

5-31-2014

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Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

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ARTICLE INFO

Article history:

Available online xxxxx

Keywords:

Communities of practice
Technology acceptance
Learning analytics
Discourse analysis
Natural language processing
Social network analysis

ABSTRACT

Participation in virtual communities of practice (vCoP) can be influenced at the same time by technology acceptance and by community factors. To overcome methodological issues connected with the analysis of these influences, learning analytics were applied. Based on a recent vCoP model, the collaborative dialogue comprising 4040 interventions in 1981 messages created by a vCoP located at a US American online university was automatically analyzed. The text-based asynchronous online discussions were scored using a cohesion-based participation and collaboration analysis. Additionally, a sample of $N = 133$ vCoP participants responded a technology acceptance survey. Thus, a combined research model including the vCoP model and an established technology acceptance model was verified. The results confirmed the vCoP model entirely, and the acceptance model only partially. As consequence for educational research, the CoP model was confirmed and extended to vCoP settings, while the acceptance model appears to need reconsideration. For academic practice, the study initiates the development of assessment tools fostering knowledge sharing through dialogue in vCoP. Also, it suggests how virtual classrooms can be extended to open spaces where value creation takes place through social learning. Learning analytics proved thus successful, provides information that impacts both theory and practice of technology-enhanced learning.

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1. Introduction

Communities of practice (CoP; [Wenger, 1998](#)) are effective environments of knowledge sharing and knowledge creation ([Paavola, Lipponen, & Hakkarainen, 2004](#)), therefore participation in CoP is desirable for many academic activities. In many cases, participation can be mediated by communication technologies, (e.g., when CoP are geographically distributed), thus building the so-called virtual CoP (vCoP; [Stewart, 2010](#)). In vCoP, participation takes place by means of technology. Hence, it may be influenced both by technology acceptance and by community factors. In the research literature, there are several examples of acceptance

studies conducted in vCoP (e.g., [Park & Yang, 2012](#)), a few examples of quantitative studies in vCoP (e.g., [Ma & Yuen, 2011](#)), and insufficient examples of studies where the combination of acceptance and community factors is examined. Methodologically, such combined analysis is somewhat problematic. Besides the conceptual and empirical aspects of acceptance research criticized by [Bagozzi \(2007\)](#) and illustrated by all articles in this special issue, quantitative CoP and vCoP research may imply content analysis of large interaction data sets, which is effortful and susceptible to subjectivity. Especially "higher education, a field that gathers an astonishing array of data about its 'customers,' has traditionally been inefficient in its data use, often operating with substantial delays in analyzing readily evident data and feedback" ([Siemens & Long, 2011](#)).

A possible solution of this problem is offered by learning analytics, i.e. the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs ([Siemens & Gasevic, 2012](#)). Online social learning such as that

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taking place in vCoP sets a particular context of learning analytics (Buckingham Shum & Ferguson, 2011) from which the discourse-centered learning analytics emerged (De Liddo, Buckingham Shum, Quinto, Bachler, & Cannavacciuolo, 2011), which appears as a promising approach for identifying patterns of activity that correspond to meaningful learning and knowledge construction. However, developing and validating such procedures is still at the very beginning. Applications of learning analytics in educational studies of vCoP are still needed to prove its assumed potential for educational research.

Against this background, the study at hand aims to apply learning analytics in a vCoP context to verify a research model combining the CoP (Nistor & Fischer, 2012) and the acceptance model (Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh, Thong, & Xu, 2012). The resulting insight in the quantitative relationships of vCoP variables may contribute to the development of innovative instructional models and automated tools for fostering vCoP.

The remainder of this paper is organized as follows. The theoretical section gives a brief overview of the addressed concepts and models of CoP and technology acceptance research, concluding with the research model and the research questions of the presented study. Further, the empirical section describes the employed research methods along with their results. Finally, the results are discussed and conclusions pertaining to educational research and practice are drawn.

2. Theoretical background

2.1. Communities of practice

Communities of Practice (CoP) are groups of people sharing goals, activities, and experiences in the frame of a given practice over lengthy periods of time (Wenger, 1998). Participation in a CoP leads to the accumulation of experience, stimulates the social construction of knowledge and the development of expertise (Paavola et al., 2004), hence, making it particularly interesting for educational research and practice.

In a CoP, expertise and expert status define the identity of the CoP members. Wenger (1998) describes a core-periphery social structure, distinguishing between central and peripheral community members. Members with higher expertise are involved in more activities, especially in those with a higher degree of difficulty and responsibility. The central members of a CoP not only possess superior knowledge and skills, but also are socially recognized as experts. Thus, expert identity is the result of negotiation with and recognition of other CoP members, which takes place in the context of participation and dialogue. Hence, experts are also successful negotiators in their social environment, and can sustain high quality dialogue within the community practice. In line with these observations, the quantitative CoP model proposed by Nistor and Fischer (2012) maintains that expertise has a strong and positive influence on participation in CoP. Moreover, the quality of the community dialogue directly reflects participants' expertise, hence impact their participation intensity.

A CoP member's expert status can be measured through social network analysis, determining a member's so-called centrality, defined by mathematic formulae expressing the relationships within the social network (Borgatti, Mehra, Brass, & Labianca, 2009). The activity in a social network can be graphically represented as a collection of nodes (persons) and arches (relations between persons). The "betweenness centrality" of a node is defined as the number of shortest paths connecting all nodes with each other and passing through that node (Freeman, 1977). Employing social network analysis, the quantitative CoP model (Nistor & Fischer, 2012) highlights a positive influence of expertise on expert status, mediated by participation.

2.2. Educational technology acceptance

When technology is employed to mediate communication in CoP and community practice, it is reasonable to assume that successful vCoP activity requires in first place the acceptance and use of technology. A prominent acceptance theory is Venkatesh's Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003, 2012) that explains the use of educational technology under the influence of use intention, further determined by performance and effort expectancy, and social influence. Additionally, facilitating conditions and computer anxiety (Nistor, Lerche, Weinberger, Ceobanu, & Heymann, 2012) directly affect the use of educational technology.

A critical review of technology acceptance models including UTAUT was done by Bagozzi (2007) who observed the oversimplifying, unidimensional definition of acceptance. This may be adequate for the study of some information systems, but gives insufficient consideration of learning and collaboration aspects. Furthermore, Bagozzi argued that "the intention-behavior linkage is probably the most uncritically accepted assumption in social science research" (p. 245). While many studies regard technology use intention as the most representative acceptance indicator and ignore the actual use behavior, the few studies that include use behavior mainly rely on self-report (Turner, Kitchenham, Brereton, Charters, & Budgen, 2010), so that the intention-behavior correlation may be inflated by common methods variance (Podsakoff, MacKenzie, & Podsakoff, 2012). Correspondingly, Nistor et al. (2012), as well as all articles in this special issue, found weak or non-significant effects of participants' technology use intention on their actual use behavior. Besides common methods variance, there are several possible explanations for the non-significant influence. For example, the UTAUT2 model (Venkatesh et al., 2012) implies that moderator variables such as experience can lead to weaker intention-behavior effects if users have much experience in using the examined technology. Another reason may be the cultural influence described by Nistor, Göğüş, and Lerche (2013), who suggest a direct influence of cultural masculinity and individualism (*sensu* Hofstede, 2001) on technology use behavior. Nevertheless, the UTAUT seems to provide a robust and reliable model that can be used to gain deeper understanding of technology acceptance in various contexts.

3. Research model

Against the presented theoretical background, a combined research model including the UTAUT (Venkatesh et al., 2003, 2012) and the CoP model (Nistor & Fischer, 2012) is depicted in Fig. 1. Accordingly, this study aims to answer the following research questions:

RQ1 (acceptance model verification): To what extent do acceptance factors (technology use intention, performance expectancy, effort expectancy, social influence, facilitating conditions and technology anxiety) predict participation in vCoP?

RQ2 (CoP model verification): Does participation in vCoP significantly mediate the influence of expertise on expert status?

4. Methodology

4.1. Population and sample

A correlational study was conducted in the vCoP of an online university located in the United States. The university provides a diverse community of career professionals with the opportunity

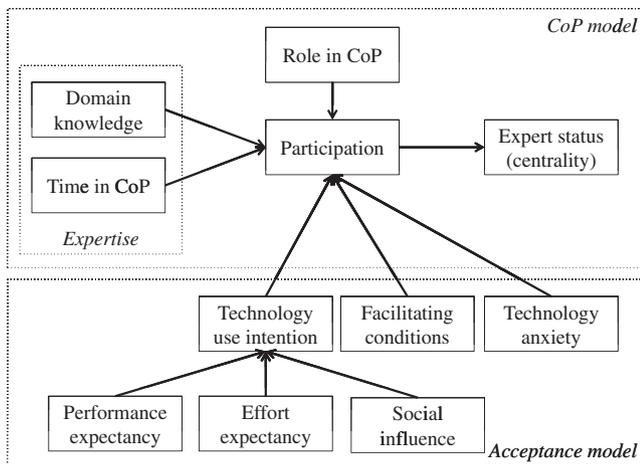


Fig. 1. Research model.

to transform themselves as scholar-practitioners so that they can effect positive social change. The faculty are mostly part-time faculty that are full-time employed at other universities but are willing to share their specific expertise and experience in their particular field of education with the online doctoral students in specializations such as Administrator Leadership for Teaching and Learning, Adult Education, College Teaching and Learning, Curriculum-Instruction-Assessment, Reading and Literacy Leadership, or Special Education, Educational Technology or Teacher Leadership. The faculty are mostly experienced researchers but range from the recent graduate that is being a “professional adjunct” until they find an Assistant Professorship, to the emeritus full professor who is not willing to give up teaching completely just yet.

Within this frame, the Educational Doctorate program employs approximately 450 part-time faculty members and 20 full-time faculty members. The part-time faculty members are hired as experts in specific domains, aiming to supplement the expertise available at the university. They report to a so-called coordinator who then in turns reports to the Program Director. Meetings in person are not feasible as the faculty live anywhere in the world that has Internet access. Synchronous communication such as phone conferences is often used but make it challenging to find a day and time when working adults in any time zone are available. Consequently, the educational doctorate program invited all faculty to a vCoP in which they can interact asynchronously as well as share information, best practices, and helpful hints. The topics range from simple technical issues, such as how to submit grades at the end of the semester, to complex pedagogical discussions on what constitutes acceptable progress in a doctoral program. The full-time faculty are often best able to answer pure technical and procedural questions whereas pedagogical discussions are often initiated by part-time faculty that has primarily taught face-to-face courses and is now adapting to the online environment. In other words, the vCoP mimics the collegial relationships common among faculty in traditional universities but would be impossible to arrange in the online environment.

While the members of this vCoP were the target population of the study, the examined sample consisted of $N = 133$ participants, whose gender, age and position are displayed in Table 1. All participants had a doctoral degree.

4.2. Variables and instruments

The acceptance variables technology use intention, performance and effort expectancy, social influence, facilitating conditions and technology anxiety were measured by questionnaire

survey, using the subscales and items adapted from Venkatesh et al. (2012) as shown in Table 2. The items were responded using a 5-point Likert scale from 1 = very low, to 5 = very high acceptance and, respectively, technology anxiety. The measurement proved reliable, with Cronbach's α values ranging between 0.78 and 0.96 (Table 2).

Participation in vCoP was operationalized as the number of interventions of each vCoP member. The quality of these interventions was considered as an indicator of expertise. Expert status was measured as betweenness centrality in the vCoP social network, i.e. the number of shortest paths connecting all vCoP members with each other and passing through that particular member. All three CoP variables were automatically determined. An extensive description and validation of the procedure is provided by Nistor, Dascălu, et al. (2013). In a nutshell, the messages were counted along with their authors' identifiers and then social network analysis was applied to extract betweenness centrality. Further, each forum discussion thread was represented as a graph with interventions as nodes and “reply to” relationships as links. The cohesion graph (Dascălu, Dessus, Trăușan-Matu, Bianco, & Nardy, 2013), built using semantic distances in WordNet (Budnitsky & Hirst, 2006; Miller, 1995), Latent Semantic Analysis (Landauer & Dumais, 1997) and Latent Dirichlet Allocation (Blei, Ng, & Jordan, 2003), was used for determining the quality of the interventions.

4.3. Procedure

All messages of the asynchronous forum discussions available between August 2010 and June 2012 were downloaded for analysis. At the same time, the questionnaire was administered to all full-time and part-time faculty members. The automated discourse analysis model (Dascălu et al., 2013; Trăușan-Matu, Dascălu, & Dessus, 2012) was applied to assess participants' expertise. Statistical data was processed using IBM SPSS Statistics version 19 for MacOS X.

5. Findings

The participants accepted the vCoP technology to a high degree (mean values of performance expectancy, effort expectancy, social influence, facilitating conditions, and use intention between 3.49 and 3.94) and reported a low level of technology anxiety ($M = 2.46$, $SD = 0.97$), as shown in Table 3. There were no significant differences in terms of acceptance variables between female and male participants. Comparing the acceptance variables between full-time and part-time faculty members, there was a significant difference ($F = 5.095$, $df = 127$, $p < .05$) only in terms of facilitating conditions that were stronger perceived by the full-time faculty ($M = 4.42$, $SD = .67$) than by the part-time faculty ($M = 3.91$, $SD = .95$).

The analyzed collaborative dialogue in the vCoP comprised a total of 4040 interventions in 1981 messages. From the entire sample, only 75 participants actively contributed to the discussions, which resulted in an average number of 30 interventions

Table 1
Participants' demographic data.

Gender	<i>n</i>	Age	<i>n</i>	Position	<i>n</i>
Female	92	25–24	2	Part-time faculty	112
Male	41	35–44	17	Full-time faculty	21
		45–54	24		
		55–64	55		
		65–74	32		
		75 or older	3		

Table 2
Questionnaire subscales and corresponding reliability.

	Items	Cronbach's α
	<i>Performance expectancy</i>	0.81
PE1	I find the EdD Community useful in my job	
PE2	Using the EdD Community enables me to accomplish tasks more quickly	
PE3	Using the EdD Community increases my productivity	
PE4	If I use the EdD Community, I will increase my chances of getting a raise	
	<i>Effort expectancy</i>	0.93
EE1	My use of the EdD Community will be easy and intuitive	
EE2	It will be easy for me to become proficient in using the EdD Community	
EE3	I will find the EdD Community easy to use	
EE4	Learning to operate the EdD Community is easy for me	
	<i>Social influence</i>	0.85
SI1	People who influence my behavior think that I should use the EdD Community	
SI2	People who are important to me think that I should use the EdD Community	
SI3	My supervisors have been helpful in introducing the use of the EdD Community	
SI4	In general, Walden University has supported the use of the EdD Community	
	<i>Facilitating conditions</i>	0.78
FC1	I have the resources necessary to use the EdD Community	
FC2	I have the knowledge necessary to use the EdD Community	
FC3	The EdD Community is not compatible with other learning tools I use	Removed
FC4	A specific person (or group) is available for assistance with difficulties when I use the EdD Community	
	<i>Computer anxiety</i>	0.88
CA1	I feel apprehensive about using the EdD Community	
CA2	It scares me to think that I could lose a lot of information using the EdD Community by hitting the wrong key	
CA3	I hesitate to use the EdD Community for fear of making mistakes I cannot correct	
CA4	The EdD Community is somewhat intimidating to me	
	<i>Use intention</i>	0.96
UI1	I intend to use the EdD Community in the next months	
UI2	I predict I will use the EdD Community in the next months	
UI3	I plan to use the EdD Community in the next months	

Table 3
Acceptance data.

		min	max	M	SD
PE	Performance expectancy	1.00	5.00	3.49	0.99
EE	Effort expectancy	1.00	5.00	3.82	1.09
SI	Social influence	1.00	5.00	3.71	1.02
FC	Facilitating conditions	1.00	5.00	3.94	0.97
CA	Computer anxiety	1.00	5.00	2.46	0.97
UI	Use intention	1.00	5.00	3.94	1.16

($M = 30.38$, $SD = 93.44$) pro participant during the analyzed period of time. The qualitative scores corresponding to expertise, the quantitative participation, the betweenness centrality corresponding to participants' expert status, and the time spent by the participants in the CoP are provided in Table 4. No significant differences were identified between genders, or in terms of the discussed topics. Several significant differences were identified, however, in terms of expertise.

The acceptance model could be only partially confirmed. Performance expectancy ($\beta = .30$, $p < .01$), effort expectancy ($\beta = .19$, $p < .05$), and social influence ($\beta = .22$, $p < .05$), significantly impacted use intention, explaining one third of its variance ($R^2 = .33$). However, the influence of use intention on participants'

actual use behavior (participation/number of interventions) was not significant. Participants' usage of the virtual CoP was only negatively influenced by their technology anxiety ($\beta = -0.26$, $p < .01$), which explained a very small part ($R^2 = .06$) of the variance in usage (see Fig. 2).

The CoP model could be entirely confirmed in the vCoP setting. Participants' expertise, i.e. their quality of interventions had a significant impact on their participation/use behavior ($\beta = .99$, $p < .000$), explaining the variance in participation almost entirely ($R^2 = .98$), whereas participants' time spent in the CoP had no significant effect. Further, participation had a significant and very strong influence on expert status ($\beta = .96$, $p < .000$), explaining a similarly high amount of its variance ($R^2 = .92$). These relationships are depicted in Fig. 3.

To test the mediating effect of participation, in the first step a regression analysis was performed with participant's number of interventions as predictor and participant's expert status as criterion ($\beta = .92$, $p < .001$); the residual variance of participant's expert status was saved. In the second step, another regression analysis was performed with the quality of interventions as a predictor and the residual variance calculated in the first step as a criterion. The effect measured by the latter regression analysis was non-significant, showing that the mediating effect of participation was significant.

Table 4
CoP data.

	min	max	M	SD	Full-time faculty		Part-time faculty		F	df	p
					M	SD	M	SD			
Expertise	0	3002	104.19	341.43	342.95	759.44	59.42	147.99	13.335	131	.000
Participation	0	830	30.38	93.44	92.10	204.76	18.80	44.41	11.768	131	.001
Expert status	0	7444	227.58	775.48	665.25	1691.97	145.52	395.34	8.388	131	.01
Time in CoP	0	11	4.09	2.65							n.s.

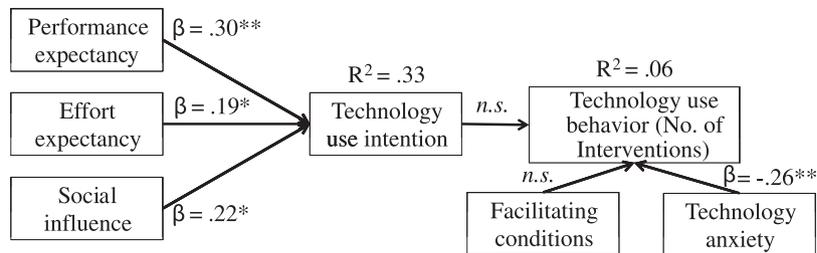


Fig. 2. Regression analysis of the acceptance model (** $p < .01$, * $p < .05$).

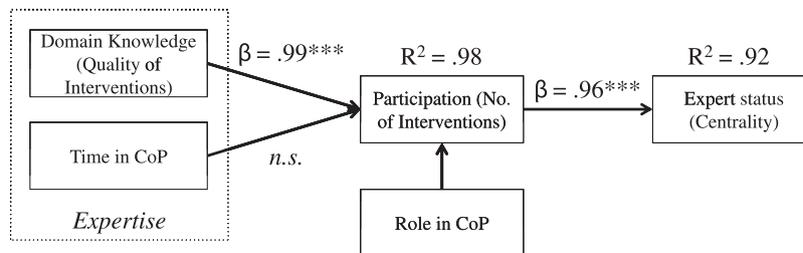


Fig. 3. Regression analysis of the CoP model (*** $p < .000$).

6. Discussion

This study aimed to apply learning analytics to verify the CoP model (Nistor & Fischer, 2012) and the acceptance model (UTAUT; Venkatesh et al., 2003, 2012) in vCoP setting. UTAUT could be reproduced with respect to participants' building use intentions under the influence of performance and effort expectancy, and under social influence. On the other hand, the hypothesized influence of technology use intention on the actual use behavior, i.e. participation in the vCoP (number of interventions in the discussions) could not be confirmed. Due to the similarity with other cases (see the other papers in this special issue), this seems to be a shortcoming of acceptance models such as UTAUT, in line with previous criticism (Bagozzi, 2007) and with previous empirical findings (e.g., Nistor et al., 2012). In this case, participants' high degree of familiarity with technology seems to be an appropriate explanation of the non-significant intention–behavior effect. The used technology is simple, the participants are familiar with it, and they are highly educated in general, so that the technology usage may be automatized, hence little dependent on attitudes. Whether or not the users build an intention to use the technology, actual usage occurs as participation in the vCoP under influence factors other than technology acceptance.

Unlike the acceptance model, the vCoP model (Nistor & Fischer, 2012) could be entirely reproduced and confirmed. As a prerequisite, the large differences between participants in domain knowledge, participation and expert status support the assumption of a core-periphery social structure (Wenger, 1998). Together with the shared goals, practice and knowledge, this confirms that the study setting can indeed be regarded as a vCoP. The core-periphery structure consists, on the one hand, of a small number of full-time faculty members with long or medium term position (employees), who are involved in most activities and have thus expert status. On the other hand, the core-periphery structure includes a large number of part-time faculty who participate only in certain activities, e.g. each faculty member supervising a small number of doctoral students. This corresponds to the “long tail distribution of participation”, where 10% of the vCoP do 90% of the work (Schworm & Nistor, 2013), which is regarded as typical for CoP, and especially for vCoP. Surprisingly, it seems that full-time faculty play the expert role in discussions on both administrative and research-ori-

ented topics, which contradicts the initial intention of the university management to hire part-time faculty as research experts, while full-time faculty may play the expert role in administrative matters. This contradiction may be explained by the scenario in which part-time faculty members initiate the discussions with questions that aim at finding out how generic research aspects are handled in the particular context of a university to which they do not primarily belong. Such a scenario illustrates a case in which the dialogue quality does not necessarily reflect the individual degree of expertise and, hence, illustrates a limitation of the automated analysis procedure.

The further verification of the CoP model confirmed that expertise determines participation in the vCoP, which further influences participants' expert status. Also, participation significantly mediates the relationship between expertise and expert status and, in line with previous findings (Nistor & Fischer, 2012; Wenger, 1998), participation was mainly determined by participants' role (full-time vs. part-time faculty) in the vCoP. The resulting model is depicted in Fig. 4.

As a consequence for educational research, the relatively new CoP model applied here (Nistor & Fischer, 2012) could be reproduced, outlining a fruitful line of research, worth to be further pursued. As for UTAUT, although it could be only partially confirmed, the intention–behavior correlation appears to be the weak link in previous acceptance models, as already suggested by several authors (e.g. Bagozzi, 2007). Future research should re-consider the influence factors of technology use behavior, and re-examine the acceptance model in specific educational contexts.

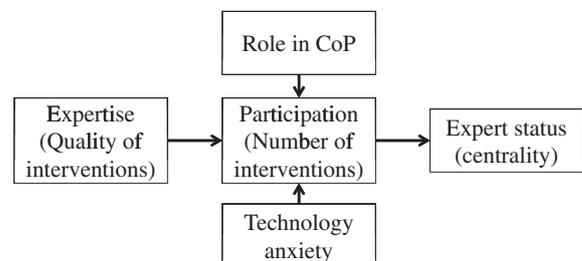


Fig. 4. Resulting model of participation in vCoP.

The learning analytics (Siemens & Gasevic, 2012) application was successful, as far as data extracted from online discussions could be used to verify two major conceptual models of the Educational Sciences. These data fitted the UTAUT model (Venkatesh et al., 2003, 2012) and the Cop model (Nistor & Fischer, 2012) in a way that was consistent with previous research literature. Furthermore, the data brought together the two models in a credible way. Both facts strongly support the validity assumption of the automated tool. The findings of this study endorse the assumption that learning analytics can innovate academic models and pedagogical approaches (Buckingham Shum & Ferguson, 2011).

For educational practice, this study prepared the development of automated tools for monitoring and assessment of collaboration in vCoP platforms. Such tools may be employed, e.g. to improve mentoring of virtual faculty in its various forms. Furthermore, as suggested by Siemens and Long (2011), learning analytics can move beyond data provided by learning management systems, and examine collaborative discourses and learning processes in vCoP. While the state-of-the-art virtual classroom usually comprises closed spaces (e.g., Slotta, 2010), the next generation virtual classroom may be connected to open spaces. Tools such as the one employed in this study can search the Internet for vCoP sustaining high quality collaborative dialogue, where value creation takes place through social learning (Wenger, Trayner, & de Laat, 2011). Students can then leave the closed academic spaces, and participate in virtual community practice related to their own study topics.

The validity of the presented findings and conclusions is limited, at the moment, to US American academic culture. The studied sample displays low diversity in terms of participants' age and education degree. The employed technology was simple and familiar, highly available and reliable. Future research should aim at a generalization of findings, collecting additional data based on higher sample diversity and other vCoP technologies.

Acknowledgements

This research was funded by the Walden University in the frame of the FRIG program. The authors would like to thank Prof. Dr. Maarten de Laat (LOOK, Open Universiteit Nederland) for the interesting and helpful discussions about the study.

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