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.

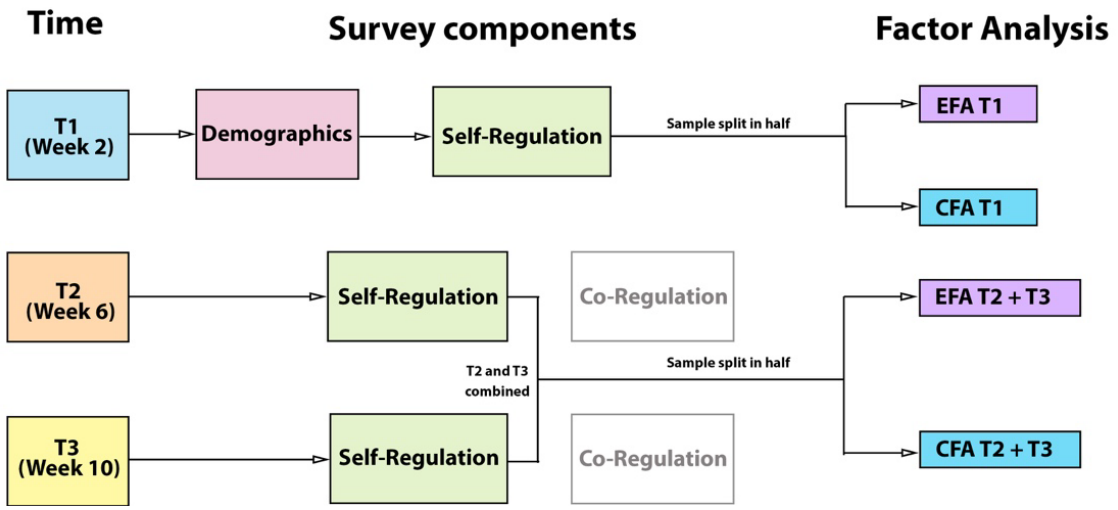

Figure 2. Sample split for EFA and CFA. EFA T1 was similar to EFA T2 + T3, and CFA T1 was similar to CFA T2 + T3 (n = 341).

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.

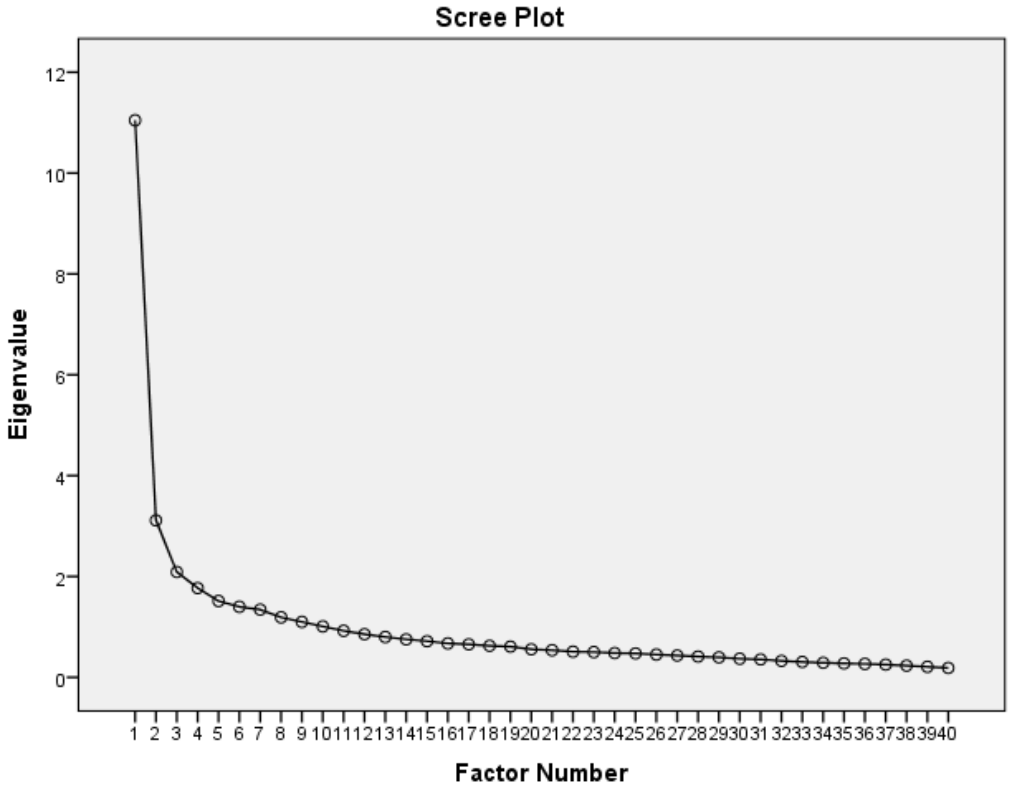

Figure 3. Factor eigenvalue by factor number

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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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.