

RESEARCH

Open Access



Exploring the role of social media in collaborative learning the new domain of learning

Jamal Abdul Nasir Ansari* and Nawab Ali Khan

* Correspondence: jnasir4@gmail.com; jnasir.rs@amu.ac.in
Department of Commerce, Aligarh Muslim University, Aligarh 202002, India

Abstract

This study is an attempt to examine the application and usefulness of social media and mobile devices in transferring the resources and interaction with academicians in higher education institutions across the boundary wall, a hitherto unexplained area of research. This empirical study is based on the survey of 360 students of a university in eastern India, cognising students' perception on social media and mobile devices through collaborative learning, interactivity with peers, teachers and its significant impact on students' academic performance. A latent variance-based structural equation model approach was followed for measurement and instrument validation. The study revealed that online social media used for collaborative learning had a significant impact on interactivity with peers, teachers and online knowledge sharing behaviour. Additionally, interactivity with teachers, peers, and online knowledge sharing behaviour has seen a significant impact on students' engagement which consequently has a significant impact on students' academic performance. Grounded to this finding, it would be valuable to mention that use of online social media for collaborative learning facilitate students to be more creative, dynamic and research-oriented. It is purely a domain of knowledge.

Keywords: Students, Social media, Higher education, Faculty members, University, SEM

Introduction

The explosion of Information and Communication Technology (ICT) has led to an increase in the volume and smoothness in transferring course contents, which further stimulates the appeasement of Digital Learning Communities (DLCs). The millennium and naughtiness age bracket were Information Technology (IT) centric on web space where individual and geopolitical disperse learners accomplished their e-learning goals. The Educause Center for Applied Research [ECAR] (2012) surveyed students in higher education mentioned that students are pouring the acceptance of mobile computing devices (cellphones, smartphones, and tablet) in Higher Education Institutions (HEIs), roughly 67% surveyed students accepted that mobile devices and social media play a vital role in their academic performance and career enhancement. Mobile devices and social media provide excellent educational e-learning opportunities to the students for academic collaboration, accessing in course contents, and tutors despite the physical

boundary (Gikas & Grant, 2013). Electronic communication technologies accelerate the pace of their encroachment of every aspect of life, the educational institutions incessantly long decades to struggle in seeing the role of such devices in sharing the contents, usefulness and interactivity style. Adoption and application of mobile devices and social media can provide ample futuristic learning opportunities to the students in accessing course contents as well as interaction with peers and experts (Cavus & Ibrahim, 2008, 2009; Kukulska-Hulme & Shield, 2008; Nihalani & Mayrath, 2010; Richardson & Lenarcic, 2008, Shih, 2007). Recently Pew Research Center reported that 55% American teenage age bracket of 15–17 years using online social networking sites, i.e. Myspace and Facebook (Reuben, 2008). Social media, the fast triggering the mean of virtual communication, internet-based technologies changed the life pattern of young youth.

Use of social media and mobile devices presents both advantages as well as challenges, mostly its benefits seen in terms of accessing course contents, video clip, transfer of the instructional notes etc. Overall students feel that social media and mobile devices are the cheap and convenient tools of obtaining relevant information. Studies in western countries have confronted that online social media use for collaborative learning has a significant contribution to students' academic performance and satisfaction (Zhu, 2012). The purpose of this research project was to explore how learning and teaching activities in higher education institutions were affected by the integration and application of mobile devices in sharing the resource materials, interaction with colleagues and students' academic performance. The broad goal of this research was to contemporise the in-depth perspectives of students' perception of mobile devices and social media in learning and teaching activities. However, this research paper paid attention to only students' experiences, and their understanding of mobile devices and social media fetched changes and its competency in academic performance. The fundamental research question of this research was, what are the opinions of students on social media and mobile devices when it is integrating into higher education for accessing, interacting with peers.

A researcher of the University of Central Florida reported that electronic devices and social media create an opportunity to the students for collaborative learning and also allowed the students in sharing the resource materials to the colleagues (Gikas & Grant, 2013). The result of the eight Egyptian universities confirmed that social media have the significant impact on higher education institutions especially in term of learning tools and teaching aids, faculty members' use of social media seen at a minimum level due to several barriers (internet accessibility, mobile devices etc.).

Social media and mobile devices allow the students to create, edit and share the course contents in textual, video or audio forms. These technological innovations give birth to a new kind of learning cultures, learning based on the principles of collective exploration and interaction (Selwyn, 2012). Social media the phenomena originated in 2005 after the Web2.0 existence into the reality, defined more clearly as "a group of Internet-based applications that build on the ideological and technological foundation of web 2.0 and allow creation and exchange of user-generated contents (Kaplan & Haenlein, 2010). Mobile devices and social media provide opportunities to the students for accessing resources, materials, course contents, interaction with mentor and colleagues (Cavus & Ibrahim, 2008, 2009; Richardson & Lenarcic, 2008).

Social media platform in academic institutions allows students to interact with their mentors, access their course contents, customisation and build students communities (Greenhow, 2011a, 2011b). 90% school going students currently utilise the internet consistently, with more than 75% teenagers using online networking sites for e-learning (DeBell & Chapman, 2006; Lenhart, Arafeh, & Smith, 2008; Lenhart, Madden, & Hitlin, 2005). The result of the focus group interview of the students in 3 different universities in the United States confirmed that use of social media created opportunities to the learners for collaborative learning, creating and engaging the students in various extra curriculum activities (Gikas & Grant, 2013).

Research background and hypotheses

The technological innovation and increased use of the internet for e-learning by the students in higher education institutions has brought revolutionary changes in communication pattern. A report on 3000 college students in the United States revealed that 90% using Facebook while 37% using Twitter to share the resource materials as cited in (Elkaseh, Wong, & Fung, 2016). A study highlighted that the usage of social networking sites in educational institutions has a practical outcome on students' learning outcomes (Jackson, 2011). The empirical investigation over 252 undergraduate students of business and management showed that time spent on twitter and involvement in managing social lives and sharing information, course-related influences their performance (Evans, 2014).

Social media for collaborative learning, interactivity with teachers, interactivity with peers

Many kinds of research confronted on the applicability of social media and mobile devices in higher education for interaction with colleagues. 90% of faculty members use some social media in courses they were usually teaching or professional purposes out of the campus life. Facebook and YouTube are the most visited sites for the professional outcomes, around 2/3rd of the all-faculty use some medium for a class session, and 30% posted contents for students engagement in reading, view materials (Moran, Seaman, & Tinti-Kane, 2011). Use of social media and mobile devices in higher education is relatively new phenomena, completely hitherto area of research. Research on the students of faculty of Economics at University of Mostar, Bosnia, and Herzegovina reported that social media is already used for the sharing the materials and exchanges of information and students are ready for active use of social networking site (slide share etc.) for educational purposes mainly e-learning and communication (Mirela Mabić, 2014).

The report published by the U.S. higher education department stated that the majority of the faculty members engaged in different form of the social media for professional purposes, use of social media for teaching international business, sharing contents with the far way students, the use of social media and mobile devices for sharing and the interactive nature of online and mobile technologies build a better learning environment at international level. Responses on 308 graduate and postgraduate students in Saudi Arabia University exhibited that positive correlation between chatting, online discussion and file sharing and knowledge sharing, and entertainment and enjoyment with students learning (Eid & Al-Jabri, 2016). The quantitative study on 168 faculty members using partial least square (PLS-SEM) at Carnegie classified Doctoral

Research University in the USA confirmed that perceived usefulness, external pressure and compatibility of task-technology have positive effect on social media use, the higher the degree of the perceived risk of social media, the less likely to use the technological tools for classroom instruction, the study further revealed that use of social media for collaborative learning has a positive effect on students learning outcome and satisfaction (Cao, Ajjan, & Hong, 2013). Therefore, the authors have hypothesized:

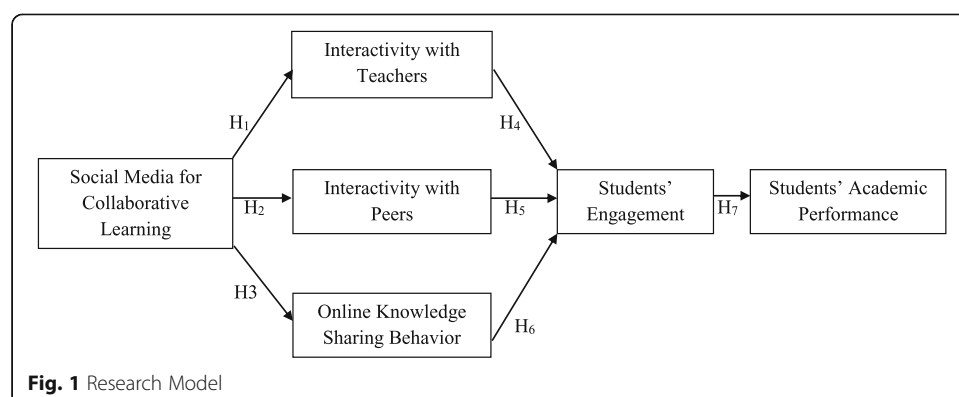
H1: Use of social media for collaborative learning is positively associated with interactivity with teachers.

Additionally, Madden and Zickuhr (2011) concluded that 83% of internet user within the age bracket of 18–29 years adopting social media for interaction with colleagues. Kabilan, Ahmad, and Abidin (2010) made an empirical investigation on 300 students at University Sains Malaysia and concluded that 74% students found to be the same view that social media infuses constructive attitude towards learning English (Fig. 1).

Reuben (2008) concluded in his study on social media usage among professional institutions revealed that Facebook and YouTube used over half of 148 higher education institutions. Nevertheless, a recent survey of 456 accredited United States institutions highlighted 100% using some form of social media, notably Facebook 98% and Twitter 84% for e-learning purposes, interaction with mentors (Barnes & Lescault, 2011).

Information and communication technology (ICT), such as web-based application and social networking sites enhances the collaboration and construction of knowledge byway of instruction with outside experts (Zhu, 2012). A positive statistically significant relationship was found between student's use of a variety of social media tools and the colleague's fellow as well as the overall quality of experiences (Rutherford, 2010). The potential use of social media leads to collaborative learning environments which allow students to share education-related materials and contents (Fisher & Baird, 2006). The report of 233 students in the United States higher educations confirmed that more recluse students interact through social media, which assist them in collaborative learning and boosting their self-confidence (Voorn & Kommers, 2013). Thus hypotheses as

H2: Use of social media for collaborative learning is positively associated with interactivity with peers.



Social media for collaborative learning, interactivity with peers, online knowledge sharing behaviour and students' engagement

Students' engagement in social media and its types represent their physical and mental involvement and time spent boost to the enhancement of educational Excellency, time spent on interaction with peers, teachers for collaborative learning (Kuh, 2007). Students' engagement enhanced when interacting with peers and teacher was in the same direction, shares of ideas (Chickering & Gamson, 1987). Engagement is an active state that is influenced by interaction or lack thereof (Leece, 2011). With the advancement in information technology, the virtual world becomes the storehouse of the information. Liccardi et al. (2007) concluded that 30% students were noted to be active on social media for interaction with their colleagues, tutors, and friends while more than 52% used some social media forms for video sharing, blogs, chatting, and wiki during their class time. E-learning becomes now sharp and powerful tools in information technology and makes a substantial impact on the student's academic performance. Sharing your knowledge will make you better. Social network ties were shown to be the best predictors of online knowledge sharing intention, which in turn associated with knowledge sharing behaviour (Chen, Chen, & Kinshuk, 2009). Social media provides the robust personalised, interactive learning environment and enhances in self-motivation as cited in (Al-Mukhaini, Al-Qayoudhi, & Al-Badi, 2014). Therefore, it was hypothesised that:

H3: Use of social media for collaborative learning is positively associated with online knowledge sharing behaviour.

Broadly Speaking social media/sites allow the students to interact, share the contents with colleagues, also assisting in building connections with others (Cain, 2008). In the present era, the majority of the college-going students are seen to be frequent users of these sophisticated devices to keep them informed and updated about the external affair. Facebook reported per day 1,00,000 new members join; Facebook is the most preferred social networking sites among the students of the United States as cited in (Cain, 2008). The researcher of the school of engineering, Swiss Federal Institute of Technology Lausanne, Switzerland, designed and developed *Grasp*, a social media platform for their students' collaborative learning, sharing contents (Bogdanov et al., 2012). The utility and its usefulness could be seen in the University of Geneva and Tongji University at both two educational places students were satisfied and accept '*Grasp*' to collect, organised and share the contents. Students use of social media will interact ubiquity, heterogeneous and engaged in large groups (Wankel, 2009). So we hypothesises

H4: More interaction with teachers leads to higher students' engagement.

However, a similar report published on 233 students revealed that social media assisted in their collaborative learning and self-confidence as they prefer communication technology than face to face communication. Although, the students have the willingness to communicate via social media platform than face to face (Voorn & Kommers, 2013). The potential use of social media tools facilitates in achieving higher-level learning through collaboration with colleagues and other renewed experts in their field (Junco,

Heiberger, & Loken, 2011; Meyer, 2010; Novak, Razzouk, & Johnson, 2012; Redecker, Ala-Mutka, & Punie, 2010). Academic self-efficacy and optimism were found to be strongly related to performance, adjustment and consequently both directly impacted on student's academic performance (Chemers, Hu, & Garcia, 2001). Data of 723 Malaysian researchers confirmed that both male and female students were satisfied with the use of social media for collaborative learning and engagement was found positively affected with learning performance (Al-Rahmi, Alias, Othman, Marin, & Tur, 2018). Social media were seen as a powerful driver for learning activities in terms of frankness, interactivity, and friendliness.

Junco et al. (2011) conducted research on the specific purpose of the social media; how Twitter impacted students' engagement, found that it was extent discussion out of class, their participation in panel group (Rodriguez, 2011). A comparative study conducted by (Roblyer, McDaniel, Webb, Herman, & Witty, 2010) revealed that students were more techno-oriented than faculty members and more likely using Facebook and such similar communication technology to support their class-related task. Additionally, faculty members were more likely to use traditional techniques, i.e. email. Thus hypotheses framed is that:

H5: More interaction with peers ultimately leads to better students' engagement.

Social networking sites and social media are closely similar, which provide a platform where students can interact, communicate, and share emotional intelligence and looking for people with other attitudes (Gikas & Grant, 2013). Facebook and YouTube channel use also increased in the skills/ability and knowledge and outcomes (Daniel, Isaac, & Janet, 2017). It was highlighted that 90% of faculty members were using some sort of social media in their courses/ teaching. Facebook was the most visited social media sites as per study, 40% of faculty members requested students to read and views content posted on social media; majority reports that videos, wiki, etc. the primary source of acquiring knowledge, social networking sites valuable tool/source of collaborative learning (Moran et al., 2011). However, more interestingly, in a study which was carried out on 658 faculty members in the eight different state university of Turkey, concluded that nearly half of the faculty member has some social media accounts.

Further reported that adopting social media for educational purposes, the primary motivational factor which stimulates them to use was effective and quick means of communication technology (Akçayır, 2017). Thus hypotheses formulated is:

H6: Online knowledge sharing behaviour is positively associated with the students' engagement.

Using multiple treatment research design, following act-react to increase students' academic performance and productivity, it was observed when self-monitoring record sheet was placed before students and seen that students engagement and educational productivity was increased (Rock & Thead, 2007). Student engagement in extra curriculum activities promotes academic achievement (Skinner & Belmont, 1993), increases grade rate (Connell, Spencer, & Aber, 1994), triggering student performance and positive expectations about academic abilities (Skinner & Belmont, 1993). They are

spending time on online social networking sites linked to students engagement, which works as the motivator of academic performance (Fan & Williams, 2010). Moreover, it was noted in a survey of over 236 Malaysian students that weak association found between the online game and student's academic performance (Eow, Ali, Mahmud, & Baki, 2009). In a survey of 671 students in Jordan, it was revealed that student's engagement directly influences academic performance, also seen the indirect effect of parental involvement over academic performance (Al-Alwan, 2014). Engaged students are perceptive and highly active in classroom activities, ready to participate in different classroom extra activities and expose motivation to learn, which finally leads in academic achievement (Reyes, Brackett, Rivers, White, & Salovey, 2012). A mediated role of students engagement seen in 1399 students' classroom emotional climate and grades (Reyes et al., 2012). A statistically significant relation was noticed between online lecture and exam performance.

Nonetheless, intelligence quotient, personality factors, students must be engaged in learning activities as cited in (Bertheussen & Myrland, 2016). The report of the 1906 students at 7 universities in Colombia confirmed that the weak correlation between collaborative learning, students faculty interaction with academic performance (Pineda-Báez et al., 2014) Thus, the hypothesis

H7: Student's Engagement is positively associated with the student's academic performance.

Methodology

To check the students' perception on social media for collaborative learning in higher education institutions, Data were gathered both offline and online survey administered to students from one public university in Eastern India (BBAU, Lucknow). For the sake of this study, indicators of interactivity with peers and teachers, the items of students engagement, the statement of social media for collaborative learning, and the elements of students' academic performance were adopted from (AL-Rahmi & Othman, 2013). The statement of online knowledge sharing behaviour was taken from (Ma & Yuen, 2011).

The indicators of all variables which were mentioned above are measured on the standardised seven-point Likert scale with the anchor (1-Strongly Disagree, to 7-Strongly Agree). Interactivity with peers was measured using four indicators; the sample items *using social media in class facilitates interaction with peers*; interactivity with teachers was measured using four symbols, the sample item is *using social media in class allows me to discuss with the teacher.*; engagement was measured using three indicators *by using social media I felt that my opinions had been taken into account in this class*; social media for collaborative learning was measured using four indicators *collaborative learning experience in social media environment is better than in a face-to-face learning environment*; students' academic performance was measured using five signs *using social media to build a student-lecturer relationship with my lecturers, and this improves my academic performance*; online knowledge sharing behaviour was assessed using five symbols *the counsel was received from other colleague using social media has increased our experience.*

Procedure and measurement

A sample of 360 undergraduate students was collected by convenience sampling method of a public university in Eastern India. The proposed model of study was measured and evaluated using variance based structured equation model (SEM)-a latent multi variance technique which provides the concurrent estimation of structural and measurement model that does not meet parametric assumption (Coelho & Duarte, 2016; Haryono & Wardoyo, 2012; Lee, 2007; Moqbel, Nevo, & Kock, 2013; Raykov & Marcoulides, 2000; Williams, Rana, & Dwivedi, 2015). The confirmatory factor analysis (CFA) was conducted to ensure whether the widely accepted criterion of discriminant and convergent validity met or not. The loading of all the indicators should be 0.50 or more (Field, 2011; Hair, Anderson, Tatham, & Black, 1992). And it should be statistically significant at least at the 0.05.

Demographic analysis (Table 1)

The majority of the students in this study were females (50.8%) while male students were only 49.2% with age 15–20 years (71.7%). It could be pointed out at this juncture that the majority of the students (53.9%) in BBAU were joined at least 1–5 academic pages for their getting information, awareness and knowledge. 46.1% of students spent 1–5 h per week on social networking sites for collaborative learning, interaction with teachers at an international level. The different academic pages followed for accessing material, communication with the faculty members stood at 44.4%, there would be various forms of the social networking sites (LinkedIn, Slide Share, YouTube Channel, Researchgate) which provide the facility of online collaborative learning, a platform at which both faculty members and students engaged in learning activities.

As per report (Nasir, Khatoon, & Bharadwaj, 2018), most of the social media user in India are college-going students, 33% girls followed by 27% boys students, and this reports also forecasted that India is going to become the highest 370.77 million internet users in 2022. Additionally, the majority of the faculty members use smartphone 44% to connect with the students for sharing material content. Technological advantages were the pivotal motivational force which stimulates faculty members and students to exploits the opportunities of resource materials (Nasir & Khan, 2018) (Fig. 2).

When the students were asked for what reason did they use social media, it was seen that rarely using for self-promotion, very frequently using for self-education, often used for passing the time with friends, and so many fruitful information the image mentioned above depicting.

Instrument validation

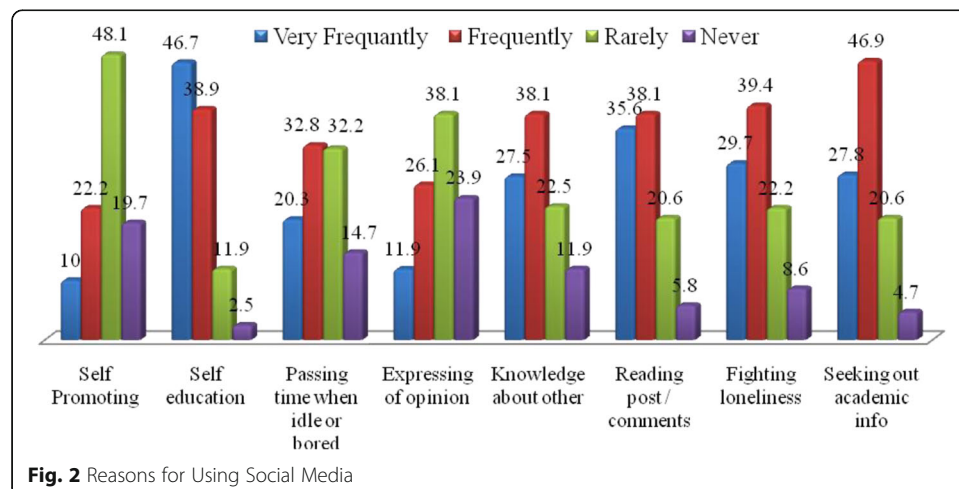
The structural model was applied to scrutinize the potency and statistically significant relationship among unobserved variables. The present measurement model was evaluated using Confirmatory Factor Analysis (CFA), and allied procedures to examine the relationship among hypothetical latent variables has acceptable reliability and validity. This study used both SPSS 20.0 and AMOS to check measurement and structural model (Field, 2013; Hair, Anderson, et al., 1992; Mooi & Sarstedt, 2011; Norusis, 2011).

The Confirmatory Factor Analysis (CFA) was conducted to ensure whether the widely accepted criterion of discriminant and convergent validity met or not. The

Table 1 Demographic Profile $n = 360$

Variables	Subgroups	Percent
Gender	Male	49.2
	Female	50.8
Age	15–20	71.7
	20–25	18.3
	25–30	5.8
	30–35	4.2
	Intermediate	60.0
Qualification	Graduate	22.8
	Post Graduate	13.3
	Other	3.9
No. of facebook friends	None	36.1
	1–200	30.0
	200–400	13.1
	400–600	20.8
Number of academic groups joined	None	25.6
	1–5	53.9
	6–10	14.2
	11–15	1.9
	Above 15	4.4
Number of educational paged followed	None	13.9
	1–5	44.4
	6–10	20.8
	11–15	11.4
	Above 15	9.4
A frequency of social media	1–5 h/week	46.1
	5–10 h/week	24.2
	10–15 h/week	17.2
	More than 15 h/week	12.5

Source: Computed and compiled by researchers on the basis of a questionnaire



loading of all the indicators should be 0.70 or more it should be statistically significant at least at the 0.05 (Field, 2011; Hair, Anderson, et al., 1992).

CR or CA-based tests measured the reliability of the proposed measurement model. The CA provides an estimate of the indicators intercorrelation (Henseler & Sarstedt, 2013). The benchmark limits of the CA is 0.7 or more (Nunnally & Bernstein, 1994). As per Table 2, all latent variables in this study above the recommended threshold limit. Although, Average Variance Extracted (AVE) has also been demonstrated which exceed the benchmark limit 0.5. Thus all the above-specified values revealed that our instrument is valid and effective. (See Table 2 for the additional information) (Table 3).

In a nutshell, the measurement model clear numerous stringent tests of convergent validity, discriminant validity, reliability, and absence of multi-collinearity. The finding demonstrated that our model meets widely accepted data validation criteria. (Schumacker & Lomax, 2010).

The model fit was evaluated through the Chi-Square/degree of freedom (CMIN/DF), Root Mean Residual (RMR), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Goodness of fit index (GFI) and Tucker-Lewis Index (TLI). The benchmark limit of the CFI, TLI, and GFI 0.90 or more (Hair et al., 2016;

Table 2 Factor loading, Cronbach's α (CA) coefficient, and composite reliability

ITEMS	INTT	INTP	ENG	CL	SAP	OKSB	CA	AVE	CR
INTT4	.898						.931	.771	.931
INTT3	.847								
INTT2	.930								
INTT1	.825								
INTP4		.896					.935	.783	.935
INTP3		.864							
INTP2		.930							
INTP1		.846							
ENG3			.881				.899	.749	.899
ENG2			.897						
ENG1			.775						
CL3				.922			.922	.799	.922
CL2				.912					
CL1				.835					
SAP5					.867		.942	.763	.942
SAP4					.875				
SAP 3					.852				
SAP2					.866				
SAP1					.894				
OKSB5						.867	.928	.723	.928
OKSB4						.897			
OKSB3						.891			
OKSB2						.881			
OKSB1						.696			

Source: Computed and compiled by researchers on the basis of a questionnaire
INTT interactivity with Teacher, *INTP* Interactivity with Peers, *ENG* Students Engagement, *CL* using social media for Collaborative Learning, *SAP* Students' Academic Performance, *OKSB* Online Knowledge Sharing Behavior, *CA* Cronbach α coefficient for latent variables, *CR* Composite Reliability, *AVE* Average Variance Extracted

Table 3 Correlations Statistics

	N	Mean	Std. Deviation	INT_P	INT_T	EN_G	SA_P	OKS_B	C_L
INT_P	360	4.4049	1.58108	1					
INT_T	360	4.0938	1.42197	.634 ^a	1				
EN_G	360	4.1278	1.42849	.663 ^a	.734 ^a	1			
SA_P	360	4.3628	1.50129	.642 ^a	.708 ^a	.795 ^a	1		
OKS_B	360	4.4972	1.45246	.526 ^a	.558 ^a	.659 ^a	.667 ^a	1	
C_L	360	4.2852	1.55916	.626 ^a	.694 ^a	.760 ^a	.764 ^a	.640 ^a	1

Source: Computed and compiled by researchers on the basis of a questionnaire

^aCorrelation is significant at the 0.01 level (2-tailed)

Kock, 2011). The model study demonstrated in the table, as mentioned above 4 that the minimum threshold limit was achieved (See Table 4 for additional diagnosis).

Results

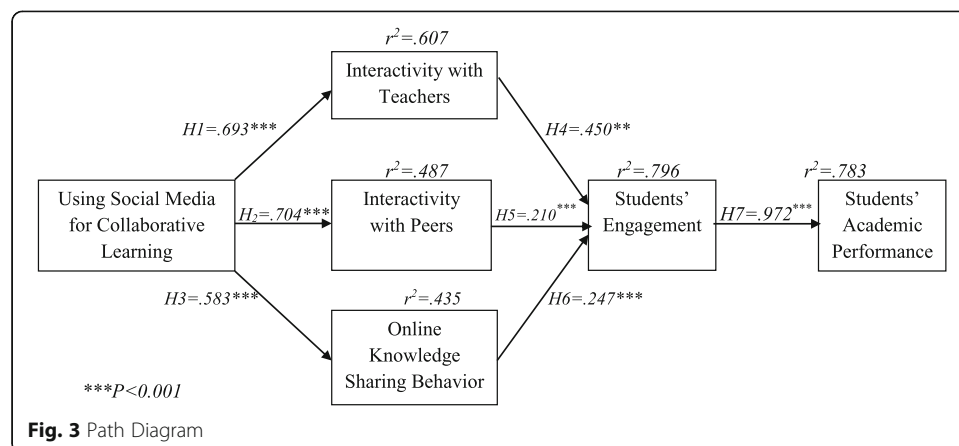
Path coefficient of several hypotheses has been demonstrated in Fig. 3, which is a variable par relationship. β (beta) Coefficients, standardised partial regression coefficients signify the powers of the multivariate relationship among latent variables in the model. Remarkably, it was observed that seven out of the seven proposed hypotheses were accepted and 78% of the explained variance in students' academic performance, 60% explained variance in interactivity with teachers, 48% variance in interactivity with peers, 43% variance in online knowledge sharing behaviour and 79% variance in students' engagement. Social media collaborative learning has a significant association with teacher interactivity ($\beta = .693$, $P < 0.001$), demonstrating that there is a direct effect on interaction with the teacher by social media when other variables are controlled. On the other hand, use of social media for collaborative learning has noticed statistically significant positive relationship with peers interactivity ($\beta = .704$, $p < 0.001$) meaning thereby, collaborative learning on social media by university students, leads to the high degree of interaction with peers, colleagues. Implied 10% rise in social media use for learning purposes, expected 7.04% increase in interaction with peers.

Use of social media for collaborating learning has a significant positive association with online knowledge sharing behaviour ($\beta = .583$, $p < 0.001$), meaning thereby that the more intense use of social media for collaborative learning by university students, the more knowledge sharing between peers and colleagues. Also, interaction with the teacher seen the significant statistical positive association with students engagement

Table 4 SEM fit indices

Fi indices	Cut off values from literature	Model study	References
Absolute fit measure			
CMIN/DF	1–2, Sometimes 1–5	1.524	Arbuckle (2008); Byrne (1994); Hair et al.(2016); Harrington (2009); Raykov and Marcoulides (2000); Schumacker and Lomax (2010), Tabachnick, Fidell, and Ullman (2007)
RMR	< 0.05, < 0.08	.008	
RMSEA	< 0.05, < 0.08	.084	
Incremental fit measure			
CFI	> 0.90	.935	
TLI	> 0.90	.924	
GFI	> 0.90	.856	

Source: Computed and compiled by researchers on the basis of a questionnaire



($\beta = .450$, $p < 0.001$), telling that the more conversation with teachers, leads to a high level of students engagement. Similarly, the practical interpretation of this result is that there is an expected 4.5% increase in student's participation for every 10% increase in interaction with teachers. Interaction with peers has a significant positive association with students engagement ($\beta = .210$, $p < 0.001$). Practically, the finding revealed that 10% upturn in student's involvement, there is a 2.1% increase in peer's interaction. There is a significant positive association between online knowledge sharing behaviour and students engagement ($\beta = 0.247$, $p < 0.001$), and finally students engagement has been a statistically significant positive relationship with students' academic performance ($\beta = .972$, $p < 0.001$), this is the clear indication that more engaged students in collaborative learning via social media leads to better students' academic performance.

Discussion and implication

There is a continuing discussion in the academic literature that use of such social media and social networking sites would facilitate collaborative learning. It is human psychology generally that such communication media technology seems only for entertainment, but it should be noted here carefully that if such communication technology would be followed with due attention prove productive. It is essential to acknowledge that most university students nowadays adopting social media communication to interact with colleagues, teachers and also making the group be in touch with old friends and even a convenient source of transferring the resources. In the present era, the majority of the university students having diversified social media community groups like Whatsapp, Facebook pages following different academic web pages to upgrade their knowledge.

Practically for every 10% rise in students' engagement, expected to be 2.1% increase in peer interaction. As the study suggested that students engage in different sites, they start discussing with colleagues. More engaged students in collaborative learning through social media lead better students' academic performance. The present study revealed that for every 10% increase in student's engagement, there would be an expected increase in student academic performance at a rate of 9.72. This extensive research finding revealed that the application of online social media would facilitate the students to become more creative, dynamics and connect to the worldwide instructor for collaborative learning.

Accordingly, the use of online social media for collaborative learning, interaction with mentors and colleagues lead better student's engagement which consequently affects student's academic performance. The higher education authority should provide such a platform which can nurture the student's intellectual talents. Based on the empirical investigation, it would be said that students' engagement, social media communication devices facilitate students to retrieve information and interact with others in real-time regarding sharing teaching materials contents. Additionally, such sophisticated communication devices would prove to be more useful to those students who feel too shy in front of peers; teachers may open up on the web for the collaborative learning and teaching in the global scenario and also beneficial for physically challenged students. It would also make sense that intensive use of such sophisticated technology in teaching pedagogical in higher education further facilitates the teachers and students to interact digitally, web-based learning, creating discussion group, etc. The result of this investigation confirmed that use of social media for collaborative learning purposes, interaction with peers, and teacher affect their academic performance positively, meaning at this moment that implementation of such sophisticated communication technology would bring revolutionary, drastic changes in higher education for international collaborative learning (Table 5).

Limitations and future direction

Like all the studies, this study is also not exempted from the pitfalls, lacunas, and drawbacks. The first and foremost research limitation is it ignores the addiction of social media; excess use may lead to destruction, deviation from the focal point. The study only confined to only one academic institution. Hence, the finding of the project cannot be generalised as a whole. The significant positive results were found in this study due to the fact that the social media and mobile devices are frequently used by the university going students not only as a means of gratification but also for educational purposes.

Secondly, this study was conducted on university students, ignoring the faculty members, it might be possible that the faculty members would not have been interested in interacting with the students. Thus, future research could be possible towards faculty members in different higher education institutions. To the authors' best reliance, this is

Table 5 Hypotheses based on the results

Hypotheses	Path coefficient	Accepted?
H1: Use of social media for collaborative learning is positively associated with interactivity with teachers.	.693***	Yes
H2: Use of social media for collaborative learning is positively associated with interactivity with peers.	.704***	Yes
H3: Use of social media for collaborative learning is positively associated with online knowledge sharing Behavior.	.583***	Yes
H4: More interaction with teacher leads to higher students' engagement.	.450***	Yes
H5: More integration with peers ultimately leads to better student's engagement.	.210***	Yes
H6: Online knowledge sharing behaviour is positively associated with the Students' engagement.	.247***	Yes
H7: Student's Engagement is positively associated with the student's academic performance.	.972***	Yes

Source: Computed and compiled by researchers on the basis of a questionnaire

*** = $p < .001$

the first and prime study to check the usefulness and applicability of social media in the higher education system in the Indian context.

Concluding observations

Based on the empirical investigation, it could be noted that application and usefulness of the social media in transferring the resource materials, collaborative learning and interaction with the colleagues as well as teachers would facilitate students to be more enthusiastic and dynamic. This study provides guidelines to the corporate world in formulating strategies regarding the use of social media for collaborative learning.

Acknowledgements

We want to express our special gratitude to the *Almighty* who has blessed us with such hidden talent to give the shape of this research paper.

Authors' contributions

Jamal Abdul Nasir Ansari: The first author of this manuscript has performed all sorts of necessary works like the collection of data from respondents, administration of the questionnaire. Collection of information from the respondents was quite challenging. The author faced a lot of difficulties while collecting data. The main contribution of the author in this manuscript is that the entire work, like data analysis and its interpretation performed by him. Additionally, the author has tried to explore and usefulness of social media and its applicability in transferring the course contents. Nawab Ali Khan: The second author of this manuscript has checked all types of grammatical issues, and necessary corrections wherever required. The author(s) read and approved the final manuscript.

Funding

The authors of this manuscript, solemnly declared that no funding agency was supported to execute this research project.

Availability of data and materials

The corresponding author declared here all types of data used in this study available for any clarification. The author of this manuscript ready for any justification regarding the data set. To make publically available of the data used in this study, the seeker must mail to the mentioned email address. The profile of the respondents was completely confidential.

Competing interests

The authors declare that they have no competing interests.

Received: 27 November 2019 Accepted: 18 February 2020

Published online: 16 March 2020

References

- Akçayır, G. (2017). Why do faculty members use or not use social networking sites for education? *Computers in Human Behavior*, 71, 378–385.
- Al-Alwan, A. F. (2014). Modeling the relations among parental involvement, school engagement and academic performance of high school students. *International Education Studies*, 7(4), 47–56.
- Al-Mukhaini, E. M., Al-Qayoudhi, W. S., & Al-Badi, A. H. (2014). Adoption of social networking in education: A study of the use of social networks by higher education students in Oman. *Journal of International Education Research*, 10(2), 143–154.
- Al-Rahmi, W. M., Alias, N., Othman, M. S., Marin, V. I., & Tur, G. (2018). A model of factors affecting learning performance through the use of social media in Malaysian higher education. *Computers & Education*, 121, 59–72.
- Al-Rahmi, W. M., & Othman, M. S. (2013). Evaluating student's satisfaction of using social media through collaborative learning in higher education. *International Journal of Advances in Engineering & Technology*, 6(4), 1541–1551.
- Arbuckle, J. (2008). *Amos 17.0 user's guide*. Chicago: SPSS Inc..
- Barnes, N. G., & Lescault, A. M. (2011). *Social media adoption soars as higher-ed experiments and reevaluates its use of new communications tools*. North Dartmouth: Center for Marketing Research. University of Massachusetts Dartmouth.
- Bertheussen, B. A., & Myrland, Ø. (2016). Relation between academic performance and students' engagement in digital learning activities. *Journal of Education for Business*, 91(3), 125–131.
- Bogdanov, E., Limpens, F., Li, N., El Helou, S., Salzmann, C., & Gillet, D. (2012). A social media platform in higher education. In *Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1–8). IEEE.
- Byrne, B. M. (1994). *Structural equation modeling with EQS and EQS/windows: basic concepts, applications, and programming*. Thousand Oaks: Sage.
- Cain, J. (2008). Online social networking issues within academia and pharmacy education. *American Journal of Pharmaceutical Education*. <https://doi.org/10.5688/aj720110>.
- Cao, Y., Ajjan, H., & Hong, P. (2013). Using social media applications for educational outcomes in college teaching: a structural equation analysis. *British Journal of Educational Technology*, 44(4), 581–593. <https://doi.org/10.1111/bjet.12066>.
- Cavus, N., & Ibrahim, D. (2008). A mobile tool for learning English words, *Online Submission* (pp. 6–9) Retrieved from <http://libezproxy.open.ac.uk/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED504283&site=ehost-live&scope=site>.
- Cavus, N., & Ibrahim, D. (2009). M-learning: An experiment in using SMS to support learning new English language words. *British Journal of Educational Technology*, 40(1), 78–91.

- Chemers, M. M., Hu, L. T., & Garcia, B. F. (2001). Academic self-efficacy and first-year college student performance and adjustment. *Journal of Educational Psychology*, 93(1), 55–64. <https://doi.org/10.1037/0022-0663.93.1.55>.
- Chen, I. Y. L., Chen, N.-S., & Kinshuk. (2009). International forum of Educational Technology & Society Examining the factors influencing participants' knowledge sharing behavior in virtual learning communities published by : International forum of Educational Technology & Society Examining the factor. *Educational Technology & Society*, 12(1), 134–148.
- Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practise in undergraduate education. *AAHE bulletin*, 3, 7.
- Coelho, J., & Duarte, C. (2016). A literature survey on older adults' use of social network services and social applications. *Computers in Human Behavior*, 58, 187–205.
- Connell, J. P., Spencer, M. B., & Aber, J. L. (1994). Educational risk and resilience in African-American youth: Context, self, action, and outcomes in school. *Child Development*, 65(2), 493–506.
- Daniel, E. A., Isaac, E. N., & Janet, A. K. (2017). Influence of Facebook usage on employee productivity: A case of university of cape coast staff. *African Journal of Business Management*, 11(6), 110–116. <https://doi.org/10.5897/AJBM2017.8265>.
- DeBell, M., & Chapman, C. (2006). Computer and internet use by students in 2003. Statistical analysis report. NCES 2006-065. National Center for education statistics.
- Dziuban, C., & Walker, J. D. (2012). *ECAR Study of Undergraduate Students and Information Technology, 2012 (Research Report)*. Louisville: EDUCAUSE Centre for Applied Research.
- Eid, M. I. M., & Al-Jabri, I. M. (2016). Social networking, knowledge sharing, and student learning: The case of university students. *Computers and Education*, 99, 14–27. <https://doi.org/10.1016/j.compedu.2016.04.007>.
- Elkaseh, A. M., Wong, K. W., & Fung, C. C. (2016). Perceived ease of use and perceived usefulness of social media for e-learning in Libyan higher education: A structural equation modeling analysis. *International Journal of Information and Education Technology*, 6(3), 192.
- Eow, Y. L., Ali, W. Z. b. W., Mahmud, R. b., & Baki, R. (2009). Form one students' engagement with computer games and its effect on their academic achievement in a Malaysian secondary school. *Computers and Education*, 53(4), 1082–1091. <https://doi.org/10.1016/j.compedu.2009.05.013>.
- Evans, C. (2014). Twitter for teaching: Can social media be used to enhance the process of learning? *British Journal of Educational Wiley Online Library*, 45(5), 902–915. <https://doi.org/10.1111/bjjet.12099>.
- Fan, W., & Williams, C. M. (2010). The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational Psychology*, 30(1), 53–74. <https://doi.org/10.1080/01443410903353302>.
- Field, A. (2011). *Discovering statistics using SPSS: (and sex and drugs and rock'n'roll)* (Vol. 497). London: Sage.
- Field, A. (2013). Factor analysis using SPSS. *Scientific Research and Essays*, 22(June), 1–26. <https://doi.org/10.1016/B978-0-444-52272-6.00519-5>.
- Fisher, M., & Baird, D. E. (2006). Making mLearning work: Utilizing mobile technology for active exploration, collaboration, assessment, and reflection in higher education. *Journal of Educational Technology Systems*, 35(1), 3–30.
- Gikas, J., & Grant, M. M. (2013). Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media. *Internet and Higher Education Mobile*, 19, 18–26. <https://doi.org/10.1016/j.iheduc.2013.06.002>.
- Greenhow, C. (2011a). Online social networks and learning. *On the horizon*, 19(1), 4–12.
- Greenhow, C. (2011b). Youth, learning, and social media. *Journal of Educational Computing Research*, 45(2), 139–146. <https://doi.org/10.2190/EC.45.2.a>.
- Hair Anderson, R. E., Tatham, R. L., & Black, W. C. (1992). Multivariate data analysis. *International Journal of Pharmaceutics*. <https://doi.org/10.1016/j.ijpharm.2011.02.019>.
- Hair Jr., J. F., Sarstedt, M., Matthews, L. M., & Ringle, C. M. (2016). Identifying and treating unobserved heterogeneity with FIMIX-PLS: part I—method. *European Business Review*.
- Harrington, D. (2009). *Confirmatory factor analysis*. Oxford university press.
- Haryono, S., & Wardoyo, P. (2012). *Structural Equation Modeling* (Vol. 331).
- Henseler, J., & Sarstedt, M. (2013). Goodness-of-fit indices for partial least squares path modeling. *Computational Statistics*, 28(2), 565–580.
- Jackson, C. (2011). Your students love social media... and so can you. *Teaching Tolerance*, 39, 38–41.
- Junco, R., Heiberger, G., & Loken, E. (2011). The effect of twitter on college student engagement and grades. *Journal of Computer Assisted Learning*, 27(2), 119–132.
- Kabilan, M. K., Ahmad, N., & Abidin, M. J. Z. (2010). Facebook: An online environment for learning of English in institutions of higher education? *The Internet and Higher Education*, 13(4), 179–187.
- Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of social media. *Business Horizons*, 53(1), 59–68.
- Kock, N. (2011). Using WarpPLS in e-collaboration studies: Mediating effects, control and second order variables, and algorithm choices. *International Journal of e-Collaboration (IeC)*, 7(3), 1–13.
- Kuh, G. D. (2007). What student engagement data tell us about college readiness. *Peer Review*, 9(1), 4–8.
- Kukulski-Hulme, A., & Shield, L. (2008). An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. *ReCALL*, 20(3), 271–289.
- Lee, S.-Y. (2007). Structural equation modeling: A Bayesian approach (Wiley series in probability and statistics). *Ecotoxicology and Environmental Safety*, 73. <https://doi.org/10.1016/j.ecoenv.2009.09.012>.
- Leece, R. (2011). Engaging students through social media. *Journal of the Australian and New Zealand Student Services Association*, 38, 10–14 Retrieved from https://www.researchgate.net/profile/Anthony_Jorm/publication/235003484_Introduction_to_guidelines_for_tertiary_education_institutions_to_assist_them_in_supporting_students_with_mental_health_problems/links/0c96052ba5314e1202000000.pdf#page=67.
- Lenhart, A., Arafteh, S., & Smith, A. (2008). *Writing, technology and teens*. Pew Internet & American Life Project.
- Lenhart, A., Madden, M., & Hitlin, P. (2005). *Teens and technology* (p. 2008). Washington, DC: Pew Charitable Trusts Retrieved September 29.
- Liccardi, I., Ounnas, A., Pau, R., Massey, E., Kinnunen, P., Lewthwaite, S., ..., Sarkar, C. (2007). The role of social networks in students' learning experiences. In *ACM Sigcse Bulletin* (39, 4, 224–237).

- Ma, W. W. K., & Yuen, A. H. K. (2011). Understanding online knowledge sharing: An interpersonal relationship perspective. *Computers & Education*, 56(1), 210–219.
- Madden, M., & Zickuhr, K. (2011). 65% of online adults use social networking sites. *Pew Internet & American Life Project*, 1, 14.
- Meyer, K. A. (2010). A comparison of web 2.0 tools in a doctoral course. *The Internet and Higher Education*, 13(4), 226–232.
- Mirela Mabić, D. G. (2014). Facebook as a learning tool. *Igarss*, 2014(1), 1–5. <https://doi.org/10.1007/s13398-014-0173-7.2>.
- Mooi, E., & Sarstedt, M. (2011). *A concise guide to market research: The process, data, and methods using IBM SPSS statistics*. Springer. <https://doi.org/10.1007/978-3-642-12541-6>.
- Moqbel, M., Nevo, S., & Kock, N. (2013). Organizational members' use of social networking sites and job performance. *Information Technology & People*, 26(3), 240–264. <https://doi.org/10.1108/ITP-10-2012-0110>.
- Moran, M., Seaman, J., & Tinti-Kane, H. (2011). *Teaching, learning, and sharing: How Today's higher education faculty use social media* (pp. 1–16). Babson survey research group, (April. <https://doi.org/10.1016/j.chb.2013.06.015>.
- Nasir, J. A., & Khan, N. A. (2018). Faculty member usage of social media and mobile devices in higher education institution. *International Journal of Advance and Innovative Research*, 6(1), 17–25.
- Nasir, J. A., Khatoon, A., & Bharadwaj, S. (2018). Social media users in India: A futuristic approach. *International Journal of Research and Analytical Reviews*, 5(4), 762–765 Retrieved from <http://ijrar.com/>.
- Nihalani, P. K., & Mayrath, M. C. (2010). Statistics I. Findings from using an iPhone app in a higher education course. In *White Paper*.
- Norusis, M. (2011). *IBM SPSS statistics 20 brief guide* (pp. 1–170). IBM Corporation Retrieved from <http://www.ibm.com/support>.
- Novak, E., Razzouk, R., & Johnson, T. E. (2012). The educational use of social annotation tools in higher education: A literature review. *The Internet and Higher Education*, 15(1), 39–49.
- Nunnally, J. C., & Bernstein, I. H. (1994). *Psychological theory*.
- Pineda-Báez, C., José-Javier, B. A., Rubiano-Bello, Á., Pava-García, N., Suárez-García, R., & Cruz-Becerra, F. (2014). Student engagement and academic performance in the Colombian University context. *RELIEVE-Revista Electrónica de Investigación y Evaluación Educativa*, 20(2), 1–19.
- Raykov, T., & Marcoulides, G. A. (2000). *A First Course in Structural Equation Modeling*.
- Redecker, C., Ala-Mutka, K., & Punie, Y. (2010). Learning 2.0-the impact of social media on learning in Europe. Policy brief. JRC scientific and technical report. EUR JRC56958 EN, Available from <http://bit.ly/djljq>. Accessed 6 Feb 2011.
- Reuben, B. R. (2008). *The use of social Media in Higher Education for marketing and communications : A guide for professionals in higher education* (Vol. 5) Retrieved from <http://dotteduguru.com/wp-content/uploads/200808/socialmediainhighereducation.pdf>). [https://doi.org/10.1108/S2044-9968\(2012\)0000005018](https://doi.org/10.1108/S2044-9968(2012)0000005018).
- Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, 104(3), 700–712. <https://doi.org/10.1037/a0027268>.
- Richardson, J., & Lenarcic, J. (2008). Text Messaging as a Catalyst for Mobile Student Administration: The "Trigger" Experience. *International Journal of Emerging Technologies & Society*, 6(2), 140–155.
- Roblyer, M. D., McDaniel, M., Webb, M., Herman, J., & Witty, J. V. (2010). Findings on Facebook in higher education: A comparison of college faculty and student uses and perceptions of social networking sites. *The Internet and Higher Education*, 13(3), 134–140.
- Rock, M. L., & Thead, B. K. (2007). The effects of fading a strategic self-monitoring intervention on students' academic engagement, accuracy, and productivity. *Journal of Behavioral Education*, 16(4), 389–412. <https://doi.org/10.1007/s10864-007-9049-7>.
- Rodriguez, J. E. (2011). Social media use in higher education : Key areas to consider for educators. *MERLOT Journal of Online Learning and Teaching*, 7(4), 539–550 <https://doi.org/ISSN1558-9528>.
- Rutherford, C. (2010). Using online social media to support Preservice student engagement. *MERLOT Journal of Online Learning and Teaching*, 6(4), 703–711 Retrieved from http://jolt.merlot.org/vol6no4/rutherford_1210.pdf.
- Schumacker, R. E., & Lomax, R. G. (2010). *A Beginner's Guide to structural equation modeling* (3rd ed.). New York: Taylor & Francis Group.
- Selwyn, N. (2012). Making sense of young people, education and digital technology: The role of sociological theory. *Oxford Review of Education*, 38(1), 81–96.
- Shih, Y. E. (2007). Setting the new standard with mobile computing in online learning. *The International Review of Research in Open and Distributed Learning*, 8(2), 1–16.
- Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of educational psychology*, 85(4), 571.
- Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). *Using multivariate statistics* (Vol. 5). Boston: Pearson.
- Voorn, R. J., & Kommers, P. A. (2013). Social media and higher education: Introversion and collaborative learning from the student's perspective. *International Journal of Social Media and Interactive Learning Environments*, 1(1), 59–73.
- Wankel, C. (2009). Management education using social media. *Organization Management Journal*, 6(4), 251–262.
- Williams, M. D., Rana, N. P., & Dwivedi, Y. K. (2015). The unified theory of acceptance and use of technology (UTAUT): a literature review. *Journal of Enterprise Information Management*, 28(3), 443–488.
- Zhu, C. (2012). Student satisfaction, performance, and knowledge construction in online collaborative learning. *Journal of Educational Technology & Society*, 15(1), 127–136.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Terms and Conditions

Springer Nature journal content, brought to you courtesy of Springer Nature Customer Service Center GmbH (“Springer Nature”).

Springer Nature supports a reasonable amount of sharing of research papers by authors, subscribers and authorised users (“Users”), for small-scale personal, non-commercial use provided that all copyright, trade and service marks and other proprietary notices are maintained. By accessing, sharing, receiving or otherwise using the Springer Nature journal content you agree to these terms of use (“Terms”). For these purposes, Springer Nature considers academic use (by researchers and students) to be non-commercial.

These Terms are supplementary and will apply in addition to any applicable website terms and conditions, a relevant site licence or a personal subscription. These Terms will prevail over any conflict or ambiguity with regards to the relevant terms, a site licence or a personal subscription (to the extent of the conflict or ambiguity only). For Creative Commons-licensed articles, the terms of the Creative Commons license used will apply.

We collect and use personal data to provide access to the Springer Nature journal content. We may also use these personal data internally within ResearchGate and Springer Nature and as agreed share it, in an anonymised way, for purposes of tracking, analysis and reporting. We will not otherwise disclose your personal data outside the ResearchGate or the Springer Nature group of companies unless we have your permission as detailed in the Privacy Policy.

While Users may use the Springer Nature journal content for small scale, personal non-commercial use, it is important to note that Users may not:

1. use such content for the purpose of providing other users with access on a regular or large scale basis or as a means to circumvent access control;
2. use such content where to do so would be considered a criminal or statutory offence in any jurisdiction, or gives rise to civil liability, or is otherwise unlawful;
3. falsely or misleadingly imply or suggest endorsement, approval, sponsorship, or association unless explicitly agreed to by Springer Nature in writing;
4. use bots or other automated methods to access the content or redirect messages
5. override any security feature or exclusionary protocol; or
6. share the content in order to create substitute for Springer Nature products or services or a systematic database of Springer Nature journal content.

In line with the restriction against commercial use, Springer Nature does not permit the creation of a product or service that creates revenue, royalties, rent or income from our content or its inclusion as part of a paid for service or for other commercial gain. Springer Nature journal content cannot be used for inter-library loans and librarians may not upload Springer Nature journal content on a large scale into their, or any other, institutional repository.

These terms of use are reviewed regularly and may be amended at any time. Springer Nature is not obligated to publish any information or content on this website and may remove it or features or functionality at our sole discretion, at any time with or without notice. Springer Nature may revoke this licence to you at any time and remove access to any copies of the Springer Nature journal content which have been saved.

To the fullest extent permitted by law, Springer Nature makes no warranties, representations or guarantees to Users, either express or implied with respect to the Springer nature journal content and all parties disclaim and waive any implied warranties or warranties imposed by law, including merchantability or fitness for any particular purpose.

Please note that these rights do not automatically extend to content, data or other material published by Springer Nature that may be licensed from third parties.

If you would like to use or distribute our Springer Nature journal content to a wider audience or on a regular basis or in any other manner not expressly permitted by these Terms, please contact Springer Nature at

onlineservice@springernature.com