic and produce a storyboard. The next step is to engage with digital media production learning material inside the LMS. This task requires the students to adjust their environment to avoid distractions (Environment Structuring) and use approaches to learn digital media such as note-taking, watching online content, and so on (Task Strategies). Students will also use Help-Seeking from People and the Internet (e.g., talk to previous students who undertook the LGDM assignment; visit YouTube and Lynda.com for further training). When the students move to the production phase of their LGDM assignment, they will need to monitor their activities and manage their time to ensure the final product will be ready on time (Time Management). It could be argued that LGDM assignments require greater motivation to accomplish the task and Motivation is considered the *sine qua non* of self-regulation. Self-efficacy (Pintrich & Zusho, 2007), task value (Pintrich, 2004), attribution to failure (Licht & Dweck, 1984), and anxiety (Zimmerman, 1989) also affect a student's ability to self-regulate. Consequently, to explore these issues further, interview questions used in this research project were mapped against these motivational constructs as reported in Chapter 4, paper 2.

Chapter 5 contains a paper that tested the frameworks developed to inform the design, implementation and evaluation of LGDM assignments. The methodological approach (Chapter 4, papers 1 and 2) was a mixed-methods (Tashakkori & Teddlie, 2010) and used self-regulation questionnaires (T1=week 2, T2=week 6 and T3=week 10), open-ended questions, LMS logs, marks attained, group contribution data (SPARKPlus), and interviews. Methodological triangulation (Bekhet & Zauszniewski, 2012), when possible was used to confirm the self-reported data from the questionnaires. This technique is flexible and allows the researcher to decide the datasets to use (Gorissen, Bruggen, & Jochems, 2013). The questionnaire sample was divided into two: students who received LGDM training online (n=199) and blended (n=149). Analysis of frequencies of student responses found that both cohorts exhibit a high score for self-regulation beliefs, overall for online and blended, 87% vs. 81%, respectively. Responses that strongly disagreed and disagreed were considered as non-self-regulation beliefs while responses that were strongly agreed and agreed as evidence of self-regulation beliefs. Using One-Way Analysis of Variance (ANOVA), the results showed that online students exhibited a statistically significant higher score on self-regulation beliefs than blended students. Studies comparing online, and blended self-regulation are rare in the literature. A study that compared online, blended and traditional settings found that blended students outperformed traditional students, but there were no statistically significant differences (Means, Toyama, Murphy, Bakia, & Jones, 2009). Many studies reported self-regulation in online settings but used different subscales in comparison to this study. For instance, studies measured metacognition (M. M. Chang, 2007; Van den Boom, Paas, & van Merriënboer, 2007), effort regulation (Carson, 2011), peer learning (R. D. Johnson, Gueutal, & Falbe, 2009), elaboration and rehearsal (Puzziferro, 2008), and critical thinking (Klingsieck, Fries, Horz, & Hofer, 2012), but none of these scales was relevant to the current study, so comparisons would be meaningless.

When the self-regulation data was split according to the gender of respondents into online and blended samples, a statistical significance was found, females online had higher scores for self-regulation beliefs than males. This was the case for Task Strategies (T1 and T3), Environment Structuring and Time Management (T2), and Help-Seeking from People (T3). Females in blended mode had high scores for Environment Structuring and Time Management (T2), and Help-Seeking from People (T3). Males in blended mode had a high score for Help-Seeking from People (T1 and T2). This gender difference for different self-regulation subscales has been reported previously in the literature (Bidjerano, 2005; Hargittai & Shafer, 2006; Zimmerman & Martinez-Pons, 1990). In a fully online programming course, there was no statistical significance between females and males (Yukselturk & Bulut, 2009). Some authors believe that these differences are the product of stereotypical views about gender (Pajares & Valiante, 2002). Although, Chapter 5 paper reported remarkable differences in the self-regulation score relating to beliefs in female and males, due to the unbalance gender of the sample, female/male ratio of 79/21, this finding is inconclusive. Limitations section further discuss these results.

Most of the research in self-regulation has been focused on predicting academic performance (Agustiani, Cahyad, & Musa, 2016; Miller, 2015; Puzziferro, 2008; Tseng, Yi, & Yeh, 2018; Weisskirch, 2018; Yukselturk & Bulut, 2007). Due to the nature of this exploratory study, prediction of performance will require multilevel modelling due to the allocation of students in groups. This was out of scope for this PhD study. Overall self-regulation score beliefs for both groups online and blended were surprisingly high. The self-regulation data in conjunction with group contribution, student responses to open-ended questions and interviews explained a positive student learning experience with the LGDM assessment task. These results will be discussed in the following section that covers datasets triangulation.

6.4 Methodological triangulation

As noted in the earlier chapters, triangulation with other data sets was undertaken to validate this study's results (Chapter 3, paper 5 and Chapter 5 paper). Additional datasets such as LMS logs of student visits to digital media resources confirmed what students reported on the self-regulated questionnaire for Task Strategies data for T1 and T2 (*I visit the digital media resources inside the LMS*) for both online and blended modes. Marks attained for the LGDM task were not used as a measure of performance but to ensure they follow a normal distribution. Group work contribution (SPARKPlus) revealed that the students had a healthy experience working with their groups. These data were also triangulated with student responses to open-ended questions and interviews where the students mentioned enjoying group work and a good mechanism to get support from their peers. Students at the interviews mentioned that working in groups has a positive outcome for their learning experience. In contrast, research conducted previously in LGDM assignments reported student group issues (Coulson & Frawley, 2017; Cox et al., 2010; Pearce & Vanderlelie, 2016). The difference can be explained with the incorporation of SPARKPlus as a tool to ensure effective group work.

The percentage of students with low self-regulation score beliefs were low in both settings, online (13%) and blended (19%). Triangulating these data with open-ended questions, these students commented that the digital media assessment was time-consuming, they did not have digital media skills, they found the assignment instructions unclear, mentioned that their groups were too large, and they had difficulties scheduling meetings with their group members. Looking at the LMS logs, some of these students never visited the digital media resources; others did it towards the end of the assignment deadline (week 10). Certainly, 10 out of 13 participants in one of the subjects who completed the self-regulation questionnaires did not visit the LGDM learning resources at all. It is likely these students assigned a low task value to the LGDM assignment and did not have the motivation to engage early in the session. The assignment weight was 10% of the total mark for this cohort. They probably relied on their group members to succeed in the task. The literature reported that if students assign a low task value, they will not be motivated to complete their assignments (Joo, Lim, & Kim, 2013; Wigfield & Eccles, 2000). The impact of these students with low self-regulation scores on their wider groups is unknown. Most of the students who mentioned that their groups were too large belong to a cohort where there were groups of eight students. These students contributed to half of the comments about finding difficulty to allocate time to organise the assignment with their groups. The other half was from the cohort that received fully online training in digital media principles (first-year subject). This subject had groups of 3 to 5 students, and the possible issue could be explained with the fact that they were new to university settings. Participants self-selected for interview, and a natural bias occurred whereby students who were highly positive about the LGDM assignment dominated the recruitment. Whilst some of these students did mention the LGDM task to be time-consuming and not having the digital media skills, in future research, it will be ideal to invite students who had a low self-regulation score to be part of the interview and to gauge their self-efficacy, task value, attribution to failure and anxiety. This information would be necessary to design a strategy to help them to have a better learning experience with LGDM assignments. Chapter 4, paper 2 and Chapter 5 paper discussed this in detail.

As noted in the paper presented in Chapter 5, the overall student experience of LGDM assignments was a highly positive learning experience for students when these tasks were systematically designed using the theoretical models developed in this study. The self-regulation data allow us to respond to the first research question affirmatively: Are the students better self-regulating their learning when LGDM assignment design follows a systematic approach? Certainly, there is evidence that the systematic approach to design, implementation and evaluation of LGDM assignments results in positive learning experiences for students. What it is still unclear is how gender differences could affect these results. Further research will need to be undertaken to elucidate this difference.

For the second research question: Is there any measurable effect on the overall student learning experience from using theoretical models to design LGDM assignments?

There seems to be strong evidence that the models have a positive effect on the overall student learning experience. Training and support in LGDM production, developing a comprehensive model to communicate to the students the rationale of the LGDM task, and developing a mechanism to ensure effective group contribution (SPARKPlus), yielded the positive results of this intervention. Comparing previous findings in the literature that did not have a systematic approach, this is evident. A study conducted in South Australia reported student apprehension, lack of technical skills, lack of time, issues assessing software and anxiety (Pearce, 2014). A recent study in an undergraduate physiotherapy course also reported issues related to the assignment such as weighting, assignment guidelines, group issues and students feeling stressed (Coulson & Frawley, 2017). Both studies did not have a systematic approach, and students did not receive digital media training. Other studies in LGDM reported technical difficulties to produce the assignment (Abate, 1998; Adams & Blair, 2014; Anderson, 2013a; Martinelli & Zinicola, 2009). The results of the current research are difficult to compare with seminal research in LGDM assignments due to its qualitative nature. Although our results confirm categorically claims of the LGDM literature such as students learning while using a multimodal representation of content (Wendy Nielsen et al., 2018; W Nielsen et al., 2017), students enjoying to be creative (Coulson & Frawley, 2017), developing communication skills (Campbell & Cox, 2018; Pearce & Vanderlelie, 2016) and overall, a positive experience (Hoban et al., 2015; Jablonski, Hoban, Ransom, & Ward, 2015; Jacobs & Clark, 2018; Vasilchenko et al., 2017; Yeh, 2018).

The current study is one of the most comprehensive approaches to date that has developed a set of theoretical frameworks to approach the LGDM task systematically. Triangulating these data sets, it was possible to validate student perceptions on self-regulation beliefs to be accurate within the context of the study population and datasets.

6.5 Conclusion

LGDM assignments can be considered pedagogically challenging as many considerations are required to design the assessment task. For instance, explaining to the students the rationale behind the LGDM assignment for them to buy-in is essential. Designing the task appropriately with adequate assessment weighting to ensure students assign a high task value, as well as defining when an assignment is required to be a group or individual task. Accurate rubrics design is important to inform student work and ensure fair marking and reward. Student training and the development of online resources to support the intervention is also a key aspect. This PhD research was very ambitious and developed a comprehensive set of student-centred theoretical frameworks to implement Learner-Generated Digital Media (LGDM) assignments in the discipline of Science in tertiary education. Due to the simple structure of the frameworks, they can be used across primary, secondary and tertiary educational settings across disciplines. This is one of the major contributions to the body of knowledge from this study. With these frameworks published in journal papers, educators can continue and develop further research in the field of LGDM assignments.

Preliminary findings on the self-regulation questionnaire data showed that both cohorts of students (online and blended) had a high score of self-regulation beliefs for LGDM assignments. Triangulating these data with other variables such as LMS logs, marks attained with the task, SPARKPlus group contribution data, open-ended questions and interviews, confirmed that the systematic implementation of LGDM assignments has a direct effect on the student learning experience. Although the finding that self-regulation has a distinctive pattern between gender is inconclusive due to the gender unbalance of students in this study.

As reported in the literature, self-regulation can predict academic achievement but the fact that the students had high self-regulation beliefs not necessary will make them learn better the subject content. As the researcher does not understand group dynamics in LGDM assignments, it may be cases that some group members only engaged in the digital media production phase. Therefore, learning the subject content will be limited for these students. Marks attained from the students will reflect group work dynamics and not necessarily understanding of the content. Even with the positive results found, the researcher cannot claim that LGDM assignments improve the quality of student learning.

As a preliminary study, the focus was on developing the theoretical models, validated surveys and explore student experience using the self-regulation lenses. The study was not designed to compare actual learning or to claim a superior quality of learning with LGDM assignments. Testing actual learning with LGDM will be ethically and logistically challenging. Ethically problematic because it will require two groups of students within the same cohort, one of them producing LGDM and the other group producing a traditional assessment task (e.g., a literature review). A solution could be asking all the students to create a literature review on a given topic and then asking them to complete a second assignment (LGDM) choosing a different topic. Then, a summative evaluation or exam will include questions in both topics to see how the students perform. The limitation will be that we may be measuring short-term rather than long-term memory. It will be challenging from the logistics perspective to test this experimental design if the groups receive different topics for their LGDM projects. Therefore, this research cannot claim that LGDM assignments improve student learning but make their education relevant to the times we live. The systematic implementation of LGDM assignments in tertiary science education can provide skills new scientists need to be successful in their future careers.

A major contribution to the body of knowledge of this research was also the development of a validated evaluation survey that can be used in the classroom. Evaluating LGDM assignments is crucial as it provides an insight into student perceptions and allows educators to fine-tune the task in the next delivery iteration. The development and validation of the self-regulation questionnaire for LGDM assignments also open multiple possibilities to change current practices in digital media assignments. The author hopes that educators and researchers will uptake the models and promote digital media principles and effective creation of digital artefacts not only in the discipline of Science but across other disciplines. Digital media is transforming societal practices, and it is important to enabling a participatory culture underpinned by collaborative practices. Twenty-first-century citizens require fluency in the digital media principles that are considered the grammar of the digital age.

6.6 Limitations of the study

The first limitation of this research was the sample size. The original sample was 1,687 students from seven science subjects across first, second- and third-year cohorts. As the self-regulation questionnaire was designed to gather data at three points of time during the session (week 2, 6 and 10), and the researchers wanted to understand how students adjust their self-regulation beliefs across the session, the study only used data from students who responded to time points: T1, T2 and T3. This resulted in the rejection of data from 951 participants in T1, 778 in T2, and 590 participants in T3. These figures yielded a final sample of 348, representative enough to run Factor Analysis, but a significantly smaller sample size than desired. From the total sample, these data generated two groups: students who received LGDM training online (n=199) and blended mode (n=149). Factor analysis was conducted combining both samples. When the sample was split in two, for online and blended, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity fell under the acceptable values which indicated that the split samples were too small for further analysis (Williams et al., 2010). It is acknowledged that combining both samples could cause some issues in the factors identified as students use different self-regulation strategies online vs. blended (Barnard et al., 2009; Broadbent, 2017). On the other hand, technically speaking, both cohorts in this research were blended learning students; the difference was that some students received LGDM training online and the others in a blended mode delivery. However, the existence of two modes of delivery for the training could still affect the subscales and items validation.

A further possible issue with the survey data could be the use of a 4-point scale that considered only Strongly Disagree, Disagree, Agree and Strongly Agree. The author did not include a middle point (neutral), to avoid “indecisive data” (Busch, 1994). The objective was to study self-regulation, and neutral responses were of limited utility. However, a similar approach was used in a recent study on developing self-regulation in self-paced open and distance learning environments that used a five-point Likert Scale including Slightly Agree as a middle point (Kocdar, Karadeniz, Bozkurt, & Buyuk, 2018). Furthermore, several studies (Adelson & McCoach, 2010; L. Chang, 1994) have found very few differences between the results of data obtained from four-point scales and the results of data captured from five-point scales. One of the major issues is that ordinal data of this sort were analysed as continuous data. Again however, several researchers have reported that ordinal data tends to behave like continuous data and consequently allows mathematical calculations to be performed (Cliff, 2014; Hsu & Feldt, 1969; Johnson & Morgan, 2016; Lunney, 1970). Notwithstanding this, several studies (e.g., Adelson & McCoach, 2010; Chang, 1994) have found very few differences between the results of data obtained from four-point scales and the results of data captured from five-point scales. Looking at these data as frequencies, it was clear that most of the students still had a high score on self-regulation beliefs.

The study was conducted in two sessions, Spring 2016 (pilot) and Autumn 2017 rather than having a longitudinal approach. The framework used to collect these data required many sources of both, qualitative and quantitative data and, for this PhD research, datasets coming from a longitudinal approach would have been out of scope concerning a PhD project. The data collection tools and supporting materials were established for longitudinal research, and this could be an area of ongoing research. However, self-regulation is context-dependent (Zimmerman, 1998; Zimmerman & Tsikalas, 2005), and it will be expected to find differences within a longitudinal study. For instance, measuring self-regulation to produce a LGDM assignment could change according to task weighting, group size or time for completion. If the task value is perceived as low by the students, or they are allocated in a large group, or the time for completion is short, this will affect motivational factors and affect their self-regulation strategies. These kinds of variable would need to be accountable for or in any longitudinal study.

Another limitation was the nature of the cohorts for this research that was unbalanced regarding gender. Seventy-nine percent of participants were females, and twenty-one percent were males. Self-regulation comparisons between gender are currently debatable, although some data showed significant differences between genders (Bidjerano, 2005; Hargittai & Shafer, 2006), other researchers reported no differences (Yukselturk & Bulut, 2009). It has been postulated that gender differences are the product of gender stereotypes (Pajares & Valiante, 2002). The difference found in gender in the currents research (in favour of females) cannot be conclusive, and further studies need to be undertaken with a more balanced population.

There were additional data sampling issues with the study population. The subjects participating in the LGDM assignment research were from the first (n=199), second (n=69), and third year (n=81), with differing levels of experience and discipline background. This could have influenced the self-regulation scores, adding an extra layer of complexity to these data. By far the major limitation was that the study was undertaken in the discipline of science in one institution. Having a cross-institutional approach would have provided additional evidence to validate the Factor Analysis of the study data and provide further evidence on the effects of how systematic implementation of LGDM could work in different settings. This approach might also allow for a 'control group', where one institution could have a systematic approach to LGDM assignments and the second institution the typical guesswork that does not consider student training and support with the task. There would however be ethical considerations with such an approach.

A possible limitation or complicating variable within the study is if the students who undertook the LGDM assignment had previous experience creating digital media. The research was conducted in Spring 2016 and Autumn 2017, and the LGDM assignments were running since Spring 2015 at the Faculty of Science. It is likely that some of the second and third-year students were exposed to the task before and became more skilled. Whilst this is pedagogically sound from the point of developing student skills, this previous exposure to LGDM creation could have affected the findings in this study.

During the implementation of this project, a new research gap was identified in LGDM assignments and can be considered a limitation for this study. There was a lack of understanding of group dynamics in LGDM. The way students organise their group work in LGDM is unknown. The literature on group work in science education mentioned that learning outcomes could be influenced by the task, the obstacles that the students face (personal or social), and leadership and management (Soetanto & MacDonald, 2017). Although data from the open-ended questions and the interviews highlighted a positive group experience, the variety of student roles in their groups are unknown. As LGDM is an authentic task, it will be hard, for instance, to define 'equal contributions.' In real life scenarios, when professionals work in groups, is not necessarily an equal contribution as there is a common goal for the team and everyone contributes to this with their best skills. Due to the nature of LGDM assignments that are time-consuming, iterative, resource intensive and have a slow learning curve (Arvidsson & Delfanti, 2019; Musburger & Kindem, 2012), students must support each other in their groups. For instance, students will search for the information, research the technology and learn digital media production skills, contribute with ideas, record audio, video, edit the project, and so on. A mechanism to ensure all the students eventually work in every possible role could be required. It would be challenging to monitor the students across all stages of their university career. There is also a question as to what self-regulation means, if students have different roles in their groups? The self-regulation subscales and items could be contextualised for specific LGDM assignments. For instance, if a student role was to edit the final video produced by the team, how are self-regulation subscales applied to that specific task? This question remains unanswered, and it will require future exploration. Certainly, LGDM group dynamics could be shaped by complex interactions that will require qualitative research such as observational studies. Whilst SPARKPlus contribution was used as a measurement of students working together effectively in this study, a deep dive into the dynamics of LGDM group work was out of the scope of this research.

A final limitation could the fact that the study had a student-centred approach and it did not gauge formal educators' perspective on the LGDM task. Anecdotal information such as emails and chats confirmed educators were satisfied with the LGDM intervention. Although this was out of scope from the study, the author considered this data should be essential in future research projects.

6.7 Recommendations for practice and research

Several areas for further research have been identified. It is recommended to study self-regulation in LGDM assignments in a large cohort and to be more balanced regarding gender. This will elucidate whether females have higher scores of self-regulation beliefs than males. This could guide group formations to maximise the student learning experience. It is crucial to study group dynamics in this new form of assignment as the opportunity for learning is not restricted to the subject content or the effective production of digital media. Potential skills to be developed include time management, conflict resolution, learning to collaborate effectively with other team members, providing feedback, and understanding of diversity, crucial for the new graduates. Also, it would be recommended to investigate the effect of year of study on self-regulation ability with LGDM assignments to determine if there are differences affected by year of the cohort as well as gender.

The next step would be to study co-regulation, as the literature in group work has found that self-regulation increased during the lifespan of a project, and is mediated by co-regulation (DiDonato, 2013). Co-regulation is defined as the process of interactions between peers that coordinate self-regulation processes (Hadwin, Järvelä, & Miller, 2011; Volet, Summers, & Thurman, 2009). A longitudinal study will be of value to gauge how LGDM projects can help students to become more self-regulated learners, which is an essential outcome for their future careers.

In the open-ended questions and interviews, five students mentioned that they need a strategy on how to work in groups. They mentioned that we ask them to work in groups, but we do not teach them how to go about it. Since Autumn 2018, students who undertake LGDM assignments watch a video on 'Ten tips to work effectively in groups', during the face-to-face lecture and it is also embedded in the digital media resources folder inside the LMS.

Developing a strategy to ensure every student will experience the different roles for LGDM creation during their university studies could be of value. Asking students to allocate their team members to different tasks and then, in the next subject or assignment iteration, redistributing those tasks could ensure that all students experience every element of LGDM production. Whilst this would not likely be tracked 'officially', this could be self-monitored through e-portfolios or other mechanisms. The crucial element is the need to explain to the students the benefits for their education and future careers.

During the study, some educators expressed concerns about students 'lifting' text from journal papers or websites to create their storyboards. The solution to avoid this potential issue was to ask the students to submit their storyboard via the Turnitin application to seek feedback from their lecturer. This process minimised the potential for academic misconduct. Another potential issue is the existence of micro-task marketplaces such as Fiverr which is a community of digital media creators (Lee, Webb, & Ge, 2014). Students can potentially hire these services to provide them with the storyboards to create their projects for a low fee. A way to prevent this is to ask the students to submit construction files by sharing a link with their lecturers in Dropbox or Google Drive. In the case that the students use online applications, it will be necessary to share the login name and password with the lecturer. This can potentially create a massive workload, and a better solution will be to foster ethical accountability within the students.

A few students requested on the open-ended questions to receive more training on copyright. Although in the lectures and workshops (online and face-to-face) copyright was covered, it would be recommended to produce a short module on LGDM assignments and copyright and to add copyright to the marking scheme.

Further training is required for educators and tutors to be on board with LGDM assignments, especially for marking purposes. This PhD project has developed online interactive modules on LGDM assignments (H5P platform) for that purpose. Ideally, the completion of the modules should be a requirement for teaching staff involved in LGDM assignments. Additionally, the project delivered a website to promote the uptake of LGDM assignments including sections for educators and students at www.digitalmediaforlearning.com. These resources are freely available, and it will contribute to the creation of a community of practice in the field of LGDM assignments.

As a result of this research, LGDM assignments at the Faculty of Science have grown organically. In open-ended questions, there were a few students that needed to complete two digital media projects in one session. They had a positive attitude saying that what they learnt about digital media, could be applied for both assignments and quoted the phrase: *'killing two birds with one stone'.* Consequently, the PhD project has identified the benefit of having a structured approach to embedding LGDM in the curriculum. There is a need to scaffold LGDM using the taxonomy of digital media types (Chapter 3, paper 2). For example, First-year students could engage in the production of an audio podcast or a poster, whilst the second year could produce a digital story or animation. Third-year students could create a more sophisticated digital artefact such a video. At the end of their degrees, the students will have the skills required for effective communication using digital media.

A recommendation to enhance the student experience with LGDM assignments is to offer drop-in clinics where students can bring their questions related to digital media production, applications and other questions they may have. The project implemented this strategy in a couple of subjects since Spring 2017, where two sessions were offered, and student groups attended. Most of the questions were related to software use and the production of green screen videos. The literature in information literacy endorses the use of drop-in clinics to offer personalised help to the students in a safe and informal environment (Funnell, 2015). Additional training on video editing is also required. This training needs to be contextualised for the assessment task. Although some students will go and learn industry standard software such as Adobe Premiere Pro, not everyone is keen to get into that level of production and commitment. Simple alternatives such as mobile and tablet apps could be of value for students who are not willing to engage heavily in the digital media production phase due to time constraints and other commitments.

As students mentioned in the open-ended questions, they need a strategy to communicate with their group members without the need to physically meet with them. Applications such as Google Hangouts and Skype can be promoted across the students. The use of Google Drive to brainstorm ideas and to communicate via chat interface could be of value for the students with competing schedules.

Open-ended questions also pointed out the need to reduce groups from 8 to 4-5 members. Larger groups appear to be more challenging for students to manage. The students also mentioned that digital media is a time-consuming task, it is essential to communicate with them at the beginning of the session and to help them to develop a work plan to improve their Time Management skills to accomplish their digital media assignment goals.

It will be ideal offering an elective subject on digital media to communicate science during the session, so the students will have an entire session to learn in-depth digital media production principles. This subject will be delivered for first and second-year students and could potentially improve their learning experience with LGDM assignments. Using a digital media principles quiz (see appendix) to test students understanding of these principles at the beginning and the end of the session. With this data, it will be possible to record the effect of LGDM instruction in student knowledge acquisition. This data could also help to identify troublesome knowledge and reshape the content in the following sessions.

This research explored motivation from a qualitative perspective with the interviews. An alternative recommendation could be to explore student motivation in LGDM assignment using a psychometric questionnaire in two settings, one with a systematic approach and the other with no systematic approach could provide an insight on how the frameworks and methodology developed in this research could have a direct impact on student motivational beliefs. Also, it will be recommended to explore student motivation with their attitude towards LGDM assignments.

Further testing of the digital media literacies framework to develop student training will be required. The inclusion of worked examples of different media types that showcase good practices could have a positive outcome for student learning and performance with the LGDM assignment. Last but not least, testing the student's attitude towards the LGDM implementation framework, do they think this framework communicates the LGDM task effectively? All of these recommendations discussed could improve the student experience and contribute to the development of digital media communication skills, essential for science students (Wendy Nielsen et al., 2018), and their careers (Hobbs, 2017).

Chapter 7:
Additional paper

Chapter 7 overview

Additional paper

This section contains a papers targeted to educational practitioners. The paper aimed to explain the digital media principles with practical examples of how to design an accurate marking rubric for LGDM assignments.

Reyna, J. (2019). Theoretical Foundations to Design Learner-Generated Digital Media (LGDM) Assessment Rubrics. In K. Graziano (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1380-1389). Las Vegas, NV, United States: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/207827/.

Certificate of authorship and originality

This chapter include a peer-reviewed conference paper. The paper has been published at the conference proceedings for SITE (Society for Information Technology and Teacher Education). The publisher is the American Association for Computers in Education (AACE). I certify that the work presented in this chapter has not previously been submitted as part of the requirements for a degree. I also certify that I carried all the work presented in this paper.

- Jorge Reyna wrote the entire manuscript.
- Peter Krockenberger did the proofread of the manuscript.

Primary Author

Production Note:
Signature removed prior to publication.

Jorge Reyna

03/31/2019

Theoretical Foundations to Design Learner-Generated Digital Media (LGDM) Assessment Rubrics

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Abstract: Learner-Generated Digital Media (LGDM) assignments empower students to become co-creator of knowledge rather than passive consumers of content. The Internet explosion, the affordability of digital technologies and devices such as a smartphone, tablets, and action cameras, created the opportunity to use digital media in the classroom. Most of the research in the field of LGDM assignments focused on learning course content and neglected the importance of effective communication in the digital space. Outside of the creative disciplines, educators do not provide student training on how to create effective digital media. Part of the issue is due to the digital native's myth and educators' lack of understanding of digital media creation. This conceptual paper aimed to discuss digital media principles such as layout design, colour theory, typography, use of images, C.R.A.P principles, and basic video techniques. Educators require working knowledge of these principles to be able to support students with their LGDM assignments. Understanding these principles educators will be able to design marking rubrics that accurately measure what students created. Applying these principles to the creation of LGDM assignments will ensure the message is visually appealing, legible, and credible. Therefore, the digital media artefact produced will engage the audience, and the message will come across effectively. Students in the 21st Century require communication skills in the digital space. The paper presents examples and discusses implications for marking rubric design.

Keywords: Digital media creation, learner-generated digital media, digital media assignments, visual design principles, marking rubric for digital media assignments.

Introduction

Before the Internet explosion, digital media production was in the hands of capital-intensive organisations due to the cost of infrastructure to create content (van Dijk & Lazonder, 2016). For instance, to produce video content, the amount of equipment required could fill a large room in the late 70s (Reyna, Hanham, & Meier, 2018). The technological advances contribute to the relative democratisation to digital media production in the early 80s. But the radical change occurred with the rise of Web 2.0 Tools that offered users the possibility to create content such as blogs, wikis, websites, online video, and so on (O'Reilly, 2009). Then, the portmanteau term (linguistic blend) *'Prosumer'* was coined to refer to users that hover between producer and consumer (Bruns, 2009), and also the term *'Produsage'* to refer to user-led content (Bruns, 2016). In the late 2000s with the development of compact digital cameras, and later on smartphones, tablets, and action cameras, the democratisation of digital media became more evident. Digital media now is embedded in almost any human activity and is reshaping social practices (Arvidsson & Delfanti, 2019). This created a fertile environment for education to embed digital media as a pedagogical agent for the students to learn the subject content (Buckingham, 2007).

In the context of higher education, digital media was introduced in the pre-service teacher's curricula as a reflective tool for their placements (Kearney & Schuck, 2003). In other disciplines such as science education, the use of digital media is to promote active learning, research and inquiry (Hoban, Nielsen, & Shepherd, 2015; Nielsen, Hoban, & Hyland, 2017). The term Learner-Generated Digital Media (LGDM) was coined to refer to digital media content developed by students to showcase their learning (Reyna & Meier, 2018). LGDM include any digital content such as audio podcast, blog, websites, posters or brochures, digital story, animation, video and games. A recent review of the literature on LGDM in Science education has revealed the lack of a student-centred approach and lack of systematic implementations (Reyna & Meier, 2018)

The pedagogical underpinning of LGDM is to promote student reflection and engage them in active learning and to promote group work and collaboration to generate an environment for deep learning (Coulson & Frawley, 2017; Pirhonen & Rasi, 2016). Other benefits of LGDM include the development of graduate attributes such as communication, project planning and time management skills (Frawley, Dyson, Tyler, & Wakefield, 2015; Morel & Keahey, 2016), and self-regulation. But also LGDM can help to develop critical thinking, report writing, research skills (Ohler, 2009), understanding of copyright, exercise creativity and develop awareness on how digital media artefacts can shape online communication (Reyna, Meier, Geronimo, & Rodgers, 2016)

Theoretical frameworks to guide the systematic approach of LGDM task design, implementation and evaluation are missing in the literature. Most of the research is characterised to be guesswork and comparison between papers are difficult due to the different approaches utilised, i.e., different digital media types. But one of the main concerns is that there are no models to evaluate the effectiveness of LGDM in the classroom. Current studies use qualitative approaches such as surveys and interviews and small samples size. The concerning is that the view from the students interviewed does not necessarily represent the view of the classroom. The findings from these surveys have not linked to, for instance, to mark attained with the task. It has been highlighted before in educational research (usage of online lectures) (Gorissen, Bruggen, & Jochems, 2013) that what students report in surveys may differ from reality. The student view as a sole way to gauge the effectiveness of an educational intervention may not provide an accurate snapshot of what is happening in the classroom (Phillips, McNaught, & Kennedy, 2012).

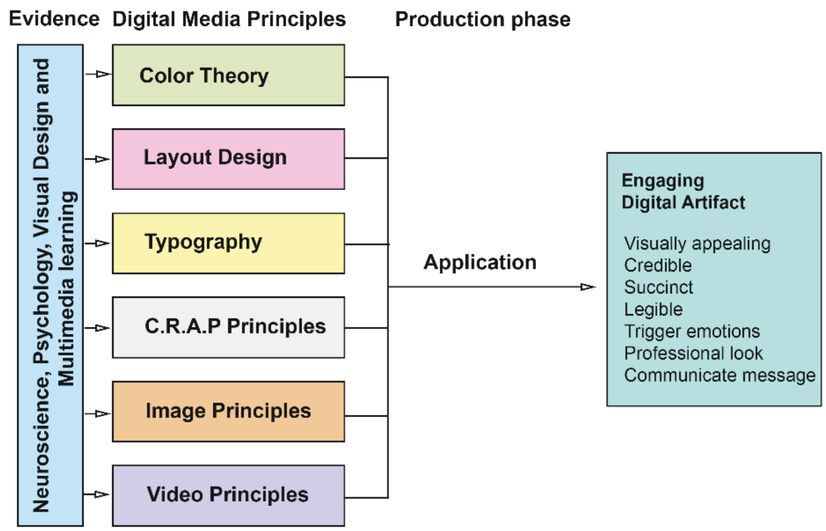
One of the gaps identified in the literature in LGDM assignments is the understanding of the principles that guide the development of effective digital media artefacts such as visuals and aesthetics. Educators outside the creative fields have no understanding of the digital media principles, considered the grammar of the 21st century (Reyna et al., 2018). The lack of knowledge in these principles is problematic as when marking LGDM assignments; there are no clear guidelines what the students meant to achieve from the digital media perspective. In the field of visual design and aesthetic, it is well-known that these principles have a profound effect on the audience and its application ensures the message will come across to the audience (Malamed, 2015). Still, there are academics, learning designers and technologist that belief creating effective digital media is a matter of 'taste'. Certainly, there are a set of rules from the visual design (Malamed, 2015), psychology (Chang, Dooley, & Tuovinen, 2002), graphic design (Williams, 2014), image principles (Kress & Van Leeuwen, 1996), and video principles (Stockman, 2011), that could influence the effectiveness of a digital media artefact to communicate to the public. Large technology corporations in the mobile industry can be a good example of how these principles are applied not only to their marketing campaigns but the user-interface design of their gadgets.

This paper aims to review the digital media principles in the context of LGDM assignments. For that purpose, the discussion of theoretical considerations informed by worked examples will help educators to understand and apply these principles. Finally, the paper will present recommendations on how to design LGDM assessment rubrics using digital media principles.

The digital media principles framework

A model was developed to help students and educators to understand and apply the digital media principles. Evidence from the fields of neuroscience (LeDoux, 1989, 1992), psychology (Koffka, 2013; Smith-Gratto & Fisher, 1999), visual design (Hashimoto & Clayton, 2009; Malamed, 2015), and multimedia learning (Mayer & Moreno, 2002) informed the digital media principles model. It outlined the basic digital media principles to apply to the LGDM production. Principles include layout design, colour theory, typography (Malamed, 2015), use of images, C.R.A.P principles (Contrast, Repetition, Alignment, and Proximity) (Williams, 2014), image and video principles (Bowen, 2013; Bowen & Thompson, 2013; Stockman, 2011) (Figure 1). The application of these principles ensures the creation of engaging digital media artefacts. To date, this is the first model that present the minimum requirements to produce digital media for learning.

Figure 1: The Digital Media Principles for Teaching and Learning. Its application in LGDM assignments will help to produce an engaging digital artefact and develop student effective communication in the digital space.



Digital media principles to create engaging content

A review of the literature in the field of LGDM as an assessment tool indicated the lack of visual design an aesthetic knowledge from educators and students. It has been reported recently in the USA that the problem is not owning the technology but its fluency on its use (Alexander, Adams Becker, & Cummins, 2016). It appeared that the digital media principles that govern the development of effective digital media artefacts (Hashimoto & Clayton, 2009; Hobbs, 2017; Malamed, 2015) are only taught in media, visual design, and film courses. Therefore, LGDM implementation follows a pedagogical flavour and opportunistic nature rather than being systematically embedded in the curricula and develop student digital media literacies (Buckingham, 2007). The LGDM intervention is one of the first to emphasise the importance to teach the digital media principles in LGDM assignments and to develop effective marking rubrics that evaluate student digital media artefacts developed as a part of an assessment task. The following sections are presenting the digital media principles with worked examples. The aim for educators is to gain practical skills to support their students in LGDM assessment tasks.

Layout design

Layout design is the way the design elements are distributed in a composition, in this case, on the screen. The concept of layout design comes from visual design (Hashimoto & Clayton, 2009; Malamed, 2015), and reinforced by Gestalt theory (Koffka, 2013) and multimedia learning principles (Mayer, 2005). The idea behind applying layout design to a digital composition is to facilitate cognitive processes and to help the user to engage with the message. There are two types of layout design, symmetric (Figure 2) and asymmetric (Figure 3) prototypes. For instance, symmetric layouts convey professionalism, balance, it is easy to follow and promotes cognitive engagement with the content.

In contrast, an asymmetric prototype is chaotic and could cause cognitive overload and the user to move away from the content, missing the point of the message. Cognitive load theory plays an important role in layout design, and the idea is to maximise user attention to the content rather than the elements placed on the layout (Malamed, 2015). It is recommended to ask the student to use symmetric prototypes when they develop digital media content. For example, a PowerPoint with audio (Slidecast) can apply the layout design principles for maximum engagement. Layout design applies to the creation of animations, graphics and even video that uses, for example, images and on-screen text.

Figure 2: Symmetric layout design.

Figure 3: Asymmetric layout design.

Colour theory

Colour creates mood, and it is crucial on how the designer combines them for maximum engagement with the digital artefact. A colour clash occurs when bright colours are combined in a particular design and causes a competition between the colours creating a disturbing effect on the viewer (Figure 4). In contrast, a neutral colour scheme ensures that the colour palette is easy to the eye and conveys elegance, professionalism and engagement (Figure 5). Colour theory has been around in visual design and psychology since the old days. It is predictable, for example, how most people will perceive colours such as red. Studies done using the colour red showed that it has a detrimental effect on exam performance (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007), but a positive effect on athletic competitions (Elliot & Aarts, 2011). Colour perception occurs within milliseconds in the brains and users can make up their minds in a visceral way about a design (whether they like it or not) (LeDoux, 1989, 1992). Experiments conducting in web design using colour theory and layout design has proved that users associate a poor colour scheme with the low credibility of the content and vice-versa (Fogg et al., 2000; Fogg et al., 2003; Robins & Holmes, 2008; Wathen & Burkell, 2002). When using colour is about conveying credibility, especially in a very fluid medium which is the Internet where users make up their minds within milliseconds. In LGDM presentations, the colour theory has a crucial role; an appropriate colour scheme ensure engagement with the digital artefact.

Figure 4: A colour clash example (asymmetric layout).

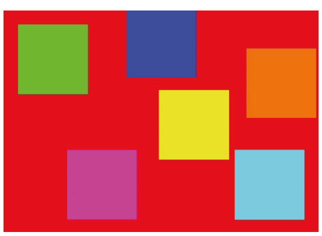


Figure 5: A neutral colour scheme (symmetric layout).

Typography

In graphic design, typography comprises typefaces, point and size, line length, line spacing (leading), letter spacing (tracking), and adjustment of the space within letter pairs (kerning) (Williams, 2014). The goal of typography is to enhance legibility (Malamed, 2015). Recommended typefaces include (but are not limited to) Arial, Book Antiqua, Courier New, Times New Roman, and the following fonts designed for electronic media: Verdana, Tahoma, Trebuchet MS, and Georgia. Designers should avoid brush script font types as they may look fancy, but sometimes it can be challenging to read, especially for people with dyslexia. When creating posters, up to three different font-types can be included in the design if they are legible and easy to read. There are many books on typography, and certainly, it is a complex area of knowledge. For LGDM assignments, the fonts recommended previously will ensure legibility.

The C.R.A.P Principles

In a good design, for example, a poster, brochure or a business card, nothing is placed by accident; everything follows a principle (Malamed, 2015). There are many principles of design, but the widely accepted in the industry are four: Contrast, Repetition, Alignment and Proximity, also known as the C.R.A.P principles (Hashimoto & Clayton, 2009; Malamed, 2015; Williams, 2014).

The contrast principle can make a specific element in the design to stand out or draw attention to the user. For example, when letters and backgrounds in design have similar values regarding colours, they lack contrast and make the reading and understanding of the information presented to be challenging. Figure 6 presents a typical example of a lack of contrast. Creating more contrast between the letters and the background will solve the problem (Figure 7). The goal of contrast in graphic design is to make an impact. However, creating contrast in a design is not only about colour, for instance, using clear fronts will help to create contrast as well (see Figure 8). It is important to avoid using patterns as the background image as it could have a negative effect in contrast (Figure 9). The human eyes like contrast because in the brain it is easy to understand the message presented. Often is possible to see examples of lack of contrast in PowerPoint presentations but hardly ever, in advertising campaigns.

Figure 6: Lack of contrast.

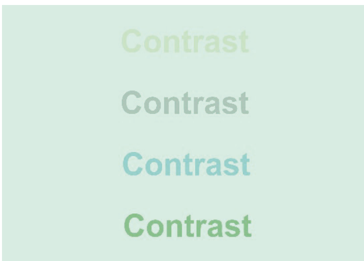


Figure 7: Good contrast.

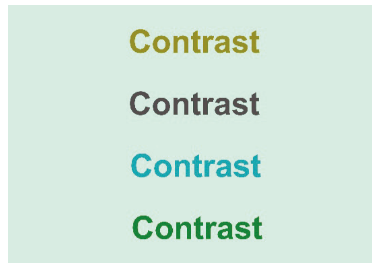


Figure 8: The effect of fonts on contrast

Figure 9: Poor contrast due to background patterns.

Repetition is a design principle that implies using the same visual element throughout a design. The effect of repetition in design will create a sense of unity, consistency and cohesiveness. To achieve repetition, the designer can use typefaces and fonts, patterns, lines and colours, images and graphics. In figure 10, repetition was used in the background to create a sense of consistency in the PowerPoint slide.

Figure 10: Repetition in a PowerPoint slide to create a sense of unity, consistency and cohesiveness.

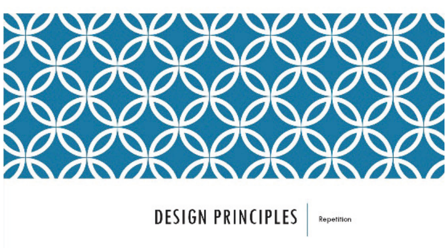
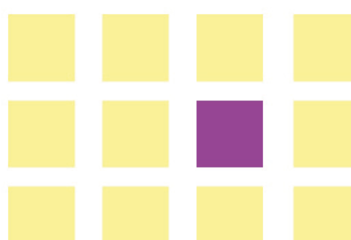


Figure 11: Contrast using colour and repetition using shapes to create a focal point.



Contrast and repetition together, create a focal point and grab the user attention. Figure 11 showcase an example when both design principles are applied together in a design.

Alignment is one of the most important design principles. The elements in a design should not be positioned arbitrarily; it should have a visual relationship with the other elements on the design. A good analogy to further illustrate alignment is a poorly organised desk where it will be hard to find the right document at the right time. When a design does not use alignment, it will make it look disorganised, illogical. Therefore, it will be hard to engage. Users may need an extra cognitive load of their brains to try to understand the information presented to them. Figure 12 presents an example of how alignment works.

Figure 12: An example of alignment makes the design easy to follow.

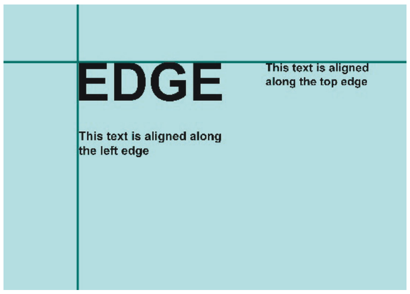


Figure 13: An example of proximity.

Proximity in design implies placing design elements together to indicate there is a relationship between those elements. Using proximity in design, it will create a visual unit which helps to give a structure to a layout. Figure 13 presents a good example of this design principle.

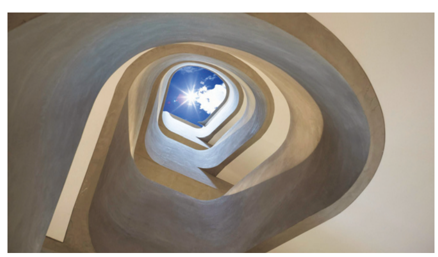
The C.R.A.P principles covered are usually applied together to produce a cohesive design. These principles are crucial to teach students, moreover if the LGDM task implies to create a poster or brochure.

Images

Using images and illustrations for LGDM assignments should be done with careful thought and consideration. The idea is to enhance the experience, improve visual appeal, and engage the audience with the topic (Malamed, 2015). The use of images must have a purpose. Otherwise, it will not give any benefit to the message. Before using images consider (1) the benefits of using an image; (2) whether it helps your audience to understand a concept; (3) whether the image is engaging and creates appeal; (4) what message the image sends. Effective images and illustrations will tell a story and complement a message and could make it unforgettable for the user. Figures 14 and 15 presents examples of how to use images effectively.

Figure 14: This image conveys a strong message that will impact any viewer. Can be used for example for a campaign to help homeless people or prevention of drug abuse.

Figure 15: This image conveys an inspirational message, a sense that there is something to achieve.



Icons are also powerful enhancers of a visual interface and are symbols that represent a function. Icons are a stand-alone design element, so it is not a good practice to combine them with pictures as it will defeat its purpose. Icons used simultaneously with images are typical in amateur designs.

Basic video principles

Video production techniques can be overwhelming as many principles are involved in producing a professional video vignette. These principles have been called the grammar of the shot and adopted since the early days of the film industry (Bowen & Thompson, 2013). These principles are still relevant even in times that digital technology empowered amateur producers to disseminate their video content in sharing platforms such as YouTube and Vimeo (Stockman, 2011). Video principles for the prosumer (a hover between professional and consumer) are four. The rule of thirds, the camera shot types, the use of tripods, and the vertical video syndrome.

The rule of thirds, which applies to photography and video production, divide the frame into nine imaginary sections (3 x 3 grid) and creates reference points that act as guides for composing the film or image (Hashimoto & Clayton, 2009) (See figure 16-17). Professional video makers align the key elements in the video composition according to this grid. The alignment can be done at the intersections or along within the horizontal and vertical lines. The human eye automatically looks for information at these grids. As a result, the rule of thirds creates an aesthetic and pleasant view and a more inviting composition for the users. The rule of thirds is considered to be a mathematical approach, but its impact on the viewer is psychological. For instance, centrally positioned images are very direct and trigger emotions in the viewers.

Figure 16: The swam eye is on the left superior third.

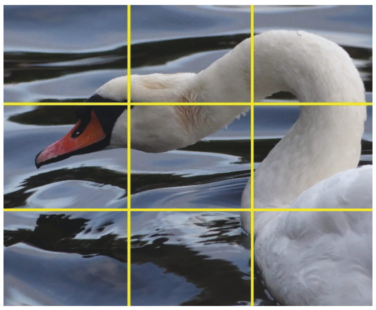
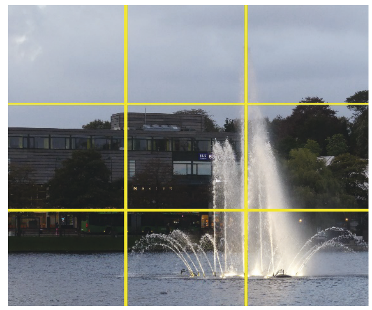


Figure 17: The water feature, located on the right.



The camera shots types are considered a common language between writers, directors, camera operators and filmmakers to communicate visual elements of a shot effectively (Bowen, 2013; Bowen & Thompson, 2013). The first type is called a long-shot, and it sets the scene, where the story is happening. It can be used effectively at the beginning of a video (Figure 18). The next level is a medium shot, this is the most common shot in a film, and it focuses on a character in a scene and still showing the surrounded area where the event is taking place (Figure 19). The close-up shot fills the screen with part of a subject, for example, a person's face, and the purpose is to show their emotions (Figure 20). The extreme close up covers a small area or detail of a subject, for example, the eyes or mouth of a character (Figure 21) (Stockman, 2011). Any professional movie or documentary has this approach of shots and makes the viewer feel immersed in the story.

Figure 18: the long shot is showing the entire scene.

Figure 19: the medium shot is showing children playing with an adult.

Figure 20: the close-up shot is showing a couple engaging in conversation.

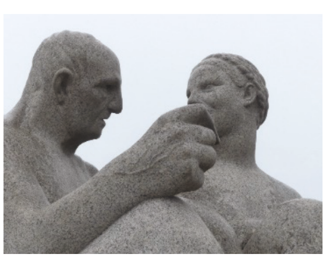
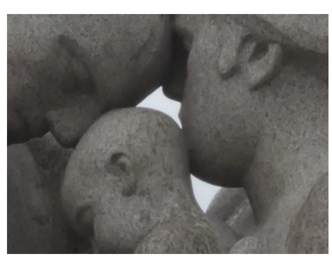


Figure 21: The extremely close-up shot is showing a family bonding together.



A movie is a combination of different shots used to convey the story. Therefore, if students engage in producing videos as LGDM assignments, they need to incorporate these principles into their projects.

The use of tripods aims for better control of the camera, smartphone or tablet and helps to avoid shaky video and to produce professional-looking footage (Stockman, 2011). There are different types of tripods and techniques, but the purpose of this section is to emphasise in the importance to produce the balanced and smooth video. Especially because when the video is uploaded online, it gets compressed which means that frame rates are cut off. If a video is slightly shaky, after upload, it will be lost resolution, and the shakiness will be more evident.

In 2011 A PSA hit the market on YouTube, warning people of Vertical Video Syndrome (VVS). The announcement pled with people to stop shooting video vertically; the video said: 'Motion pictures have always been horizontal, televisions are horizontal, computer screens are horizontal, people's eyes are horizontal…we are not built to watch the vertical video!'. VVS occur when user treats video as photography, and even being accepted in social networks such as Facebook and Instagram, and advertising panels on the streets, it is unlikely that the movie industry will change to vertical video production in the future. Although, techniques to compose video as vertical or square are under discussion in the video production industry. For instance, the latest version of GoPro 7 Action Cam supports vertical video. Consequently, it is important to emphasise to students that their digital presentations should look horizontal and follow the classic way of producing video as it is a more formal environment. If the video is exclusively to promote, for example on Instagram, then, it will be required to be a square box or vertical to be featured as a story.

Marking rubric design for LGDM assignments

The Taxonomy of Digital Media Types (Reyna, Hanham, & Meier, 2017), proposed that the effective creation of LGDM assignments should address three domains: Conceptual (storyboard), Functional (use of software), and Audiovisual (digital media principles). This model in conjunction with the concepts previously covered can guide the development of marking rubrics for LGDM assignments. For instance, under communication skills, the making rubric could have three sections: the conceptual, the functional and the audiovisual (Table 1). Students are expected to apply the digital media principles to their LGDM assignments. With the criteria, it will be possible to design, for example, a five-point rubric including High Distinction, Distinction, Credit, Pass and Fail. The rubric must include another section that deals with the learning outcomes of the course or subject, such as disciplinary knowledge and research, inquiry and critical thinking.

Table 1: A generic example of criteria to design a marking rubric to measure communication skills in LGDM assignments.

Domain	Criteria
Conceptual (Storyboarding)	The goal for 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)	Choice of software and device(s) Presentation runs smooth No image pixelation Consistent use of transitions and effects Audio quality
Audiovisual (Digital Media Principles)	Layout design Colour theory Typography, Images Video techniques

Outside the visual design, digital media, graphics and video production industry, the inclusion of 'creativity' on marking rubrics should be avoided. The anecdotal information pointed out that, for example, science students perceive the inclusion of creativity in the marking rubric as unfair. Interestingly, their perception is that combining colours in design is rather more ‘artistic’ and a matter of preference than solid foundations of visual design.

Implications for teaching and learning

The digital media principles covered in this paper are applied in the development of professional digital media since the Internet explosion. As users now are empowered to create content with the affordability of digital technologies and applications, knowledge of these principles at a prosumer level is crucial. Educators and students outside creative arts courses require a solid foundation of the principles to communicate in the digital space effectively. The contribution of this paper is to develop awareness among educators of these principles and inform (1) student training; (2) the development of LGDM marking rubric; and (3) marking student digital media projects objectively. If these principles are taught in the classroom, LGDM will be used not only as a vehicle of learning but as an effective way for students to learn to communicate effectively in the digital space. These principles can be considered the grammar of the 21st century, and they are essential to embed in the curricula regardless of the discipline of study. The author hopes that the foundations covered in this paper could inspire and help educators to provide student guidance in the creation of effective LGDM, promote communication skills and digital media literacies.

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Appendix

Table 1: Generic marking rubric to evaluate Learner-Generated Digital Media (LGDM) assignments for communication skills section. The digital media literacy framework informed rubric design.

Domain	Criteria
Conceptual (Storyboarding)	The goal for 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)	Choice of software and device(s) Presentation runs smooth No image pixelation Consistent use of transitions and effects Audio quality
Audiovisual (Digital Media Principles)	Layout design Colour theory Typography, Images Video techniques

Table 2. Validated questionnaire to evaluate students' attitude toward digital media for learning.

Category	**Item**
Demographics	Gender Age Education English as an additional language (EAL)
Digital media support	I found the digital presentation lecture engaging. I applied concepts from the lecture to my assignment. I need a better understanding of digital presentation principles. I will recommend that my peers attend this lecture. I used a storyboard to structure my project.
Attitude toward technology	I Enjoy using technology for personal/recreational matters. I am confident using technology for personal/recreational matters. I have a positive attitude towards technology for recreational matters. I enjoy using technology for learning. I am confident using technology for learning. I have a positive attitude towards technology for learning
Understanding of the assignment	I believe instructions on the assignment were clearly provided. The timeframe to complete the project was good. I understand the importance of communicating concepts/ideas in the digital world.
Knowledge construction	I believe using digital presentations helped me to understand the topic. The digital presentation assignment helped me to develop critical thinking skills.

	The digital presentation assignment helped me to develop communication skills. The digital presentation helped me to exercise my creativity. I believe digital presentations are a good way to assess students' understanding of a topic. I will encourage academics to use similar assignments in other subjects. I believe I learnt additional skills by doing this assignment.
Open-ended questions	Did you experience any issue with the assignment? What did you like most about the assignment? What did you like least about the assignment? Do you have any feedback on how to improve this assignment? Is there anything that you would like to say that has not been covered in the previous questions? If so, please feel free to provide additional feedback in the space below:

Table 3: Validated self-regulation questionnaire for Learner-Generated Digital Media (LGDM) assignments.

Subscale	**Item**
Task Strategies (TS)	I take notes from the digital media lecture to be more prepared for the task
	I take notes from the digital media workshop to be more prepared for the task
	I visit the digital media resources inside the learning management system
Goal Setting (GS)	I set standards for my assignments
	I set goals to help me manage time for my assignment
	I set short-term goals when preparing my digital media assignment
Environment Structuring (ES)	I choose the location where I work on my digital media assignment to avoid distraction
	I find a comfortable place to work on my digital media assignment
	I know where I can work most efficiently for my digital media assignment
	I choose a time with few distractions for working for my digital media assignment
Time Management (TM)	I schedule regular times a week to work on my digital media assignment
	I helped managed my time efficiently, so I was not rushing around to finish at the last minute
	I follow my planned schedule for completing the digital media project
Help-Seeking from People (HSP)	I find people who are knowledgeable in subject content so that I can ask them for help
	I share the difficulties I am having with the digital media assignment with my classmates
	I check with my classmates to find out how I am doing in my assignment
	I check with my classmates to find out what I am learning that is different from what they are learning
	I am persistent in getting help for my assignment from the instructor
Help-Seeking from the Internet (HSI)	I seek help on the Internet about my assignment topic
	I seek help on the Internet about digital media creation

Table 4: Correlations between self-regulation subscales for questionnaire validation to explore self-regulation in Learner-Generated Digital Media (LGDM), Chapter 4, paper 2. GS= Goal Setting; HSP= Help-Seeking from People, HIS= Help-Seeking from the Internet, TM= Time Management; ES= Environment Structuring; TS = Task Strategies. T1= Week 2; T2= Week 6; T3= Week 8.

		GST1	GST2	GST3	HSPT1	HSPT2	HSPT3
GST1	Pearson Correlation	1	.518**	.368**	.402**	.450**	.195**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	342	337	338	336	335	335
GST2	Pearson Correlation	.518**	1	.412**	.340**	.572**	.248**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	337	343	339	337	338	336
GST3	Pearson Correlation	.368**	.412**	1	.189**	.272**	.593**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	338	339	344	338	337	339
HSPT1	Pearson Correlation	.402**	.340**	.189**	1	.533**	.335**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	336	337	338	342	335	335
HSPT2	Pearson Correlation	.450**	.572**	.272**	.533**	1	.411**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	335	338	337	335	341	334
HSPT3	Pearson Correlation	.195**	.248**	.593**	.335**	.411**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	335	336	339	335	334	341
HSIT1	Pearson Correlation	.168**	.131*	.084	.294**	.219**	.121*
	Sig. (2-tailed)	.002	.015	.121	.000	.000	.026
	N	341	342	343	341	340	340
HSIT2	Pearson Correlation	.239**	.302**	.147**	.248**	.429**	.192**
	Sig. (2-tailed)	.000	.000	.007	.000	.000	.000
	N	340	343	342	340	341	339
HSIT3	Pearson Correlation	.137*	.152**	.439**	.156**	.241**	.507**
	Sig. (2-tailed)	.012	.005	.000	.004	.000	.000
	N	337	338	342	337	336	338
EST1	Pearson Correlation	.436**	.290**	.248**	.389**	.320**	.159**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.003
	N	338	339	340	338	337	337
EST2	Pearson Correlation	.414**	.636**	.285**	.344**	.530**	.229**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	334	338	336	334	336	333
EST3	Pearson Correlation	.158**	.252**	.667**	.109*	.215**	.560**

	Sig. (2-tailed)	.004	.000	.000	.046	.000	.000
	N	336	337	342	336	335	337
TST1	Pearson Correlation	.427**	.291**	.203**	.266**	.307**	.189**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.001
	N	335	336	337	335	334	334
TST2	Pearson Correlation	.329**	.381**	.208**	.194**	.373**	.276**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	335	338	337	335	336	334
TST3	Pearson Correlation	.177**	.100	.483**	.102	.219**	.495**
	Sig. (2-tailed)	.001	.067	.000	.061	.000	.000
	N	338	339	342	338	337	339
TMT1	Pearson Correlation	.586**	.391**	.305**	.399**	.428**	.220**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	340	340	341	340	338	338
TMT2	Pearson Correlation	.496**	.623**	.394**	.338**	.558**	.292**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	335	338	336	334	336	333
TMT3	Pearson Correlation	.336**	.341**	.736**	.201**	.251**	.620**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	333	334	337	333	332	335

		HSIT1	HSIT2	HSIT3	EST1	EST2	EST3
GST1	Pearson Correlation	.168**	.239**	.137*	.436**	.414**	.158**
	Sig. (2-tailed)	.002	.000	.012	.000	.000	.004
	N	341	340	337	338	334	336
GST2	Pearson Correlation	.131*	.302**	.152**	.290**	.636**	.252**
	Sig. (2-tailed)	.015	.000	.005	.000	.000	.000
	N	342	343	338	339	338	337
GST3	Pearson Correlation	.084	.147**	.439**	.248**	.285**	.667**
	Sig. (2-tailed)	.121	.007	.000	.000	.000	.000
	N	343	342	342	340	336	342
HSPT1	Pearson Correlation	.294**	.248**	.156**	.389**	.344**	.109*
	Sig. (2-tailed)	.000	.000	.004	.000	.000	.046
	N	341	340	337	338	334	336
HSPT2	Pearson Correlation	.219**	.429**	.241**	.320**	.530**	.215**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	340	341	336	337	336	335
HSPT3	Pearson Correlation	.121*	.192**	.507**	.159**	.229**	.560**
	Sig. (2-tailed)	.026	.000	.000	.003	.000	.000
	N	340	339	338	337	333	337
HSIT1	Pearson Correlation	1	.420**	.262**	.301**	.240**	.108*
	Sig. (2-tailed)		.000	.000	.000	.000	.046
	N	347	345	342	343	339	341
HSIT2	Pearson Correlation	.420**	1	.339**	.291**	.394**	.179**
	Sig. (2-tailed)	.000		.000	.000	.000	.001
	N	345	346	341	342	340	340
HSIT3	Pearson Correlation	.262**	.339**	1	.168**	.177**	.476**
	Sig. (2-tailed)	.000	.000		.002	.001	.000
	N	342	341	343	340	335	340
EST1	Pearson Correlation	.301**	.291**	.168**	1	.467**	.309**
	Sig. (2-tailed)	.000	.000	.002		.000	.000
	N	343	342	340	344	336	338
EST2	Pearson Correlation	.240**	.394**	.177**	.467**	1	.325**
	Sig. (2-tailed)	.000	.000	.001	.000		.000
	N	339	340	335	336	340	334
EST3	Pearson Correlation	.108*	.179**	.476**	.309**	.325**	1
	Sig. (2-tailed)	.046	.001	.000	.000	.000	
	N	341	340	340	338	334	342
TST1	Pearson Correlation	.328**	.204**	.213**	.369**	.222**	.171**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.002
	N	340	339	337	339	333	335

TST2	Pearson Correlation	.097	.226**	.248**	.255**	.453**	.266**
	Sig. (2-tailed)	.073	.000	.000	.000	.000	.000
	N	340	340	336	337	335	335
TST3	Pearson Correlation	.089	.100	.332**	.162**	.195**	.462**
	Sig. (2-tailed)	.100	.065	.000	.003	.000	.000
	N	343	342	341	340	336	340
TMT1	Pearson Correlation	.179**	.221**	.166**	.410**	.307**	.213**
	Sig. (2-tailed)	.001	.000	.002	.000	.000	.000
	N	344	343	340	341	337	339
TMT2	Pearson Correlation	.085	.230**	.158**	.269**	.473**	.289**
	Sig. (2-tailed)	.120	.000	.004	.000	.000	.000
	N	339	340	335	336	336	334
TMT3	Pearson Correlation	-.009	.076	.364**	.232**	.284**	.641**
	Sig. (2-tailed)	.868	.163	.000	.000	.000	.000
	N	338	337	337	336	331	335

		TST1	TST2	TST3	TMT1	TMT2	TMT3
GST1	Pearson Correlation	.427**	.329**	.177**	.586**	.496**	.336**
	Sig. (2-tailed)	.000	.000	.001	.000	.000	.000
	N	335	335	338	340	335	333
GST2	Pearson Correlation	.291**	.381**	.100	.391**	.623**	.341**
	Sig. (2-tailed)	.000	.000	.067	.000	.000	.000
	N	336	338	339	340	338	334
GST3	Pearson Correlation	.203**	.208**	.483**	.305**	.394**	.736**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	337	337	342	341	336	337
HSPT1	Pearson Correlation	.266**	.194**	.102	.399**	.338**	.201**
	Sig. (2-tailed)	.000	.000	.061	.000	.000	.000
	N	335	335	338	340	334	333
HSPT2	Pearson Correlation	.307**	.373**	.219**	.428**	.558**	.251**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	334	336	337	338	336	332
HSPT3	Pearson Correlation	.189**	.276**	.495**	.220**	.292**	.620**
	Sig. (2-tailed)	.001	.000	.000	.000	.000	.000
	N	334	334	339	338	333	335
HSIT1	Pearson Correlation	.328**	.097	.089	.179**	.085	-.009
	Sig. (2-tailed)	.000	.073	.100	.001	.120	.868
	N	340	340	343	344	339	338
HSIT2	Pearson Correlation	.204**	.226**	.100	.221**	.230**	.076
	Sig. (2-tailed)	.000	.000	.065	.000	.000	.163
	N	339	340	342	343	340	337
HSIT3	Pearson Correlation	.213**	.248**	.332**	.166**	.158**	.364**
	Sig. (2-tailed)	.000	.000	.000	.002	.004	.000
	N	337	336	341	340	335	337
EST1	Pearson Correlation	.369**	.255**	.162**	.410**	.269**	.232**
	Sig. (2-tailed)	.000	.000	.003	.000	.000	.000
	N	339	337	340	341	336	336
EST2	Pearson Correlation	.222**	.453**	.195**	.307**	.473**	.284**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
	N	333	335	336	337	336	331
EST3	Pearson Correlation	.171**	.266**	.462**	.213**	.289**	.641**
	Sig. (2-tailed)	.002	.000	.000	.000	.000	.000
	N	335	335	340	339	334	335
TST1	Pearson Correlation	1	.312**	.248**	.463**	.342**	.185**
	Sig. (2-tailed)		.000	.000	.000	.000	.001
	N	341	334	337	338	333	333

TST2	Pearson Correlation	.312**	1	.435**	.363**	.463**	.287**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	334	341	337	338	335	332
TST3	Pearson Correlation	.248**	.435**	1	.228**	.257**	.434**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	337	337	344	341	336	338
TMT1	Pearson Correlation	.463**	.363**	.228**	1	.550**	.398**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	338	338	341	345	337	336
TMT2	Pearson Correlation	.342**	.463**	.257**	.550**	1	.423**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	333	335	336	337	340	331
TMT3	Pearson Correlation	.185**	.287**	.434**	.398**	.423**	1
	Sig. (2-tailed)	.001	.000	.000	.000	.000	
	N	333	332	338	336	331	339

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The Digital Media Principles Quiz

The purpose of this quiz is to gauge student understanding of basic digital media principles that apply to the creation of digital media artefacts such as digital story, blog, brochure, poster, animation, video and blended media.

1. Did you complete a digital media assignment previously?
   Yes
   No

2. Did you receive any digital media training at UTS?
   Yes
   No

3. If yes, which subject?

4. Please choose the most appropriate answer in regards to layout design:
   A) The layout design is how objects are positioning on the screen
   B) Layout design applies to graphic design, animations, videos, etc.
   C) Good layout design can make a digital artefact to stand and to communicate effectively to an audience, for example, a powerpoint with audio.
   D) All the above

5. An asymmetric design always convey
   A) Balance
   B) Professionalism
   C) Helps the user to engage with the content
   D) None of the above

6. Please choose the most appropriate answer in regards to colour theory for digital media creation
   A) There are no rules on how to combine colours for digital artefacts
   B) Colour creates moods, and a complementary colour scheme is highly desirable
   C) Is about preference and is not ‘right’ or ‘wrong’
   D) Using few bright colours in design make it interesting

7. When using colours in digital media artefacts, for example, infographics:
   A) Light colour fonts on a light background is desirable
   B) Using two bright colours can make a colour clash, and it is not desirable
   C) The infographics can be effective no matter what colour scheme you use
   D) The complementary colour scheme is ineffective, and it will not make the infographics engaging for the audience.

8. Typography is the use of fonts in visual design and:
   A) In a digital media artefact, for example, an animation, you can use any font you would like
   B) You can include different types of fonts in a brochure, the more fonts, the more creative and the better for the audience.
   C) Certain fonts are more legible than others, for example, brush script fonts can be problematic and need to be avoided.
   D) When sending emails, you can use bold, italics and colour fonts without any rule. It will make your email to stand and be creative.

9. The use of background images and text over them:
   A) Can be used in any design such a poster or PowerPoint no matter how busy the background looks like
   B) Can be used with any font and the message will be legible
   C) Need to be restricted as it may make your design hard to communicate your ideas
   D) Using background images and text over is a matter of preference.

10. Images to convey messages are:
    A) Relevant only for advertising on buses and poster
    B) Can make a message stand and unforgettable for your audience
    C) Always adds value to your digital presentations
    D) Some people are more visual than others, so it is a matter of preference.

11. Video can be recorded
    A) Vertically, for example on Instagram
    B) Horizontally with a video camera but vertical with a mobile device
    C) It is a matter of preference Vertical or Horizontal

D) Videos should be recorded horizontally only. People who treat video as photographs produce the vertical video.

12. When producing video
    A) Is important to use a tripod. Otherwise, the video will look wobbly
    B) Long, medium, close-up and extremely close-up shots are required to produce video effectively
    C) Zooming in and out should be restricted during video filming
    D) All the above.

13. When producing content for digital media projects
    A) Is all about the technology, expensive equipment and the editing
    B) There are no rules to apply, and you can be creative as much as you want
    C) Is all about the content, the technology you use is not important
    D) It is a fine balance between content, digital media principles and the technology used.

14. When producing any type of digital media
    A) The first step is to write a storyboard
    B) You need to use accurate content
    C) When content is finalised you can start to think how you want to represent the content, e.g.: audio, images, moving text, video, etc.
    D) All the above.

15. The digital media principles are a set of rules that apply to the production of digital media artefacts, and they are important because:
    A) Can make it or break it when communicating a message to an online audience
    B) It's all about creativity and personal preference
    C) Can make your content professional and credible
    D) A and C are correct.

Do you think digital media principles should be taught in science to communicate effectively in the digital space? Feel free to make any relevant comment.

Figure 1: The Digital Media Literacies Framework (DMLF) for Teaching and Learning.

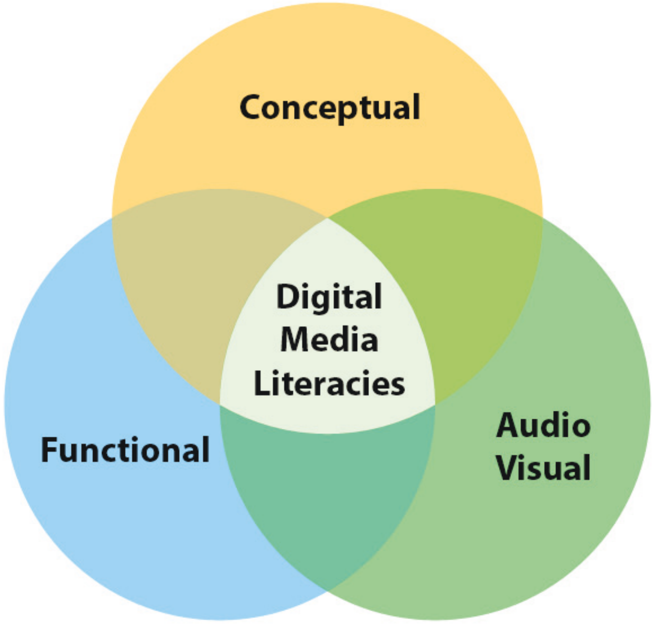

Figure 2: The Taxonomy of Digital Media Types for Teaching and Learning.

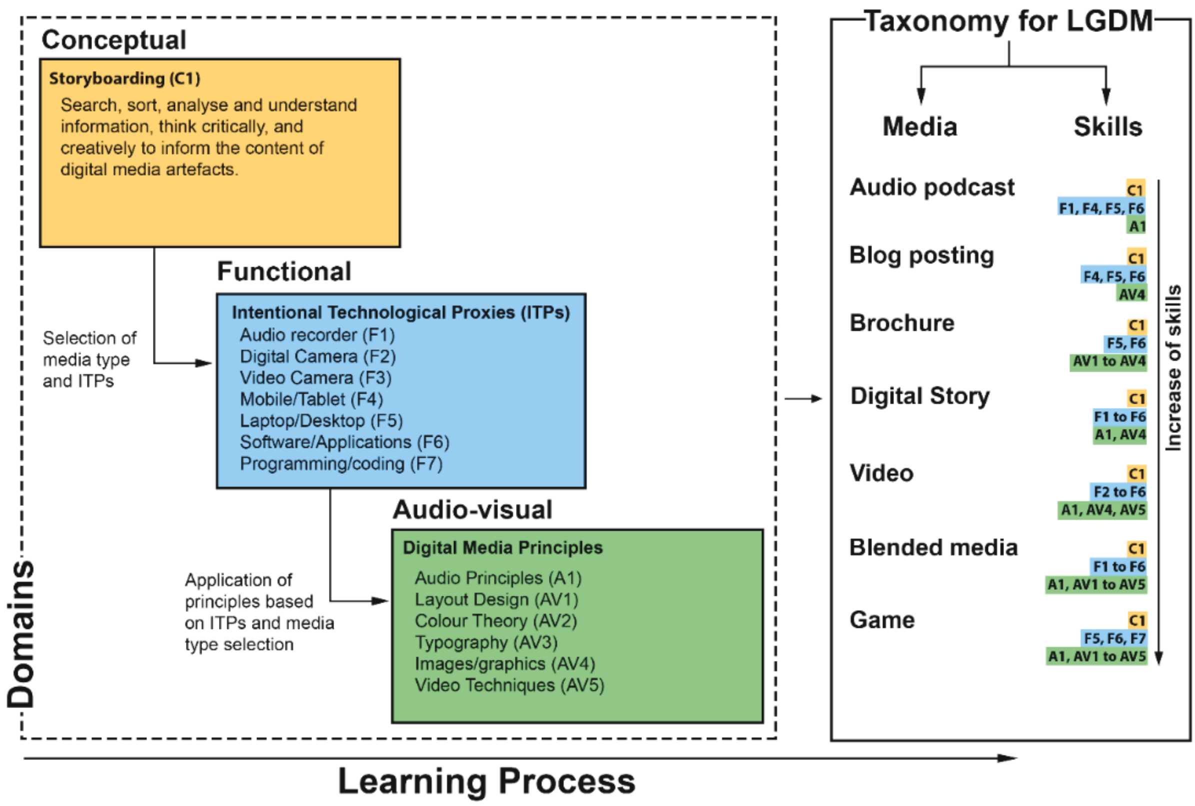

Figure 3: The Digital Media Principles for Teaching and Learning. Its application in LGDM assignments will help to produce an engaging digital artefact.

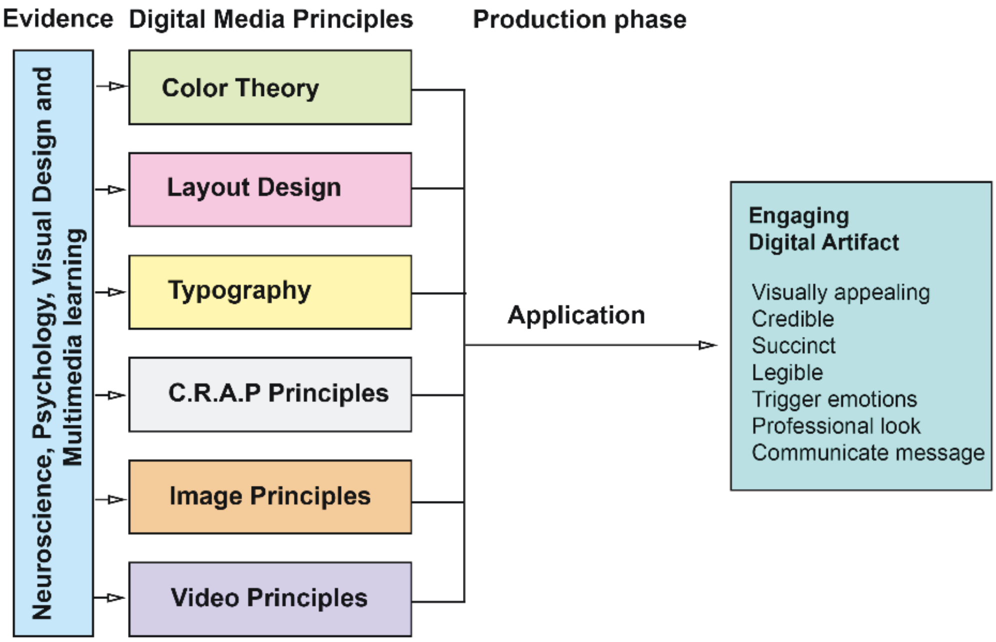

Figure 4: Learner Generated Digital Media Implementation Framework.

Figure 5: A theoretical model to research LGDM as an assessment tool in the classroom.