Challenges and possibilities for Design Based Research with semantic web technology

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Abstract

This paper addresses the first conference theme of Theories, methodologies, perspectives and paradigms for Research in Networked Learning. The three key themes of the symposium (Designs for learning with the Semantic Web) are discussed by exploring the methodological challenges and advantages that one may experience when conducting design based research with emergent technology. In particular, when technological solutions are developed more or less from scratch, simultaneously and in interaction with the pedagogical practices which make use of these solutions. The outset for this paper is a Design Based Research (DBR) project, which we are currently carrying out at a Danish high school. The project involves development of technological tools based on semantic web (web 3.0) technology. These tools are developed simultaneously and in interaction with the pedagogical practices utilizing the tools. We seek to address the aforementioned main question of the paper by, first, reviewing the stages of DBR-processes as presented by Amiel & Reeves (2008), second, presenting the specific DBR project which is our outset, and third presenting a set of methodological challenges and advantages we have experienced in our work on this project. Through the discussion presented in this paper, we draw attention to several noteworthy challenges and advantages of developing and utilizing emergent-technology-based tools in DBR. Some of these challenges concern the potentially intangible nature of emergent technology and the difficulty of communicating the potentials of the technology to practitioners and other involved parties. Other challenges are more strongly connected with the practical development process. Similarly, we explore noteworthy advantages such as emergent technology potentially granting a greater level of creative freedom in development of solutions and tools while greatly encouraging teacher and student involvement in the development process. This further provides an opportunity for a stronger focus on designing with practice in mind. In addition, the paper argues that DBR projects like the one described in this paper, are actually paradigmatic for investigation of educational contexts in rapid technological and pedagogical change because they not only take this change into account, but fundamentally and significantly build on them.

Keywords

Design Based Research, semantic web, web 3.0, emergent technology, case study.

Introduction

This paper addresses the first conference theme of Theories, methodologies, perspectives and paradigms for Research in Networked Learning. More particularly, it focuses on the methodology of Design-Based Research (DBR) which over the last decade has increasingly been adopted as a research approach within the field of networked learning, and also within the broader area of educational research (e.g. Barab, 2006; Conole, 2013, p. 131; Coto Chotto & Dirckinck-Holmfeld, 2008; Oestergaard & Sorensen, 2014; Schaverin & Alexander, 2008; Wang & Hannafin, 2005). Wang & Hannafin define DBR as

> …a systematic, but flexible methodology aimed to improve educational practice through iterative analysis, design, development and implementation, based on collaboration between researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories. (Wang & Hannafin, 2005, pp. 5-6)

As pointed out by Conole, "The choice of methodology tends to reflect both the individual's epistemological stance and their focus of inquiry" (Conole, 2013, p. 22). Given this, the widespread acceptance of DBR for

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research in networked learning is no surprise: Gauging the field by the research presented over the years in the series of Networked Learning Conferences, a general focus of inquiry is designs for learning in practice, "bringing together research in education and organisations spanning formal and informal learning settings", as it is expressed on the webpage introducing this 10th instance of the conference. Thus, engagement in real-world settings and an awareness of the need to repeatedly craft or adapt learning designs to fit different settings is characteristic of research in networked learning. Conversely, Hodgson et al. characterize the epistemology of networked learning as embodying the "over-arching concept" of "practice as epistemic, as a way of seeing and acting" (p. 293). That is, the epistemological stance of many (or most) researchers within the field will be that full academic understanding of educational practice involves engaging in it, together with practitioners, to allow its 'way of seeing' to come into view. DBR fits well with this epistemological stance and focus of inquiry.

Most research utilizing DBR to investigate networked learning has focused on designing learning environments and learning activities which make pedagogical use of existing (though often relatively new) technology, often tweaking categories in user interfaces (e.g. defining group spaces within an inherently instruction oriented user interface such as Blackboard), user roles (e.g. assigning teacher roles to students to allow them more possibilities of engaging in learning activities), or platforms (e.g. utilizing Facebook as a learning platform). Conole's description of the design focuses of the Open University Learning Design Initiative (OULDI), a project utilizing DBR, is illustrative:

> …we are focusing on three aspects of design: (1) the development of a range of conceptual tools to guide the design process…, (2) the development of visual tools to render some of the conceptual tools… and (3) the development of collaborative tools - both in terms of structures for face-to-face events, such as workshops and the use of digital tools, to foster communication and sharing. (Conole, 2013, p. 131)

The researchers thus focus on supporting practitioners' design processes through developing (in collaboration with them) the conceptual and communicational aspects of these processes. How to develop the use of digital tools is an important part hereof. However, developing digital tools themselves - for design processes and for the learning tasks that one is designing for learners to engage in - is typically not a part of DBR projects. On the face of it, this might seem surprising, given the gap noticed by several researchers between potential and actual use of technology for learning (Conole, 2013; Greenhow, Robelia, & Hughes, 2009; Molenda, 2008). One might hypothesize that this gap would be bridged more easily if the technologies themselves - not just their use - were developed in collaboration with the practitioners. On the other hand, an obvious barrier in practice is that it requires the team doing DBR to have both technological and pedagogical competences and to be able to put these to use in collaborative work with practitioners.

The outset for this paper is a DBR project which we are currently carrying out, in which technological tools are developed simultaneously and in interaction with pedagogical practices utilizing the tools. This has led us to formulate the following research question

- What are the methodological challenges and advantages of design based research with emergent technology, where technological solutions are being developed more or less from scratch, simultaneously and in interaction with the pedagogical practices which make use of these solutions?

We shall address this question by, first, reviewing the stages of DBR-processes as presented by Amiel & Reeves (2008), second, presenting the specific DBR project which is our outset, and third presenting a set of methodological challenges and advantages we have experienced in our work on this project. Thus, the Symposium's second key theme, i.e. how participatory research (here DBR) is affected during development of Semantic Web technologies, constitutes the hub around which the paper revolves. Theme one, the emergent nature of Semantic Web, is exemplified by the specific digital tool developed in our DBR project and the process of its development. In our discussion of the advantages of this type of DBR project for research and development, we address the Symposium's third key theme, how both Semantic Web technologies and participatory research may find a new place as we move forward into increasingly complex and changeable educational environments. More specifically, in line with the insights provided in Tracy (2016, in press), this symposium, we show how DBR projects of this type are actually paradigmatic for investigation of educational contexts in rapid technological and pedagogical change because they not only take this change into account, but fundamentally and significantly build on them.

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Throughout the paper, the term 'technology' refers to information technology, though some of the challenges and advantages that we draw attention to may also apply to other types of emergent technology. We shall term DBR projects that - in contrast to ours - do not involve the development of the digital tools themselves "non-technical DBR projects"

Design-based research

Amiel & Reeves (2008) argue that the ultimate goal of DBR is to strengthen the connection between educational research and real-world problems. They further argue that this strengthened connection is needed because "[…] traditional predictive research in educational technologies has had limited impact in informing actual use." (Amiel & Reeves, 2008). In DBR, technology is viewed as a process rather than just a product, and this process influences and has implications for how educational technologists conduct research. DBR as a research method places a strong emphasis on a multi-stage iterative research process. This iterative process goes beyond merely evaluating an innovative product or intervention. Amiel & Reeves (2008) describes it as a process of refinement of problems, solutions, methods and design principles. The iterative DBR-process is made up of the following four distinct stages:

- In the first stage of a DBR-process the researcher conducts analysis of practical problems in close collaboration with practitioners. The goal of this first stage is to gain an in-depth understanding of the learning ecology in question, as well as to identify issues within the complex learning ecology, which the DBR-project focus on developing improved pedagogical and technological designs for.
- The second stage focuses on development of solutions for the identified issues and practical problems. These solutions, which in the initial iterations often appear as prototypes of technological implementations and pedagogical designs, are informed by existing design principles and technological innovations.
- The third stage involves continuous cycles of testing and refinement of solutions in practice. There is a strong emphasis on involving practitioners – primarily students and teachers – in order to examine and gain valuable feedback on how the solutions influence the educational practice, learning activities and so on.
- The fourth and final stage of the iterative DBR-process is focused on reflection and aims to produce specific design principles which ideally can be generalized and used to inform and enhance the implementation of similar technological and pedagogical designs and solutions in similar educational contexts.

The challenges and advantages that we bring to attention throughout this paper will primarily be related to the first two stages of the DBR process, though a few will also relate to the third stage. This is because the significance of the emergent nature of Semantic Web technologies is greatest in the development stages: On the one hand, the possibilities of fundamentally affecting the direction of development are largest here, but on the other hand, the potentials of the not-yet-existing technologies are most difficult to envisage and explain.

Semantic web technology in upper secondary classes at a Danish high school

The DBR project which forms the outset for this paper takes place at a Danish high school and explores the cross-contextual educational potential of semantic web (web 3.0) technology in upper secondary biology and chemistry teaching. The project involves development of technological applications as part of the development of designs for learning to support students in transforming their learning between different biology and chemistry related contexts. The project involves two teachers as co-designers.

The basic design idea of the project is to develop semantic web enriched concept maps in the form of a web application, "Web3map", and corresponding learning activities. The learning activities developed with Web3map involve the following steps: 1) Students produce concept maps intended to help them better understand and provide an overview of key concepts within a part of the curriculum. For this, they use an existing concept mapping tool, installed on their own laptops. 2) They upload these concept maps to Web3map. 3) The application creates a recognizable, visual, web based representation of the original concept map, which simultaneously translates the map into a semantic web representation - currently through the use of RDFa (Resource Description Framework in Attributes). This makes the uploaded concept maps more easily accessible to other semantic web based applications and search engines. The main objective of Web3map, however, is to automatically identify relevant semantic web content related to the concepts within each individual concept map and then present this as additional information that the student can access, for instance by clicking on a concept

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in their concept map. This content can include simple information from semantic web databases such as Wikidata, text and images from Wikipedia, videos from Youtube, or parts of semantic web learning objects. The aim is for Web3map to be able, additionally, to make suggestions to students about the inclusion of concepts and conceptual relationships not present in the students' map, but present in other maps uploaded to the application. This will allow Web3map to become a resource for knowledge building within and across classes, as well as a resource for establishing connections between topics and learning settings for individual students. It will thus facilitate networked learning in especially the first, third and fourth of the senses articulated in the following definition of networked learning, originally supplied by Goodyear, Banks, Hodgson, and McConnell (2004), and recently supplemented with a phrase by the second author:

> Networked learning is learning in which information and communications technology (ICT) is used to promote connections: between one learner and other learners; between learners and tutors; between a learning community and its learning resources; between the diverse contexts in which the learners participate. (Dohn, 2014, p. 30)

To further investigate the empirical realization of Web3map's potentials in these regards, we shall in our next iteration of testing assess its use across several classes studying related topics and its application in different use case scenarios within class, e.g. student preparation for exams and ordinary classroom activities.

Discussion

A key point of DBR is that it seeks to avoid the temptation of merely adapting the educational environment to fit new techniques, devices or technologies. DBR projects that involve emergent technology or solutions built from scratch have the advantage in comparison to non-technical DBR of being far more flexible, because the functionality and shape of the solutions are not limited by pre-existing core-implementation. Conversely, the number of challenges that one should take into account is substantial. Some of the advantages and challenges, which we have experienced, are variations of ones that will be found in non-technical DBR projects, while others are more closely related to this particular type of DBR project. In the following we discuss the advantages and challenges based on whether they are primarily related to 1) the organizational setting of the learning ecology, 2) collaboration with teachers, 3) collaboration with students, 4) development of solutions and tools, and 5) researchers and their role.

Advantages and issues related to the organizational setting

A number of the advantages and challenges relate strongly to the organizational setting, in particular to the issue of ensuring the necessary support and backing from school management. These issues were especially prominent during the first stage of the DBR process where a common ground was to be established between researchers, teachers and management. They encompass questions of access to teachers, students, and their time. Though these issues are not exclusive to DBR projects utilizing emergent technology, they do take on a unique twist. For instance, it is difficult to provide a precise estimate of the time teachers and students will need to familiarise themselves with pedagogical designs and technological solutions based on an emergent technology.

At our project school, we arranged a meeting at an early stage with key people from school management. The goal of the meeting was to give management an understanding of the project's research objectives and potential for student learning in order to ensure that the two involved teachers were allowed preparation time and time in class to activities related to the project. Here, the general challenge of DBR projects of acquiring economic support for designs-not-yet-fully-articulated was amplified by the fact that the technology itself was yet to be developed, meaning that there were no precedents to refer to. This made it difficult for management and teachers to grasp what the technology is, how it works, and how it might be relevant to utilize in support of teaching in class.

This amplification is integral to technology-developing DBR projects. In general, it will be aggravated by the fact that the problems to be improved by new learning designs and new technological solutions will not yet be clearly identified because the initial examination of the learning ecology has yet to be conducted. For this reason, we found that we as researchers also did not have a clear idea at this point, of how the learning designs and technological solutions might turn out.

In our case, enough common ground was created with management through referring to the potentials of semantic web technology regarding more efficient information search and personalization of virtual learning

environments (Halimi, Seridi-Bouchelaghem & Faron-Zucker, 2014; Jeremić, Jovanović, & Gašević, 2009; Konstantinidis, Ioannidis, Spachos, Bratsas, & Bamidis, 2012; Li & Wang, 2007; Shabajee, McBride, Steer & Reynolds, 2006). This helped clarify our intentions with the project sufficiently to allow management to see its relevance. At the same time, it served as tangible examples of what the technology is, and as background for explaining how we expected to utilize the technology to solve problems experienced by the students and teachers. This allowed all participating parties to engage in a clarifying debate on their own terms. A similar strategy of drawing on perceived general potentials is to be generally recommended for explaining how a certain emergent technology is expected to prove both academically novel and educationally beneficial.

Advantages and issues related to collaboration with teachers

Close collaboration with teachers is pivotal for DBR projects. According to (Cobb, 2000, p. 331), "[…] the overriding concern should be that of establishing an effective basis for communication so that the teacher and the researchers constitute a pedagogical community united by a common purpose." In our work, this basis has been established through the involvement of both teachers and researchers in all processes, from the planning of new pedagogical designs and technological features to the actual activities in class involving student interaction and testing of new implementations of the Web3map application. So far, we have found that the utilization of emergent technology poses a number of challenges in relation to collaboration with teachers. Most of these relate to the novelty and intangible nature of the semantic web technology.

At its core, semantic web technology tends to work behind the scenes. This makes it less transparent. To counteract this issue, we found it useful to relate our technological and pedagogical design ideas to situations on the web where users (often without knowing it), are in contact with variations of the technology. For instance, we used Google Knowledge Graph as an example of semantic web technologies' ability to automatically gather and merge relevant and related information from many sources. This, and other examples, helped give the teachers involved in the project a better initial understanding of the use potential of the technology. It also helped spark their imagination and generated a very fruitful early discussion, in which they presented several interesting ideas for utilizations of semantic web technology to enhance existing activities in their classes as well as generate new ones. This experience generalizes to the insight that it is necessary but may also be fruitful to provide teachers with just the right - and right amount of - information about 'what goes on behind the scenes' and that continuous explanation of the developed solutions and tools enhances their opportunities for participating in the design process.

The teachers involved in our project have been very enthusiastic about trying new technologically supported pedagogical ideas. This has considerably reduced the challenge of making the potentials of Web3map recognizable for them. In projects where teachers are more hesitant to engage with unfamiliar technology, it is even more important for researchers to create a clear and understandable vision for the technology to be developed. In such projects it may also be necessary for researchers to get directly involved in classroom practice and help the teachers teach their students how to use the developed solutions. Doing this raises methodological questions concerning the validity of the research data procured. On the other hand, as Barab and Squire indicate, the ethical issues connected with researchers choosing to "… stand idly by and watch a teacher struggle to use their curricula" (Barab & Squire, 2004, p. 10) may counterbalance the methodological concerns in practice.

Advantages and issues related to collaboration with students

For the most part, our interaction with students at the project school has consisted in introductory activities, observations in class, and identifying problems in practice. This has informed the ongoing development of the Web3map application. The advantages and challenges we have experienced in regards to collaboration with students mostly relate to the second and third stage of the DBR-process. Again, this is because the significance of the emergent nature of Semantic Web technologies is greatest in the development stages.

An advantage of involving students in the iterative design process is that it inherently supports their interest in the project. Naturally, they also need to perceive the pedagogical designs and technological tools as relevant or useful within their practice (Mitchell, 1993). The novelty of the semantic web technology involved in our project seemed to contribute to their initial interest in participating. They did not express any presumptions about the technology as they might have done, had the technology involved been one, which they were already using at home or in some other context – such as might have been the case with social media. However, to maintain student interest it is vital to continuously ensure that they have a clear understanding of project goals.

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In DBR, the initial setting of goals for development of theory and technological solutions is a key principle (Wang & Hannafin, 2005, p. 16). Still, the necessity of communicating these goals to students and the challenges of doing so are often overlooked. When conducting DBR with emergent technology it is, however, especially important, perhaps even essential. If an emergent technology is particularly novel or very complex, it can be very difficult to provide students with sufficient introduction. Partly, because they are likely to find it difficult to relate the technology and its possibilities to activities they are familiar with. And partly, because the explanations which teachers and researchers can give at the early stages of the DBR project will tend to be vague. Ensuring that sufficient time is set aside for researchers and teachers to explain new developments, features and functionalities as they are implemented is therefore of utmost importance. In our project, we found that students were far more likely to engage with the technology if we continuously provided them with short and simple explanations and demonstrations of new features introduced in each new version of the Web3map application. On the other hand, when the purpose of the features as well as the end goals of the project were not clear enough to the students, their interest and dedication diminished. Furthermore, the amount of time between iterations of testing – in some cases months - meant that students had partly forgotten how to work with the software. This additionally increased the need for explanations and demonstrations at the beginning of each test in practice. Issues like these are likely to be far more significant when dealing with an emergent technology due to its unfamiliarity and lack of relatability.

Advantages and issues related to development of solutions and tools

Another facet of DBR is the actual practical development of technological solutions and tools - in this case the ongoing development of the Web3map application. During development, we have come across a number of issues and advantages worth paying attention to. Again, they have primarily appeared during the second stage of the DBR process where the technological potentials are most difficult to envisage.

Early in development, we noticed that the emergent nature of semantic web technology makes it difficult to find inspiration from other developers as well as examples of people who have used the particular technology for purposes similar to ours. The flipside of this however, is the advantage of fewer constraints on development because of existing design conventions. Thus, the emergence of the technology encouraged us as researchers/developers to seek solutions uniquely suited to solve the issues that we discovered in the educational practice of students and teachers. Similarly, use of emergent technology can mean that no existing system, software platform or application is suitable to use as a foundation for development. Potentially, however, this holds the greatest advantage of utilizing emergent technology as part of a DBR project: First, the researchers/developers do not have to deal with limitations in an existing implementation, which might force them to give up on desired functionalities. Second, the lack of pre-designed applications or platforms provides a greater level of creative freedom in the development process and may encourage stronger involvement of practitioners (teachers and students).

Nonetheless, working with emergent technology often feels like traveling in uncharted waters. Thus, in developing prototypes for the Web3map application, it proved very difficult to foresee problems because of the novelty of the software. This was not only due to limitations in our own experience with the technology, but also to the lack of an established developer-community working with the technology and/or its educational utilization. The lack of such a community makes finding ideas for solutions to specific problems encountered during the development process much more challenging. In comparison, commonly used technologies often have large, established developer-communities, which one can look to for general inspiration as well as for guidance specific development-problems.

So far, the issues we have looked at concern difficulties in the actual development process stemming from the unpredictable nature of emergent technology. A further issue concerns the coordination and timing of activities in practice (for instance in classes). As predicting problems in the development is difficult, so is precise determination of how long it will take to implement various functionalities. In our collaboration with the two teachers we found that this posed challenges for planning students' learning activities with Web2map. In general, researchers and teachers may, as part of their initial planning, agree on certain dates where the new pedagogical designs and technological solutions can be tested. But it may prove difficult for the researcher/developer to assess which functionalities it will be realistic to implement in time for each deadline. The researcher/developer runs the risk of either being too ambitious – due to not foreseeing pitfalls that would

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be obvious had they had extensive experience with the technology – or too unambitious because they may be afraid to promise more than they can deliver.

Advantages and issues related to researchers and their role

Working with emergent technology also has a number of implications for researchers, their role, and the kind of research questions they are able to ask within a DBR project. One key advantage that we have experienced is that design with and for the use of emergent technology enhances researcher focus on using actual problems in practice as the starting point for design: Because the technology itself has to be developed, researchers cannot begin the design process with (implicit or explicit) intentions of implementing pre-existing designs for learning. Iteratively creating pedagogical designs and technological solutions from scratch also means that researchers are not limited by the framework of existing it-applications. This gives them much greater freedom in their technological research. The importance of participation as starting point for design is emphasised further in another paper in this symposium (Tracy, 2016, in press). Here, Tracy makes the point that it can be highly problematic and restrictive, when researchers approach participatory research with (partially) completed designs. A key advantage of working with emergent technology in DBR is that it allows researchers to ask different pedagogical questions - and ask these questions on a more fundamental level while taking into account both pedagogical and technological aspects. The way tests are situated and carried out will be different compared to when researchers are focussing purely on either pedagogical or technological aspects, and it gives researchers better opportunities to take into account the complexity of local contingencies during the design process. A DBR project, which concerns the intersections between pedagogy and technology, but only focusses on designing for one of them, runs the risk of not taking the complexity of the other one sufficiently into account.

Doing DBR with emergent technology requires that one or more of the researchers involved in the project possess technological competence. Of course, this requirement may pose the challenge of finding new partners for research groups where such competence is not already present. Another challenge is that research on the pedagogical aspects of the DBR project will progress rather slowly in comparison with non-technical DBR projects. Nonetheless, in our experience this challenge is outweighed by the fact that developing technological solutions with emergent technology encourages and supports iterative pedagogical design, because of the opportunity it gives researchers to inform the technological design pedagogically at a fundamental level.

Concluding remarks

The aim of this paper has been to explore what the methodological challenges and advantages of design based research with emergent technology are. More specifically, we have focused on technological solutions being developed more or less from scratch, simultaneously and in interaction with the pedagogical practices, which make use of these solutions. We have presented a discussion of some of the most prominent challenges and advantages that we ourselves have experienced during an ongoing DBR project involving the use of semantic web technology in a Danish high school setting. We have discussed advantages and issues in relation to five different categories: organizational setting, collaboration with teachers, collaboration with students, development of solutions and tools, and researchers and their role. We have found that several of the challenges across the first three categories concern the intangible nature of semantic web technology and the resulting difficulty of communicating the potentials of the technology as well as its actual use. The emergent nature of the technology is also the cause for several development related challenges, such as limited possibilities to seek out experience and support from established developer communities. On the other hand, the novelty of semantic web technology (and, presumably, likewise for other emergent technologies) contains a number of advantages, such as granting researchers and developers more creative freedom in development of technological solutions and greatly encouraging teacher and student involvement in the development process. This further allows for a stronger focus on designing with practice in mind. Finally, engaging with this particular kind of DBR requires researchers to be both pedagogically and technologically oriented. Whilst posing a potential challenge to the formation of research teams, this requirement promotes research, which takes into account and designs for the multitude of contingencies encountered in the complex reality of the education context in which the design is situated.

Through discussing the methodological advantages and challenges we have experienced in our work on this particular DBR project we have explored the Symposium's second key theme, i.e. how participatory research is affected during development of Semantic Web technologies, stressing throughout the emergent nature of this

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technology (first key theme). Furthermore, this discussion also addresses the Symposium's third key theme, how both Semantic Web technologies and participatory research may find a new place as we move forward into increasingly complex and changeable educational environments. In particular, we have argued that DBR projects, like the one we describe in this paper, are actually paradigmatic for investigation of educational contexts in rapid technological and pedagogical change because they not only take this change into account, but fundamentally and significantly build on them.

References

Amiel, T., & Reeves, T.C. (2008). Design-based research and educational technology: Rethinking technology and the research agenda. Educational Technology & Society, 11 (4), 29–40.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. The journal of the learning sciences, 13(1), 1-14.

Barab, S. (2006). Design-Based Research: A Methodological Toolkit for the Learning Scientist. In K. Sawyer (Ed.), The Cambridge Handbook of the Learning Science (pp. 153-169). Cambridge: Cambridge University Press.

Cobb, P. (2000). Conducting teaching experiments in collaboration with teachers. In A.E. Kelly & R.A. Lesh (Eds.), Handbook of research design in mathematics and science education. (pp307-333). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Conole, G. (2013). Designing for learning in an open world (Vol. 4). London: Springer.

Coto Chotto, M., & Dirckinck-Holmfeld, L. (2008). Facilitating Communities of Practice in Teacher Professional Development. Paper presented at the 6th International Conference on Networked Learning, Lancaster.

Dohn, N. B. (2014). Implications for networked learning of the 'practice' side of social practice theories - a tacit-knowledge perspective. In V. Hodgson, M. de Laat, D. McConnell, & T. Ryberg (Eds.), The Design, Experience and Practice of Networked Learning (pp. 29-49). Dordrecht: Springer.

Goodyear, P., Banks, S., Hodgson, V., & McConnell, D. (Eds.). (2004). Advances in Research on Networked Learning. Dordrecht: Kluwer Academic.

Greenhow, C., Robelia, B., & Hughes, J. E. (2009). Learning, Teaching, and Scholarship in a Digital Age: Web 2.0 and Classroom Research: What Path Should We Take Now? Educational researcher, 38(4), 246-259. doi: 10.3102/0013189x09336671.

Halimi, K., Seridi-Bouchelaghem, H., & Faron-Zucker, C. (2014). An enhanced personal learning environment using social semantic web technologies.Interactive Learning Environments, 22(2), 165-187.

Jeremić, Z., Jovanović, J., & Gašević, D. (2009). Semantic web technologies for the integration of learning tools and context-aware educational services (pp. 860-875). Springer Berlin Heidelberg.

Konstantinidis, S. T., Ioannidis, L., Spachos, D., Bratsas, C., & Bamidis, P. D. (2012). mEducator 3.0: combining semantic and social web approaches in sharing and retrieving medical education resources. In Semantic and Social Media Adaptation and Personalization (SMAP), 2012 Seventh International Workshop on (pp. 42-47). IEEE.

Li, X., & Wang, Y. (2007). Knowledge Processing and Service System for Digital Education based on Semantic Web. In Integration and Innovation Orient to E-Society Volume 1 (pp. 499-506). Springer US.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. Journal of educational psychology, 85(3), 424-436.

Molenda, M. (2008). Historical foundations. In J. M. Spector, M. D. Merrill, J. van Merriënboer, & M. P. Driscoll (Eds.), Handbook of research on educational communications and technology (pp. 3-20). New York: Taylor & Francis.

Oestergaard, R., & Sorensen, E. K. (2014). Networked Learning and Design Based Research for welfare innovation through further education. Paper presented at the 9th International Conference on Networked Learning.

Schaverin, L., & Alexander, S. (2008). Researching networked learning generatively. Paper presented at the 7th International Conference on Networked Learning.

Shabajee, P., McBride, B., Steer, D., & Reynolds, D. (2006). A prototype Semantic Web-based digital content exchange for schools in Singapore. British journal of educational technology, 37(3), 461-477.

Tracy, F. (2016, in press). Problematising Participatory Research for Developing Semantic Web Technologies. 10th International Conference on Networked Learning.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. Educational Technology Research and Development, 53(4), 5-23.