Explaining learning achievement in student experience of blended learning: What can a sociomaterial perspective contribute?

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Drawing on theories of student approaches to learning and sociomaterial perspectives on learning, we investigated how a combination of sociocognitive and sociomaterial variables explain variation in 365 students' learning achievement in a first year human biology blended learning course in an Australian research intensive university. We used a close-ended questionnaire to measure students' approaches to learning through inquiry, approaches to using online learning technologies, and their use of on-campus physical learning spaces. We obtained use of online learning tools in terms of frequency and duration through analytics provided by a proprietary learning management system. Students' learning achievement was evaluated using six assessment tasks in the course. Correlation analyses were conducted to examine the relationship between approaches, use of online learning tools, use of on-campus physical learning spaces, and achievement. Based on the correlation results, we regressed learning achievement on approaches, use of online learning tools and physical learning spaces. The results showed that introducing sociomaterial variables into the regression model, a significant proportion of learning achievement was explained over and above the explanations offered by sociocognitive factor alone, highlighting the important role of both sociocognitive and sociomaterial factors in blended learning.

Introduction

To investigate students learning experience in blended learning, in which students move forth and back across in-class and on-line contexts, some bodies of research have predominantly focused on sociocognitive variables such as motivation (e.g., Albert, & Dahling, 2016), emotion (e.g., Schutz & Pekrun, 2007), and self-efficacy (e.g., Wu, 2017). Other bodies of research into learning have focused predominantly on material aspects of the experience, such as frequency and time spent on interacting with online learning tools (Greller & Drachsler, 2012). In comparison, few studies look at combinations of sociocognitive and sociomaterial variables and how these are related to qualitatively different outcomes. With the increasingly use of technologies, which form an integral part of the learning processes, and learning occurs in both physical and virtual learning spaces, students' decisions about sociomaterial aspects, such as their choices of what type of technologies to use, how to use them, their decisions about where to engage in learning are likely to be shaping and being shaped by sociocognitive factors, including how they conceive of blended learning, how they approach face-to-face (f2f) and online learning, and how they perceive the blended learning environment. However, there is little evidence of the relationship amongst sociocognitive and sociomaterial variables and their combined contributions to the learning outcomes.

To better understand the complexity of variables involved in students' learning experience in blended environments, this study contributes to previous research by considering associations amongst sociocognitive and sociomaterial variables, and their combined contributions to academic achievement. Drawing on student approaches to learning research (known as SAL, Pintrich, 2004) and sociomaterial research (e.g., Fenwick, 2014, Fenwick, Edwards, & Sawchuk, 2015), this study investigates a first year student blended learning experience which required them to move back and forth between in-class and on-line contexts.

Student approaches to learning (SAL)

A key outcome from many studies in SAL research is that students' learning achievement is closely related to a number of interrelated factors, including their prior

learning experience, their perceptions of current learning contexts, and how they approach their learning (e.g., Prosser & Trigwell, 1999; Ramsden, 2003). Deep and surface approaches to learning have been consistently identified across disciplines and amongst students in different countries (e.g., Chan, 2014; Duarte, 2007; Trigwell, Ashwin, & Millan, 2013; Trigwell, Ellis, & Han, 2012); and variation in approaches to learning has been demonstrated to be logically related to qualitatively different levels of learning achievement (e.g., Ellis & Goodyear, 2013, Prosser & Trigwell, 1999).

In the contexts of blended courses, how students approach learning, how they use online learning technologies, and their levels of learning achievement have also been found to be logically interrelated: while some students understand the purpose of online learning technologies and use them in a meaningful way to broaden and deepen concepts and ideas in their study, other students limit their using of online learning technologies to merely fulfilling some practical purposes, such as downloading and information gathering (e.g., Ellis & Bliuc, 2016). These outcomes have promising implications for how they might link with research on sociomaterial aspect of learning.

Sociomaterial perspectives on learning

A collective body of theories have contributed to the development of sociomaterial research in learning. These include complexity theory (e.g., Siemens, 2014), cultural historical activity theory (e.g., Miettinen, Lehenkari, & Tuunainen, 2008), actor-network theory, and spatiality theory (e.g., Massey, 2005). Although these areas of research have approached the issues of sociomateriality from different perspectives, they have a common interest in recognising dynamic association between people and artefacts, and their combination in knowledge creation and consolidation (Fenwick, 2015). For example, cultural historical activity theory focuses on "activity" which is coordinated by both human and non-human elements as the primary unit of analysis.

Sociomaterial perspective on learning seeks to understand the interconnections between humans, tools, tasks, and learning environments involved in learning. This perspective is especially useful in the digitally-enabled learning, in which students' learning take places in both physical and virtual spaces, shaped by material objects and the decisions they make about them, such as the approaches they adopt, the perceptions they have, and where they choose to learn. Drawing on sociomaterial framework, which is able to take into consideration the importance of materiality in learning, and drawing on SAL research on students' approaches and perceptions of learning, we aim to investigate the relative contributions of student approaches to learning, use of online learning technologies, and use of on-campus physical learning spaces, to their learning achievement.

Method

Participants

The participants were 365 first year undergraduates (females: 69%, males: 31%), who were enrolled in a first year compulsory human biology course in an Australian research intensive university. Their ages ranged from 18 to 53 (Mean (*M*) = 19.72, standard deviation (*SD*) = 3.55).

The learning context

The course was semester-long and was an introductory course to human anatomy and physiology. Apart from learning the contents in human biology, the course also aimed to develop students' inquiry skills, such as creative and critical thinking abilities, scientific writing proficiency, and capacities of research and inquiry.

The course was a blended course which had both f2f and online teaching and learning components. The f2f component included a two-hour lecture per week, a three-hour laboratory session per fortnight, and a two-hour workshop per fortnight when there was no laboratory session. Being an integral and essential part of the course, the online component served as both preparation and revision of the f2f teaching and learning, which was organized under the assumption that students had completed the relevant online learning.

Instruments

Three instruments were used to collect data and the details are described in the following:

Close-ended questionnaire. The closed-ended questionnaire, which was designed to capture students' approaches to learning through inquiry, approaches to using online learning technologies, and their use of on-campus physical learning spaces. The development of the questionnaire was based on the SAL literature (e.g., Biggs, Kember, & Leung, 2001; Ellis, Bliuc, & Goodyear, 2012) and an internal study of the University on patterns of using on-campus physical learning spaces.

The *Deep approaches to inquiry* scale (5 items; $\alpha = 0.71$) describes approaches to learning through inquiry as being proactive, with deep thinking to pursue a line of inquiry (e.g., "I often pursue independent pathways when researching something").

The *Surface approaches to inquiry* scale (4 items; $\alpha = 0.63$) are approaches that lack of thinking, and are heavily dependent upon teachers (e.g., "Researching something for a task means only using the resources given to me by the teacher").

The *Deep approaches to using online learning technologies* scale (5 items; $\alpha = 0.72$) assesses using technologies as a way to promote deeper understanding of the key ideas and to facilitate research (e.g., "I spend

time using the learning technologies in this course to connect key ideas to real contexts").

The *Surface approaches to online learning technologies* scale (4 items; α = 0.66) describes using learning technologies as merely to satisfy course requirements (e.g., "I only use the learning technologies in this course to fulfil course requirements").

The single item on *students' use of on-campus physical learning spaces* asks students to choose from: (1) 2-3 days per week for 3-4 hours; (2) 3-4 days per week and stays for 5-6 hours; (3) 4-5 days per week and stays for 8-12 hours. These patterns were identified in a big data study conducted by the University.

Students' use of online learning tools. The data were captured through the learning analytics function in a proprietary learning management system – Blackboard, which recorded the frequency of accessing each online learning tool (count); and the duration of total time for accessing all the online learning tools (minute). The tools used in the course were grouped into three main educational purposes: interactive activities, curriculum information, and adaptive quizzes. The interactive activities consisted of different exercises (e.g., multiple-choice and terminology and image matching). The curriculum information included timetables, outlines of learning objectives and outcomes, reading materials, online videos of course contents, and lecture notes. The adaptive quizzes (through HBonline.com) distributed testing items matching with students' abilities.

Students' learning achievement. Students' learning achievement was measured by six assessment tasks: (1) five summative quizzes throughout the semester (15%); (2) an oral presentation of a case study (8%); (3) questions and reflections of each workshop (3%); (4) peer review of a draft scientific report (4%); (5) final scientific report (20%); and (6) final exam (50%). The learning achievement was scored on 100 point (M = 67.93, SD = of 10.13).

Procedure

Data collection strictly followed the ethical requirements of the University. We ensured that participation of the study was voluntary and all the information of the participants was used anonymously. The questionnaire data collection was taken place in one laboratory session towards the end of the semester so that the students could reflect upon their whole learning experience in the course. Students' use of online learning tools was obtained from the Blackboard using the learning analytics functions upon completion of the course. The students' learning achievement was obtained with the permission from the students.

Data analysis

To answer relative contributions of students' approaches to learning through inquiry and using online learning technologies, use of online learning tools, and use of on-campus physical learning spaces, to students' learning achievement, we conducted correlation analyses followed by hierarchical regression analyses. On the basis of correlation results, we constructed three regression models: in the first model, only students' approaches to learning through inquiry and using online learning technologies variables were entered because SAL research has consistently identified the importance of approaches to learning in learning achievement. In the second model, we added use of online learning tools into the model. In the last model, we added use of on-campus physical learning spaces as an additional variable to predict the learning achievement. This allowed us to examine the contributions of both sociocognitive factors and sociomaterial factors to learning achievement in a single model.

Results and discussion

Results of correlation analyses are presented in Table 1, which shows that the deep approaches to inquiry were positively and moderately correlated with the deep approaches to using online learning technologies (r = .22, p < .01). It had negative and moderate association with the surface approaches to inquiry (r = -.41, p < .01) and the surface approaches to using online learning technologies (r = -.29, p < .01). The surface approaches to inquiry had positive relation with the surface approaches to using online technologies (r = -28, p < .01), but negative and weak relation with the deep approaches to using online technologies (r = -.14, p < .01). The correlation between the two approaches to using online learning technologies was negative and moderate (r = -.46, p < .01).

Concerning the interrelationship between approaches, use of online learning tools, and use of on-campus physical learning spaces and learning achievement, the results showed that while only deep approaches to inquiry significantly and positively related to learning achievements (r = .23, p < .01), all the variables of use of online learning tools are significantly and positively associated with learning achievements (interactive activities: r = .22, p < .01; curriculum information: r = .23, p < .01; adaptive quizzes: r = .28, p < .01; and the total course access time:r = .15, p < .01). The use of on-campus physical learning spaces was also positively correlated with the learning achievement (r = .15, p < .01).

Table 1: Results of correlation analyses

Variables	SAI	DAT	SAT	Interactive activities	Curriculum informatio	Adaptive quizzes	Access time	Physical spaces	Learning achieveme
DAI	-.41**	.22**	-.29**	-.04	-.04	-.05	.04	.10	.23**
SAI	---	-.14**	.28**	.15**	.13*	.08	-.05	-.03	-.10
DAT	---	---	-.46**	.06	.05	.04	.06	.06	.-.05
SAT	---	---	---	-.05	-.03	.05	-.07	-.05	-.04
Interactive activities	---	---	---	---	.97**	.64**	.54**	.09	.22**
Curriculum information	---	---	---	---	---	.67**	.45**	.08	.23**
Adaptive quizzes	---	---	---	---	---	---	.24**	.15*	.28**
Access time	---	---	---	---	---	---	---	.07	.15**
Physical spaces	---	---	---	---	---	---	---	---	.22**

Notes: DAI = deep approaches to learning through inquiry, SAI = surface approaches to learning through inquiry, DAT = deep approaches to using online learning technologies, and SAT = surface approaches to using online learning technologies.

For regression analyses, we only used variables which showed significant correlations with the learning achievement, and the results of three regression models are displayed in Table 2. Table 2 shows that in model 1, the deep approaches to learning through inquiry significantly predicted academic performance, F (1, 363) = 16.05, $p < .01$, $f^2 = .08$, accounting for approximately 7% of the variation in the learning achievement. In model 2, introducing the four variables of use of online learning tools explained an additional 8% of variation in students' learning achievement, and this R^2 change was significant, F (5, 359) = 7.96, $p < .01$, $f^2 = .18$. However, among the four variables, only frequency of access to adaptive quizzes was a significant predictor to learning achievement (β = .34, $p < .01$). In the third model, including use of on-campus physical learning spaces made an additional 1% contribution to learning achievement, F (6, 358) = 7.47, $p < .01$, $f^2 = .19$. The third regression model reveals that altogether students' deep approaches to inquiry (β = .28, $p < .01$), frequency of access to adaptive quizzes (β = .31, $p < .01$), and use of on-campus physical learning spaces (β = .24, $p < .05$), could explain approximately 16% of students' learning achievement. The results of our last regression model demonstrate that in addition to sociocognitive aspects of learning (i.e., approaches), introducing sociomaterial aspects of learning (i.e., online tools and learning spaces) explained an additional 9% of students' learning achievement, suggesting the importance of materiality in blended learning.

Table 2: Results of hierarchical regression analyses

Variables	B	SE B	β	t	adjusted R^2	ΔR^2	p	f^2
Model 1					.07**	---		
Deep approaches to inquiry	2.47	.62	.27	4.00			.00**	.08
Model 2					.15**	.08**		.18
Deep approaches to inquiry	2.60	.59	.28	4.36			.00**	
Interactive activities	0.04	.08	.13	0.51			.61	
Curriculum information	-0.04	.05	-.22	-0.88			.38	
Adaptive quizzes	0.42	.11	.34	3.87			.00**	
Access time	0.01	.01	.07	0.90			.37	
Model 3					.16**	.01**		.19
Deep approaches to inquiry	2.59	.59	.28	4.39			.00**	
Interactive activities	0.05	.08	.17	0.67			.50	
Curriculum information	-0.05	.05	-.26	-1.03			.30	
Adaptive quizzes	0.39	.11	.31	3.60			.00**	
Access time	0.01	.01	.07	0.88			.38	
Physical spaces	1.88	.90	.14	2.09			.04*	

The results of correlation analyses showed that at the level of variables, students' approaches to learning through inquiry and approaches to using online learning technologies were logically aligned with each other: the two deep approaches and the two surface approaches were positively related; the deep approaches were negatively associated with the surface approaches; and more of using deep approaches to learning through inquiry was associated with better achievement. Apart from the approaches, students' use of different online learning tools and use of physical learning spaces, which are often not considered in most of SAL studies, are also logically related to the learning achievement, that more frequent access to multiple learning activities is related to better learning. Our regression analyses suggested that the predictive power of a combination of sociocognitive and sociomaterial elements to students' learning achievement was much larger than the sociocognitive factor alone.

Conclusion

In this study, we found that not only do the sociocognitive aspects of students' learning experience, as shown in their self-reported approaches to learning through inquiry and using online learning technologies, are important contributing elements to the quality of their learning achievement; but also the sociomaterial aspects of "things", both intangible things, as their use of a variety of online learning tools available in the LMS, and tangible things, as their use of physical learning spaces, such as library, learning hubs, computer laboratories, lecture theatres, are able to explain variations in their learning achievement. In fact, the materiality, which has been backgrounded in the research, even makes a slightly larger contribution to the learning achievement than the long-time focused sociocognitive factors. These results have both theoretical and practical implications. Theoretically speaking, our results suggest that research should be expanded by including elements of the neglected material dimensions when attempting to understand and explain students' learning success, especially in the technologically enabled blended learning where online tools and virtual environments take a significant proportion of learning experience. Only through a combination of human and non-human factors, can we continuously identify factors or a combination of factors which affect students' learning. Practically, teachers should consider improving both students' sociocognitive and sociomaterial learning experience. For the former category, teachers can ask more successful students to share ideas about how they approach the learning through inquiry, such as formulating meaningful research questions, integrating multiple perspectives from research, and exemplar and meaningful ways of using the learning technologies (e.g., using learning technologies to help with conceptual developments in learning). To improve students' sociomaterial learning experience, teachers should help students understand the values of online learning activities, which are not to be separated from their f2f learning, in order to maximise students' online participation.

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