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Editorial introduction: Collaborative learning enhanced by mobile technologies

Since the early trials of supporting learning with mobile devices in the mid-1970s (Chiang et al., 2016), opportunities for learning enhanced by mobile applications, devices and networks have undergone major technological leaps. These early trials mostly focused on technological issues and how the relationship between the device and a human being could improve learning. By the millennium, a significant shift had occurred in the research field, with sociocultural approaches to understanding mobile learning taking centre stage (Crompton, 2013; Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez, & Vavoula, 2011; Wali, Winters, & Oliver, 2008). More recently, a movement within the field of mobile learning has emerged, which focuses on how collaborative learning could be enhanced by applying various mobile technologies (Berge & Muilenburg, 2013; Traxler & Kukulska-Hulme, 2016). This movement also finds support in the technological development during the recent decade. The era of smart devices includes the emergence of different touchscreen devices with opportunities for instant social and technological networking. Mobile devices such as small portable laptops, smart phones, tablets and, more recently, various wearable devices have since made up a technological platform for enhancing collaborative learning. The emergence of *mobility* as an essential aspect of everyday life underlines a need to update the conceptualisations of how we learn (Traxler & Kukulska-Hulme, 2016).

Collaborative learning enhanced by mobile technologies occurs in both informal and formal educational settings. It could occur in situations where human beings learn about content during leisure activities or while studying, working or performing other everyday activities. Collaborative learning enhanced by mobile technologies also embraces distribution of content in groups of two or more people. Such learning in this research field is linked to togetherness in terms of enhancing dialogues between individuals (Berge & Muilenburg, 2013; Dillenbourg, 1999; Sharples & Spikol, 2017; Traxler & Kukulska-Hulme, 2016).

However, designing mobile educational settings needs the consideration of many aspects of collaborative learning to be successful. These aspects of *mobile collaborative learning* include physically co-located learners as well as learners that are separated by time and place. It embraces an understanding of mobile technologies as a feature that is possible to enhance by collaboration and provides evaluation opportunities, as well as observes and enhances collaborative learning activities in everyday informal and formal educational settings. Besides awareness of the rapid technological development, it is also important to understand its impact on the learners' context and how learners' communicate with each other (Amara, Macedo, Bendella, & Santos, 2016).

Examples of recent research of collaborative learning and mobile technologies includes, among others, the study by Delen and Krajcik (2017). They show how mobile applications in informal settings, such as museums, can support and enhance science learning. In their study, they applied augmented reality and tablets in a design aimed at supporting collaborative learning between teachers and museum educators. The design helped establish a time- and place-independent link between the museum and the teachers' formal educational setting. Reychav and McHaney (2017) also performed a study that followed the research theme of collaborative

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learning enhanced by mobile technologies in formal educational settings. The students used mobile devices while working together on an assignment. The study showed that gender was related to learning and working together in groups. They claimed that female students benefited from collaborative learning and educational settings that integrate mobile technologies. Maor (2017) performs an example of workplace settings. The study focused on teachers' mobile collaborative learning and found that such learning seems to enhance teachers' development of content knowledge as well as their pedagogical and technological skills. Nevertheless, these studies are examples of separate studies on different topics. To reach a deeper understanding of a specific topic, there is a need for coherent publications such as special issues and book-projects including different studies that deal with a wide range of theoretical ideas and designs that push the boundaries further. This special issue shall be read as an attempt to achieve this by collecting nine papers all focused on collaborative learning enhanced by mobile technologies.

Particularly in a society characterised by social and cultural changes, and driven by a wide dissemination of emerging smart mobile technologies, there is a need for coherent publications that shed light on new theoretical developments regarding how human beings come together and learn. In effect, to bring light to the impact of such development, research is needed that explores various ways of designing such learning and that compares effects on collaborative learning from different mobile technologies. Moreover, researching collaborative learning enhanced by mobile technologies also informs understanding about how learning is provided in a society characterised by an emerging digitalisation (Duval, Sharples, & Sutherland, 2017; Traxler & Kukulska-Hulme, 2016).

To sum up: this special issue focuses on research that combines and takes into account key findings from social aspects of learning and development within the smart technological era. These findings are points of departure for this special issue's ambition of analysing, discussing and disseminating various ways of how collaborative learning can be enhanced by mobile applications, devices and networks.

Studies in collaborative learning enhanced by mobile technologies

This special issue includes papers that contribute theoretically to discussions about how collaborative learning could be enhanced by mobile technologies, while other papers emphasise how the design of mobile technologies could enhance collaborative learning. There is also a review paper that summarises the state-of-the-art in mobile collaborative language learning. Together, they illustrate the need to sum up the current work and develop new theoretical insights and designs in order to inform future work on how collaborative aspects of learning relate to mobile technologies. The special issue emerged as a result of an international research symposium held in Sundsvall, Mid Sweden University on October 12–13, 2015. The symposium, organised by the research group HEEL (Higher Education and E-Learning), identified collaborative learning enhanced by mobile technologies as a key area for further research. There are many opportunities to explore the intersection between collaborative learning and mobile learning, which are often regarded as separate research fields.

This special issue includes nine articles produced by 28 scholars from four continents and ten different countries: Australia, China, Denmark, Finland, New Zealand, Spain, Sweden, Taiwan, United Kingdom and USA. Six of the papers focused on higher education, two papers on K–12 education and one paper on adult informal learning. Notably, all but one of the papers adopted a learner's perspective rather than a teacher's perspective.

The first paper in this issue, "Mobile collaborative language learning: State of the art," by Agnes Kukulska-Hulme and Olga Viberg, presents a literature review of mobile collaborative language studies published in 2012–2016. The aim of the paper is to deepen our understanding of how

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mobile technologies have been used to support collaborative learning among second and foreign language learners. The systematic search for literature created by the authors includes studies on Mobile-Assisted Language Learning (MALL) with a specific focus on collaborative learning. The paper uses a content analysis for MALL's evaluation framework. Results, for example, show clear benefits of collaboration in mobile language learning, in which affordances like flexible use and peer coaching have been emphasised, and in which studies often take a social constructivist approach to learning. The paper points out that additional knowledge about important processes and steps involved in mobile learning design for fostering collaborative learning practices is needed.

In "Taking an instrumental genesis lens: New insights into collaborative mobile learning," Teresa Cerratto Pargman, Jalal Nouri and Marcelo Milrad focus on how collaborative learning emerges in four tablet-mediated Swedish elementary school classrooms. The authors adopt an ethnographic approach including classroom observations of teachers and students as well as semistructured interviews with teachers. The paper draws on the instrumental genesis theory including the Collective Instrumented Activities and Situations Model (CIAS model), which provides a theoretical lens for the analysis of appropriation processes involved in mobile collaborative activities mediated by digital artefacts. The findings show that the tablet emerges as a collaborative digital instrument through the establishment of teachers' and students' multiple instrumental mediations. Moreover, emotional and spatial mediations are of importance when understanding teachers' intentions in designing collaboration, participation and engagement in the classroom.

In the paper, "Understanding nomadic collaborative learning groups," Thomas Ryberg, Jacob Davidsen and Vivien Hodgson develop three categories of practice for nomadic collaborative learning groups. Nomadic learners refer to students who accomplish their work across locations, collaborate with others and can be distributed in time. The study includes two undergraduate student groups engaged in self-organised, long-term collaborations based on problem- and project-based learning. The students used mobile and digital technologies as well as physical and/or nondigital technologies in their group work. The paper found that in both groups, there was a fluidity, situatedness and improvisational aspect to how they negotiated the orchestration of their work. Their ways of utilising space, places, technologies and activities over time was a complex interweaving of the digital and physical

In "A tale of two communication tools: Discussion-forum and mobile instant-messaging apps in collaborative learning," Zhong Sun, Chin-Hsi Lin, Minhua Wu, Jianshe Zhou and Liming Luo compare the learning-related uses of an online discussion forum against the use of a mobile instant messaging app. Combining different technologies is essential since the literature has tended to focus on individual technological tools rather than examining how the choice of one tool over another impacts collaborative learning. The study includes 78 undergraduate preservice teachers. Based on the results of the content analysis, social network analysis and a survey of student attitudes, it was found that while both tools facilitated collaborative learning, they appeared to have different affordances. Using the online discussion forum resulted in more communication aimed at knowledge construction, while using the mobile instant messaging app resulted in more social interactions.

The paper, "Authoring and enactment of mobile pyramid-based collaborative learning activities," is positioned in the field of mobile Computer Supported Collaborative Learning. Kalpani Manathunga and Davinia Hernández-Leo study the impact of mobile orchestration in higher education learning scenarios. Central in the paper is Collaborative Learning Flow Patterns and the so-called PyramidApp, which implements a Pyramid CLFP particularisation to support face-to-face and distance mobile learning in higher education. The PyramidApp

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contains both a web-based authoring tool and an enactment tool. Data are collected through a mixed approach and contain both quantitative and qualitative data from teachers and students that took part in evaluating the PyramidApp. Results show that the teachers appreciate the design and applicability of the PyramidApp in their educational contexts and that the PyramidApp supports activities that seems to have a positive impact on the students' learning.

In "Mobile technology affordance and its social implications: A case of 'Rain Classroom'," Xiangming Li and Song Shuqiang explore learner engagement and disposition to share when using the mobile application Rain classroom. The application integrates information publishing before class, real-time answering and interaction in class, and reviewing after class. The participants were graduate-level engineering students ($N = 387$) that were assigned to a test group and a control group. Based on the results of two surveys, which were issued before and after a 14-week experiment, the results show that the test group had a positive attitude towards the mobile technology tool and obtained statistically higher scores in both learning engagement and their willingness to continue the learning experience.

In "Toward personal and emotional connectivity in mobile higher education through asynchronous formative audio feedback," Päivi Rasi and Hanna Vuojärvi develop a teaching approach that can be characterised as collaborative case-based learning. The method is a designed-based research, and the study explores how students experienced the use of audio feedback. The participants were Finnish teacher students ($N = 50$), and the data collection methods included a questionnaire, transcribed audio feedback and student performance results. The study focuses on utility, emotional support and learning, and the results indicate that formative audio feedback could promote students' emotional engagement. The students welcomed audio feedback but expressed a desire to combine written and audio feedback.

In the paper, "Mobile-based collaborative learning in the fitness center: A case study on the development of English listening comprehension with a context-aware application," Gi-Zen Li, Jin-Yao Chen and Gwo-Jen Hwang present a mobile application used within a ubiquitous learning system—an application aimed at improving the user's English listening comprehension. The aim of the study is to investigate learning strategies in groups and a combination of qualitative and quantitative methods. The participants ($N = 36$) were Chinese native speakers who were equipped with a smartphone when they were at a fitness centre. The study includes pre- and post-tests, and the results show that the students improved their listening comprehension; the application also helped them retain the knowledge.

In "The effect of 'here and now' learning on student engagement and academic achievement," Gavin Northey, Rahul Govind, Tania Bucic, Mathew Chylinski, Rebecca Dolan and Patrick van Esch present a low-investment blended learning approach to facilitate collaboration outside of the classroom. The study is quasi-experimental, and the aim is to study the effects of "here and now" learning on student engagement and academic achievement. Four classes ($N = 118$) were assigned to be test groups, and two classes were the control group. Two surveys were used to collect data. The findings show that suggested learning design has a positive influence on both student engagement and academic outcomes.

Concluding remarks

The papers of the special issue emphasise that collaborative learning enhanced by mobile technologies is a phenomenon that relates to a broad range of educational settings. Here, it is illustrated with studies performed in the formal educational system (ie, primary school and higher education). In the mobile learning scenarios, formal settings are linked to the application of informal resources and spaces to form seamless and ubiquitous educational settings where

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boundaries between formal and informal aspects of learning can be dissolved. These studies show how contextual aspects of conceptual space, physical space, social space, technology and time have an impact on how people collaboratively learn as enhanced by mobile technologies.

Collaborative learning enhanced by mobile technologies needs to be studied with a wide range of different research approaches and different research methods. As shown in this special issue, it depends on which problems the paper focuses on. From ethnographic approaches on one side, to quasi-experimental, pre–post-testing approaches on the other side, all aim to provide knowledge to inform the next step in understanding the relationship between collaborative learning and mobile technologies.

While the papers emphasise design issues and the learners' perspective, a possible conclusion to draw is that there is a need for further work in other certain areas within this field, eg, research focusing on collaborative learning and mobile technologies in teaching and leadership. Such studies could analyse and discuss instruction supported by mobile technologies as well as different aspects of teachers' and school leaders' beliefs about the relationship between collaborative learning and mobile technologies. This knowledge can then be used to both inform practice and adapt to future policy development. Another focus not highlighted in this special issue is that of critical studies of policy issues and how the societal debate is linked to its impact on learning.

This special issue has shed light on the importance of research in the intersection of collaborative learning and mobile technologies. By drawing on the papers, there are at least three opportunities for further research where this special issue might serve as a starting point. First, there is a need for further theoretical development, which could be guided by exploring the use of lesser known theories such as instrumental genesis theory and nomadic collaborative learning. Second, future research could investigate effects of using specific media and comparing different media for mobile collaborative learning such as mobile instant messaging, social networking and audio feedback. Finally, there is a need to continue designing prototypes and mobile applications for collaborative learning, which are built on previous research and rigorously evaluated. We believe that these three opportunities for further research are essential in developing a deeper understanding of how mobile applications could be used to enhance collaborative learning.

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