

Best of EDEN 2016

**Special Issue of the
European Journal of Open, Distance and E-Learning**



The best research papers presented
at the 2016 EDEN Annual Conference and 9th EDEN Research Workshop

Annual Conference, 2016 June, Budapest
9th EDEN Research Workshop, 2016 October, Oldenburg

Edited by
Ulrich Bernath, András Szűcs

European Distance and E-Learning Network, 2018
in collaboration with the
Ulrich Bernath Foundation for Research in Open and Distance Learning

Best of EDEN 2016

Published by the European Distance and E-Learning Network

Editor:

Ulrich Bernath, András Szűcs

EDEN Secretariat, c/o Budapest University of Technology and Economics

H-1111 Budapest, Egry J. u. 1, Hungary

Tel: (36) 1 463 1628

E-mail: secretariat@eden-online.org

<http://www.eden-online.org>



Supported by the Erasmus+ Programme of the European Union

The publication reflects the author's view, the EACEA and the European Commission are not responsible for any use that may be made of the information it contains.

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

ISSN 1027 5207

Introduction

Starting from its origins, an important duty of EDEN has been to exchange academic and professional experience, to promote navigation on the rapidly evolving scene. Research in open, distance and e-learning is indispensable for development, decision-making and for improving quality of services. The interest for innovations is increasing as the pace and the extent of changes are dramatically fast and wide.

EDEN conferences have become major events in Europe with increasing attendance from all other continents. The Best Research Paper Award was launched in 2008 and it is granted at the EDEN Annual Conferences as well as at our Research Workshops. The selection process takes place in collaboration with the Ulrich Bernath Foundation for Research in Open and Distance Learning.

The extended scholarly works of the finalists of the BRPA competition at the EDEN 2016 Annual Conference in June in Budapest, Hungary (*Re-Imagining learning Environments*) and the Research Workshop in October in Oldenburg, Germany (*Forging new pathways of research and innovation in open and distance learning: Reaching from the roots*) have been included in this volume.

In the networked society, digital technology has changed many aspects of day-to-day life. Long-standing societal, business and institutional systems have either lost their relevance or have transformed beyond recognition. Education does not stand untouched and we observe emerging and declining paradigms, changing expectations from society, new and emerging types of informal learning experience and often operating in unsteady environments.

The powerful combination of the 'information age' and the consequent disruption provides the impetus to look at new models and approaches for education (e.g. OERs, MOOCs, PLEs, Learning Analytics). This has taken a fantastical leap into aggregating, curating and co-producing outside the boundaries of formal learning.

We are set a challenge to understand our learning environments. There are new business models, policies, different ways to understand the technological influences, new interpretations of the collaborative and social-networked society: the learning environment, in its widest sense. Present core questions include the tension between human and machine approaches to learning – raising the important question of what in education is best done by humans and what by machines? New knowledge is needed about combining scalability with personalisation, as well as about learning context and contextualisation.

The social and socio-economic context is more important than ever. Society itself can be understood as a learning environment, with questions of learners' connection with the community and the empowerment of the practitioners.

We thank the authors of this volume, representing seven countries in and outside Europe, for their committed and high quality contributions, enhancing further the EDEN tradition to acknowledge scholarly excellence

Dr András Szűcs
Secretary General, EDEN

Dr Ulrich Bernath
Chair, Board of Trustees
Ulrich Bernath Foundation
for Research in Open and Distance Learning

Budapest – Oldenburg, January 2018

Editorial Board of the European Journal of Open, Distance and E-Learning

Ulrich Bernath, Acting Chief Editor, Ulrich Bernath Foundation for Research in Open and Distance Learning, Germany

Diana Andone, Politechnica University of Timisoara, Romania

Deborah Arnold, University of Burgundi, France

Lisa Marie Blaschke, Carl von Ossietzky University of Oldenburg, Germany

Anne Gaskell, The Open University in the East of England, United Kingdom

Carl Holmberg, International Council for Open and Distance Education (ICDE), Sweden

Mehmet Kesim, Anadolu University, Turkey

Elsebeth Korsgaard Sorensen, Aarhus University, Denmark

Gila Kurtz, The Centre of Academic Studies, Israel

Fabio Nascimbeni, MENON Network, Belgium

Don Olcott, Jr., United States Distance Learning Association (USDLA), USA

Ebba Ossiannilsson, Lund University, Sweden

Wim van Petegem, EuroPACE and K. U. Leuven, Belgium

Stella Porto, University of Maryland University College, United States of America

Timothy Read, UNED, Spain

Paul Ruehl, Virtuelle Hochschule Bayern, Germany

Albert Sangra, Regional Associate Editor, Universitat Oberta de Catalunya, Spain

András Szűcs, EDEN, United Kingdom

Alan Tait, The Open University, United Kingdom

Antonio Teixeira, Universidade Aberta, Portugal

Costas Tsolakidis, University of the Aegean, Greece

Erwin Wagner, Zentrum für Fernstudien und Weiterbildung, Universität Hildesheim, Germany

Steve Wheeler, University of Plymouth, United Kingdom

Dénes Zarka, Budapest University of Technology and Economics, Centre for Learning Innovation and Adult Learning, Hungary

Table of Contents

Annual Conference, Budapest

Academics' Use of Academic Social Networking Sites:

The Case of ResearchGate and Academia.edu1
*Hagit Meishar-Tal, Holon Institute of Technology, Learning Technologies,
Efrat Pieterse, West Galilee College, Israel*

Pen or Keyboard – An Empirical Study on the Effects of Technology on Writing Skills12
*Benedetto Vertecchi, Antonella Poce, Francesco Agrusti, Maria Rosaria Re,
Università Roma Tre, Italy*

A Benchmarking Study of K-Means and Kohonen Self-Organizing Maps Applied to
Features of Mooc Participants22
Rosa Cabedo Gallén, Edmundo Tovar Caro, Technical University of Madrid, Spain

How Do Faculty Members React Towards the Use of Personal Mobile Devices by
Students in the Classroom?37
*Hagit Meishar-Tal, Holon Institute of Technology (HIT), Alona Forkosh-Baruch,
Levinsky College, Israel*

9th Research Workshop, Oldenburg

Use of MOOCs in Traditional Classroom: Blended Learning Approach47
*Antonia Bralić, Blaženka Divjak, Faculty of Organization and Informatics,
University of Zagreb, Croatia*

From Evaluation to Sensemaking: Emergent Development of a Masters Distance Learning
Research Methods Module59
Palitha Edirisingha, Phil Wood, University of Leicester, United Kingdom

Contributions to Science Teaching Practice of an Online Community of Practice of
Teachers and Researchers81
*Margarida Morais Marques, Maria João Loureiro, Luís Marques,
CIDTFF – Research Centre “Didactics and Technology in Education of Trainers”,
DEP – Department of Education and Psychology, University of Aveiro, Portugal*

Best of EDEN 2016

**Special Issue of the
European Journal of Open, Distance and E-Learning**



The best research papers presented
at the 2016 EDEN Annual Conference 2016 June, Budapest

Edited by
Ulrich Bernath, András Szűcs

European Distance and E-Learning Network, 2018
in collaboration with the
Ulrich Bernath Foundation for Research in Open and Distance Learning

Members of the Jury for the EDEN Best Research Paper Award at the 2016 Annual Conference in Budapest

Andrea Karpati, Chair of the Jury, Professor Faculty of Science, Centre for Science Communication and UNESCO Chair for Multimedia in Education, ELTE University, Hungary

George Veletsianos, Associate Professor, Canada Research Chair in Innovative Learning and Technology, School of Education and Technology, Royal Roads University, Canada

Wim van Petegem, Expert Multicampus & Engineering Education, KU Leuven, Belgium;
EDEN Vice President

Ulrich Bernath & Thomas Hülsmann, Trustees and Directors of the Ulrich Bernath Foundation for Research in Open and Distance Learning, Germany

Academics' Use of Academic Social Networking Sites: The Case of ResearchGate and Academia.edu

Hagit Meishar-Tal, Holon Institute of Technology, Learning Technologies, Efrat Pieterse, West Galilee College, Israel

Introduction

In the past few years, the Internet has seen the advent of academic social-networking sites (ASNS) such as Academia.edu and ResearchGate. These sites allow users to upload academic articles, abstracts, and links to published articles; track demand for their published articles; and engage in professional interaction, discussions, and exchanges of questions and answers with other users. The sites, used by millions (Mangan, 2012), constitute a major addition to scientific media.

This study investigates the nature of the use and the perceived utility of the sites for academics whose professional careers are based on the performance and publication of studies. In a world that offers numerous and diverse online publishing opportunities (sites of formal journals, personal sites and blogs, and general social networks such as Facebook and LinkedIn), the question is what comparative advantage academic networking sites offer and why faculty members use them. Do these sites fit the definition of “social network”? And which of their affordances serve their users?

Literature review

In recent years, professional networks that offer information sharing and communication tools for professional purposes have arisen alongside the general social networks. The best known of them is LinkedIn (LI), which provides a platform on which people and businesses communicate for purposes of working relations, employee search, and career management. Among the additional Academic Social Networking Sites (ASNS) that have evolved in recent years, two—Academia.edu and ResearchGate – offer themselves as professional and social networks of researchers, combining characteristics of social networks with the publication of studies, all adjusted to the needs and compartment of academic researchers (Ovadia, 2014). They accommodate customary social-network elements such as the construction of a personal profile and interactivity with peers along with specific tools for academic

requisites, such as uploading and tagging of articles and tracking of citations (Jordan, 2015).

ASNS have the potential of revolutionizing the patterns of information publication and sharing in the academic world. By offering platforms for interrelations among scholars around the world, they may influence the structure and dynamic of the research community. Official academic publishing is based on acceptance of articles by refereed academic journals – either in print or in online academic databases that are accessible mainly to those who are active in an academic establishment – for which a fee is usually charged. The time that passes between research and the publication of its findings in such a journal is lengthy and may exceed one year. Academic social networks challenge this model and circumvent the hurdles that impede exposure to the public. What is more, they do so easily and at no charge. They encourage authors to upload full-text articles that appeared in academic journals, lectures presented at conferences, and even drafts, and make them accessible to the public (Wilkinson et al., 2003). They also allow readers to respond to an article or ask the author about it (Thelwall & Kousha, 2014), thereby encouraging interaction between readers and researchers.

The literature relates to five main affordances of academic social networks for researchers:

1. *Management of an online persona*: In ASNS, in addition to basic personal details, the researcher may present his or her professional experience, ideas, and capabilities, including the number of citations and downloads of his or her articles, thereby cultivating an online identity and promoting his or her professional reputation (Barbour & Marshall, 2012).
2. *Diffusion of studies*: The platform provides a place where account holders can upload articles to the cybersphere. In this manner, knowledge about a new article rapidly reaches the community that takes an interest in its topic and, accordingly, may be read (Espinoza Vasquez & Caicedo Bastidas, 2015).
3. *Collaboration*: The ability of ASNS to bridge distances encourages cross-disciplinary and cross-border collaborations. Some scholars argue that academic social networks replicate, and in certain cases even improve, the experience of social activity at a conference by helping to create and expand researchers' professional networks (Kelly, 2013). The two networks discussed in this study provide tools (e-mail and internal messaging systems) for direct

communication and presentation of details for the establishment of personal relations among researchers.

4. *Information management:* Veletsianos (2013) suggests that ASNS serve as a source for the collection and organization of personal academic information including ideas, drafts, and anything else that a researcher on the network gleans from articles, references, and citations.
5. *Measurement of impact:* Academic impact is measured in terms of the number of citations of an article and the quality of the journals in which the article appears. Online academic networks offer additional metrics, such as number of persons who read or download an article (Gruzd, Staves, & Wilk, 2011).

Employing the uses and gratifications theory to analyze the use of web sites and social networks

The uses and gratifications theory, an outgrowth of leisure-culture and mass-media studies, posits that media consumers are autonomous and active agents who base their consumption media decisions on a range of personal considerations and cognitive, affective, and social needs. The theory offers a contrast to the critical perspective, which sees media consumers as passive agents who are prone to media manipulations and influences (Rubin, 2002; Katz et al., 1974). It identifies five major types of needs to which media respond:

1. Cognitive needs, including consumption of information and knowledge.
2. Affective needs, including excitation, enjoyment, and pleasure.
3. Social needs, including creating a sense of group belonging, influencing and contributing to others, etc.
4. Individual needs, including the response to personal needs, self-promotion, personal gain, and enhancement of personal confidence.
5. Escapist needs, i.e., using the technology to flee from reality and create an alternative virtual and imagined reality.

The uses and gratifications theory helps to understand the behaviour of those who visit user-generated content sites such as YouTube, Wikipedia, and social networks. Research on users' behaviour in these environments divides the use of the sites into three types: consumption of information, participation in social interaction, and creation of information (Shao, 2009). According to Stafford, Stafford and Schkade (2004), the singular characteristic of the gratifications and users that typify recourse to the Internet, as opposed to the use of television and other traditional media, is the

centrality and the interactive characteristics of the social gratification. Studies on the uses and gratifications of participants in social networks reinforce this point; they repeatedly stress the centrality of the gratification created by *communicating with friends*, establishing relations with existing friends, and finding old or new friends (Raacke & Bonds-Raacke, 2008; Park, Kee, & Valenzuela, 2009). Seidman (2013) notes the centrality of the social calculus as a motive for the use of social networks. The social element, he says, relates more to the need for *a sense of belonging* than to the need for interaction. Other research, among students who use Facebook groups, indicate that one of the gratifications derived from the use of FB is *self-promotion* and the *acquisition of social status* (Park, Kee, & Valenzuela, 2009; Ellison, Vitak, Gray, & Lampe, 2014). Additional studies that look into the gratifications that people seek when they use social networks specify the need for *ego-bolstering* as a principal one. Another gratification that typifies the use of social networks is “killing time” and *escapism* (Quan-Haase & Young, 2010).

This study attempts to explain the potential of academic Web sites and create a profile of their use. Given the scanty attention that empirical research has devoted to ASNS to date, this study may enhance our understanding of the allure of these sites and academics’ motives for using them. We emphasize two questions in particular: Which motive, the social or the personal, is stronger in using ASNS, and to what extent do users refer to ASNS in ways that are familiar and known in reference to social networks?

Research methods and tools

The research was design to investigate what are the reasons for using ASNS by academics. The following operative questions were stated:

1. What are the characteristics of academics’ use of ASNS?
2. What main gratifications do academics obtain by using ASNS?
3. What is the relation between frequency of use and nature of use of ASNS?

This is a quantitative study, based on a survey among faculty members at three different academic institutions in Israel – two colleges and one university. For the purposes of the study, a dedicated questionnaire was constructed, composed of three main sections: Users’ demographic characteristics, characteristics of the use of academic networks and motivations for use.

The questionnaires were sent to all faculty members at three institutions. Eighty-one faculty members responded – 57% men and 43% women. They were fifty years old on average (SD = 10.3), ranging in age from twenty-nine to seventy-two. The rate of participant ownership of an account on social-networking sites and academic-networking sites is shown in Figure 1.

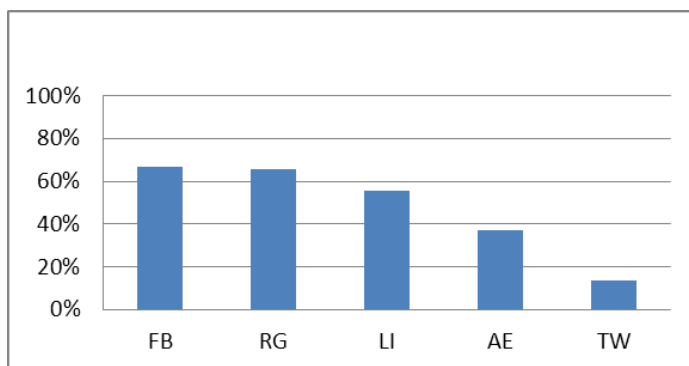


Figure 1. Rate of Account Ownership on Social-Networking Sites

Some 75% of respondents have at least one account with one of the two academic-networks chosen for this study (RG/AE); 25% have accounts with both. The preferred academic network among Israeli academics is ResearchGate, with which more than 65% have an account. The percent of those with an account on RG approximates that of those who have a presence on FB – 67%. Only 37% have an account with AE, 56% have an account with LI, and only 14% have one with TW.

Findings

q1. What are the characteristics of academics' use of ASNS?

Longevity of use

About 42% of those who have accounts with ASNS (N = 59) have had them for more than two years. Some 30% subscribed approximately two years ago, 13% joined the networks in the previous year, and 13% did so the previous half-year.

Frequency of visits to ASNS

Some 38% of those who have accounts with ASNS (N = 60) visit the sites infrequently, 20% do so once per month, 27% visit approximately once per week, and 15% do so almost every day.

Nature of use

To examine the way academics use ASNS, the participants were shown a list of possible modes of activity on each of the two academic networks. The list was composed of six items aggregated into three variables, two items per variable (information consumption, information sharing and diffusion, and interaction with other users). The participants were asked to rank the extent to which they engage in these activities on a five-level Likert scale (1 = *not at all*; 5 = *to a very great extent*). Table 1 presents the findings.

Table 1: Use of ASNS

	Mean	S.D.
Information consumption	2.48	1.1
Information sharing	2.02	1.00
Interaction	1.82	1.00

The table shows that the most common form of activity is information consumption ($M = 2.48$, $SD = 1.11$), followed by *information sharing* ($M = 2.02$, $SD = 1.00$) and *interaction* ($M = 1.82$, $SD = 1.00$). To refute the null hypothesis, an Anova test with repeat measurements was performed, yielding a significant difference among the three groups ($F(2, 57) = .71$ $p < 0.001$). The reason for the difference is that the *information consumption* use is significantly more common than the *information sharing and diffusion* and *interaction* uses.

q2. What main gratifications do academics obtain by using ASNS (acquisition of information and knowledge; enjoyment; group belonging; self-promotion; escapism)?

To answer this question, the participants were presented with twenty-six possible motives for ASNS use. The motives were derived from the uses and gratifications theory and adjusted to the context of social-network use. The participants were asked to rank the extent of their identification with each motive on a five-level Likert scale (1 = *not at all*; 5 = *very much*). The factor analysis detected five main groups of gratifications: Self-promotion and ego-bolstering ($\alpha = .964$), Acquisition of professional knowledge ($\alpha = .941$), Belonging to professional community ($\alpha = .889$), Interaction with professional peers ($\alpha = .905$), Escapism ($\alpha = .945$).

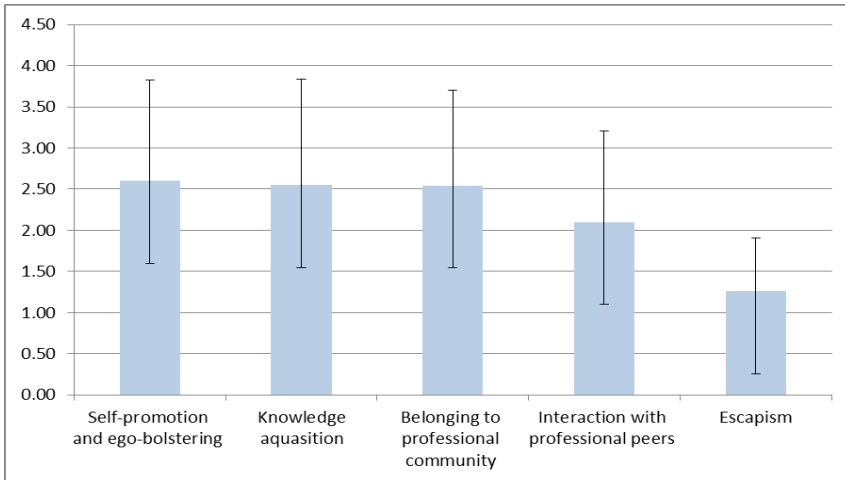


Figure 2. Presents the ranking of the uses and gratifications obtained from ASNS

To check for the presence of significant differences among the four principal motives (self-promotion, acquisition of professional knowledge, belonging to an information community, and interaction with others), an Anova test with repeat measurements was performed among the four complex indicators (the mean of the statements in each factor). The findings show significant differences among the various kinds of gratification and, specifically, that *interaction with professionals* is a significantly less important gratification than *self-promotion and ego-bolstering* and *belonging to a peer community*.

q3. What are the relation between frequency of use and nature of use?

A relation was found between frequency of ASNS use and participant’s age. Namely, the older an academician is, the more frequently he or she uses the network ($r = .413, p < 0.005$). A relation was also found between frequency of use and each of the three types of uses: Information consumption ($r = .771, p < 0.05$), Information sharing ($r = .570, p < 0.05$), Interaction ($r = .406, p < 0.05$).

Conclusions

This study investigates the uses and gratifications that academic faculty members derive from two academic social-networking sites, Academia.edu and ResearchGate. It invoked the uses and gratifications theory (Katz, Blumler, & Gurevitch, 1974) as a point of departure and adjusted this genetic theory, developed in the context of mass-media consumption, to the specific context of academic networks and their singularities.

The study was conducted among a relatively small population from three different academic institutions on the basis of a voluntary response to an online questionnaire. It found a difference among these institutions in the extent of use of the various networks and faculty members' perception of the gratifications that the networks give them.

The findings indicate that researchers use ASNS mainly for consumption of information, slightly less for sharing of information, and very scantily for interaction with others. This finding itself indicates that academic networks do not function as other social networks do. In social networks such as Facebook, interaction with others is the main use (Boyd & Ellison, 2007); academic networks, in contrast, are used chiefly for information consumption and are perceived more as a database of sorts than as a place to establish social or professional relations and interact with others.

As for the gratifications that motivate users to visit ASNS, four main ones were found: self-promotion and ego-bolstering, acquisition of professional knowledge, belonging to a peer community, and interaction with peers (Park, Kee, & Valenzuela, 2009). Escapism, a factor that typifies the gratifications that social networks deliver (Quan-Haase & Young, 2010), proved to be weak if not irrelevant in regard to academic networks.

The four main gratifications that typify the use of academic networks largely reflect the uses and gratifications theory but require some adjustment. The original theory separates emotional factors from personal ones (Katz, Blumler, & Gurevitch, 1974); in ASNS, self-promotion (personal) and ego bolstering (affective) are inseparable. The "social" factor, in contrast, is split in two where academic networks are concerned: belonging to a peer community and interaction with peers are identified as separate factors. They are different in that peer-group affiliation does not necessarily require interaction with others and is manifested in unilateral action by the user. Interaction with others, in contrast, entails user initiative and responsiveness.

The centrality of the self-promotion and ego-bolstering motive stresses the utilitarianism that drives the use of social networks generally and academic networks specifically. The creation of social capital and personal advancement by means of activity on social networks is well known in research on such networks (Ellison, Vitak, Gray, & Lampe, 2014; Valenzuela, Park, & Kee, 2009). From this standpoint, the behaviour of users of ASNS shows that they recognize the network as a mechanism for the creation of social capital and for an attempt to transform it into professional

capital. In a world where academic faculty members are judged by the number of works that they publish and the number of citations that the works receive an instrument that allows them to influence the extent of their exposure and increase the likelihood of citation delivers much power and utility.

The high score of the *consumption of professional academic information* gratification stresses the importance that academics see in having direct and open access to academic information as argued by Veletsianos and Kimmons (2011).

The separation between the two social gratifications *The sense of belonging* and *Interaction with professional peers*, and the fact that the sense of *belonging to a community of practice* was ranked higher strengthen Seidman's (2013) notice the social gratification of social networks relates more to the need for a sense of belonging than to the need for interaction.

The fact that interaction in this environment and academics' motivation to engage in it are significantly weaker than the other uses and gratifications could be explained on the ground that the social potential of ASNS has not yet been fully realized by the academics because they are so new.

References

1. Barbour, K., & Marshall, D. (2012). The academic online: Constructing persona through the World Wide Web. *First Monday*, 17(9). Retrieved from <http://firstmonday.org/ojs/index.php/fm/article/view/3969>
2. Boyd, D. M., & Ellison, N. B. (2007). Social Network Sites: Definition, History, and Scholarship. *Journal of Computer-Mediated Communication*, 13, 210–230. doi: 10.1111/j.1083-6101.2007.00393.x
3. Ellison, N. B., Steinfield, C., & Lampe, C. (2007). The benefits of Facebook "friends:" Social capital and college students' use of online social network sites. *Journal of Computer-Mediated Communication*, 12(4), 1143-1168.
4. Ellison, N. B., Vitak, J., Gray, R., & Lampe, C. (2014). Cultivating social resources on social network sites: Facebook relationship maintenance behaviors and their role in social capital processes. *Journal of Computer Mediated Communication*, 19(4), 855-870.

5. Espinoza Vasquez, F. K., & Caicedo Bastidas, C. E. (2015). Academic Social Networking Sites: A Comparative Analysis of Their Services and Tools. *Proceedings of the iConference 2015*.
6. Gruzd, A., Staves, K., & Wilk, A. (2011). Tenure and promotion in the age of online social media. *Proceedings of the American Society for Information Science and Technology*, 48(1), 1-9.
7. Jordan, K. (2015). *What do academics ask their online networks?* An analysis of questions posed via Academia.edu.
8. Katz, E., Blumler, J. G., & Gurevitch, M. (1974). Uses and gratifications research. *Public Opinion Quarterly*, 37(4), 509-524.
9. Kelly, B. (2013). *Using social media to enhance your research activities*. Paper presented at the Social Media in Social Research 2013 Conference.
10. King, K. P., Leos, J. A., & Norstrand, L. (2015). The Role of Online Health Education Communities in Wellness and Recovery. In V.C.X. Wang (Eds.), *Handbook of Research on Advancing Health Education through Technology*, Chapter 7 (pp. 139-170). IGI Global.
11. Ko, H., Cho, C. H., & Roberts, M. S. (2005). Internet uses and gratifications: A structural equation model of interactive advertising. *Journal of advertising*, 34(2), 57-70.
12. Ovadia, S. (2014). ResearchGate and Academia.edu: Academic social networks. *Behavioral & Social Sciences Librarian*, 33(3), 165-169.
13. Park, N., Kee, K. F., & Valenzuela, S. (2009). Being immersed in social networking environment: Facebook groups, uses and gratifications, and social outcomes. *CyberPsychology & Behavior*, 12(6), 729-733.
14. Price, R. (2012, August 15), Announcing Academia.edu Analytics. [Blog post] Academia.edu. Retrieved from <http://blog.academia.edu/post/29490656413/announcing-academiaedu-analytics>
15. Quan-Haase, A., & Young, A. L. (2010). Uses and gratifications of social media: A comparison of Facebook and instant messaging. *Bulletin of Science, Technology & Society*, 30(5), 350-361.
16. Raacke, J., & Bonds-Raacke, J. (2008). MySpace and Facebook: Applying the uses and gratifications theory to exploring friend-networking sites. *Cyberpsychology & behavior*, 11(2), 169-174.

17. Rubin, A. (2002). The uses-and-gratifications perspective of media effects. In J. Bryant & D. Zillman (Eds.), *Media effects: Advances in Theory and Research* (pp. 525–548). Mahwah: Lawrence Erlbaum.
18. Seidman, G. (2013). Self-presentation and belonging on Facebook: How personality influences social media use and motivations. *Personality and Individual Differences, 54*(3), 402-407.
19. Shao, G. (2009). Understanding the appeal of user-generated media: a uses and gratification perspective. *Internet Research, 19*(1), 7-25.
20. Stafford, T. F., Stafford, M. R., & Schkade, L. L. (2004). Determining uses and gratifications for the Internet. *Decision Sciences, 35*(2), 259-288.
21. statista.com (2015). *Global social networks ranked by number of users 2016*. Retrieved from <http://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users>
22. Thelwall, M., & Kousha, K. (2014). Academia.edu: social network or academic network? *Journal of the Association for Information Science and Technology, 65*(4), 721-731.
23. Valenzuela, S., Park, N., & Kee, K. F. (2009). Is there social capital in a social network site? Facebook use and college students' life satisfaction, trust, and participation. *Journal of Computer-Mediated Communication, 14*(4), 875-901.
24. Veletsianos, G. (2013). Open practices and identity: Evidence from researchers and educators' social media participation. *British Journal of Educational Technology, 44*(4), 639-651.
25. Veletsianos, G., & Kimmons, R. (2011). Networked Participatory Scholarship: Emergent techno-cultural pressures toward open and digital scholarship in online networks. *Computers & Education, 58*(2), 766–774.
26. Wilkinson, D., Harries, G., Thelwall, M., & Price, L. (2003). Motivations for academic Web site interlinking: Evidence for the Web as a novel source of information on informal scholarly communication. *Journal of information science, 29*(1), 49-56.

Pen or Keyboard – An Empirical Study on the Effects of Technology on Writing Skills

*Benedetto Vertecchi, Antonella Poce, Francesco Agrusti,
Maria Rosaria Re, Università Roma Tre, Italy*

Abstract in Italian

Il presente studio, realizzato nell'ambito del modulo "Metodi e tecniche di scrittura in educazione" attivo presso l'Università Roma TRE, parte dall'assunto in base al quale gli studenti possono sviluppare le loro capacità di scrittura e pensiero critico grazie a specifiche attività dedicate allo scopo. Tali attività hanno riguardato, in particolare, l'elaborazione di saggi brevi, effettuati sia a mano, sia su tastiera, per verificare la differenza nei risultati ottenuti in base alla tecnologia adottata. Lo sviluppo del pensiero critico è alla base di altre ricerche del Laboratorio di Pedagogia Sperimentale – Università Roma TRE (eg. Poce, 2012), dove lo studio di autori classici in un percorso di apprendimento strutturato ha mostrato elaborazioni critiche e personali dell'apprendimento. L'obiettivo generale del modulo nel quale si è realizzata la sperimentazione è identificare un modello da poter applicare in diversi contesti e situazioni. Meta obiettivi sono stati identificati nell'opportunità per gli studenti di migliorare il corretto uso della lingua (grammatica, morfo-sintassi, accuratezza lessicale, capacità argomentative e sviluppo del pensiero critico e della creatività al temo stesso). I lavori degli studenti sono stati valutati dai ricercatori LPS, usando strumenti di valutazione appositamente sviluppati. I risultati vengono presentati nella versione estesa del contributo.

State of the art

As stated in the scope of the conference "The social and socio-economic context is more important than ever. Society itself can be understood as a learning environment, with questions of learners' connection with the community and the empowerment of the practitioners". This means that certain skills, the so called 21st century skills, must be prompted and developed. Writing skills are of paramount importance in this context and, as educators and researchers, we are primarily engaged in understanding the effect the use of mobile devices has on such abilities.

The relation between digital tools and writing skills regards different scientific fields, such as education, neuroscience and sociology. Everyone, teenagers in particular, is used to communicate through smartphones, tablets or PCs, writing short text messages. However, in these cases, writing skills are not developed in an efficient and productive way even if they are practiced every day. International studies and research highlight a drastic reduction of argumentation capabilities in writing for people who make too much use of texting.

Research carried out by Drew Cingle and Shyam Sundar (2012) from Penn State University (USA) has shown that an excessive use of short text messages compromises grammar accuracy and linguistic skills in high school students. Jennifer Myers (2012) from Calgary University states that reading on paper and using traditional tools for writing promote a more creative use of the language; this does not happen with digital writing. A study by Cambridge Assessment (Suto, 2012) carried out among 633 university teachers states that writing skills have been considered at the top of university students' problems.

Even if certain advantages are present due to almost synchronous communication, at the same time a strong limitation on the potentialities of both written and oral language use occurs. Crystal (2001) talks of an Internet language made of a mixture of oral and written speech, which has an impact on learning and on certain skills in particular.

In 2012, a conference entitled *Handwriting in the 21st century? An educational summit* has been organized in Washington (USA). During the summit, it was highlighted that the obligatory use of keyboard in primary school writing activities generates problematic issues. In the USA, youngest generations face difficulties when they have to read handwritten texts. In relation to this, the conference indicated the need to change this situation and reintroduce handwriting as a necessary activity for the development of learning, argument and critical thinking skills.

Also neuroscience is interested in the effects of handwriting. Studies in the field highlight differences in learning among students who use digital tools to write and students who write by hand (Longcamp et al., 2008, 2011; Spitzer, 2013). Handwriting influences reading comprehension because it activates different and specific parts of the brain: handwritten character recognition happens in connection with handwriting muscle movements, providing, at the same time, visual receptors and memory capacity (Longcamp et al., 2011). In China, for instance, it has been shown that computer

writing severely restricted primary school students reading skills. In one of the most recent reports by OECD, *Students, Computers and Learning. Making the Connection* (2015), for the first time, the Organization state that better results in reading are shown by those pupils who make less intensive use of technology in learning.

Within the above context, this contribution refers to the activity carried out at Roma Tre University, where a group of students' writing skills have been tested, taking into account critical thinking skills levels as a referential criteria. Assignments foresaw the use of pen or keyboard on different controlled situations. Data and results were analysed accordingly and compared as described below.

Research design and methodology

The present study carried out within the module *Writing Methods and Techniques in Education*, hold out at University Roma TRE – Laboratory of Experimental Pedagogy (LPS), starts from the assumption that students can develop their writing and critical thinking skills thanks to specific writing activities. Such activities regard the elaboration of short essays, both by hand and on computer keyboards, with the aim to highlight the gap in results. The development of critical thinking skills is at the basis of other LPS researches (Poce, 2012) where the study of classical authors in a structured learning path has shown development in the students' personal and critical elaboration of knowledge.

The general objective of the module where the experimentation took is to improve students' writing skills in different disciplinary and learning contexts. Meta-objectives have been identified in the opportunity for students to improve also their correct use of the language (grammar, morpho-syntax, lexicon accuracy), argument skills and to develop critical thinking and creativity skills as well.

Over the lecturing, students have produced short essays on the topics discussed with the lecturer. Assignments were marked by LPS researchers, using an *ad hoc* essay assessment grid. Short essays written by students were produced in two different ways: by hand or keyboard. All data have been collected and analysed to highlight the different results in skills development according to the writing tool employed.

In the following paragraph a description of the assessment tool based on critical thinking level indicators is given.

Assessment tool

A short essay is a semi-structured test in which students have to present their ideas following a given structure. The main purpose of this kind of test is to present a set of ideas on a given topic following the order that makes most sense to a reader; therefore, the focus of an essay is its linear and logic structure.

The initial thesis provided in the guidelines, the limited time and space frame and the attention to the typical essay structure represent close *stimuli*, which the student must use in order to organize the development of the proposed topic. In particular, the guidelines contain a thesis, a series of questions the student has to answer, the sources and data given to develop and support his/her personal thesis and a predetermined text length. The presence of these stimuli facilitates the production of more homogeneous tests and, consequently, an easier use of an essay assessment grid.

Within this project, a specific assessment grid was outlined to evaluate students' essays. In a short essay, one's verbal ability is used in a specific way, that is in relation to the correct use of language and argumentation of a specific topic, and not in a general way. In this way, the teacher is able to evaluate the students' critical acquisition of knowledge and how they use this knowledge in their essays. Moreover, the acquisition of specialized vocabulary will be clear and immediate. In relation to this, the essay assessment grid contains a macro-indicator of *Basic linguistic skills*, thanks to which the evaluator can assess linguistic form of the text.

As for other macro-indicators, *Justification* assesses students' ability to elaborate on their thesis and to support their arguments, throughout their short essay. An essay is a specific kind of text that contains all the information readers need to know in the order in which they need to receive it; the ability to produce written argumentation on a given topic is paramount to write a good essay.

Relevance is a macro-indicator that analyses text consistency, such as the correct use of outlines and students' capability to accurately use given *stimuli*. Therefore, short essays involve several different operations: introducing the argument, analysing data, raising counter arguments, concluding; this indicator assesses the correct text structure.

The *Importance* macro-indicator assesses the knowledge students use in their essay; asking students to write an essay on a specific topic is a good way to assess the bulk of their study.

Finally, *Critical evaluation* and *New ideas* are macro-indicators that analyse students' critical thinking skills, by assessing personal and critical elaboration of sources, data and background knowledge with the use of new ideas and solutions associated with the initial hypothesis and student's personal thesis.

The macro-indicators presented in the assessment grid have been selected to help evaluators during the evaluation phase: indicators, descriptors and marks are provided in detail for an easier use of the grid and to allow a reliable test evaluation.

Table 1: Assessment grid

Macro-indicators	Indicators	Descriptors	Marks	Score
Basic linguistic skills	Grammar Accuracy (Punctuation, Spelling, Morpho-syntax, Lexicon)	Expression is		
		<input type="checkbox"/> rich and original	Excellent	5
		<input type="checkbox"/> appropriate	Very good	4
		<input type="checkbox"/> mainly correct	Good	3
		<input type="checkbox"/> not precise	Insufficient	2
		<input type="checkbox"/> not correct and improper	Clearly insufficient	1
Justification	Elaboration ability (thesis definition and elements of reasoning)	Elaboration is		
		<input type="checkbox"/> rich and articulate	Excellent	5
		<input type="checkbox"/> clear and ordered	Very good	4
		<input type="checkbox"/> too synthetic	Good	3
		<input type="checkbox"/> quite consistent	Insufficient	2
		<input type="checkbox"/> inconsistent	Clearly insufficient	1
Relevance	Consistency (the topic under issue is mentioned)	The outline is		
		<input type="checkbox"/> complete, deep and original	Excellent	5
		<input type="checkbox"/> complete and correct	Very good	4
		<input type="checkbox"/> generic	Good	3
		<input type="checkbox"/> partial	Insufficient	2
		<input type="checkbox"/> out of line	Clearly insufficient	1
Importance	Knowledge of the topic (main issues related to the topic are mentioned)	Knowledge is		
		<input type="checkbox"/> critical and deep	Excellent	5
		<input type="checkbox"/> complete	Very good	4
		<input type="checkbox"/> appropriate	Good	3
		<input type="checkbox"/> superficial	Insufficient	2
		<input type="checkbox"/> not sufficient	Clearly insufficient	1
Critical evaluation	Personal and critical elaboration of sources and background	Elaboration is		
		<input type="checkbox"/> critical and well sounded	Excellent	5
		<input type="checkbox"/> wide and adequate	Very good	4
		<input type="checkbox"/> essential and simple	Good	3
		<input type="checkbox"/> partial	Insufficient	2
		<input type="checkbox"/> contradictory	Clearly insufficient	1
New ideas	New information, new ideas and solutions to the issues raised in the question	New information and possible solutions are inserted		
		<input type="checkbox"/> widely, critically and originally	Excellent	5
		<input type="checkbox"/> deeply	Very good	4
		<input type="checkbox"/> correctly	Good	3
		<input type="checkbox"/> simply and/or partially	Insufficient	2
		<input type="checkbox"/> no new information and solutions are given	Clearly insufficient	1
Final mark			Total	30

The above essay assessment grid was used by LPS researchers to evaluate short essays written by the students engaged in the "Writing Methods and Techniques in Education" module active in the Education course at Roma TRE University.

Analyses and findings

The evaluation of the students' short essays has shown an improvement as for all the skills connected with Critical Thinking macro-indicators and students' writing ability itself. The table below highlights results by each student (A, B, C, etc.) participating in the module on each test and their results are measured on a scale from 5 (*Clearly Insufficient* for all the indicators) to 30 (*Excellent* in every indicator). In general, students have improved their ability to write texts in various disciplinary and learning contexts.

Table 2: Activities and results

Student	First test	Second test	Third test (keyboard)	Fourth test	Fifth test (Keyboard)	Sixth test
A	16	20	21	25	21	26
B	24	/	/	25	/	18
C	17	22	19	30	27	30
D	20	24	15	20	17	21
E	19	15	20	24	19	24
F	20	23	28	28	27	23
G	16	/	16	/	/	/
H	15	16	20	22	22	26
I	15	22	20	29	22	22
J	15	/	15	19	22	23
K	19	15	26	26	/	22
L	27	/	27	26	23	29
M	19	23	/	26	22	23
N	21	26	27	29	26	27
O	20	/	/	23	23	25
P	18	17	18	26	20	21
Q	19	/	/	24	/	/
R	16	21	24	28	22	28

As shown by the comparison between the first and the last test, most students have improved their writing skills: test score has increased from 1 point (e. g. student D) to 13 points (e. g. student C).

Only in the case of student B results test worsened in the last test compared to the first: however, as shown in the table above, student B did not complete all the learning path activities and wrote only 3 short essays out of a total of 6. For this reason, student B's performance cannot be taken into account for the overall evaluation of the project.

In general, the trend of the last test score is good and 4 students out of a total of 16 (25%) obtained an excellent mark (27-30 points).

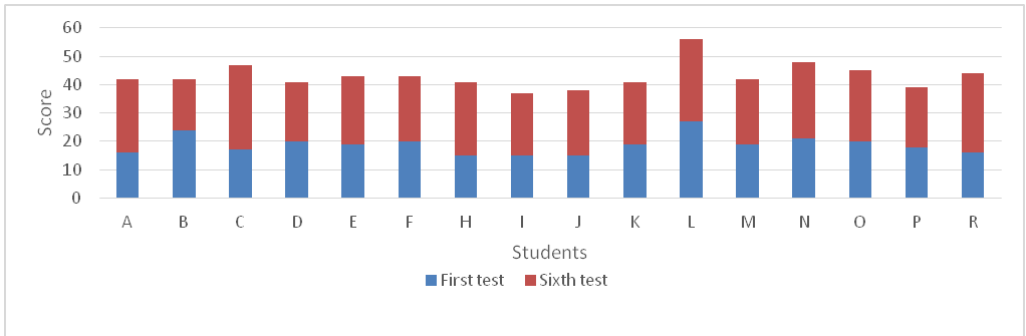


Figure 1. Comparison of First test and Last test

In particular, handwritten short essays got higher scores than computer written texts: collected data shows that short essay written on keyboard usually worsen the student’s performance over the learning path.

If we take the case of Student C, as shown in the following tables, she/he has significantly improved her/his performance during the project, going from an unsatisfactory first test (17 points) to an excellent final test (30 points); it must be noted that all short essays written on keyboard obtained a lower score than previous and following tests, probably affecting his/her learning path trend.

Even if the third test score of Student A is higher than the second one (second test: 20 points; third test: 21 points), it reduces the learning path performance improvement. Student A’s test scores increase on average by 4 points, except in tests written on PC: third test (1 point) and fifth test (-3 points).

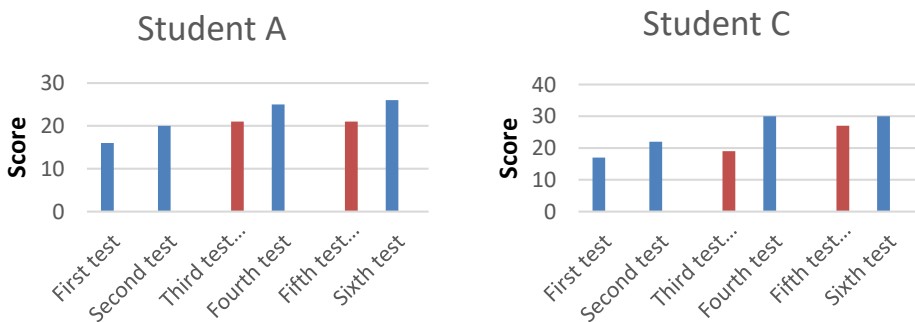


Figure 2. Students A and C results in all the activities

A more detailed comparison between the score of the third keyboard test and the fourth handwritten test shows different performances for each student: in most cases, the fourth test has been marked with higher scores than the third one. In some students' performance, the difference in marks is very high between the third and the fourth test (e.g. Student I: 20 points in third test vs. 29 points in fourth test; Student P: 18 points in third test vs. 26 points in fourth test).

All fourth test scores are passing (good) scores and 5 students out a total of 13 (38%) obtained an excellent score. On the other hand, 11 third test performances are lower than fourth test ones.

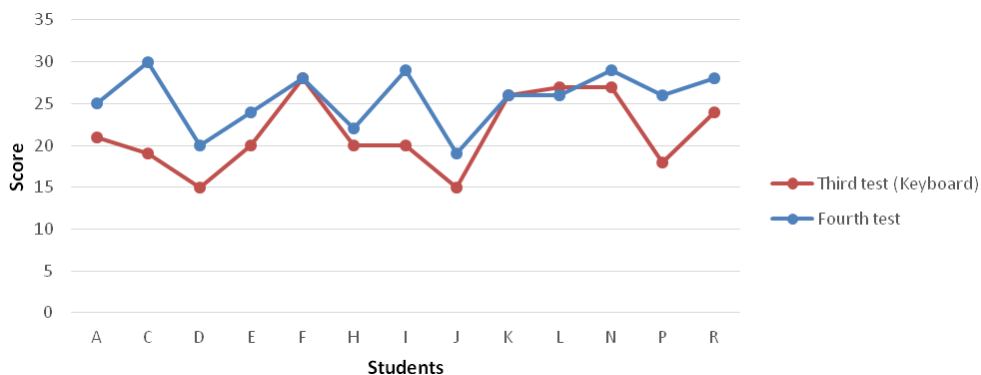


Figure 3. Comparison of third test (keyboard) and fourth test

Conclusive remarks and possible developments

The figure below represents a synthesis of the trend of the essay tests performed. Results for keyboard tests are clearly identifiable.

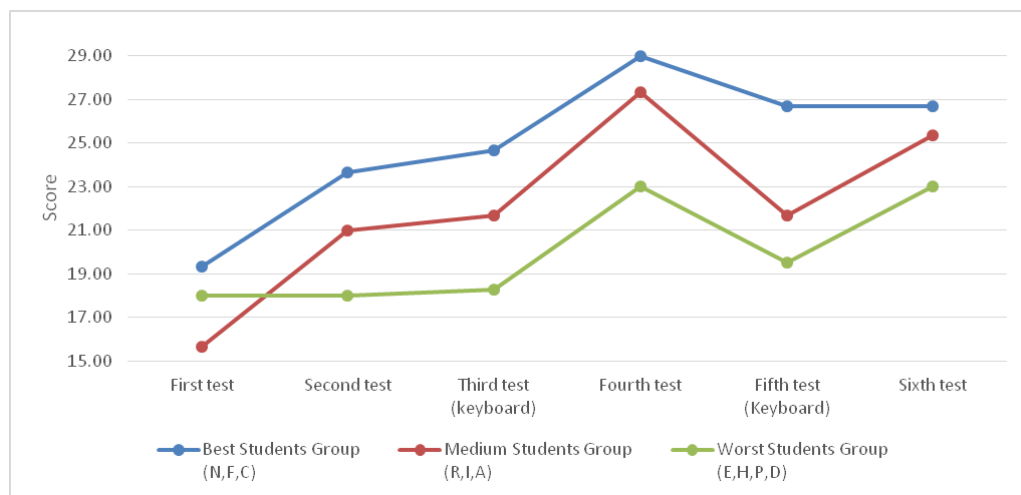


Figure 4. Comparison of all the activities for group of students

From the analyses carried out and the results shown in the figure above, some main considerations can be singled out:

- the project learning path aims at successfully developing correct use of the language (grammar, morpho-syntax, lexicon accuracy), writing and argument skills as well as critical thinking and creativity;
- the use of PC in writing activities reduces the performances of the majority of students.

Therefore, the experience within the project demands researchers to further develop such a model further, also extending its application to other fields of knowledge. It would be, in fact, interesting to observe if this model, which asks students to reflect through writing short essays, analysed in the above mentioned modalities, promotes critical thinking and written production, even in a context where, traditionally, it is not common to read and write about topics based on essentially humanistic and pedagogical features.

References

1. Cingle, D., & Sundar, S. (2012). Texting, Techspeak, and Tweens: The Relationship between Text Messaging and English Grammar Skills. *New Media & Society*, May 11. Retrieved from <http://nms.sagepub.com/content/early/2012/05/10/1461444812442927>
2. Crystal, D. (2001). *Language and the Internet*. Cambridge, UK: OUP.

3. Longcamp, M., Boucard, C., Gilhodes, J. C., Anton, J. L., Roth, M., Nazarian, B. et al. (2008). Learning through Hand or Typewriting Influences Visual Recognition of New Graphic Shapes: Behavioural and Functional Imaging Evidence. *Journal of Cognitive Neuroscience*, 20, 802-815.
4. Longcamp, M., Hlushchuk, Y., & Hari, R. (2011). What differs in Visual Recognition of Handwritten vs. Printed Letters? An FMRI Study. *Human Brain Mapping*, 32, 1250-1259.
5. Myers, J. (2012, February 17). Texting Affects Ability to interpret Words. [Blog post] Utoday. Retrieved from <http://www.ucalgary.ca/news/utoday/february17-2012/texting>
6. Poce, A. (2012). *Contributi per la definizione di una tecnologia critica: un'esperienza di valutazione*, premessa di Vertecchi B. Milano: FrancoAngeli.
7. Ritchel, M. (2011, October 22). A Silicon Valley School That Doesn't Compute. [Blog post] New York Times, Technology. Retrieved from http://www.nytimes.com/2011/10/23/technology/at-waldorf-school-in-silicon-valley-technology-can-wait.html?_r=0
8. Spitzer, M. (2013). To Swipe or not to Swipe? The Question in Present-day Education. *Trends in Neuroscience and Education*, 2(3-4), 95-99. Retrieved from <http://www.sciencedirect.com/science/journal/22119493/2/3-4>
9. Suto, I. (2012). *What are the Impacts of Qualifications for 16 to 19 Year Olds on Higher Education? A Survey of 633 University Lecturers*. Cambridge Assessment. Retrieved from <http://www.cambridgeassessment.org.uk/Images/116010-cambridge-assessment-he-research-survey-of-lecturers-executive-summary.pdf>

A Benchmarking Study of K-Means and Kohonen Self-Organizing Maps Applied to Features of Mooc Participants

*Rosa Cabedo Gallén, Edmundo Tovar Caro,
Technical University of Madrid, Spain*

Abstract

MOOC format is characterized by the great diversity of enrolled people. Their heterogeneity represents an opportunity to identify the underlying relationships present in the internal structure of the data. This paper aims at identifying and analysing MOOC participants' profiles by running two unsupervised clustering techniques: K-Means as a partitioning approach and Kohonen's Self-Organizing Maps (SOM) as a competitive learning technique.

The dataset comes from MOOCKnowledge project data collection. After the execution of both clustering algorithms, the evaluation stage is performed with the validation measures: an intra-cluster measure and an overall quality criterion for K-Means, and two measures related to topological ordering for SOM.

The interpretation of the resulting profiles is made with the help of a matrix of prevalence levels. The similarities between the two resulting clustering on the one hand, and some pinpointed differences on the other are highlighted. They cannot be evaluated in advance without the opinion of an expert familiarized with the specifications of the MOOC.

After a preliminary study the results are not considered conclusive. For sure there is a long way in order to help stakeholders on how to identify and select the appropriate clustering according to several quality criteria.

Abstract in Spanish

Este artículo tiene como objetivo la identificación y el análisis de un conjunto de perfiles de participantes MOOC con la aplicación de dos técnicas de agrupamiento no supervisadas: K-Means como algoritmo particional y Kohonen Self-Organizing Maps (SOM) como una técnica representativa de aprendizaje competitivo.

El conjunto de datos del estudio tiene su origen en el proyecto MOOCKnowledge. Tras la etapa de ejecución, la evaluación del

agrupamiento se realiza con una selección de medidas de validación: una de dentro de cada grupo (intra-cluster) y la segunda de calidad global del agrupamiento (average Silhouette width) para K-Means, así como dos medidas relacionadas con el orden topológico para SOM.

La interpretación de los perfiles resultantes de los dos agrupamientos se realiza con la ayuda de una matriz de niveles de prevalencia. Tanto las similitudes como las diferencias identificadas en las matrices no pueden evaluarse de antemano sin la opinión de un experto familiarizado con el formato MOOC.

Tras un estudio preliminar los resultados no se consideran concluyentes. Sin duda, hay todavía un largo camino para ayudar a las partes interesadas sobre cómo identificar y seleccionar la agrupación adecuada de acuerdo con varios criterios de calidad.

Keywords: MOOC profiles, K-Means, Kohonen's Self-Organizing Maps, SOM, cluster analysis, clustering

Introduction

This paper has the final purpose of dealing with a comparative study of two clustering approaches (K-Means and SOM) on a subset of participants' features of a MOOC in the scope of the personal development. According to this study, clustering can be discovered as a useful exploratory technique for identifying and analysing MOOC participants' profiles, a format characterized by a great diversity of enrolled people that come from different personal and professional backgrounds, a very large range of knowledge levels, dissimilar motivations and goals, as well as many other heterogeneous issues that make more challenging their clustering.

In the field of MOOC format the knowledge of participants' profiles are rather limited and just confined to a description of participants' features and their percentage of presence in the courses. Definitely, and according to (Liyaganawardena, Adams, & Williams, 2013), the lack of information about MOOC participants for sure represents a challenge for researchers.

Clustering technique in this study is performed by running K-Means and SOM algorithms with a subset of variables collected from a survey with the aim of grouping the participants of a MOOC in a cohesive way. Participant's variables include gender, date of birth, nationality, educational level, employment status, previous MOOC experience, goals setting and, finally, the role of interaction in the learning process. Two aspects are addressed, firstly the clustering evaluation by applying quality criteria

to the resulting clustering of K-Means (intra-cluster value and average Silhouette width) and SOM (estimated topographical accuracy and average distortion measure) and, secondly, their further interpretation with a view to identifying underlying relationships in the internal structure of the features that make up participants' profiles. In conclusion, clustering results may help designers and other policy-makers to have a deeper understanding of the diversity of participants' profiles.

The paper is structured as follows. Firstly, it is briefly described Open Education movement and introduced MOOCKnowledge project. Next, K-Means and SOM techniques are proposed. Afterwards a description of KDD-based methodology is detailed. Then evaluation and interpretation clustering are outlined. Finally, this paper presents the most relevant preliminary conclusions of the comparison of internal structure of both K-Means and SOM clustering and possible lines of future work are discussed.

Open Education movement

The Declaration of Paris on Open Educational Resources (OER) recommends promoting the knowledge and using of open and flexible education from a lifelong learning perspective (UNESCO, 2012), which for the Lisbon European Council represents a basic component of European Social model in order to build a more inclusive, tolerant and democratic society (Commission of the European Communities, 2001). In the same way, OpenCourseWare (OCW) program initiative represents one step further and Massive Open Online Courses (MOOC) alternative provides an opportunity to access to Open Education scenario to a great number of people from any place in the world. The desire of learning without constraints leads to identify a diversity of profiles that considers people intentions, needs, motivations and goals, among others. All these features play an important role in the new educational trends and have the support of the European institutions (Commission of the European Communities, 2001), but unfortunately they have little prominence in Open Education research. MOOCKnowledge project, an initiative of the European Commission's Institute of Prospective Technological Studies (IPTS), aims to establish large-scale cross-provider data collection on European MOOCs to cover partially the participants' underrepresentation, where their diversity and variety of profiles represent a relevant issue (Kalz et al., 2015).

Clustering techniques: K-Means and SOM algorithms

Clustering is an example of unsupervised learning that aims to find natural partitions into groups (Fariás, Durán, & Figueroa, 2008). This paper is focused on two clustering techniques, K-Means and its four methods (Lloyd, 1982; Forgy, 1965; MacQueen, 1967; Hartigan & Wong, 1979) as a partition-based clustering algorithm and Kohonen's Self-Organizing Maps (SOMs) as a representative technique of Artificial Neural Networks (ANNs) (Kohonen, 1989). Clustering can be a useful exploratory technique for identifying and analysing MOOC participants' profiles with the purpose of discovering underlying relationships in the internal structure of participants' features that could provide support for MOOC designers and other policy-makers.

K-Means takes as input parameters a set S of entities and an integer K (number of clusters), and outputs a partition of S into subsets S_1, \dots, S_k according to the similarity of their attributes (Chen et al., 2002). The main points of interest for this paper are the four K-Means methods, the estimation of the number of clusters (K) (Jain, Murty, & Flynn, 1999) and the minimization of the total distance between the group's members and their centroids (intra-cluster distance).

SOM technique, developed by Teuvo Kohonen in 1982, is a type of Artificial Neural Network (ANN) model inspired by a kind of biological neural network (Hertz, Krogh, & Palmer, 1991) and is performed to identify, classify and extract features of high-dimensional data (Deligiorgi, Philippopoulos, & Kouroupetroglou, 2014). This network architecture considers on the one hand a neurons' learning network and on the other hand the training vectors (input layer) of dimension n . The elements of these two layers are fully connected and the training set is mapped into a two-dimensional lattice (Kohonen, 1989).

Methodology

This methodological proposal is based on Knowledge Discovery in Databases (KDD) system, which is built up of a set of stages (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). Figure 1 shows the main stages of KDD methodology, especially Data Mining and its three main grouped tasks (execution, analysis and model refining) regarding clustering model. The execution task is focused on K-Means and SOM clustering approaches, analysis is in charge of fitting the parameterization of clustering algorithms and model refining is committed to the experiment improvement. Then, the next stage (clustering evaluation) is involved in the validation of quality measures and subsequent the interpretation of the (sub-) optimal clustering. Finally, a matrix of prevalence levels for

each feature reflects the weights for both K-Means and SOM approaches. Previously, two interrelated stages have been carried out: Data cleaning and Data transformation. Their tasks are extremely important by tackling the initial dataset to input data to clustering stage.

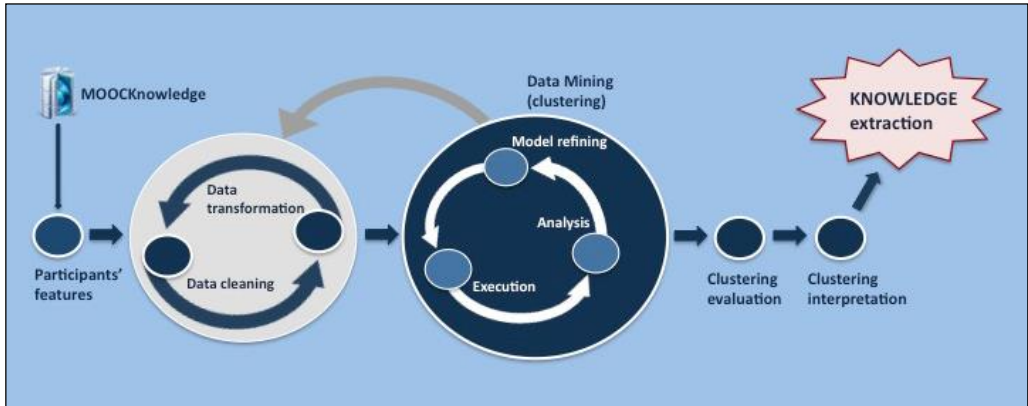


Figure 1. Stages of Knowledge Discovery in Databases (KDD) Process

MOOCKnowledge project conducted an online multilingual survey although for this paper it was only selected a MOOC in the field of personal development that was offered by a Spanish higher education institution and provided by MiriadaX in the autumn of 2014. The number of enrolled population was about 10,000 and the number of fully filled out pre-questionnaires was 715. This is undoubtedly an opportunity for applying K-Means and SOM clustering algorithms with real-world data from hundreds, even thousands of people. Finally, the data sample was made up of the following participants' features:

- Demographics (gender, date of birth is transformed into a new variable identified as age).
- Nationality is transformed into a new variable based on Human Development Index (HDI). This indicator represents a summary measure in three key dimensions (life expectancy, education, income) of human development with four levels (very high, high, medium and low) (Selim, 2015).
- Educational level (pre-primary education, primary education or first stage of basic education, low secondary or second stage of basic education, (upper) secondary education, post-secondary non-tertiary education, first stage of tertiary education, second stage of tertiary education).

- Employment status (employed for wages, self-employed, out of work and looking for work, out of work but not currently looking for employment, student, military, retired, unable to work).
- Previous experience in MOOC format.
- Setting of participants' goals regarding their enrolment in a MOOC (establishment of standards for assignments, establishment of short- and long-term goals, maintenance of high standards in learning, management of temporal planification, confidence in the work quality assurance).
- Importance of the three types of interaction (learner-learner, learner-instructor and learner-content) identified by (Moore, 1989) from participants' perspective.

The interface used in this study is RStudio Version 0.99.491 licensed under the terms of version 3 of the GNU Affero General Public License. Furthermore, R 3.2.3 GUI 1.66 Mavericks build (7060), part of the Free Software Foundation's GNU Project, is the selected environment for performing this study (RStudio Team, 2015).

As a reflection of real-world data, it was needed an additional effort in data cleaning process for dealing with extreme outliers. Most of the fields of a set of records were empty so they were finally rejected in order to deal with a more consistent data exploitation. This study had mixed data types (continuous and categorical) and, consequently, standardization and transformation tasks were performed. The chosen techniques were to apply the Z-score standardization method for continuous data and replace categorical data with binary data. On that point, data sample was ready for a clustering analysis with 657 resulting records.

The number of iterations running K-Means for each method was 120 times and SOM was iteratively performed 480 times. In order to evaluate the quality of K-Means clustering, it was applied an intra-cluster measure and the average Silhouette width, respectively. The chosen K-Means clustering was the one with the minimum intra-cluster value (5,553.208), which matched with Hartigan-Wong's method and $K = 4$. The clustering candidate had a value close to zero (0.09) for average Silhouette width criterion, which revealed it could not be ensured that all participants were properly grouped (a value close to 0 in a range value between -1 and 1) (Nguyen & Rayward-Smith, 2008), although was the highest value of all the implementations. The estimated topographical accuracy and the average distortion measure, which should be minimized and maximized respectively, were the two selected quality measures to evaluate the resulting SOM clustering, with values of 38.136 and 0.98. Both indicators

were referred to what degree the topology reflects the relationships in input data (sample data) (Wehrens & Buydens, 2007). These statistics evaluated clusters without any previous knowledge related to MOOC participants' features and as result it could be chosen the local (sub)-optimal clustering and afterwards extracted the meaningful information about MOOC participants.

Measure criteria were focused on data themselves and evaluated clusters without prior knowledge of MOOC participants. This stage, clustering interpretation, was the process that made possible the extraction of previously unknown knowledge and useful information from a subset of variables from the MOOC pre-questionnaire.

Results and discussions

Due to the heterogeneity of MOOC participants' profiles, there was no knowledge in advance about their number within the specific MOOC of this study. The application of unsupervised clustering techniques allowed the selection of the best of all the resulting clustering from both algorithms with the help of the established quality criteria. All those clusters show to what extent each of the participants' features contributes to the internal structure for the identified MOOC participants' profiles by running K-Means with the method Hartigan-Wong and SOM.

An overview into the different profiles evinced significant similarities between K-Means and SOM approaches in the number of participants, as is shown in Table 1. However, it would be necessary a deeper analysis of the features that comprise the different clusters in order to verify this first impression.

Table 1: Number of participants per profile

Number of participants	Profile 1	Profile 2	Profile 3	Profile 4
K-Means	105	277	48	227
SOM	42	278	120	217

The demographic information (age and gender) and the MOOC experience of participants are shown in Table 2 and Table 3, respectively. The ages of participants varied over a very fairly similar range of weights for the eight clusters. It was highlighted that the maximum age was located in K-Means, while the minimum was in SOM. The weights of gender belong to women and it was noteworthy their greater presence except in S_Profile4, where the majority were men. Finally, regarding the MOOC experience of participants, only a profile, K_Profile3, had an inexplicable

weight at first sight. It could seem that its participants had taken a significant number of courses although, of course, a deeper analysis is required.

Table 2: Demographics and MOOC experience of participants for K-Means clustering

Features	K_Profile1	K_Profile2	K_Profile3	K_Profile4
Age	38	49	40	28
Gender (Female)	0.638	0.635	0.604	0.722
MOOC experience	5	5	24	8

Table 3: Demographics and MOOC experience of participants for SOM clustering

Features	S_Profile1	S_Profile2	S_Profile3	S_Profile4
Age	37	39	42	22
Gender (Female)	0.738	0.669	0.658	0.387
MOOC experience	8	5	6	6

Human Development Index (HDI) had a similar weight for both techniques, although it seemed that in SOM could prevail with the weight very high. In any case, one reason could be that these weights reflect that most participants came from countries mapped with a very high- and high-HDI index. HDI values are shown in Table 4 and Table 5.

Table 4: Matrix of prevalence levels of participants' HDI for K-Means

Feature	K_Profile1	K_Profile2	K_Profile3	K_Profile4
	HIGH	VERY HIGH	HIGH	HIGH
HDI	MEDIUM	LOW	MEDIUM	MEDIUM
	LOW	LOW	LOW	LOW

Table 5: Matrix of prevalence levels of participants' HDI for SOM

Feature	S_Profile1	S_Profile2	S_Profile3	S_Profile4
	VERY HIGH	VERY HIGH	VERY HIGH	HIGH
HDI	LOW	MEDIUM	LOW	LOW
	LOW	LOW	LOW	LOW

For the purpose of making a preliminary analysis, each of features' weights that contributed to shape those eight profiles set above (Table 1) were mapped to very high, high, medium and low values. These new tables, called matrix of prevalence levels, are shown in Table 6, Table 8, Table 10, Table 12 for K-Means and Table 7, Table 9, Table 11, Table 13 for SOM.

Among the items that make up the educational level feature of a participant, the only one with a predominant weight was Second stage of tertiary education for both

clustering. This variable had a high or very high prevalence weight for all profiles except for one on SOM clustering. Participants’ educational level values are shown in Table 6 and Table 7.

Table 6: Matrix of prevalence levels of participants’ educational level for K-Means

Feature	K_Profile1	K_Profile2	K_Profile3	K_Profile4	
educational level	Pre-primary education	LOW	LOW	LOW	LOW
	Primary education or first stage of basic education	LOW	LOW	LOW	LOW
	Lower secondary or second stage of basic education	LOW	LOW	LOW	LOW
	(Upper) secondary education	LOW	LOW	LOW	LOW
	Post-secondary non-tertiary education	LOW	LOW	LOW	LOW
	First stage of tertiary education	LOW	LOW	LOW	LOW
	Second stage of tertiary education	HIGH	HIGH	HIGH	HIGH

Table 7: Matrix of prevalence levels of participants’ educational level for SOM

Feature	S_Profile1	S_Profile2	S_Profile3	S_Profile4	
educational level	Pre-primary education	LOW	LOW	LOW	LOW
	Primary education or first stage of basic education	LOW	LOW	LOW	LOW
	Lower secondary or second stage of basic education	LOW	LOW	LOW	LOW
	(Upper) secondary education	LOW	LOW	LOW	LOW
	Post-secondary non-tertiary education	LOW	LOW	LOW	LOW
	First stage of tertiary education	MEDIUM	LOW	LOW	LOW
	Second stage of tertiary education	VERY HIGH	VERY HIGH	VERY HIGH	MEDIUM

The items student and employed for wages had high prevalence in K-Means on K_Profile4 and K_Profile2 respectively. It stood out that it could characterize young students on K_Profile4 a high student’s weight combined with the fact that the average age was 28 years, although it would be needed further analysis in order to verify this hypothesis. K_Profile2 showed the same circumstance with the element employed for wages and the average age 49 years that could characterize middle age employed people. The weight of element employed for wage in SOM has similar values for the four profiles. The element out of work and looking for work had the same weight for six of the eight profiles, except for a low value and a medium value for K_Profile3 and S_Profile3, respectively. Participants’ employment status values are shown in Table 8 and Table 9.

Table 8: Matrix of prevalence levels of participants’ employment status for K-Means

Feature	K_Profile1	K_Profile2	K_Profile3	K_Profile4	
employment status	homemaker	LOW	LOW	LOW	LOW
	student	LOW	LOW	LOW	HIGH
	employed for wages	MEDIUM	HIGH	MEDIUM	LOW
	out of work and looking for work	MEDIUM	MEDIUM	LOW	LOW
	out of work but not currently looking for wages	LOW	LOW	LOW	LOW
	retired	LOW	LOW	LOW	LOW
	self-employed	LOW	LOW	LOW	LOW
	unable to work	LOW	LOW	LOW	LOW

Table 9: Matrix of prevalence levels of participants’ employment status for SOM

Feature	S_Profile1	S_Profile2	S_Profile3	S_Profile4	
employment status	homemaker	LOW	LOW	LOW	LOW
	student	MEDIUM	MEDIUM	MEDIUM	LOW
	employed for wages	MEDIUM	MEDIUM	MEDIUM	MEDIUM
	out of work and looking for work	MEDIUM	MEDIUM	MEDIUM	LOW
	out of work but not currently looking for wages	LOW	LOW	LOW	LOW
	retired	LOW	LOW	LOW	LOW
	self-employed	LOW	LOW	LOW	LOW
	unable to work	LOW	LOW	LOW	LOW

One of the most interesting features for this study was the setting of participant’s goals because of its specific distribution of the weights on every cluster. K-Means preserved the same prevalence in each of the profiles, although K_Profile1 attracted the attention with its very high weight to all and each of the five elements. SOM had a quasi-identical circumstance in terms of profiles’ behaviour, although all their weights had equal or lower prevalence. Participants that belonged to S_Profile1 had the highest prevalence with a high value to the element participant’s confidence in the quality assurance of their work. The rest of the weights were uniform in each of the profiles. Therefore, this feature should be analysed in a more detailed way. Participants’ goals values are shown in Table 10 and Table 11.

Table 10: Matrix of prevalence levels of participants’ goals for K-Means

Feature	K_Profile1	K_Profile2	K_Profile3	K_Profile4	
goals setting	standards establishment	VERY HIGH	MEDIUM	MEDIUM	MEDIUM
	short- and long-term goals establishment	VERY HIGH	MEDIUM	MEDIUM	MEDIUM
	high standards maintenance	VERY HIGH	MEDIUM	MEDIUM	MEDIUM
	temporal planification management	VERY HIGH	MEDIUM	MEDIUM	MEDIUM
	confidence in work quality assurance	VERY HIGH	MEDIUM	MEDIUM	MEDIUM

Table 11: Matrix of prevalence levels of participants' goals for SOM

Feature	S_Profile1	S_Profile2	S_Profile3	S_Profile4
goals setting standards establishment	MEDIUM	MEDIUM	MEDIUM	LOW
goals setting short- and long-term goals establishment	MEDIUM	MEDIUM	MEDIUM	LOW
goals setting high standards maintenance	MEDIUM	MEDIUM	MEDIUM	LOW
goals setting temporal planification management	MEDIUM	MEDIUM	MEDIUM	LOW
goals setting confidence in work quality assurance	HIGH	MEDIUM	MEDIUM	LOW

Focused on the three types of interaction, on K-Means clustering the range of weights took values from very high to medium. On the other hand, the range of weights in SOM was from high to low. In K-Means, Learner-Content interaction was the element with a very high prevalence on K_Profile1 and a high value for K_Profile2 and K_Profile3. Learner-content interaction in SOM was depicted with a high weight except for a medium prevalence for S_Profile4. Learner-learner interaction was the least representative interaction for the eight clusters and, finally, Learner-teacher interaction did not show such a regular behaviour as the other two characteristics described above. Undoubtedly, the three interactions played their role in each and every one of the profiles, even on those where the prevalence was low, and also a deeper analysis should be accomplished. The values for the three types of interactions are shown in Table 12 and Table 13.

Table 12: Matrix of prevalence levels of types of interactions of participants for K-Means

Feature	K_Profile1	K_Profile2	K_Profile3	K_Profile4
interaction learner-learner	MEDIUM	MEDIUM	MEDIUM	MEDIUM
interaction learner-content	VERY HIGH	HIGH	HIGH	MEDIUM
interaction learner-teacher	HIGH	MEDIUM	MEDIUM	MEDIUM

Table 13: Matrix of prevalence levels of types of interactions of participants for SOM

Feature	S_Profile1	S_Profile2	S_Profile3	S_Profile4
interaction learner-learner	MEDIUM	MEDIUM	MEDIUM	LOW
interaction learner-content	HIGH	HIGH	HIGH	MEDIUM
interaction learner-teacher	HIGH	MEDIUM	HIGH	LOW

The above comparative of participants' features does not allow a generalization of the partial results to the whole data collection because this study represents a preliminary stage that requires both an additional analysis of resulting clustering and the help of an expert that guides and contextualizes the interpretation process for both approaches (K-Means and SOM) and finally determines which one is closer to the real picture of MOOC participants.

In conclusion, the results bring to light that it is not possible to determine the best clustering without additional analysis.

Conclusions

In this study it was chosen two types of algorithms from two different approaches, a partitional clustering algorithm and an artificial neural network. The comparison of K-Means (Lloyd, Forgy, MacQueen, and Hartigan-Wong) and SOM was performed with the aim of finding out which of them fitted better. These clustering techniques were applied under some specific conditions to an enhanced understanding of a subset of features of participants in a MOOC in the field of personal development. They definitely might represent a way of discovering the intrinsic structure of data sample and, consequently, designers and other policy-makers could also have a deeper knowledge of the diversity of participants' profiles. It should be emphasized that the role played by experts in MOOC format has a critical subjective component and their relevance is even greater because the results of clustering are largely influenced by data sample, the selected variables and the clustering algorithm used.

As conclusion, therefore, it can be said that the results bring to light that it is not possible to determine which one is the best clustering (K-Means and SOM) without an additional analysis where the role of MOOC experts is more than relevant.

A more realistic understanding of people profiles is a step forward for many disciplines that call for a more in-depth knowledge of their customers and Open Education is no exception. Therefore, future work in the short to medium term involves a deeper research of clustering techniques and KDD methodology, especially evaluation and interpretation clustering stages, with the involvement of the whole MOOC Knowledge data collection.

References

1. Chen, G., Jaradat, S., Banerjee, N., Tanaka, T., Ko, M., & Zhang, M. (2002). Evaluation and comparison of clustering algorithms in analyzing ES cell gene expression data. *Statistica Sinica*, 12, 241–262. Retrieved from <http://www3.stat.sinica.edu.tw/statistica/oldpdf/A12n112.pdf>
2. Commission of the European Communities. (2001). *Making a European Area of Lifelong Learning a Reality* (No. COM(2001) 678 final). Brussels.
3. Deligiorgi, D., Philippopoulos, K., & Kouroupetroglou, G. (2014). An Assessment of Self-Organizing Maps and k-means Clustering Approaches for Atmospheric

Circulation Classification. *Proceedings of the 2014 International Conference on Environmental, Venice, Italy*, Vol. 17, 17–23.

4. Farías, R., Durán, E. B., & Figueroa, S. G. (2008). *Las Técnicas de Clustering en la Personalización de Sistemas de e-Learning*. Paper presented at the XIV Congreso Argentino de Ciencias de la Computación. Retrieved from http://sedici.unlp.edu.ar/bitstream/handle/10915/21990/Documento_completo.pdf?sequence=1
5. Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P. (1996). From data mining to knowledge discovery in databases. *American Association for Artificial Intelligence*, 17(3), 37–54. Retrieved from <http://www.csd.uwo.ca/faculty/ling/cs435/fayyad.pdf>
6. Forgy, E. W. (1965). Clustering analysis of multivariate data: efficiency versus interpretability of classifications. *Biometrics*, 21, 768–769.
7. Hartigan, J. A. & Wong, M. A. (1979). A k-means clustering algorithm. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 28(1), 100–108. Retrieved from http://www.labri.fr/perso/bpinaud/userfiles/downloads/hartigan_1979_kmeans.pdf
8. Hertz, J., Krogh, A., & Palmer, R. G. (1991). *Introduction to the Theory of Neural Computation*. Santa Fe Institute Studies in the Sciences of Complexity lecture notes. Redwood City, CA: Addison-Wesley Longman: Basic Books. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.35.978&rep=rep1&type=pdf>
9. Jain, A. K., Murty, M. N., & Flynn, P. J. (1999). Data Clustering: A Review. *ACM Computing Surveys (CSUR)*, 31(3), 264–323. Retrieved from <https://www.cs.rutgers.edu/~mlittman/courses/lightai03/jain99data.pdf>
10. Kalz, M., Kreijns, K., Wahlout, J., Castaño Muñoz, J., Espasa, A., & Tovar, E. (2015). Setting-up a European Cross-Provider Data Collection on Open Online Courses. *International Review of Research in Open and Distributed Learning*, 16(6), 62–77. Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/2150/3553>
11. Kohonen, T. (1989). *Self-Organization and Associative Memory* (3rd ed.). New York, NY: Springer-Verlag.

12. Liyanagunawardena, T., Adams, A. A., & Williams, S. A. (2013). MOOCs: A systematic study of the published literature 2008-2012. *The International Review of Research in Open and Distributed Learning*, 14(3), 202–227. Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/1455/2602>
13. Lloyd, S. P. (1982). Least squares quantization in PCM. Technical Note, Bell Laboratories. *IEEE Transactions on Information Theory*, 28(2), 128–137. Retrieved from <http://www.cs.nyu.edu/~roweis/csc2515-2006/readings/lloyd57.pdf>
14. MacQueen, J. (1967). Some methods for classification and analysis of multivariate observations. *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*, University of California, Berkeley, Calif., 281–297. Retrieved from https://projecteuclid.org/download/pdf_1/euclid.bsm/1200512992
15. Moore, M. (1989). Three Types of Interaction. *American Journal of Distance Education*, 3(2), 1–7. Retrieved from http://aris.teluq.quebec.ca/portals/598/t3_moore1989.pdf
16. Nguyen, Q. H., & Rayward-Smith, V. J. (2008). Internal quality measures for clustering in metric spaces. *International Journal of Business Intelligence and Data Mining*, 3(1), 4–29. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?rep=rep1&type=pdf&doi=10.1.1.205.5025>
17. RStudio Team. (2015). *RStudio: Integrated Development for R*. Boston, MA: RStudio, Inc. Retrieved from <http://www.rstudio.com>
18. Selim, J. (2015). *Human Development report 2015*. Work for Human Development. selim - Google Académico. New York, NY: United Nations Development Programme (UNDP). Retrieved from http://hdr.undp.org/sites/default/files/2015_human_development_report_1.pdf
19. UNESCO. (2012). *2012 PARIS OER DECLARATION*. Presented at the 2012 WORLD OPEN EDUCATIONAL RESOURCES (OER) CONGRESS, Paris.
20. Wehrens, R., & Buydens, L. M. (2007). Self-and super-organizing maps in R: the Kohonen package. *Journal of Statistical Software*, 21(5), 1–19. Retrieved from <http://www.jstatsoft.org/v21/i05/paper>

Acknowledgement

This work has been partially funded by a tender (JRC/SVQ/2013/J.3/0035/NC) of the European Commission's Institute for Prospective Technological Studies (IPTS) and by Regional Government of Madrid (eMadrid S2013/ICE-2715).

How Do Faculty Members React Towards the Use of Personal Mobile Devices by Students in the Classroom?

*Hagit Meishar-Tal, Holon Institute of Technology (HIT),
Alona Forkosh-Baruch, Levinsky College, Israel*

Introduction

In recent years a growing number of students use mobile technologies in classes, e.g. laptops, tablets of all sorts or smartphones; these are used as substitutes to the traditional means of taking notes in class (Kurtz & Meishar-Tal, 2015). Usage of mobile technological means in class enables several advantages to students, such as immediate knowledge organization, access to online information that supports in-class learning, or student communication. These may empower and support the learning process altogether (Sharples, 2000).

This new situation is beneficial for the institute itself: the fact that students arrive with personal mobile devices to class saves a vast amount of resources as an alternative to expenses for the construction of computer labs and their maintenance. In fact, this new situation turns all spaces within the organization into potentially capable of becoming ICT-saturated zones (Emery, 2012; Hamza & Noordin, 2013; Nykvist, 2012).

For faculty, this may serve as an advantage, since students' accessibility to online information via mobile technologies enables lecturers' usage of these devices in their lessons, thereby creating interest and a variety of learning modes, as well as allowing constructivist pedagogy and active learning (Campbell & Pargas, 2003; Meisha-Tal, 2014).

The literature presents several examples for effective usage of mobile devices for in-class learning, e.g. active learning through interactive surveys (Kohen-Vacs et al., 2012), or using the built-in camera in some mobile devices as well as the microphone and recording devices for documenting learning processes (Benedict & Pence, 2012; Zadok & Meishar-Tal, 2014). Research shows that the implementation of mobile technologies within learning processes by faculty has positive influence on motivation

for learning (Rau, Gao & Wu, 2008), as well as on the level of active learning in the lessons (Barak et al. 2006; Melton & Kendall, 2012).

Aside of the advantages of using mobile technologies in class, some disadvantages can be identified as well. The main drawback is the distraction issue: mobile technologies distract the students by creating diversions from the main course of the lesson and creating temptations for students (Barkhuus, 2005; Gehlen Baum & Weinberger, 2012). In a study that examined uses of mobile technologies in lessons, findings suggest that these not only do not contribute to the learning process, but may also harm or hinder it (Fried, 2008). The reason for this finding is the possible difficulty in carrying out multiple cognitive tasks simultaneously (multi-tasking) (Kraushaar & Novak, 2010).

Hence, it is not surprising that many faculty members in higher education hold negative attitudes towards students using mobile devices in their lessons. They see students' uses of these devices as a nuisance, since they pose a competition for their students' attention. Students using mobile devices in the lesson are considered by their lecturers as rude and a distraction to themselves and to others (Baker et al. 2012). Several faculty members perceive usage of mobile technologies as contributing to superficial learning and damaging the teacher-student dynamics that is created within the lesson (Handal et al., 2013).

The goal of this study is to examine how teacher educators cope with students bringing mobile devices into lessons, in a situation that lacks an overt policy regarding this phenomenon (e.g. is bringing these devices allowed or forbidden, is using them in lessons allowed etc.). We were interested in whether teacher educators initiate incorporation of mobile devices in their lessons, if they forbid usage of these devices, or if they are indifferent regarding the phenomenon and do not interfere in their students' behaviour regarding the utilization of mobile technologies in their lessons.

Research questions

1. How do teacher educators perceive the usage of mobile devices by students in class?
2. How and to what extent do teacher educators react to the usage of mobile devices by students in class?
3. What is the connection between teacher educators' perception regarding students' usage of mobile devices and their reaction de facto to these uses?

4. What is the connection between teacher educators' perception regarding students' usage of mobile devices and their acquaintance with possible uses of these devices?

Method

The study was conducted using a quantitative method. A questionnaire was distributed among faculty members of two academic colleges of education. The questionnaire contained five parts: the first part included demographic information (e.g. gender, age); the second part focused on the usage frequency of mobile devices in classes (including laptops, smartphones and tablets); the third part focused on perceptions regarding uses of mobile technology in classes; the fourth part focused on the reactions of teacher educators towards uses of mobile technology in classes, and finally, respondents were requested to grade their acquaintance with implementing mobile technologies and applications to enhance their students' learning.

Respondents included 152 teacher educators from two academic colleges of education, 86 from one college and 66 from the other college; of these, 121 were female and 31 men. Age range was 33-70 (\bar{x} =50.4), average years of teaching \bar{x} =21.36, average years of teaching in the college \bar{x} =9.3. Respondents reported an average of ICT competencies of \bar{x} =4 on a 1-5 Likert scale. The questionnaire was analyzed statistically, and teacher educators' attitudes and reactions towards students' uses of mobile technologies in lessons were examined.

Results

Findings show that the most common device among students, according to faculty assessment, is the smartphone. Laptops and tablets were evaluated as less widespread among students, but still available to some students (Table 1).

Table 1: Students' inventory of mobile devices, according to faculty perceptions (N=141)

Type of device	Estimation of mobile devices available for students by faculty	SD
Smartphones	4.48	.81
Laptops	1.88	.78
Tablets/iPads	1.44	.72

Q1: How do teacher educators perceive the usage of mobile devices by students in classes?

The research tool included a question with 18 items referring to faculty attitudes towards usage of mobile technologies, divided into 4 categories: advantages for

students, disadvantages for students, advantages for faculty, disadvantages for faculty. The average of each category was computed, representing each category (Table 2).

Findings show that the average ranking of perceived advantages is significantly higher than that of the perceived disadvantages of using mobile technologies, regarding usage of mobile devices, with regards to faculty, with $t(151) = 9.801$ with $p < 0.001$, as well as students, with $t(151) = 12.798$ with $p < 0.001$. As for perceived disadvantages in using mobile technologies in classes, disadvantages for students were perceived as higher than disadvantages for faculty.

Table 2: Faculty perceptions regarding the advantages and disadvantages of using mobile technologies in classes (N=152)

Categories of perception	Average	SD
Advantages for students	3.50	.92
Advantages for teacher educators	3.49	.90
Disadvantages for students	2.89	.97
Disadvantages for teacher educators	2.30	.94

The complexity of faculty perceptions regarding student usage of mobile devices in classes was also evident in open-ended questions in which respondents were requested to explain their attitudes towards usage of mobile devices. One of the teacher educators wrote: "It's complicated. On one hand, I think that you should allow uses for learning purposes. On the other hand, students do not follow the rules, and enter social networking sites instead, and this interferes with the learning." Another lecturer wrote: "As you may have noticed, my responses supposedly contradict. I think that laptops can be used in classes and that they promote learning. On the other hand, they also pose a major diversion. A lot depends on the students' level of maturity, if the lesson is great; otherwise they will not be involved at all."

Q2: How and to what extent do teacher educators respond to usage of mobile devices in classes?

The research tools included a question containing 8 items describing possible reactions of faculty towards students' uses of mobile technologies in classes. These were divided into 3 categories: Proactive response, Preventive response, Indifference.

According to the highest average computed for each respondent, they were assigned to one of the three groups/categories. Findings show that most teacher educators (64%) do not exhibit an active response, but rather respond indifferently, about one third (30%) reported active and initiative responses that reflect encouragement of students

in using mobile devices and even initiating activities; the remaining 15% claimed that they prevent usage of mobile devices in classes.

Q3: What is the connection between faculty perceptions regarding usage of mobile devices by students in class and their responses to these uses?

Findings reveal a significant correlation between a preventive mode of reaction and perceptions of perceived disadvantages of mobile technologies usage in class, as well as a significant negative correlation between avoidance and perceptions of the advantages of using mobile technologies in classes, that is, the more the perceptions of disadvantages is higher, the more reactions of prevention are displayed, and the more the perceptions of advantages is higher, the less reactions of prevention are displayed (Table 3).

Table 3: Correlations between faculty perceptions regarding students' usage of mobile technologies in classes and their reaction towards usage de-facto (N=152)

	Preventive	Indifference	Proactive
Perceived disadvantages for teacher educators	.486**	-.301**	-.390**
Perceived disadvantages for students	.483**	-.284**	-.481**
Perceived advantages for teacher educators	-.379**	.287**	.612**
Perceived advantages for students	-.424**	.313**	.652**

Notwithstanding, as for proactive indifference and reactions, they are in direct relationship with perceptions of the advantages in using mobile devices in class, but in reverse relationship with the perceptions of disadvantages in using mobile devices in class. The strength of the correlation is especially strong between proactive reactions of teacher educators and perception of the possible advantages for students and teacher educators in using mobile technologies: $r=.652$ and $r=.612$ respectively.

Q4: What is the connection between faculty acquaintance with mobile technology usage in class and attitudes towards using mobile devices by students and their reaction to this usage?

We examined whether the degree of faculty knowledge of mobile technology usage in class is connected with their perceptions regarding usage of mobile devices by students. For this purpose, teacher educators were presented with several possibilities of usage, and were requested to grade their familiarity with each of them on a 1-5 Likert scale. Table 4 presents teacher educators' knowledge of possible uses of mobile devices.

Table 4: Level of teacher educators' knowledge of possible uses of mobile devices for learning (N=152)

	Average	SD
Information source	4.03	1.17
Computerized learning environments	3.23	1.35
Digital learning products/outcomes	3.05	1.46
Collaborative tools	2.95	1.44
Educational forums	2.91	1.48
Online surveys	2.49	1.42
Social networking sites	2.39	1.38
Documentation of learning processes	2.16	1.41
Location-based information	2.07	1.31
Writing and documenting apps	1.76	1.17
Augmented reality	1.63	1.12
Measurement and inquiry apps	1.62	1.09

The data highlights that the degree of faculty knowledge regarding possible uses of mobile technologies in class differs according to its utilization. Basic uses, e.g. searching for information and computerized learning environments are familiar to teacher educators to a greater extent, however, more advanced possibilities, e.g. collaborative tools, online surveys and documentation tools for the learning process (for example, Evernote) are less familiar.

Based on faculty grading of the possible uses of mobile technology in education, we computed a new measure: familiarity with uses of mobile technologies ($\alpha=.915$), which is the average grading of all uses per lecturer. In addition, Pearson's correlations were computed for between this measure and perceptions regarding uses of mobile technologies. Findings are presented in table 5.

Table 5: Correlation between level of acquaintance with mobile technology uses for learning and perception of advantages and disadvantages of its incorporation in class (N=152)

	Perception of advantages for teacher educators	Perception of disadvantages for teacher educators	Perception of advantages for students	Perception of disadvantages for students
level of acquaintance with mobile tech. uses	.418**	-.318**	.382**	-.346**

Data shows that positive attitudes towards mobile technologies (including advantages for faculty as well as students) are significantly correlated with the level of

acquaintance with mobile technology uses. Respectively, negative attitudes towards mobile technologies are significantly but negatively correlated with the level of acquaintance with mobile technology uses.

In addition, we examined the correlations between the level of acquaintance with mobile technology uses and faculty reactions to students' uses of these devices. Findings show that there are significant correlations between acquaintance with mobile technology uses and two reactions: the preventive and proactive modes (-.231** and .514** respectively); that is, a positive significant correlation between knowledge regarding uses of mobile technology in classes and the proactive response mode, and a negative significant correlation with the preventive reaction mode. As for the indifference reaction – no correlation was found. Therefore, we can state that the more teacher educators know what to do with mobile technologies in their classes, the more they display a proactive mode of response, and the less they display a preventive mode.

Discussion

The goal of the current study is to examine the perceptions and reactions of faculty to students' use of mobile technologies in classes. Findings show that in spite of the growing scope of mobile devices (mostly smartphones, but also laptops and tablets) the initiated usage by faculty is not as widespread respectively. Most teacher educators do not respond to the perceived change in the noticeable change in availability of mobile devices for students. They do not change the course of the lesson and do not adapt it to the new possibilities posed by these new technologies. However, most of them do not prevent the students from using these means in a spontaneous and informal mode. The possible reason for this may faculty's mixed attitudes towards mobile technologies: on one hand, they acknowledge the advantages in using these devices in the lessons, but on the other hand they are also aware of the disadvantages in using it.

Another reason that faculty do not respond to the change in their classes is the fact that most teacher educators lack the knowledge regarding the utilization of mobile technologies in effectively in class. They report that their knowledge of the different possible uses of mobile devices in class is mediocre at best in most categories. The only use familiar to most teacher educators is search of information on the Internet. This may explain why in spite of the fact that faculty acknowledge the advantages of using mobile technologies in class, they do not initiate these uses.

This explanation is supported by the finding that indicates a correlation between the rates of faculty exposure and the perceived benefits in using mobile technologies and the variety of its possible uses. Findings show that the more exposure rates of faculty are higher and the more they are knowledgeable regarding usage of mobile technologies in learning, the more they initiate its usage and the less resistance is exhibited in the form of preventing its use by students in classes. Hence, in order to promote faculty positive attitudes towards mobile technologies, they should be exposed to their various uses and trained to utilize them effectively in their classes (Zadok & Meishar-Tal, 2014).

As for the transferability of the current study, it was conducted in two colleges in which the current scope of mobile devices was relatively low. Hence, further large-scale studies in additional colleges may allow us to receive a larger perspective regarding informal usage of mobile devices in higher education altogether. It will also enable us to examine differences in faculty reaction based on the scope and availability of the devices in classes.

References

1. Baker, W. M., Lusk, E. J., & Neuhauser, K. L. (2012). On the use of cell phones and other electronic devices in the classroom: Evidence from a survey of faculty and students. *Journal of Education for Business*, 87(5), 275-289.
2. Barak, M., Lipson, A., & Lerman, S. (2006). Wireless laptops as means for promoting active learning in large lecture halls. *Journal of Research on Technology in Education*, 38(3), 245.
3. Barkhuus, L. (2005). Bring your own laptop unless you want to follow the lecture: Alternative communication in the classroom. *Proceedings of the 2005 international ACM SIGGROUP conference on supporting group work*, 140-143.
4. Benedict, L., & Pence, H. E. (2012). Teaching chemistry using student-created videos and photo blogs accessed with smartphones and two-dimensional barcodes. *Journal of Chemical Education*, 89(4), 492-496.
5. Campbell, A. B., & Pargas, R. P. (2003). Laptops in the classroom. *ACM SIGCSE Bulletin*, 35(1), 98-102.
6. Dahlstrom, E. (2012). *Consummation of information technology/BYOD*. ECAR Study of Undergraduate Students and Information Technology.

7. Davis, N., Eickelmann, B. & Zaka, P. (2013). Restructuring of educational systems in the digital age from a co-evolutionary perspective. *Journal of Computer Assisted Learning*, 29(5), 438–450.
8. Emery, S. (2012). *Factors for Consideration when Developing a Bring Your Own Device (BYOD) Strategy in Higher Education*. Retrieved June 6, 2015 from <http://wp.vcu.edu/assistivetechlogy/wp-content/uploads/sites/1864/2013/09/Emery2012.pdf>
9. Foulger, T. S., Waker, M. L., Burke, D., Hansen, R., Williams, M. K., & Slykhuis, D. A. (2013). Innovators in Teacher Education. *Journal of Digital Learning in Teacher Education*, 30(1), 21-29.
10. Fried, C. B. (2008). In-class laptop use and its effects on student learning. *Computers & Education*, 50(3), 906–914.
11. Gehlen-Baum, V., & Weinberger, A. (2012). Notebook or Facebook? How students actually use mobile devices in large lectures. In A. Ravenscroft et al. (Eds.), *EC-TEL 2012, LNCS 7563* (pp. 103-112). Berlin: Springer-Verlag.
12. Geist, E. (2011). The game changer: Using iPads in college teacher education classes. *College Student Journal*, 45(4), 758.
13. Hamza, A. and Noordin, M.F. (2013) BYOD Usage by Postgraduate Students of International Islamic University Malaysia: An Analysis. *International Journal of Engineering Science Invention*, 2(4), 14-20.
14. Handal, B., MacNish, J., & Petocz, P. (2013). Adopting Mobile Learning in Tertiary Environments: Instructional, Curricular and Organizational Matters. *Education Sciences*, 3, 359-374.
15. Kohen-Vacs, D., Ronen, M., & Bar-Ness, O. (2012). Integrating SMS Components into CSCL Scripts. *Proceedings of the Wireless, Mobile and Ubiquitous Technology in Education (WMUTE), 2012 IEEE Seventh International Conference*, 107-111. IEEE.
16. Kraushaar, J. M., & Novak, D. C. (2010). Examining the Effects of Student Multitasking with Laptops during the Lecture. *Journal of Information Systems Education*, 21(2), 241-251.
17. Lai, K. W., Khaddage, F., & Knezek, G. (2013). Blending student technology experiences in formal and informal learning. *Journal of computer assisted learning*, 29(5), 414-425.

18. Meishar-Tal, H. M. (2014). Designing mobile learning activities for outdoor learning. *Proceedings of the 1st International Conference on the use of iPads in Higher Education – ihe 2014, Paphos, Cyprus*.
19. Meishar-Tal, H. M., & Kurtz, G. (2015). The Laptop, the Tablet, and the Smartphone Attend Lectures. In J. Keengwe (Ed.), *Promoting Active Learning through the Integration of Mobile and Ubiquitous Technologies* (pp. 183-193). Hershey, PA: Information Science Reference. doi:10.4018/978-1-4666-6343-5.ch011
20. Melton, R., & Kendall, N. (2012). The Impact of Mobilization in Higher Education. *The global eLearning Journal*, 1(4).
21. Nykvist, S. S. (2012). The trials and tribulations of a BYOD science classroom. *Proceedings of the 2nd International STEM in Education Conference, Beijing Normal University*, 331-334.
22. O'Bannon, B. W., & Thomas, K. (2014). Teacher perceptions of using mobile phones in the classroom: Age matters! *Computers & Education*, 74, 15-25.
23. Rau, P., Gao, Q., & Wu, L. (2008). Using Mobile Communication Technology in High School Education: Motivation, Pressure, and Learning Performance. *Computers & Education*, 50, 1-22. Doi: 10.1016/j.compu.2006.03.008
24. Schaal, S., Grübmeier, S., & Matt, M. (2012). Outdoors and Online-inquiry with mobile devices in pre-service science teacher education. *World Journal on Educational Technology*, 4(2), 113-125.
25. Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers and Education*, 34, 177-193.

Acknowledgement

This study was funded by the MOFET institute research fund.

Best of EDEN 2016

**Special Issue of the
European Journal of Open, Distance and E-Learning**



The best research papers presented
at the 9th EDEN Research Workshop, 2016 October, Oldenburg

Edited by
Ulrich Bernath, András Szűcs

European Distance and E-Learning Network, 2018
in collaboration with the
Ulrich Bernath Foundation for Research in Open and Distance Learning

Members of the Jury for the EDEN Best Practice Award at the 9th EDEN Research Workshop in Oldenburg

Dianne Conrad, Chair of the Jury, Centre for Distance Education, Athabasca University, Canada;
Co-editor, International Review of Open and Distributed Learning (IRRODL)

Airina Volungeviciene, Director of Innovative Studies Institute, Vytautas Magnus University, Lithuania;
President of EDEN

Som Naidu, Monash University, Australia; Executive Editor, Distance Education;
President of Open and Distance Learning Association of Australia (ODLAA)

Ulrich Bernath, Trustee and Chair of the Board of Directors of the Ulrich Bernath Foundation for
Research in Open and Distance Learning, Germany

Use of MOOCs in Traditional Classroom: Blended Learning Approach

Antonia Bralić, Blaženka Divjak, Faculty of Organization and Informatics, University of Zagreb, Croatia

Best Research Paper Award Winner

Abstract

MOOCs were initially designed as stand-alone products but blended learning programs have been developed to utilize the benefits of MOOCs. This paper presents case study research of incorporating a MOOC into traditionally delivered course with specific goals of giving students opportunity to experience learning in virtual environment and helping part-time students in achieving particular learning outcomes. Benefits and obstacles of such an effort were researched in a case study where part of the traditionally delivered learning was replaced with a MOOC at a compulsory graduate level course. Students were asked to choose between completing a MOOC and taking project-based activity to work towards the final grade. While going through the MOOC, it was required from students to keep a *learning diary* to showcase the understanding of the content but also to provide insight for qualitative analysis based on a set of questions that the students were required to answer. The case study research was based on qualitative analysis of the learning diaries and on quantitative review of achieved results. Qualitative analysis of the answers to open ended questions showed that students' overall feedback has been positive. Students were generally satisfied with this form of learning, despite some difficulties, such as language barrier or sufficient prior knowledge or required workload. Most appreciated characteristics of MOOCs were self-paced learning and the option to assess knowledge on regular basis, especially among part-time students.

Introduction

Growing popularity of Massive Open Online Courses (MOOCs) is indisputable. Morris (2014) for example states that "MOOCs are available to students to supplement their learning and personalized learning environments, and use of learning analytics are set to transform education". Until today, different options of integrating MOOCs

in formal education have been explored, implemented, and evaluated. Two main types of embedding MOOCs in traditional taught classes to achieve learning outcomes have been noted: (a) recognizing results achieved in MOOCs before enrolling in a learning program (prior learning) and (b) supplementing or replacing segments of academic courses with content from MOOCs. Variety and availability of MOOCs have been a strong encouragement for both cases. This paper focuses on the latter. Goal is to enhance learning processes and ultimately, increase retention of acquired knowledge and engage learners. This method of teaching has advantages and challenges, as discovered in previous research. A right blend should take best of offline and online learning to create a system that enable students to achieve learning goals in the best possible way.

Many blended learning programs in academic setting today are created around traditional courses that are now enriched with online content and capabilities. Blended learning program can be built with any online content, not necessarily MOOC content. There are multiple benefits of incorporating MOOCs in traditionally taught courses. Griffiths, Mulhern, Spies, and Chingos (2015) study generated six of them: “replaying lectures, augmenting or replacing secondary materials, filling gaps in expertise, exposing students to other styles of teaching and class discussion, reinforcing key skills, and teaching students how to teach online”. Series of authors claim that blended learning approach can enhance teaching and learning, for example (Morris, 2014; Gilbert & Flores-Zambada, 2011). Several attributes characteristic for blended learning agenda at some institutions were detected by (Sharpe, Benfield, Roberts, & Francis, 2006): “flexibility of provision, supporting diversity, enhancing the campus experience, operating in a global context and efficiency”, which can also be translated to benefits of programs like this. Often mentioned downside of MOOCs is low completion rate. Koller, Ng, Do, and Chen (2013) coin the term *retention funnel* and state that high dropout rates in MOOCs can be alarming for traditional educators. Embedding MOOCs in traditional face to face (f2f) classes by assigning credit to its partial or full completion could partly solve drop out problem. One student that participated in the covered case study in this paper stated that she “used MOOCs earlier to supplement the classroom learning but due to university related commitments she was not able to complete MOOCs. That is why incorporating a MOOC in classroom taught courses so its completion counts towards the final grade is a great motivator”. Computer literacy and technology acceptance are general challenges of online learning that need to be kept in mind. Israel (2015) emphasizes that integrating a course that is not designed to be a part of a blended learning

program, holds its challenges, such as ensuring student engagement. Having benefits and challenges of MOOCs in mind, it has become clear that a proper blend of online and classroom activities has to be created to achieve success among a targeted student audience.

Series of studies and experiments have been conducted to trial and evaluate the use of MOOCs in traditional taught courses. Griffiths et al. (2015) have conducted a study to “examine the use of MOOCs in fourteen campus-based courses”. No statistical difference in pass rate or final score was registered in those studies, but feedback covering rating, interest, amount learned, and difficulty was better for traditional taught classes. Further on, blended learning with MOOC content was piloted at San José State University (SJSU), leveraging an edX course in class. Flipped classroom model including projects and quizzes was implemented. This program achieved “a high success rate with 90% of the students passing the final exam, as compared with 55% in the traditional class of the previous year” (Ghadiri, Qayoumi, Junn, Hsu, & Sujitparapitaya, 2013) in (Yousef, Chatti, Schroeder, & Wosnitza, 2015). Israel (2015) reviewed models of blending MOOCs in traditional classroom teaching; major findings were that “there is modest positive impact on learning outcomes, no significant evidence of negative effects for any subgroups of students, and lower levels of student satisfaction are recognized in blended MOOCs in classrooms. A blended learning program has also been experimented at Vanderbilt university as well where Coursera *Machine learning* MOOC was incorporated in a graduate level course on machine learning. MOOC chapters were built in the course, accompanied with additional learning and tasks that were important for the students. Students’ experience was evaluated through a focus group and qualitative analysis. The student feedback was overall positive; students appreciated flexibility, possibility to learn *at their own pace*, and bite sized videos, but also realized that it takes motivation and self-discipline to stay on track. Students did not participate in forums and discussions but described forums as useful to realize the issues other students might have. Students appreciated the flipped classroom model and the possibility to apply what has been learned outside of class. Students were asked to give a rating of the course and the blended approach in 2012 had higher satisfaction score than the traditional taught course in 2006, on these small samples, which needs to be taken into consideration (4.17 and 3.83 respectively) (Bruff, Fisher, McEwen, & Smith, 2013). This model is similar to the one applied at University of Zagreb, Faculty of Organization and Informatics in Croatia (FOI) that is presented in this paper.

Case study and research questions

The course Discrete Mathematics with Graph Theory (DMGT) is taught in the first year of master level of study programs Information Systems and Software Engineering at FOI. It is taught as a blended learning course and both full-time and part-time students are enrolled in the course. The syllabus consists of two parts: in the first part different topics in discrete mathematics are covered and the second half is dedicated to the graph theory and its applications. The topics have sound foundations in mathematical theory but offer multitude of applications of the covered theory in computer science and business, e.g. problem solving exercises that are performed individually or in teams (Divjak, 2015). Incorporation of a MOOC in the course is learning outcomes-based. The constructive alignment for the two learning outcomes (out of 7) for the course DMGT is presented in Table 1. Term “constructive alignment” is coined by John Biggs (2003). In order to guarantee achievement of intended learning outcomes they must be aligned with teaching and learning method, assessment and student workload.

Table 1: Constructive alignment of two of the learning outcomes on the course DMGT

Course learning outcomes related to MOOCs	Teaching and learning method	Assessment method	Student workload – ECTS credits
LO1: Solve real world problems in ICT with methods from graph theory and discrete maths individually and in collaboration (fully covered here)	Students work in teams of three on posing and solving authentic problems	Teacher assessment and peer assessment of problem solving based on prepared criteria and scoring rubrics	LO1: 40 hours = 1.5 ECTS (approx. 20% of the course 7 ECTS)
LO2: Use mathematical literature from multiple sources, at least one tool for processing mathematical language, and an e-learning system, having specific characteristic of mathematics in mind (partially covered here)	Alternative: students participate in selected MOOCs	Alternative: assessment of MOOC performance (90% of a final grade); diary analysis and presentation of MOOC to other students (10%)	LO2: 20 h

MOOC has been offered as an alternative activity to project work that was credited towards the final grade in the course. Both activities are aligned to the same learning outcomes as it is shown in Table 1. There is a two-folded goal for the introduction of MOOC in the course. Firstly, to give students more online learning experience and secondly to help part-time students, that are working and are not able to fully participate in campus teaching, in meeting the course’s learning outcomes. We researched the case study in order to answer the following research question:

1. Can use of MOOCs help in giving students positive learning experience in virtual environment and help part-time students in achieving particular learning outcomes?
2. How to align course learning outcomes and student workload with use of MOOCs in a specific course?
3. What are the main challenges for students in using MOOCs?

MOOC learning program is covered and evaluated in this paper for academic years 2014/2015 and 2015/2016. In the first academic year, students were asked to choose a course-related MOOC on Coursera platform and a teacher needed to approve a choice. In the second academic year students were supposed to choose a course among those that were preselected and offered in LMS (Moodle), to provide a more focused approach and increase quality of the program.

Case study analysis: quantitative and qualitative

The sample in this research was made out of graduate students enrolled in DMGT course. In the academic year 2014/2015, there were 107 students enrolled in DMGT class, 28 female and 79 male students, out of which 9 chose to complete a MOOC. In year 2015/2016, 88 students were enrolled, 75 male and 13 female, out of which 22 chose a MOOC. In both years, part-time and full-time students were enrolled in the course but part-time students were particularly encouraged to take a MOOC. Some trends are shown in Table 2.

Table 2: Metrics, 2014/2015 and 2015/2016

Name of metric	2014/2015	2015/2016
Percentage of students that chose MOOC over project work	8.26%	25%
Average final grade of students who completed a MOOC	37.94%	52.93%
Average final grade of students who completed project work	45.53%	50.48%
Average evaluation of MOOC related tasks (by teacher)	85%	71.67%

Number of users that chose MOOC over project work grew significantly in 2015/2016. This could be related to previous experiences shared by students that attended DMGT course. In year 2014/2015 better average final grade was achieved by students who completed project work but the results changed in 2015/2016 when a better final grade was achieved by those students who chose MOOC over project work. This change can be explained in different ways but since there was too small proportion of all students taking MOOCs to make any reliable conclusion based on quantitative data. Data taken from the second year is more reliable because every fourth student took a MOOC. Based on that, it seems that the achievement of learning outcomes is on very similar

level for both groups. Finally, MOOC related tasks have been graded better in 2014/2015. This grade consists of two parts: 90% are based on MOOC's final grade received by students and 10% on their diary quality and short presentation of MOOC to other students. Further research needs to be done in the upcoming years of teaching this course with the same approach, to be able to detect trends and more reliable results because the main limitation of the quantitative part of this research is a small number of students in MOOCs.

Students were obliged to keep a learning diary when going through the MOOC. Diary was roughly determined by required open-ended questions. *Journal* feature in Moodle was used to keep learning diaries by students and to deliver feedback by teachers. Questions that were set in front of the students to describe their experience with MOOC were essentially the same in both academic years as it can be seen in table 3. In 2015/2016 the questions were fine tuned to gather more detailed information and the volume of required handed review was increased from 400-800 words to 800-1000 words. Open ended questions offer guidance and ensure loose uniformity in results. Still, this way of feedback gathering allows enough flexibility to express personal experience and opinion. The answers relevant to the research questions are analyzed in the following paragraphs.

Table 3: Questions asked in MOOC learning diary

-
1. Which MOOC did you choose and what success did you achieve? Certificate/points upload
 2. What did you learn? Please refer to learning outcomes of the course DMGT.
 3. Elaborate your weekly activities in MOOC by explaining what you learned. Have you encountered this content earlier in your studies at FOI?
 4. How are content and methods covered in MOOC related to DMGT course?
 5. Elaborate your weekly activities in MOOC by explaining what you learned. Have you encountered this content earlier in your studies at FOI? (only in 2015/2016)
 6. How would you describe your experience with using MOOCs?
 7. Estimate the time required to successfully complete the MOOC (personal opinion, not what is listed on MOOC site)
 8. What changes could we introduce to DGMT course based on your experience with the MOOC you took?
-

Connection between MOOC and DMGT course (questions 1-5)

As required, all students have uploaded a screenshot of their certificates of completion and shared the results they achieved. Similarly, a description of weekly activities was done, in more or less detail, by all students. Most variety was encountered in questions covering connections between MOOCs and DMGT as well as courses taken throughout formal education. Students that took different MOOCs were able to

connect them with particular learning outcomes of DMGT not necessarily the ones from Table 1: (a) “I would link the Coursera course to a specific learning outcome of DMGT: to use mathematical literature from multiple sources, at least one tool for processing mathematical language, and an e-learning system, having specific characteristic of mathematics in mind.”; (b) “I would connect MOOC learning outcomes with three DMGT learning outcomes”. Some students have found loose connection between MOOC content and classroom taught content. Several have emphasized that MOOC in fact covers practical implications of what is taught in the classroom taught course and how well they supplement: “DMGT and MOOC are complementing each other very well. In DMGT I received theoretical grounds and MOOC helped be to understand the theory following practical examples”. One of the most mentioned elements of this type of learning was the language of MOOCs. Learning in English was rather new for most students and the feedback was various: (a) “I was sceptical because of the language barrier (...) and taking a MOOC was quite a challenge because it required combining English language and important content”; (b) “I liked this way of learning because, in addition to learning itself, I had a chance to practice my English skills and to think about this topic in English”. Not all language related feedback was positive: (a) “As the MOOC was progressing, it took more time and effort to complete everything in the curriculum. Completion was additionally slowed down by English language”; (b) “I spent most of the time translating tasks to Croatian to understand what needs to be done”.

Experience with using MOOCs (question 6)

Generally speaking, the experience of taking a MOOC has been positive, with majority of students reporting that they would encourage continuing this way of teaching DMGT and that they will continue to use MOOCs to supplement their own learning: (a) “As I was going through the course I selected, I have also browsed through the platform and detected several other courses I plan to take at a certain point”; (b) “The entire experience (...) is very positive. This is the first time I have studied something this way, but it is definitely not the last one”. In the first year, choosing a MOOC that fitted DMGT was students’ responsibility and the reactions were various. Some have appreciated this approach: “A significant advantage was that we (students) were not limited by a certain topic, but only by an area that needs to be covered in a MOOC”, while some would have preferred to have a specific MOOC to take: “It would be good to have a specific course as a task, rather than being given the option to choose any course that fits DMGT. Coursera library is very extensive so it took some time to find the appropriate course”. Based on this type of feedback, practice changed in the second

year and a list of potential MOOCs was shared in LMS. Self-paced learning was much appreciated; students valued the option to learn when possible and when it suits them. It also helped to have a structure in place to keep them on track: (a) “I was able to plan my time dedicated to learning. The only element to have in mind was the quizzes deadline, where I had three attempts without time limit, which was more than fair”; (b) “Being time-flexible was one of the most important elements of MOOCs”; (c) “Advantage of MOOCs is the possibility to access content anytime, when I was focused and motivated, and interested in that content. Thanks to this, I was able to master the content in a more efficient way – simple and fast”. Students also have had positive experience with more frequent knowledge evaluation: “More frequent knowledge evaluation is far more effective than having two exams per semester”.

Time required to successfully complete the MOOC (question 7)

To fit MOOC in a classroom taught course properly, it is important to value the time spent to complete the MOOC. This aligns with ECTS points awarded for each traditionally taught course in formal education. As mentioned in Table 1, goal was to cover MOOCs with estimated 40-50 hours to completion, to fit approximately 30% of complete DMGT course ECTS load. The actual time spent on completing a MOOC occasionally differs from what is stated on MOOC providers’ websites. Still, most students have shared that the time it took them to complete the MOOC corresponds to what is stated on MOOC homepage. However, common feedback was that the required time can prolong significantly depending on prior knowledge of the subject and consequently speed of completing follow up tasks, as well as on efforts put into studying follow up literature: (a) “In the beginning I was fast with solving problems (...) because I have encountered this content before (1h-2h/week). Later, it took me longer to solve tasks and I needed to go through materials again (4h-5h/week)”; (b) “It took the same amount of hours as stated on Coursera site to complete the MOOC, but to rewind the videos and to fully understand the content, it took twice as much time as suggested”; The role of English as the language of all chosen MOOCs was also significant in actual time required to complete the MOOC: (a) “Some tasks were easy while some required significant effort to master mathematical cryptography terminology in English”; (b) “If a student understands English well, it is possible to follow lectures at a higher playback speed”. Challenging tasks are not merely a time consuming activity; some students report that challenging tasks make MOOC participation more interesting: “Tasks that trigger intensive thinking are the reason why I’m glad I chose MOOC”, but also: “It would be hard to follow MOOC content without basic subject knowledge gained in classroom.”. Interesting feedback in regards

to time spent on MOOC was given by a student who stated that “5 hours per week is the optimal amount of time to dedicate to this type of learning, as it’s likely that individuals spend the same amount of time on activities that are not at all connected to university related tasks”.

Discussion and conclusion

After analysing learning diaries and overall student performance on the course let us summarize answers to research questions. Since the small sample is serious limitation of the quantitative part of research conclusions are mostly based on qualitative analysis of students’ diaries.

Can use of MOOCs help in giving students positive learning experience in virtual environment and help part-time students in achieving particular learning outcomes?

According to feedback gathered in the learning diaries, MOOCs have supported learning in virtual environments, providing an experience that was new for majority of students that participated and opening doors to online learning for students. To them, possibility to learn at their own pace was very important. Recognition of the value of forums, discussions, and partnering with other to achieve best results justifies that the MOOC activity is an alternative to the team work that also has a goal to enhance collaboration skills of students. Furthermore, feedback showed that part time students are happy about the opportunity to have an option to manage their learning. This option was mentioned as an improvement opportunity for traditionally taught classes as well. Common student feedback was that this exercise resulted in exploring MOOC platforms and what they have to offer. Authors, after carefully examining answers, strongly believe that students will continue to use MOOC platforms to supplement the classroom teaching, or to expand their knowledge in general. Knowledge assessments have also been accepted well by students; general belief is that regular knowledge assessment increases knowledge retention and reduces stress related to adopting big amount of content.

How to align course learning outcomes and student workload with use of MOOCs in a specific course?

In order to introduce MOOCs into traditional classroom fine tuning with learning outcomes, assessment methods and students’ workload is required. Special attention should be given to student’s workload having in mind students’ prior knowledge and possible language barriers. Therefore, a teacher should check all recommended

MOOCs very carefully in advance and estimate student workload. Actual students' workload for non-native English speaker students is usually higher than listed on an official MOOC declaration. Interestingly, intended learning outcomes (Table 1) were not always recognized by students as covered by MOOC exercise. The possible explanation is that students are not very interested in the pedagogical foundation of the course and the concept of learning outcomes. Students much more easily map concrete content than abstract competences such as problem solving.

What are the main challenges for students in using MOOCs?

Language has been pointed as a barrier for multiple students. Obviously, good command of English language can significantly contribute to the MOOC completion. Still, even though English language was emphasized as a barrier, it was also characterized as a positive challenge as all students successfully finished courses despite of the potential language barrier. Further, students emphasized importance of previous knowledge (mathematics and programming) that enable them to be successful in MOOC despite of the declaration at the beginning of majority of MOOC that no specific prior knowledge has been required. Finally, students appreciate applications and implementations of knowledge as well as more frequent knowledge and skills assessment. Students are also aware that self-motivation and completing tasks in time is required to successfully complete the MOOC, which requires thorough planning of MOOC related activities so they fit in students' schedule.

To conclude, blending MOOCs in DMGT course resulted in multiple findings and opened further research questions. Even though the model described in this paper is similar to certain models and researches in blended learning, this model is based on learning outcome approach and have student workload and prior knowledge in mind. Furthermore, part-time students perceived offering MOOCs flexibility as an alternative to project team work very positively. Comparing research results to similar research, it was found that it is similar in some segments but differs in others. For example, similar as in research by (Israel, 2015), there was no evidence of negative effects for learners that completed MOOCs. There is not a significant difference in final grade among students who joined project work and those who completed a MOOC. However, unlike in research by (Israel, 2015), all students that took MOOC reported high level of satisfaction. This research is a starting point for further research in blending MOOCs in traditionally taught courses, to detect trends, progress, and generate guidelines for a successful implementation of online content from strategic point of view.

References

1. Biggs, J. (2003). *Teaching for Quality Learning at University* (2nd ed.). Buckingham: Society for Research into Higher Education /Open University Press.
2. Bruff, D., O., Fisher, D. F., McEwen, K. E., & Smith, B. E. (2013). Wrapping a MOOC: Student Perceptions of an Experiment in Blended Learning. *MERLOT Journal of Online Learning and Teaching*, 9(2).
3. Divjak, B. (2015). *Assessment of complex, non-structured mathematical problems*. Presented at the IMA International Conference on Barriers and Enablers to Learning Maths: Enhancing Learning and Teaching for All Learners, M.A. Hersh and M. Kotecha (eds.).
4. Ghadiri, K., Qayoumi, M. H., Junn, E., Hsu, P., & Sujitparapitaya, S. (2013). *The Transformative Potential of Blended Learning Using MIT edX's 6.002x Online MOOC Content Combined with Student Team-Based Learning in Class*. Retrieved June 8, 2016, from <https://www.edx.org/sites/default/files/upload/ed-tech-paper.pdf>
5. Gilbert, J. A., & Flores-Zambada, R. (2011). Development and Implementation of a “Blended” Teaching Course Environment. *MERLOT Journal of Online Learning and Teaching*, 7(2). Retrieved from http://jolt.merlot.org/vol7no2/gilbert_0611.htm
6. Griffiths, R., Mulhern, C., Spies, R., & Chingos, M. (2015). Adopting MOOCs on Campus: A Collaborative Effort to Test MOOCs on Campuses of the University System of Maryland. *Online Learning*, 19(2). Retrieved from <http://eric.ed.gov/?id=EJ1062937>
7. Israel, M. J. (2015). Effectiveness of Integrating MOOCs in Traditional Classrooms for Undergraduate Students. *International Review of Research in Open and Distributed Learning*, 16(5), 102–118.
8. Koller, D., Ng, A., Do, C., & Chen, Z. (2013, June 3). Retention and Intention in Massive Open Online Courses: In Depth [Blog post]. EDUCAUSEreview. Retrieved July 17, 2016, from <http://er.educause.edu/articles/2013/6/retention-and-intention-in-massive-open-online-courses-in-depth>
9. Morris, N. P. (2014). *How Digital Technologies, Blended Learning and MOOCs Will Impact the Future of Higher Education*. Paper presented at the International Conference e-Learning 2014. Multi Conference on Computer Science and

Information Systems, Lisbon, Portugal, July 15-19, 2014. International Association for the Development of the Information Society. Retrieved from <http://eric.ed.gov/?id=ED557272>

10. Sharpe, R., Benfield, G., Roberts, G., & Francis, R. (2006). *The undergraduate experience of blended e-learning: a review of UK literature and practice*. The Higher Education Academy. Retrieved from https://www.heacademy.ac.uk/sites/default/files/sharpe_benfield_roberts_francis_0.pdf
11. Yousef, A. M. F., Chatti, M. A., Schroeder, U., & Wosnitza, M. (2015). A Usability Evaluation of a Blended MOOC Environment: An Experimental Case Study. *International Review of Research in Open and Distributed Learning*, 16(2), 69–93.

From Evaluation to Sensemaking: Emergent Development of a Masters Distance Learning Research Methods Module

*Palitha Edirisingha, Phil Wood,
University of Leicester, United Kingdom*

Abstract

Evaluation of student learning is ever more important in higher education today, due to managerial reasons as well as a genuine interest among teachers to improve students' learning. Such module evaluation is generally carried out using end-of-module/semester questionnaires. While these evaluation tools may capture some reflections of student learning, they are often poorly focused, and rely wholly on summative perspectives which are captured at a point remote to the learning process itself. This paper reports on an initial investigation centring on developing a formative framework for evaluating distance learning modules. It is distinguished from typical summative questionnaire evaluations by the collection of *live feedback* from students as they undertake a module, allowing for insight and feedforward to develop materials as students undertake the module. This is achieved by using a modified version of an approach called "Lesson Study", a collaborative planning and evaluation tool which originated in Japan (Lewis et al, 2009). The evaluation framework that we develop here is centred on the notion of *sensemaking* (Weivk, 1995).

Keywords: Distance Learning, Emergent Evaluation, Sense Making, Lesson Study, Module Evaluation, Research Methods.

Introduction

The evaluation of modules in higher education is an important driver for change and curriculum development. Whilst a number of different approaches have been developed to evaluate modules, the standard tool used in evaluating student experience is the summative questionnaire which students are asked to complete at the conclusion of a module. These questionnaires often cover a spectrum of issues, but they often focus on issues around learning, rather than the experience and nature of the learning itself. Statements are often general in nature, e.g. "what was the quality of

learning resources?” which can lead to over-simplified responses which lose the nuances of personal experiences.

There are a number of issues with the accuracy and utility of summative questionnaires. Firstly, many students, especially on distance learning courses, do not bother to fill in the questionnaires, either because they are busy professionals, or because they are happy with their experiences so do not value the opportunity to share their views. Secondly, questionnaires are inherently retrospective, which can lead to over-simplification of views, as a nominal overall impression is given, with little differentiation concerning a range of experiences. Thirdly, with the evaluation being undertaken after the module has finished, means that any potential improvements can only be undertaken after the students have finished their learning; future cohorts might gain from any given evaluation, but not those completing the evaluation. Finally, the analysis of questionnaire data is often reductive, leading to numeric summaries, with little explanatory or discursive insight into the complexities of the activities undertaken. This means that general patterns become important rather than individual experiences, losing the idiosyncratic nature of student experience, which might be especially important for distance learners.

The restrictions above are recognised within the literature already (Wachtel, 1998) and have led to the development of alternative approaches in an attempt to gain a better evaluation of learning, whilst also acting as the starting point for cyclical development of the curriculum. For example, Ellery (2006) developed a multidimensional evaluation framework for use on a campus-based course on data analysis in social science research methods. The approach not only gathered information from students, but also captured lecturer perspectives in an attempt to create a more complete picture of student experience and learning. A number of methods were used to capture evaluative data that were then used to inform curriculum and pedagogic development. Benson et al. (2009) extended the idea of formative evaluation further by developing a participatory evaluation model, that again was multi-modal, based on the work of Jackson and Kassam (1998) which is

“a process of self-assessment, collective knowledge production, and cooperative action in which the stakeholders in a development intervention participate substantively in the identification of the evaluation issues, the design of the evaluation, the collection and analysis of the data, and the action taken as a result of the evaluation findings” (Jackson & Kassam, 1998; p.3).

Here, students were involved in identifying the terms of evaluation before being involved in data capture and interpretation. This made them and lecturers joint investigators into their own work, and gave a sense of joint responsibility for improving modules and learning. However, in both cases, these alternative approaches were developed within campus-based contexts. In addition, some of the same restrictions can occur, with evaluation leading to improvements for future learners rather than those who have completed the evaluation. In this investigation, we attempted to develop an alternative model which could be used in distance-learning contexts, and which could lead to new activity *in-action*, i.e. which would allow those involved in the consultation to gain from their involvement as they follow the module under analysis.

In developing a different approach to evaluation, we have chosen to develop a process which is closer to sensemaking (Weivk, 1995). The underlying basis for sensemaking is that groups or organisations attempt, collectively, to understand and give meaning to their experiences. As with evaluation, sensemaking often occurs at the end of a process, retrospectively gaining insight into experiences to help develop better processes for the future. However, Klein et al, (2006; p.71) state that, “Sensemaking is a motivated, continuous effort to understand connections (which can be among people, places, and events) in order to anticipate their trajectories and act effectively”. This leaves the possibility of sensemaking as an interactive tool for understanding and developing practice as it emerges. If we can begin to understand the trajectories being followed by students as they undertake a module, we can begin to act effectively as the module unfolds. We can also begin to gain insights into the idiosyncrasies of student engagement and learning within a module. This approach also sees tutors and students as partners in the development of their learning, which itself can lead to a cyclical process of communal change (Figure 1).

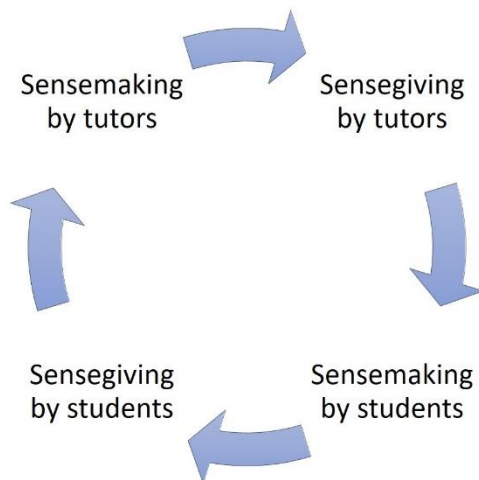


Figure 1. The process of sensemaking and sensegiving between students and tutors (based on Iveroth & Hallencreutz, 2016; p.51)

Iveroth and Hallencreutz (2016) see sensemaking as offering a cyclic process where change leaders and employees are able to use action and dialogue to move practice forward. Figure 1 shows a process where tutors are able to build new elements in a distance learning module, thereby sensegiving to the students. Iveroth and Hallencreutz (2016; pp.49-50) describe sensegiving as

“the process whereby an individual tries to influence others’ sensemaking processes...A sensegiver provides open communication and cues in such a way that it affects the construction of meaning of others.”

Students in turn make sense of these materials, and through their work, plus any dialogue about the work in turn sensegive to the tutors. By trying to understand the student work and perspectives, the tutors in turn make sense of the experiences, adding and changing subsequent materials and approaches to take account of the ideas they receive. The cycle then begins again. It is this cyclical sensemaking process that we chose to develop to help us change, and hopefully improve, the learning experiences of the students. The process which we used to aid this cyclical change process was an approach called lesson study which is outlined below.

Aims of the pilot study

This investigation was undertaken on a distance-learning MA in International Education course. The programme includes a 30-credit module on research methods,

the second module of four which make up the first 120 credits of the masters course. We decided to focus on this particular module as it has been identified as one which students struggle with and which often leaves them with poor and incomplete understanding. Other researchers have also identified the issues in teaching research methods at Master's level (e.g., Barraket, 2005) and at a distance (e.g., Schulze, 2009). In developing an evaluative process, we wanted to create an approach which allowed for:

- diagnostic and formative module information;
- a clear link to curriculum development;
- a framework for distance learning change and development which relies on more than a *performative* activity;
- putting pedagogy (interpenetration of teaching, learning, curriculum and assessment and their interaction with teachers and students) at the centre of the process;
- emergence and trialling of new approaches as a standard element of our work.

The cohorts we work with are small, typically 8 to 10 students per intake (with two intakes per year) which needs to be kept in mind when considering the process and results we have gained. We are presenting this work within a particular context and the degree to which it might translate, especially to very large distance learning courses, is not known.

Outlining the Evaluative Framework and Pilot Data Collection

In developing a cyclical model to allow a sensemaking approach, we decided to use a variant of lesson study (Lewis et al., 2009), a framework which attempts to help teachers improve their pedagogy by working collaboratively to improve student learning. Lesson study has been a core feature of educational development in Japan for over 100 years. Since the end of the 20th century it has moved beyond Japan, and is now a well-established method for pedagogic development in countries around the world, being increasingly embedded in countries across all continents. It is a collaborative form of action research (Wood et al., 2017) which relies on dialogue and joint endeavour meaning that it cannot be undertaken by individual tutors to reflect on their own practice.

A basic cycle of lesson study is given in Figure 2, and begins with a group (as few as two will work) of teachers coming together to identify a *learning challenge*. The learning challenge is a specific element of learning that students struggle with and

often fail to understand well. Having identified such a challenge, the group then work together to plan a lesson which engages with the elements of that challenge to create a pedagogic experience which will help students gain a greater level of understanding. This requires the teacher group to spend time considering not only the teaching element of the lesson, but also the learning of the students. How will they engage with and make sense of the subject matter? How will particular activities be understood and completed?

Once the lesson is planned and resourced, one member of the group teaches the lesson, whilst the other members observe a number of students. The observations focus on trying to note how students react and make sense of the lesson material. Once the lesson has finished, the teacher group reconvenes to consider the evidence for student learning and the degree to which the lesson has helped them move forward in their understanding. If there is the opportunity, a second lesson can be taught again to a parallel group, making amendments to the original lesson where necessary, to maximise the level of pedagogic insight gained from the process.

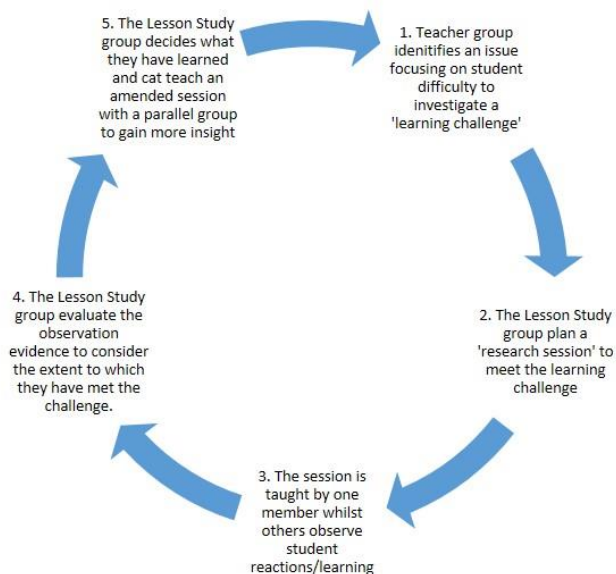


Figure 2. A basic lesson study cycle

To date, lesson study has only been applied in face-to-face contexts, in large part due to the school-based context within which the vast majority of lesson study takes place together with the central role for observation. We decided that we would develop a modified version of this approach as the basis for developing and evaluating student

learning as it occurred within a distance learning module. Our research was undertaken with three students from a cohort of five who were undertaking the research methods module, and did so using an amended version of the cycle in Figure 2. A central element of the lesson study approach is the observation of the research lesson, an activity which obviously does not translate directly to a distance learning context. However, where appropriate, the use of discussion board dialogue might stand in place of this element of the cycle. We decided to use individual semi-structured stimulated recall interviews (Lyle, 2003) as the main source of evidence for approaches to, and levels of, learning (see Appendix 1 for questions used) in place of observations, and hence the amended lesson study cycle looked like that given in Figure 3.

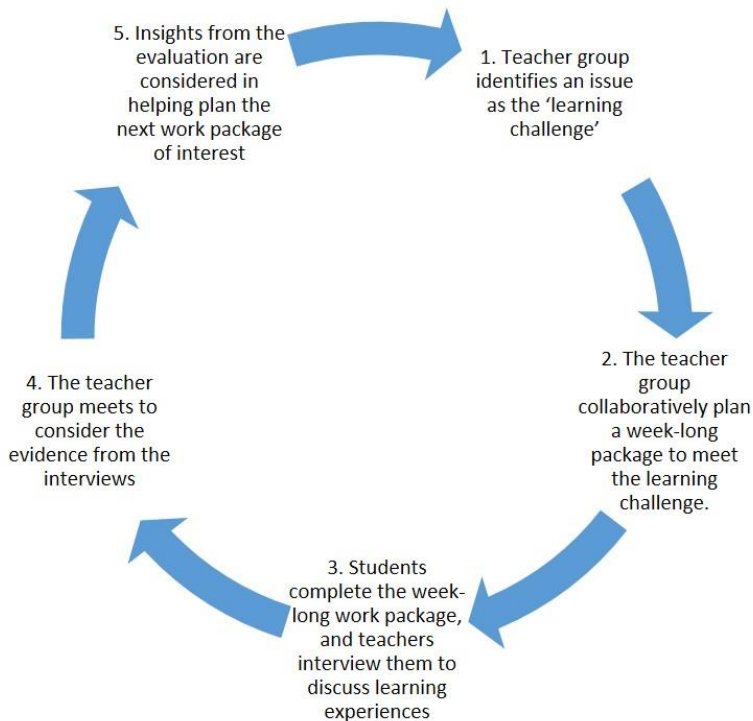


Figure 3. Modified lesson study cycle for distance learning contexts

This cycle was used to investigate two areas of the research methods module which often cause problems in student learning:

- developing research questions;
- organisation, analysis and interpretation of data.

Having completed these two cycles of investigation, we decided to include an extra step in the process, based on research in lesson study at higher education level (Wood & Cajkler, 2016). In a final, third, cycle which focused on the development of critical writing in student work, we included a step before the first planning meeting which consisted of individual interviews with the three students to investigate their understanding of some of the key concepts of critical writing, and to ascertain the pedagogic approaches they preferred when learning online. This amended cycle is shown in Figure 4. This amended cycle, by engaging with students both before and after the learning which was to be undertaken meant that they became part of the process of sensegiving early in the cycle. It allowed us to get a much clearer and deeper understanding of the issues they faced before beginning to plan an area of work.

The module lasted for 16 weeks, with the three cycles of modified lesson study occurring at weeks 2, 7 and 12 (see Figure 5). In addition, general individual interviews were undertaken with the three students at the beginning, middle and end of the module. The intention of using this model was to help us to develop a deeper understanding of what students believed they were learning, but also how they were making sense of the module materials. As such, this gave us an opportunity to evaluate, amend and develop approaches as the module unfolded (hence the idea of an emergent sensemaking approach). The approach also allowed us to gain ideas and insights from each other as tutors as we developed the module together.

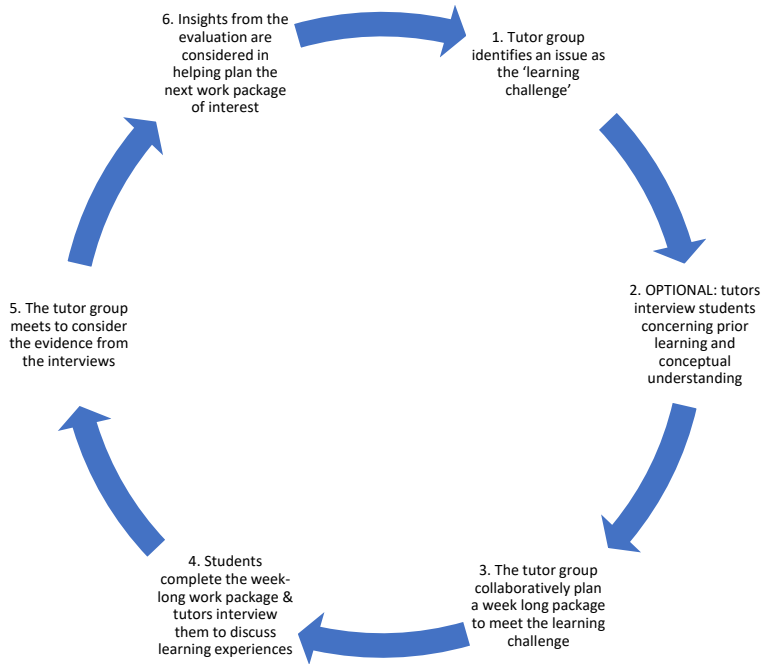


Figure 4. Enhanced modified lesson study cycle for distance learning contexts

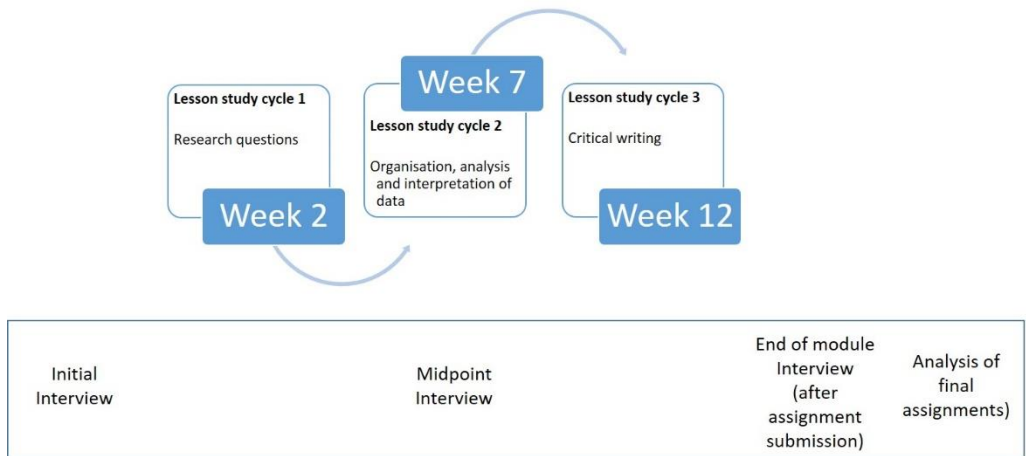


Figure 5. Overall schematic of data collection for emergent evaluation approach

Results

This pilot study allowed us to gain a number of insights. Here, we focus on the reflections and advantages we gained as curriculum developers, and also consider some of the possible issues and challenges of scaling up the approach to larger groups.

Initial starting points

At the beginning of the module, the initial interviews we completed gave us very useful insights into relevant prior learning of students. One student had completed a social research methods course at undergraduate level, and therefore felt that she had a relatively clear foundation on which to build her studies,

“The fourth year [of my degree] was a dissertation research. So I’d got some experience with it. I mean it’s been a few years but with the readings, it’s starting to all kick back in and I’m starting to remember the things that I was doing back then.” (student C)

Another student had come from a non-social sciences discipline, but had been involved professionally in small-scale research projects, so had some practical experiences of research involvement, but little theoretical perspective.

“I’ve done little bits and bobs subsequently. Things like in my work when I have been generating outcomes of projects. Carrying out things like student focus groups etc., things like that. So not hugely detailed or in-depth in terms of my actual research in the past, but as I say, some exposure to it.” (Student A)

This helped us understand the very different starting points from which students enter the module on research methods, and the extent to which we could assume a basis in research methods or not.

The interviews also gave us opportunity to understand in some detail the learning practices students had developed in their first module, prior to studying the research methods module. Again, even though we only conducted interviews with three students, all had very different approaches to their studies, often based on prior learning approaches, but also practical, work-based constraints. This included different preferences in terms of working with others, and sources of information. Student A had a preference for collaborating with others in his work, whilst Student B preferred to read and work individually, partly the result of a hectic work schedule

which meant she was away from home on work-related visits on a regular basis. There was also a wide variation in the use of digital media. Student A made use of a number of Apps, and worked predominantly on an iPad, whilst Student C preferred to use a laptop unless she was away from home.

By using the information from the initial interviews we were able to gain some critical and rich insights into prior learning and students' approaches to their learning. These provided useful starting points for our collaborative planning sessions once the lesson study cycles started.

Cycles 1 and 2

The first two modified lesson study cycles (see Figure 3) which focused on research questions and data organisation, analysis and interpretation, proved to be very positive experiences for the two of us as researchers. The opportunity to discuss and build a week-long work package of study activities through discussion allowed us to develop a more critical and in-depth consideration of the content to be covered. During the second cycle, we were also able to use student stimulated recall data from the first cycle to inform our discussions. In the planning meetings we built out from some basic principles to create possible narratives and activities to create a coherent package for students. An example of notes written on a white board from the planning meeting for modified lesson study Cycle 2 is shown in Figure 6.

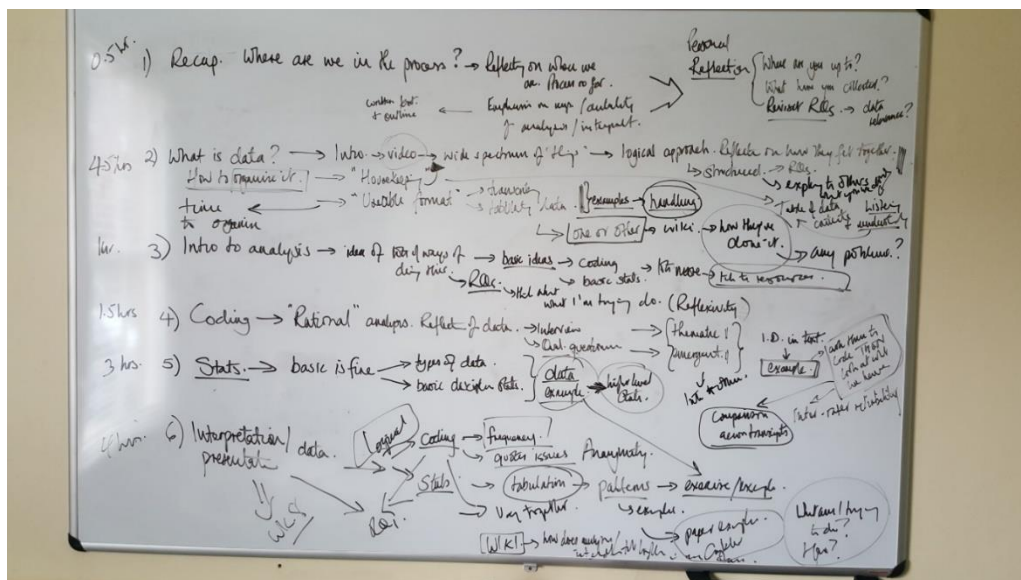


Figure 6. An example of board notes from the planning meeting for lesson study Cycle 2

In these meetings we considered how we thought the students would engage with the materials and how this would help them in understanding the issues and concepts covered during that week. These predictions were then considered again when we evaluated the week's work package in the evaluation meeting, having interviewed students to understand their perception of their learning. As such, this approach gave us a lot of insight and further questions concerning the development of curriculum materials. As we evaluated one element of the work, it helped us consider the development of the next element, often in ways we had not envisaged, leading to the notion of an emergent process.

Cycle 1 of lesson study focused on helping students understand and develop research questions. Past experience had suggested to us that students often struggle moving from a broad research topic to specific questions. The research question work package therefore focused on the process of filtering from an initial idea to a set of research questions. This was done by asking students to begin by watching a short video on developing research questions before writing a 2-3 paragraph outline of their potential research project. Once this was complete, they were then asked to construct 2 or 3 statements central to this initial description. These statements were then to be converted into questions. Finally, both the initial description and the questions were posted onto a communal wiki for peer discussion.

The interviews with students at the end of the first cycle of lesson study helped us to understand what students had focused on, and how they had made sense of their experiences of their work on research questions. Student A reflected on how the materials had helped him to narrow in on a set of research questions from a broad starting point, and from this to how the research questions might be linked to the use of particular data collection methods,

"..so what I'd got from the learning I suppose is taking it down to something quite tight and quite focuse." (Student A).

Student C took a very different approach to the work package. She decided to use a thinking framework she used in science teaching with her students as a medium for focusing in on research questions,

"you start off with a big circle on the outside, a smaller one inside, and getting to a smaller idea. So you start off with a broader concept

on the outside of the circle, and with research and everything, slowly getting it smaller and smaller” (Student C).

Whilst the focus on starting with a broad idea and narrowing from there worked well, the collaborative nature of the wiki had less universal success. Whilst two of the students found the opportunity to share ideas useful, the third student was less sure,

“..everyone’s just too busy with their own areas and people are selfish with their time. They don’t want to dedicate, rightly or wrongly, they don’t have the time to input into somebody else’s work or reflect. If it was marked I’m sure you would get greater input.” (Student B).

These insights helped us understand that the students had started positively in relation to the learning challenge, i.e. that the materials which had been developed had helped them create some good research questions. This meant that we could be confident going forward into the module that they had a sound basis for further work, and did not require further support in this area. However, it also gave us insights into the partial success of the wiki as a collaborative space.

Cycle 2 of lesson study focused on another area which often challenges students, the development of data analyses. Often, the challenge here is in understanding how analysis methods work, and how data should be treated after collection. In many research methods texts, data analysis is seen as a singular process, leading to ‘mechanical’ understandings of process rather than a more holistic engagement with data. With this challenge in mind we started by breaking down the process of data analysis (Figure 7).

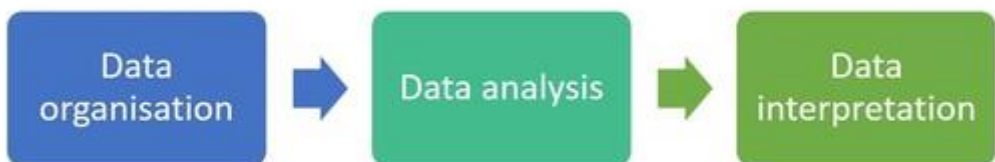


Figure 7. Developing a finer-textured approach to data analysis

Therefore, the work package started with an explanation of how data should be organised, with consideration of transcribing, and organising quantitative data. This

then led to a section data analysis which asked students to analyse data they had collected themselves for a pilot study they were developing across the module. This offered worked examples on which to base their work, but the concrete opportunity to work on their own data was deemed important in supporting their understanding. The work package then concluded with some reflections on some simple frameworks for interpreting and writing about data.

Interviews with the students after they had completed the work package suggested that they had found the resources easy to interact with. They tended to focus on those resources which aligned with their own collected data, and did not necessarily work with those activities which outlined analysis methods which they did not need,

“Yeah. So I basically tried to focus on the things that I was working on. So I focused on the interview and observation thinking that if it would come to it, I would come back to the website to have a little look at the questionnaire part.” (Student C).

The students did voice a general confidence in the work they had completed, being able to talk at length about the analysis methods they had used. They also commented on the focus on interpretation, finding it useful, but also to an extent, difficult. This appeared in part to be the result of a difficulty regarding the creation of a well-considered and weighted interpretation. It was this reflection which led us to complete a third cycle focused on helping students understand the structure and process of writing a research methods assignment.

Cycle 3

In the final cycle of modified lesson study we attempted to consider how a participative model (Wood & Cajkler, 2016) would work (see Figure 3). In cycles 1 and 2, we had started to develop a sensemaking approach which allowed us to consider and modify materials as the students were completing the module, but the student involvement was still, overall, retrospective. By using a participative approach, we could gain insights from the students before planning the session. We started by asking the students to explain particular pertinent issues such as ‘critical writing’ to gauge their understanding of core concepts for the week-long work package on assignment writing. We then went on to ask them what they believed they would gain from most in the week given the focus on starting their assignments. These reflections were extremely useful in helping us understand what activities would have most potential

impact in taking their learning forward, and some of their ideas and reflections were incorporated into our discussions and curriculum development. For example,

“Well I suppose I look at criticality in two ways. Criticality I suppose around questioning...It’s going into it in a bit more detail and interpreting that. Then at the same time, balancing those interpretations against other findings I suppose.” (Student A).

Other issues which came across as important, and in which some of the students had less confidence, was the development of a coherent argument, the discussion of data (reinforcing comments from Cycle 2), and how to develop a reflective voice regarding critical writing about the research process. Interesting, in each of these cases, students often offered clear, but brief definitions of key terms which suggested some understanding, but little depth.

On the basis of the student interviews, we planned a week-long work package which looked at an exemplar of an assignment from a previous cohort. It was introduced in general and then offered consideration and advice on the issues of:

- Coherence, showing how various aspects of the writing needed to create threads through the work. An example of this was the importance of the research questions as a thread through the assignment (see Figure 8).
- Discussing data, particularly in terms of how patterns and exceptions might be the focus of quantitative data writing, and how quotes might be used in qualitative analyses of data.
- Finding a reflective voice, with suggestions for further reading, as well as consideration of the difference between analytical and reflective writing.

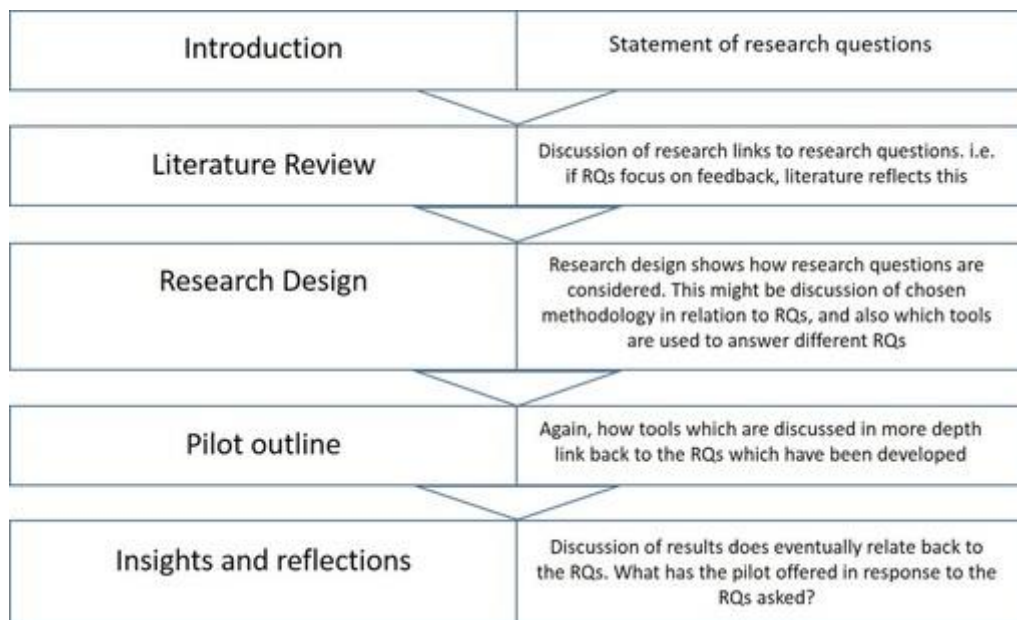


Figure 8. Diagram from the section on coherence in writing showing how research questions could be a thread throughout the assignment.

After the work package had been completed by the students, there was strong support for the utility of the resources provided. For example,

“Well it helped in terms of helping me getting mine structured and giving an idea between the tone or voice...the focus you need to do within the sections.” (Student A).

We believe that by engaging the students before the planning, we were able to target our work and how we planned for their learning much more clearly. Indeed, a participatory approach allowed the students the opportunity for a possibility of sensegiving from which we made sense, before creating a work package. In this way, whereas in Cycles 1 and 2 we had been the primary sensegivers in the process (i.e. creating the work packages as we believed they needed to be), in Cycle 3 the students became the primary sensegivers whilst we then made sense of their perceptions. We then used this sensemaking together with our own expertise to develop a framework for helping them overcome the challenges they had identified for us.

Understanding patterns of engagement over the module

The emergent sensemaking approach allowed us to develop elements of the curriculum in real time, driven by student response and reflection, thereby helping us shape the content and approach of the module. This meant that we gained a deeper understanding of the complexities of pedagogies, with the chance to respond to need. In this way the process became both diagnostic and formative rather than summative as often happens in module evaluation. Whilst the lesson study cycles allowed us to engage with specific parts of the process of student learning. It also allowed us to begin to understand the very different ways in which students make sense of their studies, and the approaches they used over the course of the module. Table 1 shows the contrast of Students A and B in terms of their approaches to learning over the course of the module.

Table 1: Comparison of two students' approaches to learning during the module

Student A	Student B
First attempt at social sciences research	Some experience of social science research
Makes use of iPad for most work	Makes use of iPad for reading, laptop for writing
Valued wiki/research diary for peer feed forward	Hardly used wiki – found it was of little use
Major focus on videos and some reading	Engages with module work through reading
Developed research around a learning development project	Developed research around international student disability
Focused on resources and discussion with others on the module to help develop and critique ideas	Focused on reading to make sense of the module
A very reflective approach	A practical approach as training for the dissertation
Pilot study used in professional work	Module work has led to a more evidence-based and critical approach to professional work

The two contrasted quite markedly in the way they approached their learning. Student A worked quite collaboratively, enjoying the opportunity to discuss his ideas with others, and posting regularly on a communal wiki as he found peer feed forward helpful in his work. His iPad was also central to his work, including regular use of video content. However, Student B mainly engaged with content through the use of reading which was completed through a mixture of iPad and laptop use. Here, engagement with others, through either informal discussion or the use of the wiki, was almost absent. This student very much preferred to work alone on a specific work-based project.

These insights helped us to understand the need for creating rich resource environments which would allow students to navigate their way through the course in ways which would suit them. There needed to be a flexibility in the way we presented

materials so that all participants could construct a positive and well-structured approach to their learning.

Discussion

Sensemaking, in this context pursued through the use of a modified version of lesson study, makes the processes students engage in through their studies more explicit than would be the case in dominant summative evaluation systems. As the outlines in Table 1 above demonstrate, the students in our sample have approached their work very differently, whilst arriving at similar endpoints by the conclusion of the module. These processes might remain totally hidden in traditional end of unit evaluations, or partially hidden if using learning analytics. The use of lesson study does not itself give a complete picture, but it does make room for dialogue, and in the case of Cycle 3, for joint development of learning approaches and materials. As such, it is possible to begin to construct rich narratives which highlight the complexity of student work, and which may help build more robust and well targeted online environments for students to navigate and engage with.

An important part of the opening up of dialogue is the understanding, all be it somewhat incomplete, of the learning ecologies the students build in making a success of their studies. The students in this study are predominantly educational professionals from a range of contexts. Their work can sometimes lead them to need to travel abroad during their studies, or may require them to work in short bursts between periods of high professional workload. To begin to understand how these impact on their studies, how they react, and how they mediate the different stresses and constraints on their time can all be useful in designing successful online resources.

By developing dialogue with students over the course of the module, together with *just in time* materials development, we were able to focus on elements of the module we knew from experience students struggled with. This led to course development and reflection in *real time*, focusing on the students and their emerging work. In Cycle 3, the use of interviews before the materials development, allowed us to create focused and well-targeted materials which could then be tested and assessed. As such, there was a rapid cycling of sensegiving and sensemaking which the lesson study approach allowed to emerge. This is a time intensive process, but for elements of work where students really struggle, it appears to provide a possible process for creating better learning experiences.

From our own perspective, the use of lesson study also allowed us to make space for *deep work* (Newport, 2016). All too often, development work on distance learning materials can fall into an accelerated process in a busy academic department where academics are responsible for a number of different programmes and other activities. This can lead to *quick fixes* and default approaches. Using lesson study led us to make time to focus on important pedagogic issues. Newport (2016) characterises deep work as a process of acting in a focused and undistracted way on cognitively demanding issues. By focusing on elements of a module, with collaborative planning and evaluation meetings, we were able to engage in this way.

These insights demonstrate that we were able to gain a deeper, though still partial, understanding of student learning, but also makes clear the difficulties which exist when attempting to *capture* the nature and detail of student learning. We were only able to identify and work with some aspects of the module, and from the perceptual accounts of three students. However, whilst we accept that we were not gaining a whole picture of the student experience, we were nevertheless engaging, and making sense of student learning at a much deeper level than standard evaluative processes allow.

Final thoughts

Using a modified approach to lesson study as the basis for sensemaking and change has proved to be a very positive experience. It allows for rolling renewal and development of materials, and moves away from the overly-general summative evaluations which are often too vague to help develop new pedagogic approaches. We believe that a sensemaking process, in this case through the use of a modified lesson study approach, can offer useful insights and allow for curriculum development which is both well-grounded in an understanding of student needs, and also which helps programme tutors gain a shared perspective concerning the course they are responsible for. We also believe that lesson study, in a modified form, translates well from a face-to-face setting to one which supports development of distance learning pedagogies.

There were inevitable challenges, the most important being time. The three cycles of lesson study led to intensive work, with interviews leading to planning and weekly study package design and development within one working week before student use. This means that time was not only being made to complete the lesson study cycle, but also to complete a work package within a five-day window. This was intensive work,

but did rely on a foundation of pre-existing module material, so that package development was in some cases a process of editing and reorienting rather than starting from scratch. Because of the intensive work required to develop a work package, and the multiple cycles used across the module, we envisage this approach being used in a targeted manner, at most across two modules per year. In this way, it could be used as an integral approach to renewing and innovating on distance learning courses. To attempt to use it on a larger number of modules over one academic year would, in our opinion, be unsustainable. The core aspect of this approach is the dialogic and formative nature of the process. This takes time, and whilst the rewards, we believe, are potentially great, the required input is intense over a relatively short period of time.

It also has to be stressed that the cohort involved in this pilot study was small, with only three students being involved in the interviews, and five overall in the cohort (The enrolment in this cohort was less than the usual number which is 8 -12). There is a question mark as to how well this model would scale-up, but we see no reasons why it should not work with larger cohorts. A small group of students would need to be identified and invited to participate. Particular characteristics would also need to be selected to ensure that a representative, or recognised, set of issues could be considered. This might include students with different first languages, if an international group, or participants located in different technological contexts.

Finally, there is a wider question mark over the degree to which sensemaking would fit within wider, increasingly performative, evaluation frameworks used by universities. We see this approach as being used instead of summative evaluations for the simple reasons that it appears to give more nuanced, more critical and in-depth insight into the learning and needs of students. However, as such it is working with the complexities of pedagogy and students; the use of summative statistics would be drastically over-reductive in this context, but is often the type of data that university quality assurance systems appear to require within some national contexts, such as the UK.

We see sensemaking as focusing on developing the quality and focus of curriculum approaches through diagnostic and formative debate with students and other colleagues. This pilot has demonstrated that a great deal can be gained by working collaboratively through a modified lesson study approach, supported by more general periodic interviewing. The constant, iterative approach allows for immediate

incorporation of lessons learned and suggests that we can gain a much more in-depth understanding of student learning patterns and needs.

References

1. Barraket, J. (2005). Teaching Research Methods Using a Student-Centred Approach? Critical Reflections on Practice. *Journal of University Teaching and Learning Practice*, 2(2), 62-74.
2. Benson, R., Samarawickrema, G., & O'Connell, M. (2009) Participatory evaluation: implications for improving electronic learning and teaching approaches. *Assessment & Evaluation in Higher Education*, 34(6), 709-720.
3. Ellery, K. (2006) Multi-dimensional evaluation for module improvement: a mathematics-based case study. *Assessment & Evaluation in Higher Education*, 31(1), 135-149.
4. Iveroth, E., & Hallencreutz, J. (2016) *Effective Organisational Change: Leading through sensemaking*. Abingdon: Routledge.
5. Jackson, E. T., & Kassam, Y. (1998). *Knowledge shared: Participatory evaluation in development cooperation*. West Harford, CT: Kumarian Press.
6. Klein, G., Moon, B., & Hoffman, R. F. (2006) Making sense of sensemaking I: alternative perspectives. *IEEE Intelligent Systems*, 21(4), 70–73.
7. Lewis, C. C., Perry, R. R., & Hurd, J. (2009). Improving mathematics instruction through lesson study: A theoretical model and North American case. *Journal of Mathematics Teacher Education*, 12, 285–304.
8. Lyle, J. (2003). Stimulated recall: a report on its use in naturalistic research. *British Educational Research Journal*, 29(6), 861-878.
9. Newport, C. (2016). *Deep Work, Rules for focused success in a distracted world*. London: Little Brown.
10. Schulze, S. (2009). Teaching Research Methods in a distance education context: Concerns and challenges. *South African Journal of Higher Education*, 23(5), 992-1008.
11. Wachtel, H. K. (1998) Student Evaluation of College Teaching Effectiveness: a brief review. *Assessment & Evaluation in Higher Education*, 23(2), 191-212.
12. Weick, K. E. (1995). *Sensemaking in organizations*. Thousand Oaks, CA: Sage.

13. Wood, P., & Cajkler, W. (2016). A participatory approach to Lesson Study in higher education. *International Journal for Lesson and Learning Studies*, 5(1), 4-18.
14. Wood, P., Fox, A., Norton, J., & Tas, M. (2017). The Experience of Lesson Study in the UK. In L.L. Rowell, C. Bruce, J.M Shosh, & M.M. Riel (Eds.), *The Palgrave International Handbook of Action research*.

Contributions to Science Teaching Practice of an Online Community of Practice of Teachers and Researchers

Margarida Morais Marques, Maria João Loureiro, Luís Marques, CIDTFF – Research Centre “Didactics and Technology in Education of Trainers”, DEP – Department of Education and Psychology, University of Aveiro, Portugal

Abstract

Communities of practice (CoP) can promote teachers' professional development (TPD) and change their practices. However, empirical evidence is still scarce. To contribute to address this shortcoming, a single case study was carried out aiming the analysis of an online CoP involving teachers and researchers. Data collection included the used platform statistic data and posts automatically recorded, as well as the CoP's documents. Content analysis took into account Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Professional Growth (IMTPG) and was centred in (a) the external domain and the curricular development (CD) practices; (b) the domain of the consequences of the work carried out regarding the developed science teaching strategies; (c) the evidence of their innovative nature; and (d) the CD principles enacted. The results show that (a) the members' participation varied during the interaction period and their dynamic fits an adaptation of Wenger et al.'s (2002) stages of development of a CoP, with two action-research cycles; (b) the CoP developed diverse teaching strategies coherent with recommendations from the literature; (c) the teaching practices were innovative and challenging; and (d) the CoP enacted several principles of CD suggested in the literature. Moreover, the empirical results validated the dimensions of the IMTPG.

Abstract in Portuguese

As comunidades de prática (CoP) podem promover o desenvolvimento profissional de professores e mudar as suas práticas, existindo, porém, poucas evidências empíricas. Contribuindo para reduzir esta lacuna, efetuou-se um estudo de caso único cujo objetivo foi a análise de uma comunidade de prática *online*. A recolha de dados as estatísticas da

plataforma usada, mensagens gravadas automaticamente e documentos da CoP. A análise de conteúdo teve em conta o *Interconnected Model of Teacher Professional Growth* (IMTPG) de Clarke e Hollingsworth (2002) e centrou-se: (a) nos domínios externo e das práticas de desenvolvimento curricular (DC); (b) no domínio das consequências do trabalho realizado no que respeita às estratégias de ensino de ciências; (c) nas evidências de inovação das práticas; e (d) nos princípios de DC operacionalizados. Verificou-se que (a) a participação dos membros variou ao longo do tempo e a sua dinâmica se enquadra numa adaptação das fases de desenvolvimento de CoP de Wenger et al. (2002), com dois ciclos de investigação-ação; (b) a CoP desenvolveu diversas estratégias de ensino coerentes com recomendações da literatura; (c) as práticas letivas foram inovadoras, do tipo *challenging*; e (d) a CoP operacionalizou vários princípios de DC sugeridos na literatura. Os resultados empíricos validaram também as dimensões do IMTPG.

Keywords: online communities of practice, teacher's professional development, Interconnected Model of Teacher Professional Growth, science teaching practices, curricular development, innovation.

Introduction

The open and distance learning movement is increasingly growing and can take different formats and shapes. One relatively new form of learning, particularly about practices, is a consequence of the participation in social group, as communities of practice or CoP (Lave & Wenger 1991; Wenger, 1998). CoP work on common interests, shared objectives and resolve problems that are genuine and emergent from the practices of the CoP's members. When these communities use online communications Tools, such as discussion boards or even mobile phones, to allow interaction between the members and with artefacts or resources available in an online platform, they are usually called online CoP.

Over the years, CoP have been extensively used to support professional development (PD) and manage knowledge within organizations, in several professional contexts, such as midwives, Liberian tailors, navy quartermasters and meat cutters (Lave & Wenger, 1991) or even teachers (e.g., Cuddapah & Clayton, 2011; Howell, 2007). However, and particularly in the Education area, studies frequently focus on the description of how CoP can be created and sustained, as well as their advantages for PD without presenting evidence of change in the teaching practices of their members (Avalos, 2011; Dede, 2006; Lai et al., 2006). It is also uncommon narratives of work

carried out in CoP involving teachers and researchers. Hence, this work aims to contribute to fill this gap, reporting the contributions of an online CoP, involving teachers and researchers, to improve Science Education (SE) teaching practices.

In line with the above mentioned, a single case study was carried out. An online CoP, involving teachers and researchers in the domain of SE was analysed. The online CoP members collaborate, using diverse online communication tools, to develop a curricular module related with sustainably (Marques, 2014). The analysis was performed taking into account the Interconnected Model of Teacher Professional Growth (IMTPG) of Clarke and Hollingsworth (2002) and based on empirical data concerning the interactions between the online CoP members and documents created during the life cycle of the community.

Clarke and Hollingsworth (2002) claim that teacher professional growth occurs through reflection and enactment in four domains: external (the stimulus triggering the professional growth), personal (i.e., the teacher's knowledge, beliefs and attitudes, in sum, their competencies), practice (the teacher's experimentation in his/hers professional actions), and consequence (the acknowledged consequences of the experimented actions). By presenting these domains interconnected, the model proposes that a change in one domain can induce change(s) in another domain(s). Thus, this model recognises multiple possible pathways in professional growth, and, therefore, the occurrence of learning in different contexts and formats.

The developed work, the PhD of the first author, was based on two assumptions, arising from the literature:

- online CoP have the potential to contribute to teacher professional growth (Dede, 2006; Lai et al., 2006; Loureiro et al., 2009); and
- a change in a teacher external domain, e.g., through the participation in an online CoP, can induce changes in its practices and consequence domains (Clarke & Hollingsworth, 2002).

This study, as other previous studies (Justi & Driel, 2006; Witterholt, Goedhart, Suhre, & Streun, 2012), uses the IMPG to support the understanding of teacher professional growth, regarding teaching practices developed in an online CoP. The research questions were defined to focus the analysis in some of the IMTPG domains. They are:

1. What are the dynamics of interaction of the selected online CoP? – external and practice domains;

2. To what extent are the teaching strategies mobilised within the selected online CoP coherent with indicators, from SE research, regarding effective strategies concerning pupils' learning? – consequence domain;
3. What is the potential of the work carried out by the members of online CoP for the development and adoption of innovative teaching practices and, thus, for PD? – consequence domain;
4. What principles of curricular development (CD), recommended in the literature, were enacted during the development of the curricular module by the online CoP? – consequence domain.

Each one of these questions was analysed during the course of the PhD of the first author, as previously referred, and is coherent organisation (made in the thesis introduction and conclusions) of four papers published in peer-reviewed journals as follows: question 1 in Marques, Loureiro, and Marques (2016), question 2 in Marques, Loureiro, and Marques (2015a) question 3 in Marques, Loureiro, and Marques (2011) and question 4 in Marques, Loureiro, and Marques (2015b). This contribution is based in the conclusions of the PhD and, thus, a synthesis of the main results and recommendations regarding measures to promote the contributions of online CoP aiming the innovation of SE teachers' practices. Figure 1 shows the relation between the research questions, the IMTPG and the emergent recommendations. The explanation of the connection between the IMTPG domains will be made in the final section of the paper.

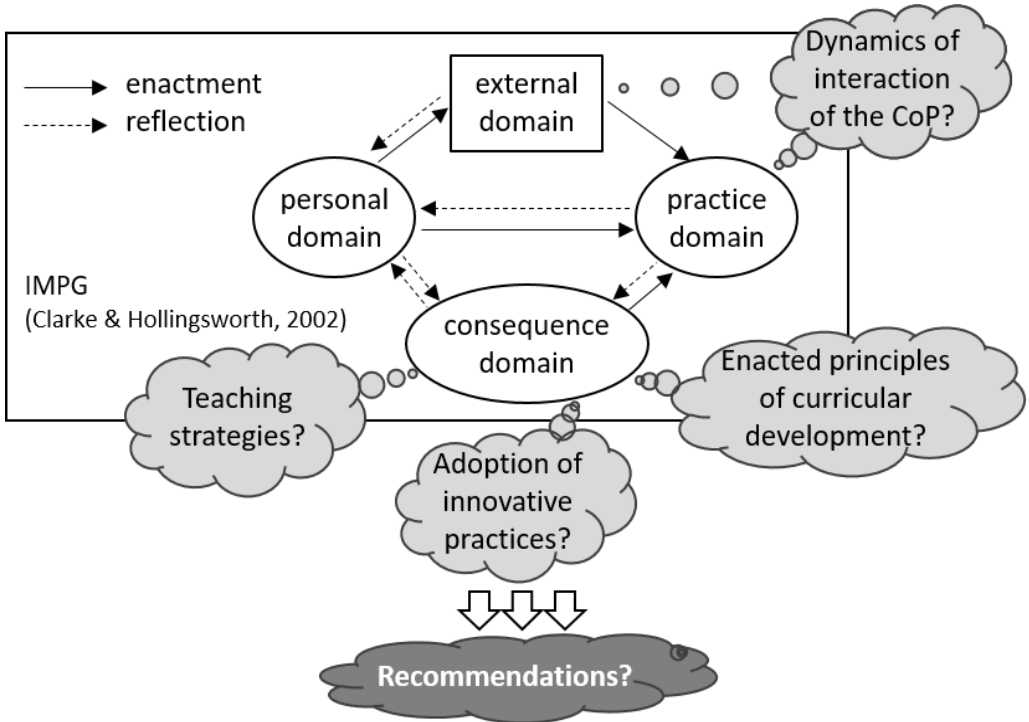


Figure 1. Relation between the research questions, the Interconnected model of teacher’s professional growth or IMTPG (Clarke & Hollingsworth, 2002), the published papers and the emergent recommendations

Methodology and contextualisation

The nature of the study is qualitative descriptive and exploratory (Berg, 2001; Yin, 2009), as the documentation of the contribution of teacher participation in online CoP to teaching practice improvement is still scarce (Avalos, 2011; Lai et al., 2006). Both the contemporaneity of the phenomena (in-depth study the selected online CoP), the real life context studied, and the type of research questions proposed, justify the option for a single case study methodology (Yin, 2009). Additionally, the aim was to deeply understand a single case, without concerns to compare it with other cases and to generalise the results (Yin, 2009).

The studied online CoP was established and sustained under a Portuguese research project, named “Investigação e práticas lectivas em Educação em Ciência: Dinâmicas de interação – IPEC” (Research and practices in Science Education; dynamics of interaction), financed by the Portuguese Foundation for Science and Technology (FCT). In the context of the project four group were created. One of these groups, G2,

was selected as the object of the present study since it presented several features of an online CoP. Namely the members had a common goal, a shared practice, developed a common repertoire, had a high sense of community, extensively used online asynchronous community tools, in particular discussion forums (more suitable to promote reflexivity), and collaborated during a long period, almost two school years (Marques, 2008). Without the linearity and time constraints of synchronous communication tools, where messages are typically brief, informal, and superficial, asynchronous conferences are recognized in the literature as more conducive to higher order thinking through literate writing (Lapadat, 2002) and were the ones chosen by the group to interact at a distance.

G2 consisted of five female teachers (four specialists in *biology and geology* and one in *physics and chemistry*), and three researchers in SE (two male and one female). The teachers had a long teaching experience (11 to 21 years), most of them had a post-graduation in SE, and all of them used information and communication technologies (ICT), mainly word processor, Internet browser and e-mail. None of these teachers had experience using ICT in distance learning. Regarding the researchers, all had a PhD degree and more than 20 years of research experience. Two of them used ICT tools as the teachers did and one was an expert in educational technology, thus used ICT with several objectives, including teaching. The group developed a curricular module related with the sustainability of a quarry and used a field trip strategy accordingly with Orion (1993). The author posits that a field trip has three moments properly articulated: before the field trip, the actual field trip and after the field trip. Before the field trip a preparation phase is carried out to reduce the novelty space in its cognitive, geographic and psychological aspects. In other words, this is a contextualization phase of the aimed learning. This phase is followed by a phase where students interact with the natural phenomena on the site of the field trip, through concrete activities (observation, data gathering, questioning the quarry responsible ...). Back in the classroom, after the visit, the students analyse and organise the data and derive conclusion, in other words, this phase aims more abstract conceptual learning.

To reply the first question (What are the dynamics of interaction of the selected online CoP?) two years of online interactions regarding the planning, implementation and assessment of a curricular module developed by G2 and all the documents produced in this context, were analysed. The platform statistics were downloaded in order to analyse the dynamic of the interaction (number of posts by month along the two years). The posts and the documents were submitted to content analysis to characterise the

dynamic of online CoP phases. The analysis scheme was produced as a result of a literature review, regarding CoP life cycle, allowing to compare several models of CoP phases of development (Gongla & Rizzuto, 2001; Grossman et al., 2000; Howell, 2007; McDermott, 2000; Wenger, 1998; Wenger, McDermott, & Snyder, 2002). Content analysis was performed using an adaptation of Wenger et al.'s model, integrating features of other analysed, coherent with G2's empirical data. The resultant instrument is one of the contributions of PhD and is presented in the annex I. Concerning the online CoP work strategy, it was contrasted with the action-research cycles of Altrichter and colleagues (1993). More details regarding the methodological options of this particular study are presented in Marques et al. (2016).

To answer the research question 2 (To what extent are the teaching strategies mobilised within the selected online CoP coherent with indicators, from SE research, regarding effective strategies concerning pupils' learning?), a literature review of international studies, particularly meta-analyses of strategies with impact on pupils' science learning (Furtak et al., 2012; Marzano, Gaddy, & Dean, 2000; Schroeder et al., 2007; Wise, 1996; Wise & Okey, 1983) was performed. The emergent instrument of analysis (Annex I) was applied to the curricular module plan and development, its members' final reports and the group's published papers and communications. More details regarding this work are presented in Marques et al. (2015a).

Regarding research question 3 (What is the potential of the work carried out by the members of online CoP for the development and adoption of innovative teaching practices and, thus, for PD?), the study of the innovative features of G2's practices was performed with literature descriptors proposed by Jaskyte et al. (2009) and Cachapuz, Praia, and Jorge (2002). Here, the empirical data was submitted to content analysis using these authors' indicators of innovative teaching practices in SE (Annex III). Once again, the resulting analysis scheme is one contribution of this work. More details about this analysis' methodology are presented in Marques et al. (2011).

At last, to address research question 4, G2's enactment of CD principles, identified through a review of international literature (e.g., Anderson & Rogan, 2011; Gaspar & Roldão, 2007; Kelly, 2009; Pacheco, 2005), was also analysed. A qualitative analysis instrument with six descriptors was proposed and applied to the CoP's empirical data. Figure 2 synthetize the CD principles that emerged from the literature. More details regarding this work are presented in Marques et al. (2015b).

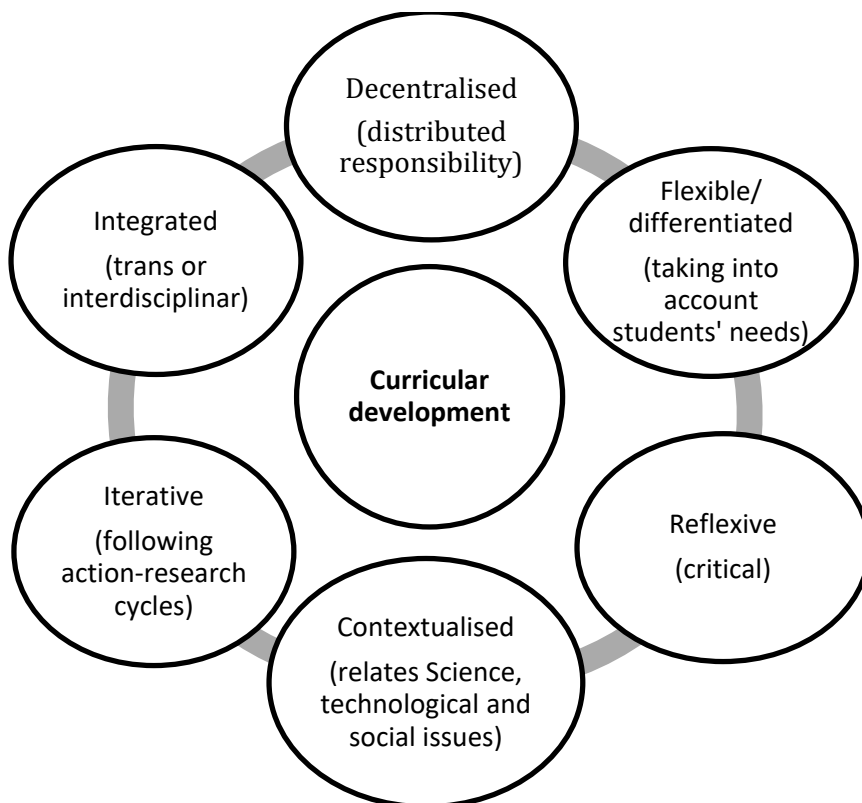


Figure 2. Schematic synthesis of the CD principles

Results presentation and discussion

As mentioned before, the research guided by question 1 addresses the external and practice domains of the IMTPG. Regarding G2 teachers' *external domain*, the data collected allowed acknowledging the following CoP's phases of development in G2's online interactions:

- Potential phase – involved the exploitation of the online platform used for the interaction between the G2 members, the discovery of members' common interests regarding the teaching practice and the negotiation of the group work plan, taking into account problems emerging from the teacher's practices (see the description below);
- Coalescing phase – G2's members shared teaching experiences, discussed educational concepts, made recommendations, read academic documents about SE (journal articles, reports, ...), and developed a common practice – a curricular module that was implemented by one of the teachers;

- Maturing phase – comprised the assessment of the curricular module and the identification of the cutting edge issues, particularly the definition of the module’s educational aims and assessment strategies. As a consequence, the curricular module and all the teaching materials were revised to be enacted by all the teachers. The implementation was made in collaboration with school colleagues not previously involved in the project IPEC;
- Stewardship – G2 developed a sense of property and pride in the developed work, which was translated into its dissemination during the implementation of the revised module and in scientific meetings (Marques et al., 2016).

The Figure 3 presents the statistics of the interaction during the development of the curricular module by G2 and the online CoP phases along the interaction period that fits an adaptation of Wenger et al.’s model, as referred in the previous section.

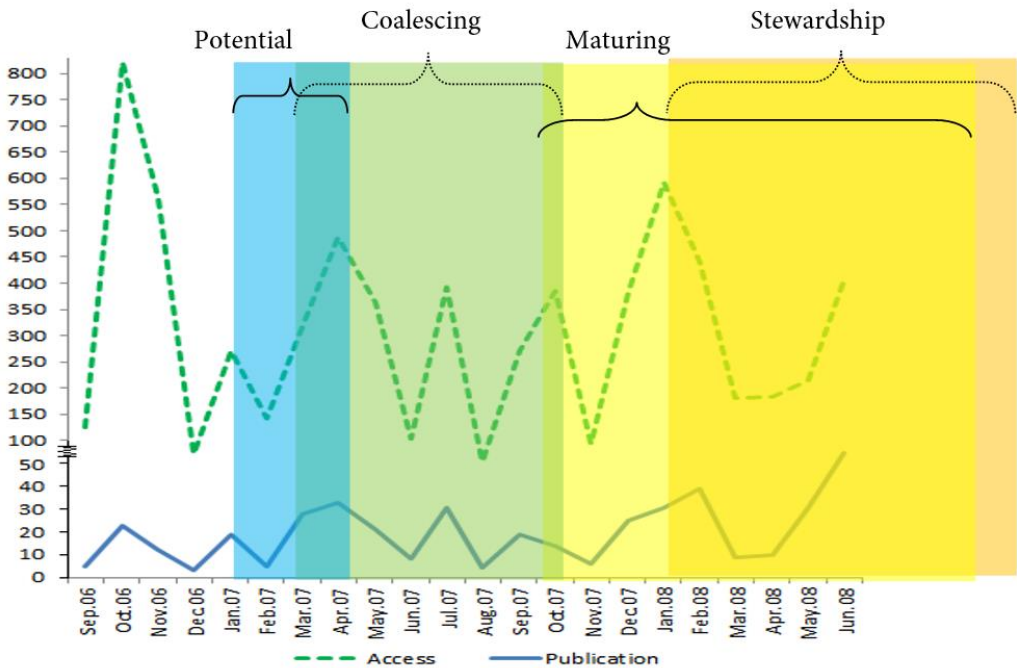


Figure 3. Frequency of access and publication of messages in fora by the teachers from G2

Concerning the *practice domain* and the description of the CoP’s phases, it can be inferred that, during the course of about two scholar year, G2’s collaboratively developed a curricular module performing two cycles of action-research, similar to the cycles proposed by Altrichter and colleagues (1993): planning, implementation and

evaluation. The starting point (in the *external domain*) was a reflection enacted by a questionnaire where teachers were invited to share their problems related with scientific topics and teaching strategies. This allowed the identification of teaching practices problems by the teachers themselves and a sense of ownership during the development of the curricular module materials and its implementation. During the evaluation phase, new problems emerged related to the definition and alignment of the module objectives with the assessment strategies. This led to an unexpected collaborative processes; a working journey with invited experts (highly valued by the teachers) was organised to discuss the new problems. The reflection during the journey initiate another action-research cycle during the maturing phase as described above.

Considering the theoretical framework of categorization of action-research cycles proposed by Mamlok-Naaman and Eilks (2012), G2's research process started as a practice action-research and evolved to an emancipatory mode, due to the development of innovative teaching practices, which were disseminated by the teachers involved in their development. Moreover, action-research promoted teachers' autonomy and changes in the teaching practices, as recognised in the literature (Borko, 2004).

Moving towards IMPG's *consequence domain*, under research question 2, the analysis showed that G2 developed a curriculum integrated field trip, contextualized in real word situations and combining diversified teaching strategies, such as learning of contextualized phenomena, debate in small groups or intentional questioning (Marques et al., 2015a). All of these were referred in the literature as effective science teaching strategies (e.g., Schroeder et al., 2007; Wise, 1996). Regarding the mobilized resources, the main ones were information and communication technologies, e.g., for presenting information, either by teacher and by pupils, or for reducing the novelty-space (Orion, 2007); several laboratory and outdoors instruments; and G2's fieldwork guide. The traditional blackboard and textbook were not frequently used, contrasting with other studies' results (e.g., Herbert et al., 2003). Considering IPEC's teachers teaching practices characterization, made at the beginning of the project (Marques et al., 2008), this analysis revealed an evolution of G2's teachers teaching strategies that was acknowledged by themselves (e.g., Morgado et al., 2008). Additionally, the development of a content analysis instrument for effective teaching strategies in SE allows educators aligning specific teaching strategies with indicators from meta-analytic studies (e.g., Schroeder et al., 2007). This instrument is also useful for science

teachers that which to diversify and adapt their set of teaching strategies, sustaining their options in literature recommendations.

Still in the consequence domain, the research question 3 prompted the analysis of the coherence of G2's teaching practices with innovation indicators for SE, present in the literature (Marques et al., 2011). In this study, empirical data was collected and linked to 13 out of 14 innovation descriptors in science teaching, supporting the claim that G2 developed challenging innovative practices (Adams, 2003). Moreover, other teachers from G2's schools got involved in this CoP practices. This contributes to sustaining the claim that innovation created by teachers can more easily be disseminated and adopted (Towndrow et al., 2010).

Finally, the literature review performed for research question 4 allowed identifying six CD principles. Crossing these with the empirical data revealed that G2 enacted all the principles:

- not centralized CD – in this CoP, the decision making was shared both by teachers and researchers, as well as with other teachers from the G2 teachers' schools and even some contributions from their students;
- CD flexible and differentiated – the definition of alternative teaching and learning sequences and the adaptation of the initial curricular module, to better fit each teacher educational context, were important features;
- CD contextualized in Science-Technology-Society-Environment – the curricular module is based on pupils' analysis and decision making regarding a controversial societal problem;
- Integrated CD – there is an explicit articulation of the academic subjects of Geology and Chemistry;
- CD with iterative phases – two cycles of action-research were identified;
- Reflexive CD – this was shown in previous related work (Cruz, 2010).

Considering the above presented, the participation in this online CoP originated a CD coherent with literature emerging principles, which was a relevant consequence for the teaching practices of G2 members. This study allowed to empirically validate a set of theoretical CD principles, as well as the literature-emergent analysis instrument (Marques et al., 2015b).

Conclusions and implications

In this case study, Clarke and Hollingsworth (2002) IMPG revealed to be useful for the understanding of the implications for the professional growth of teachers participating in an online CoP. Additionally, this study allowed to recognize some features for the adaptation of the model to this context (see Figure 4), which are explained in the following paragraphs.

Regarding the process leading to the development of a curricular module, the results were analysed considering two cycles of action-research. These contributed to the changing of teaching practices, in an emancipator way (Mamlok-Naaman & Eilks, 2012). In Figure 4, the changes in the analysed domains are represented, after triangulation with the members' views, which were disseminated in papers and communications. The adaptation of the IMPG to this online CoP context is a theoretical contribution of this work.

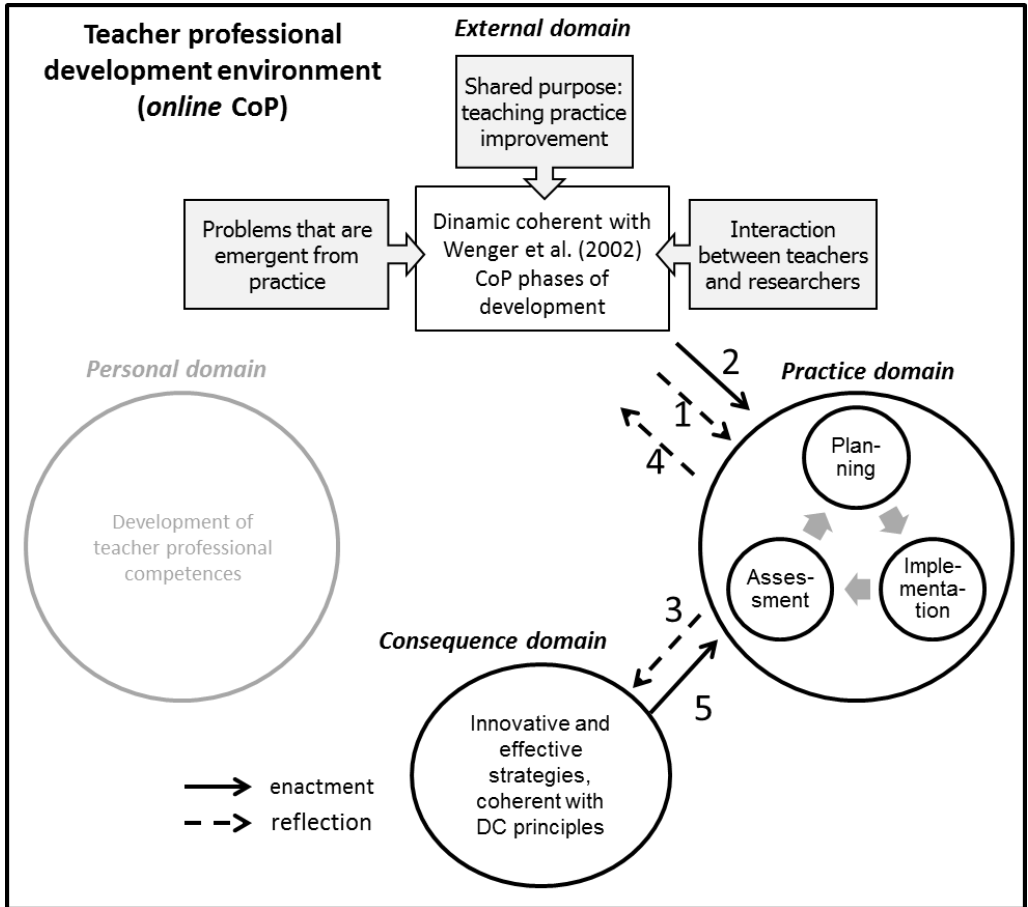


Figure 4. Adaptation of Clarke and Hollingsworth (2002) interconnected model of professional growth to the studied case

In this case study, the environment of professional growth or teacher PD, named changing environment by Clarke and Hollingsworth, is the online CoP formed under the IPEC project. The interaction dynamics established in this community are coherent with an adaptation of Wenger, McDermott, and Snyder (2002) model. It inclusively revealed a high variation in the levels of participation in the CoP activities, during a two-year collaboration period. Among the stimuli characterizing this teachers’ external domain are:

- the identification of problems emergent from the teachers’ practices (Marques et al., 2008), and hence, with high relevance for the teachers and attending their professional concerns;

- the continued interaction between science teachers and researchers in SE, in an online environment. This type of partnership is recommended in the literature (e.g., Kraayenoord, Honan, & Moni, 2011);
- the sharing of a common purpose – improving teaching practice (Marques et al., 2008; Wenger, 1998).

Reflection processes about, e.g., ideas and concepts discovered/revisited through academic readings on SE; teaching experiences; or the explanation of why some curricular decisions were made (as stated in, e.g., Morgado et al., 2008), induced changes (represented by arrow 1, in Figure 4) in the practice domain. In this manner, they lead to professional experimentation (represented by arrow 2) regarding planning CD processes (collectively, literature informed, and with distance communication tools); the implementation of new ways of teaching (new, at least for the teachers involved in the online CoP); and even the development of unusual assessment processes (Lucas & Vasconcelos, 2005). All of these occurred in a cycle of action-research (Altrichter et al., 1993) that lead to the development of the first version of the curricular module.

The reflective processes, on the curricular module's assessment results, induced changes in the consequence domain (represented by arrow 3). G2 members acknowledged the innovative character of the developed practices (Morgado et al., 2008). This study's results support G2's self-report, as it allowed identifying empirical evidence pointing to the development of innovative and effective teaching strategies, which are also coherent with CD principles from the literature. Simultaneously, the same reflective processes lead to changes in the external domain (represented by arrow 4) as the CoP's dynamics started including interactions with teachers from G2 teachers' schools, i.e., each G2 teacher was a disseminator of the curricular module, an innovation, in their own school community. Thus, the action-research process they undertaken acquired an emancipatory feature (Mamlok-Naaman & Eilks, 2012). Furthermore, the acknowledgment of the consequences valued by G2 members lead to the second action-research cycle, with contributes from their local group of teachers, involving more experimentation in the practice domain (represented by arrow 5).

Finally, the personal domain appears greyed in Figure 4, due to the fact that this case study focused in the identification of contributions of an online CoP of teachers and researchers to their professional growth at the teaching practice level. Further research should include the analysis of changes in the personal domain, as well as consider

other theoretical frameworks, such as activity theory (Engeström, 1999; Vygotsky, 1978).

At last, each one of the papers related to this synthesis effort present a set of lessons learned. Here, we highlight the following recommendations to enhance the contributions of online CoP of teachers and researchers in SE to the teaching practices:

- expect participations peaks in the community activities and act accordingly, e.g., by promoting member's interactions in critical periods;
- value teachers' contributions, increasing their confidence in their ability to participate;
- avoid deadlines close to the end of the terms, when Portuguese teachers seem to be submitted to higher workload – similar limitations have been reported before (Pereira, 2007), but not at this level of detail;
- propose the development of cycles of action-research of the emancipatory type (Mamlok-Naaman & Eilks, 2012).
- support teachers in the theoretical clarification of teaching strategy (Leite, 2010);
- support teachers in the broadening of their teaching strategies repertoire;
- support teachers in the development of innovative challenging teaching practices (Towndrow et al., 2010), instead of innovations imposed by, e.g., the government (Aubusson, 2002).

References

1. Adams, R. (2003). *Perceptions of innovations: exploring and developing innovation classification*. Unpublished PhD, Cranfield University, Cranfield.
2. Altrichter, H., Posch, P., & Somekh, B. (1993). *Teachers investigate their work: an introduction to the methods of action research*. London: Routledge.
3. Anderson, T. R., & Rogan, J. M. (2011). Bridging the educational research-teaching practice gap: Curriculum development, Part 1: Components of the curriculum and influences on the process of curriculum design. *Biochemistry and Molecular Biology Education*, 39(1), 68–76.
4. Aubusson, P. (2002). An ecology of science education. *International Journal of Science Education*, 24(1), 27-46.
5. Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. *Teaching and Teacher Education*, 27, 10-20.

6. Berg, B. L. (2001). *Qualitative research methods for the social sciences* (4th ed.). Needham Heights, MA: Allyn and Bacon.
7. Borko, H. (2004). Professional development and teacher learning: mapping the terrain. *Educational Researcher*, 33, 3–15.
8. Cachapuz, A., Praia, J., & Jorge, M. (2002). *Ciência, Educação em Ciência e Ensino das Ciências*. Lisboa: Ministério da Educação.
9. Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18, 947-967.
10. Cruz, M. G. (2010). *Interações em comunidades de prática online e reflexividade docente: um estudo de caso envolvendo professores de ciências*. Dissertação de Mestrado não Publicada, Aveiro: Universidade de Aveiro.
11. Cuddapah, J. L., & Clayton, C. D. (2011). Using Wenger's Communities of Practice to Explore a New Teacher Cohort. *Journal of Teacher Education*, 62(1), 62-75.
12. Dede, C. (Ed). (2006). *Online professional development for teachers: Emerging models and methods*. Cambridge, MA: Harvard Education Press.
13. Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engestrom, R. Miettinen & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 19-38). New York: Cambridge University Press.
14. Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and Quasi-Experimental Studies of Inquiry-Based Science Teaching: A Meta-Analysis. *Review of Educational Research*, 82(3), 300–329.
15. Gaspar, I., & Roldão, M. C. (2007). *Elementos de desenvolvimento curricular*. Lisboa: Universidade Aberta.
16. Gongla, P., & Rizzuto, C. R. (2001). Evolving communities of practice: IBM Global Services experience. *IBM Systems Journal*, 40(4), 842-462. Retrieved from <http://ieeexplore.ieee.org/document/5386943/>
17. Grossman, P., Wineburg, S., Woolworth, S., & Washington, U. o. (2000). *What Makes Teacher Community Different from a Gathering of Teachers?* (pp. 64): Center for the Study of Teaching and Policy - University of Washington.

18. Herbert, S., Rampersad, J., Akinmade, C., & Maharaj-Sharma, R. (2003). *Lower Secondary Science Teaching and Learning: A Glimpse into the Science Classroom*. School of Education: UWI, St. Augustine.
19. Howell, J. D. (2007). *Online communities of practice and their role in the professional development of teachers*. Unpublished PhD Thesis, Queensland University of Technology, Brisbane.
20. Jaskyte, K., Taylor, H. and Smariga, R. (2009). Student and Faculty Perceptions of Innovative Teaching. *Creativity Research Journal*, 21(1), 111-116.
21. Justi, R., & Driel, J. v. (2006). The use of the Interconnected Model of Teacher Professional Growth for understanding the development of science teachers' knowledge on models and modelling. *Teaching and Teacher Education*, 22, 437-450.
22. Kelly, A. V. (2009). *The curriculum: Theory and practice* (6th ed.). London: SAGE.
23. Kraayenoord, C. E. v., Honan, E., & Moni, K. B. (2011). Negotiating knowledge in a researcher and teacher collaborative research partnership. *Teacher Development*, 15(4), 403-420.
24. Lai, K. W., Pratt, K., Anderson, M., & Stigter, J. (2006). *Literature Review and Synthesis: Online Communities of Practice*. Retrieved June 1, 2008, from http://www.educationcounts.govt.nz/__data/assets/pdf_file/0019/7480/lrs-online-com.pdf
25. Lapadat, J. C. (2002), Written Interaction: A Key Component in Online Learning. *Journal of Computer-Mediated Communication*, 7(4), 0. doi:10.1111/j.1083-6101.2002.tb00158.x
26. Lave, J., & Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. Cambridge: University Press.
27. Leite, T. (2010). *Planeamento e concepção da acção de ensinar* (Vol. 2). Aveiro Universidade de Aveiro.
28. Loureiro, A., Vaz, C., Rodrigues, M.R., Antunes, P. e Loureiro, M.J. (2009). *Factores críticos de sucesso em comunidades de prática de professores online*. Paper presented at the VI Conferência Internacional de Tecnologias de Informação e Comunicação na Educação, Challenges 2009.
29. Lucas, S., & Vasconcelos, C. (2005). Perspectivas de ensino no âmbito das práticas lectivas: Um estudo com professores do 7^o ano de escolaridade. *Revista Electrónica*

- de Enseñanza de las Ciencias*, 4(3), Artículo 4. Retrieved from http://reec.uvigo.es/volumenes/volumen4/ART4_Vol4_N3.pdf
30. Mamlok-Naaman, R., & Eilks, I. (2012). Different types of action research to promote chemistry teachers' professional development: A joined theoretical reflection on two cases from Israel and Germany. *International Journal of Science and Mathematics Education*, 10(3), 581-610.
 31. Marques, L., Loureiro, M. J., Praia, J. F., Lopes, C., Marques, M. M., Pinho, S., et al. (2008). *Descrição detalhada das actividades efectuadas no decurso do projecto IPEC*. Aveiro: Universidade de Aveiro.
 32. Marques, M. M. (2008). *Gestão curricular intencional numa comunidade de prática online: Um estudo de caso envolvendo professores de ciências*. Unpublished MA dissertation. Aveiro: Universidade de Aveiro. Retrieved from <http://hdl.handle.net/10773/1022>
 33. Marques, M. M. (2014). *Comunidades de prática online: contributos para a prática letiva: um estudo de caso no âmbito da Educação em Ciência envolvendo professores e investigadores*. Unpublished PhD. Aveiro: Universidade de Aveiro. Retrieved from <http://ria.ua.pt/handle/10773/13142>
 34. Marques, M. M., Loureiro, M. J. & Marques, L. (2011). Planning innovative teaching practices in a community of practice: a case study in the contexts of the Project IPEC. *International Journal of Web Based Communities, Special Issue*, 7(4), 429-441. doi: 10.1504/IJWBC.2011.042989
 35. Marques, M. M., Loureiro, M. J., & Marques, L. (2015a). Science teaching strategies developed in an online community of practice: a case study. *International Journal of Web Based Communities*, 11(3/4), 305-321, doi: 10.1504/IJWBC.2015.072134
 36. Marques, M. M., Loureiro, M. J., & Marques, L. (2015b). Desenvolvimento curricular numa comunidade de prática – princípios operacionalizados no âmbito do projecto IPEC. *Revista Academia y Virtualidad*, 8(1), 35-53. ISSN 2011-0731, doi: 10.18359/ravi.444
 37. Marques, M. M., Loureiro, M. J., & Marques, L. (2016). The dynamics of an online community of practice involving teachers and researchers. *Professional Development in Education*, 42(2), 235-2577. doi: 10.1080/19415257.2014.997396

38. Marzano, R. J., Gaddy, B. B., & Dean, C. (2000). *What Works in Classroom Instruction*. Aurora, CO: Mid-continent Research for Education and Learning.
39. McDermott, R. (2000). Community development as a natural step. *Knowledge Management Review*, 3(5), 16-19.
40. Morgado, M., Rebelo, D., Marques, L., Loureiro, M. J., Fernandes, I., Tavares, A., et al. (2008). *Exploração Sustentada de Recursos Geológicos – Uma Abordagem Didáctica Interdisciplinar Desenvolvida em Contexto On-line*. Artigo apresentado no XV Simpósio sobre Enseñanza de la Geología, Universidade de Alcalá: Guadalajara.
41. Orion, N. (2007). A Holistic Approach for Science Education for All. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(2), 111-118.
42. Pacheco, J. A. (2005). *Estudos Curriculares: para a Compreensão Crítica da Educação*. Porto: Porto Editora.
43. Pereira, M. (2007). *Co-construção de estratégias de ensino numa Comunidade de Prática online*. Unpublished MA dissertation. Aveiro: Universidade de Aveiro.
44. Schroeder, C. M., Scott, T. P., Tolson, H., Huang, T.-Y., & Lee, Y.-H. (2007). A Meta-Analysis of National Research: Effects of Teaching Strategies on Student Achievement in Science in the United States. *Journal of Research in Science Teaching*, 44(10), 1436–1460.
45. Towndrow, P., Tan, A., Yung, B., & Cohen, L. (2010). Science Teachers' Professional Development and Changes in Science Practical Assessment Practices: What are the Issues? *Research in Science Education*, 40(2), 117-132.
46. Vygotsky, L. (1978). *Mind and society*. Oxford: Blackwell.
47. Wise, K. C. (1996). Strategies for teaching science: What works? *Clearing House*, 69(6), 337-338.
48. Wise, K. C., & Okey, J. R. (1983). A meta-analysis of the effects of various science teaching strategies on achievement. *Journal of Research in Science Teaching*, 20(5), 419-435.
49. Witterholt, M., Goedhart, M., Suhre, C., & Streun, A. (2012). The Interconnected Model of Professional Growth as a means to assess the development of a mathematics teacher. *Teaching and Teacher Education*, 28(5), 661–674.

50. Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. Cambridge: Cambridge University Press.
51. Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice: a guide to managing knowledge*. Boston: Harvard Business School Press.
52. Yin, R. K. (2009). *Case study research: design and methods* (4th ed. Vol. 5). California: Sage Publications.

Acknowledgement

The authors acknowledge the engagement of the teachers involved in the IPEC project and the support of the Portuguese Foundation for Science and Technology, through the funding given to the Project IPEC (POCI/CED/58825/2004) and to the doctoral studies of the first author (SFRH/BD/36177/2007).

Annex I – Q1’s content analysis framework

Analysis framework of the stages of development of an online CoP involving teachers and researchers in SE. The features that are not part of Wenger and colleagues’ CoP life cycle are highlighted in bold.

Stages of development	Some typical activities in CoP involving teachers and researchers	Cycles of action-research
Potential	<p>Tension: balancing discovery and imagination. Teachers and/or researchers of a loose network find a potentially common interest in a domain: to promote student and teacher learning. Discovery of similar educational problems, the sharing of a passion and the possibility of professional development.</p> <p>Awareness of the value of the community. Negotiation of the educational topic (domain) and engaging issues, e.g., through the definition of a work plan.</p> <p>Identification with some members within the larger group, e.g., defining work groups.</p> <p>Exploration of the community’s facilities (available or in development), e.g., an online platform with several communication tools.</p> <p>Giving/receiving technical support, e.g., asking for orientation related to the use of an online communication tool.</p>	<p>Identification of problems that emerge from practices</p> <p>Reflection</p>
Coalescing	<p>Tension: balancing incubating community and delivering immediate value.</p> <p>Improvement of the community’s relationships and trust, e.g., through face-to-face meetings. Official launch of the community through community events. Discussion of group’s norms.</p> <p>Delivering immediate value by negotiating what knowledge is useful to be shared and how to share it, e.g., to share literature references on education, to share teaching experiences, to discuss educational concepts, etc. Development of deep knowledge on the individual practice of each other.</p> <p>Awareness that colleagues are resources for learning.</p> <p>Involvement in group’s discussions.</p> <p>Giving/receiving technical support, e.g., asking for orientation related to the use of an online communication tool.</p>	<p>Reflection (cont.)</p> <p>Planning</p> <p>Implementation</p> <p>Evaluation</p>
Maturing	<p>Tension: balancing the focus on the progression of the domain and the expansion of the community’s membership and perspectives.</p> <p>Focus on developing a comprehensive corpus of knowledge and on cutting edge issues within the CoP’s domain (organise, classify and identify gaps in the developed work) – higher demands of time and commitment.</p> <p>Expansion of the community’s membership and perspectives.</p> <p>Disruption of the community’s interaction, intimacy and</p>	<p>Evaluation (cont.)</p> <p>Reflection</p> <p>Planning</p> <p>Implementation</p> <p>Evaluation</p>

	domain. Common regulation of group's behaviour. Commitment to colleagues' growth. Growth of the community, through cycles of high and low energy.	
Stewardship	Ownership of the developed knowledge and practice, e.g., presenting the developed work in public. Building relationships with other communities. Open-mindedness (through accepting and soliciting) to new ideas and members, to keep the relevance. Tension: balancing ownership and open-mindedness.	Evaluation (cont.) Reflection Public presentation of the results
Transformation	Returning to a previous stage, conversing into a social group, division into different communities, merging with others or end of the CoP. Tension: balancing the let go of the community (fade away through the loss of its members) and the live on (remembering the community through its legacy). Possibility of returning to the community's facilities to access the built knowledge.	

Annex II – Q2's content analysis framework

Type of action enacted by the teachers (t) or the students (S) and its description

Type of action	Description of the action
Focus	The protagonist (T or S) defines and/or negotiates the learning objectives, orally or with the support of educational resources.
Planning	The protagonist (usually S) decides on and makes arrangements for the tasks to be performed, by whom, how and with what resources, orally or with the support of educational resources.
Exposure	The protagonist (T or S) presents ideas orally or with the support of educational resources, without major interventions of others and with a longer or shorter duration.
Questioning	The protagonist (T or S) raises questions orally or written, to be answered by S.
Debate	The protagonist (usually S), in interaction with other protagonists, analyses and orally exchanges ideas on a topic to reach a consensus.
Research and synthesis	The protagonist (usually S) collects information/data, processes it and synthesizes it, with the support of the needed educational resources.
Manipulating instruments	The protagonist (usually S) observes and interacts with laboratory or fieldwork instruments.

Frequency of action of the different actors

Protagonist of the action	Before Ñ (a)	Field trip Ñ (a)	After Ñ (a)	Total Ñ (a)
Teacher				
Individual student				
Students in small groups				
Teacher and students in the Class - shared protagonism				

Frequency of use of the different resources

Resources to support the action	Before Ñ (a)	Field trip Ñ (a)	After Ñ (a)	Total Ñ (a)
The resources are not explicit				
Worksheet produced by the teacher or other material provided by the teacher (for example, a newspaper article or legislation)				
Technology related with static text and image (for example, computer and datashow to display electronic non interactive presentations)				
Interactive technology (for example, computer with Internet access and specific software)				
Laboratory and fieldwork material (for example, geological map, rock samples, camera, microscope or test tubes)				

Annex III – Q3's content analysis framework

Descriptors used posits that innovative SE teaching practices:

1. aims the acquisition/development of concepts, capacities, attitudes and values;
2. bases teaching on socio-constructivist perspectives – proposes the study of open problems;
3. bases teaching on socio-constructivist perspectives – promotes students' active participation;
4. bases teaching on socio-constructivist perspectives – promotes learning through the negotiation of meaning;
5. values a global perspective of science – connects information to real problems (STS contexts);
6. values a global perspective of science – promotes an interdisciplinary or a transdisciplinary approach to the content;
7. values a global perspective of science – promotes awareness of the dynamic nature of science;
8. teaches to different learning styles, e.g., through varied teaching methods, activities and materials;
9. propose synthesis activities and critical reflection;
10. gives unorthodox and unusual assignments;
11. modifies old teaching strategies and develops new (research-based) approaches;
12. encourages student feedback and reacts to it;
13. uses different methods of assessment, develops new and diverse student learning assessment tools and learning assessment includes concepts, capacities, attitudes and values;
14. evaluates the effectiveness of her/his innovative teaching method.