



---

## CONTRIBUTIONS TO TEACHING PRACTICE OF AN ONLINE COMMUNITY OF PRACTICE OF TEACHERS AND RESEARCHERS

*Margarida Marques, Maria João Loureiro, Luís Marques, University of Aveiro, Portugal*

---

### Summary

Communities of practice (CoP) have the potential to promote teachers' professional development (PD) and change practices. However, empirical evidence is still scarce. This study aims to contribute to address this shortcoming by analysing an online CoP. A qualitative, descriptive, and exploratory single case study was performed. It focused on both the teaching practice and the CoP's dynamics of interaction. Data collection included online platform information (statistic data and posts automatically recorded) and documents. Data analysis was based on content analysis and was organized accordingly the Interconnected Model of Teacher Professional Growth that Clarke and Hollingsworth proposed in 2002. The analysis was made on: (a) the external domain and domain of practice of curricular development (CD), in other words, their dynamics of interaction; (b) the domain of the consequences in the teaching practice, regarding the developed science teaching strategies; (c) evidence of their innovative nature; and (d) the principles of curricular development (CD) enacted. The results show that (a) the members' participation varied during the interaction period and their dynamic fits an adaptation of the stages of development of a CoP proposed by Wenger et al. in 2002, with two cycles of action-research; (b) the CoP developed diverse teaching strategies, usually not explored by teachers, and coherent with commendations in the literature; (c) the teaching practice was innovative, in a challenging way; and (d) the CoP enacted several principles of CD recommended in literature, namely flexibility and differentiation. The empirical results also allowed to validate the dimensions of the Clarke and Hollingsworth's model, as well as to adapt it to the specificity of the analysed case.

### 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 a certain practice, is the one happening as a consequence of the participation in a social grouping, working on issues and solving problems, genuine and emergent from the practice of common interest as happens in the so called *communities of practice* or CoP (Lave & Wenger, 1991; Wenger, 1998). When these communities use telecommunications, such as online discussion boards or even mobile phones, to allow interaction of members with each other and with artefacts or resources, they are usually called virtual or online CoP.

Over the years, the CoP concept has 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 the description of how CoP can be created or sustained, as well as their advantages for PD, without presenting evidence of change in teaching practices. Hence, *this work aims* to contribute to fill in this gap, by reporting the contributions of an online CoP, of teachers and researchers, to the changing of teaching practices in Science Education (SE) (Figure 1).

In line with the above presented, a *case study* of a specific CoP in the context of SE, collaborating at distance through online technologies to develop a curricular module, was performed (Marques, 2014). The analysis was organized taking into account the Clarke and Hollingsworth (2002) *interconnected model of professional growth* (IMPG), which was based on empirical data. The authors 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), 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 can induce change(s) in another domain(s). Thus, this model recognizes multiple possible pathways in professional growth, and, therefore, the occurrence of learning in different contexts and formats.

The developed work is 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 the practice and consequence domains (Clarke & Hollingsworth, 2002).

This study, as other studies before (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 teacher domains. They are:

1. What are the dynamics of interaction of the selected online CoP? – external and practice domains;
2. To what extend are the teaching strategies, of the selected online CoP, coherent with literature indicators, from the SE research, regarding strategies effective in pupils' learning? – consequence domain;
3. What is the potential of the selected online CoP for the development and adoption of innovative teaching practices and, thus, for PD? – consequence domain;

4. What principles of curricular development (CD), acknowledged in the literature, were enacted in the development of the curricular module of the selected online CoP? – consequence domain.

Each one of these questions was analysed in previous work (question 1 in Marques, Loureiro, & Marques, 2016; question 2 in Marques, Loureiro, & Marques, 2015a; question 3 in Marques, Loureiro, & Marques, 2011; and question 4 in Marques, Loureiro, & Marques, 2015b), being this a synthesis effort to present some of the main lessons learned. Therefore, the developed work allowed presenting a set of recommendations regarding measures to promote the contributions of online CoP to innovation of teachers' practices in SE. Figure 1 synthesizes the relation between the research questions, the IMPG, the published papers and the emergent recommendations.

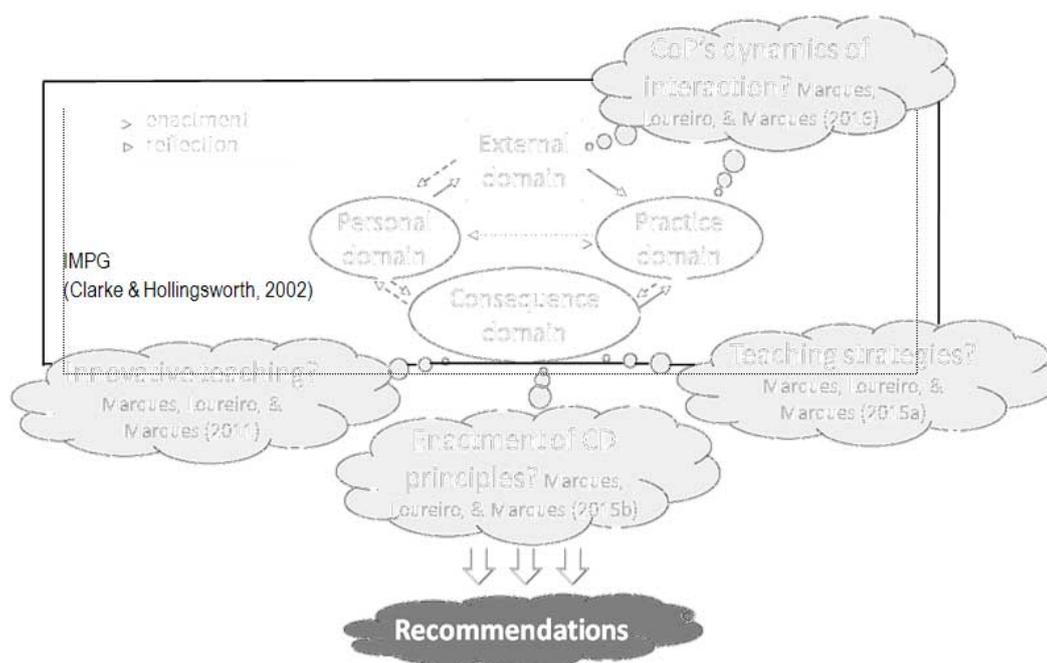


Figure 1. Relation between the research questions, the Interconnected model of professional growth or IMPG (Clarke & Hollingsworth, 2002), the published papers and the emergent recommendations

## Methodology and contextualisation

The *research design* of this 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 changing is still scarce (Avalos, 2011; Lai et al., 2006). Both the contemporaneity of the phenomenon, in a real life context, and the type of research questions proposed justify the case study methodology option (Yin, 2009). Additionally, the aim was to deeply understand a single case, without concerns of comparing it to other cases nor with result generalizations (Yin, 2009).

*The CoP selected* for study was formed and sustained under a Portuguese research project, the “Investigação e práticas lectivas em Educação em Ciência: Dinâmicas de interacção” (IPEC).

In previous work (Marques, 2008), an IPEC group, named G2, was selected for analysis due to the fact it presented several features of a CoP in its interactions.

Under *research question 1*, two years of online interactions regarding the planning, implementation and assessment of a curricular module by G2, as well as all the documents produced in this context, were submitted to content analysis. The analysis scheme was produced as a result of a literature review, regarding CoP life cycle, allowing comparing several models of CoP phases of development (Gongla & Rizzuto, 2001; Grossman et al., 2000; Howell, 2007; McDermott, 2000; Wenger, 1998; Wenger, McDermott, & Snyder, 2002). This allowed selecting a model, Wenger et al. (2002), and adapting it to integrate other models' features, coherent with G2's empirical data. The resultant analysis instrument is one of the contributions of this work. Additionally, descriptive statistical analysis was used to determine G2 members' levels of access and publication in online fora. More details regarding this work methodology options are presented in Marques et al. (2016).

To attend *research question 2*, 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 was applied to the curricular module developed by G2, its members' reports regarding the IPEC project and the group's published papers and communications. More details regarding this work are presented in Marques et al. (2015a).

Regarding *research question 3*, the study of the innovative features of G2's practices was performed with literature descriptors the work of Jaskyte et al. (2009) and of Cachapuz, Praia, and Jorge (2002). Here, the empirical data was submitted to content analysis using these authors' indicators of innovative teaching practices in SE. 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. In this, a qualitative analysis instrument was proposed and applied to the CoP's empirical data. More details regarding this work are presented in Marques et al. (2015b).

## **Results presentation and discussion**

As mentioned before, the research guided by *question 1* addresses the external and practice domains of the IMPG. 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 in the interaction under the project IPEC, the discovery of members' common interests regarding the teaching practice, and the negotiation of a work plan for G2;

- Coalescing phase – G2's members shared teaching experiences, discussed educational concepts, made recommendations for academic readings about SE, and, hence, developed of a common practice;
- 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;
- Hosting phase – G2 developed a sense of property and pride in the developed work, which was translated into its dissemination in the teachers' schools and in education congresses (Marques et al., 2016).

In the *practice domain* of the referred model, G2's development of a curricular module based in two cycles of research-action (e.g. Altrichter, Posch, & Somekh, 1993). Considering the theoretical frame of categorization of action-research modes, explored 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. Additionally, the literature recognizes action-research as a promoter of teachers' autonomy and of teaching practice changing as well (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 (L. 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 empirically validating 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 2), 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 (Mamluk-Naaman & Eilks, 2011). In Figure 2, 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.

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:

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

Margarida Marques et al.

- the identification of problems emergent from the teachers' practices (L. 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 (L. 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 2) 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.

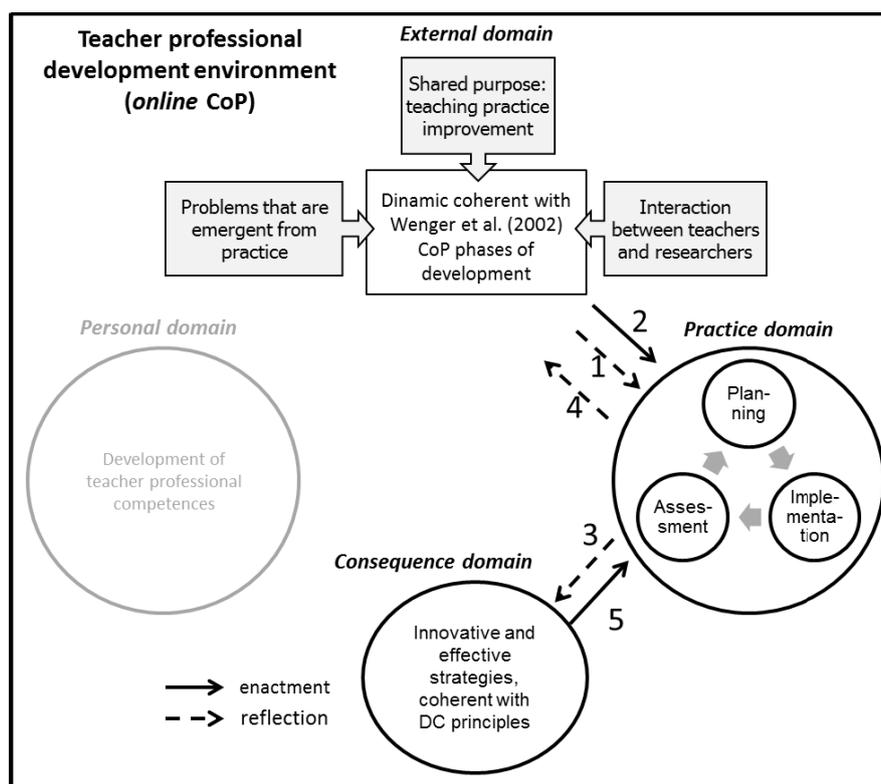


Figure 2. Adaptation of Clarke and Hollingsworth (2002) interconnected model of professional growth to the studied case

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, 2011). 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 2, 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, 2011).
- 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: Cranfield University.
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* (4<sup>th</sup> 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). *Interacções em comunidades de prática online e reflexividade docente: um estudo de caso envolvendo professores de ciências*. Unpublished MA dissertation. 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. Engeström, 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. *International Business Machines Systems Journal*, 40(4). Retrieved from [http://www.providersedge.com/docs/km\\_articles/Evolving\\_CoP\\_-\\_IBM\\_Global\\_Svcs.pdf](http://www.providersedge.com/docs/km_articles/Evolving_CoP_-_IBM_Global_Svcs.pdf)
17. Grossman, P., Wineburg, S., Woolworth, S., & Washington, U. O. (2000). *What Makes Teacher Community Different from a Gathering of Teachers?* 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., & 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* (6<sup>th</sup> 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](http://www.educationcounts.govt.nz/__data/assets/pdf_file/0019/7480/lrs-online-com.pdf)
25. Lave, J., & Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. Cambridge: University Press.
26. Leite, T. (2010). *Planeamento e concepção da acção de ensinar* (Vol. 2). Aveiro: Universidade de Aveiro.
27. Loureiro, A., Vaz, C., Rodrigues, M. R., Antunes, P., & 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.
28. Lucas, S., & Vasconcelos, C. (2005). Perspectivas de ensino no âmbito das práticas lectivas: Um estudo com professores do 7º ano de escolaridade. *Revista Electrónica de Enseñanza de las Ciencias*, 4(3). Retrieved from [http://reec.uvigo.es/volumenes/volumen4/ART4\\_Vol4\\_N3.pdf](http://reec.uvigo.es/volumenes/volumen4/ART4_Vol4_N3.pdf)

29. 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.
30. 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.
31. 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>
32. 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>
33. 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
34. 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
35. 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
36. 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
37. Marzano, R. J., Gaddy, B. B., & Dean, C. (2000). *What Works In Classroom Instruction*. Aurora, CO: Mid-continent Research for Education and Learning.
38. McDermott, R. (2000). Community development as a natural step. *Knowledge Management Review*, 3(5), 16-19.
39. 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.
40. Orion, N. (2007). A Holistic Approach for Science Education for All. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(2), 111-118.

41. Pacheco, J. A. (2005). *Estudos Curriculares: para a Compreensão Crítica da Educação*. Porto: Porto Editora.
42. Pereira, M. (2007). *Co-construção de estratégias de ensino numa Comunidade de Prática online*. Unpublished MA dissertation. Aveiro: Universidade de Aveiro.
43. 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.
44. 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.
45. Vygotsky, L. (1978). *Mind and society*. Oxford: Blackwell.
46. Wise, K. C. (1996). Strategies for teaching science: What works? *Clearing House*, 69(6), 337-338.
47. 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.
48. 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.
49. Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. Cambridge: Cambridge University Press.
50. Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice: a guide to managing knowledge*. Boston: Harvard Business School Press.
51. Yin, R. K. (2009). *Case study research: design and methods* (4<sup>th</sup> ed. Vol. 5). California: Sage Publications.