

**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 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). 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. The main focus was 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, Green, Qarabash, Preston, Bartindale, & Balaam, 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, West, Kenny, Chooniedass, Demczuk, Mitchell, Chateau, & Scott, 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 systematic protocol

of identification, screening, filtering, and selection, the crucial steps for information-gathering (Figure 1).

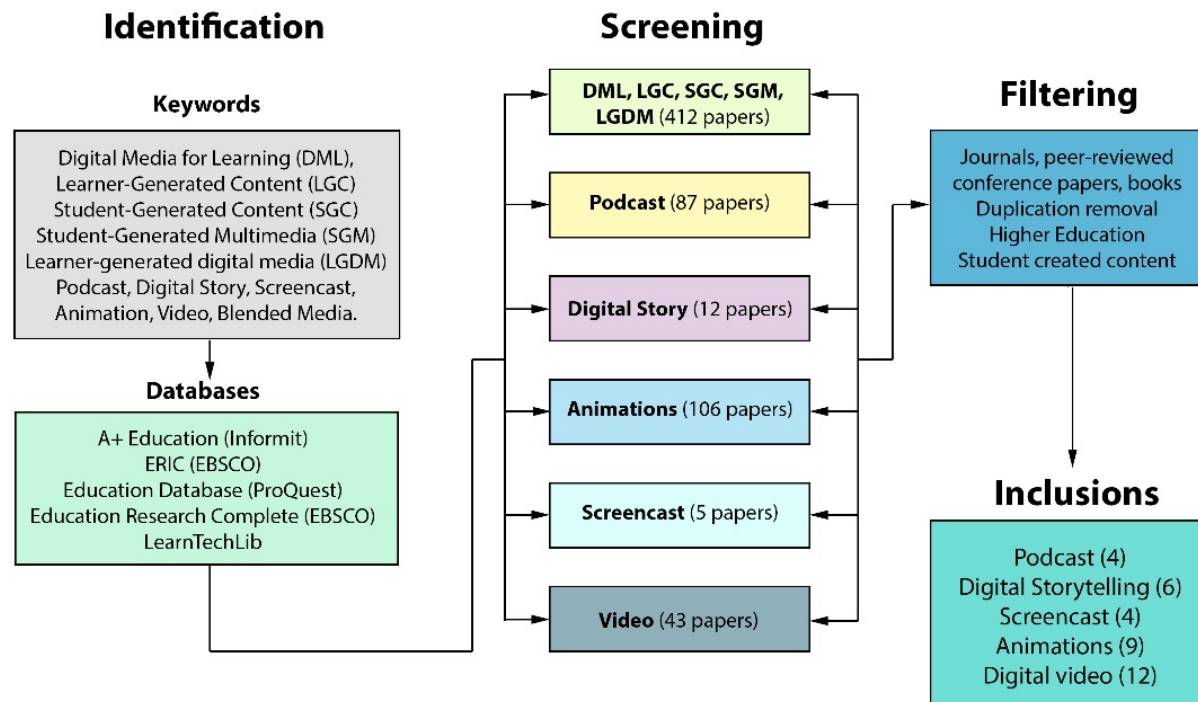


Figure 1: Literature review workflow on LGDM in science education

The process of gathering the data took place repeatedly across reputable educational databases such as A+ (Informit), ERIC (EBSCO), Education Database (ProQuest), Education Research Complete (EBSCO), and LearnTechLib (AACE). 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). DML comprised papers on using digital media to deliver subject content (n=322 papers), while 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. 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 through 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, Kynäslähti, Lipponen, Vesterinen, Vahtivuori-Hänninen, Mylläri, & Tella, 2013).

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 the 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, Bartle, & Longnecker, 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 summary, there is no comprehensive model for implementing learner-generated podcast in the classroom which considers content and technical aspects and highlights educator and student roles. Studies on learner-generated podcast 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 digital stories are not seen by the scientific community as a rigorous methodology for presenting information (Cheng, 2017; 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 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 Centre for Digital Storytelling (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 own ideas and skills and also reported minor technical issues (Martinelli & Zinicola, 2009).

In summary, the use of learner-generated digital stories in science education is in its early stages. Although theoretical frameworks for storytelling have been applied, 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 didn't. 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.

In summary, 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 as a way 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 were 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.

In summary, 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 further gauge their effect on learning.

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 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 in tertiary science education. 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. Our literature review 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.

Recommendations

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. In other words, 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 developing 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 LGDM assignments 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 LGDM 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.

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