

Wikis in higher education

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Essays

Essay 1: Kummer, C. (2013). *Factors influencing wiki collaboration in higher education*. doi:10.2139/ssrn.2208522

Essay 2: Kummer, C. (2013). Students' intentions to use wikis in higher education. In R. Alt & B. Franczyk (Eds.), *Proceedings of the 11th International Conference on Wirtschaftsinformatik (WI2013)* (Vol. 2, pp. 1493–1508). Leipzig.

Essay 3: Kummer, C. (2013). *Facilitating collaboration in wikis*. doi:10.2139/ssrn.2250367

Essay 4: Kummer, C. (2013). *Using fuzzy set qualitative comparative analysis (fsQCA) to identify indicators for wiki collaboration*.

Note. Essays 1 and 3 have been published as working paper. Essay 2 has been published in a peer reviewed conference proceeding.

1 Introduction

As a teacher, I like wikis, because they are particularly suitable for collaborative learning, as they allow students to construct, share, and explore information and knowledge gained from peer-to-peer communication (Haythornthwaite, 2006). And although I already used wikis to facilitate collaboration, I am dissatisfied with the situation, as adopting collaboration in teaching confronted me with two problems: How can I facilitate collaborative learning in wikis? How can I assess collaborative learning that has taken place in wikis? Both problems were the research impetus for this doctoral thesis.

This synopsis introduces results from four studies that investigated how collaborative learning in wikis can be facilitated and assessed. Together with the four studies, this synopsis forms a cumulative doctoral thesis. The studies have been documented in four essays:

- Essay 1: Factors influencing wiki collaboration in higher education,
- Essay 2: Students' intentions to use wikis in higher education,
- Essay 3: Facilitating collaboration in wikis,
- Essay 4: Using fuzzy set qualitative comparative analysis (fsQCA) to identify indicators for wiki collaboration.

Starting with the research impetus to ease the use of wikis in higher education for collaborative learning, this synopsis denominates research aims that have motivated the four studies. By highlighting common focal points and the relation between the four separate studies, I connect my doctoral research to a common cause. Furthermore, the methods and findings are briefly introduced and discussed with regard to their contribution both to science and to practice.

For many years universities communicated generic graduate attributes (e.g. global citizenship) their students have acquired after studying. Graduate attributes are skills and competencies that are relevant for both employability and other aspects of life (Barrie, 2004). Over the past years and due to the Bologna Process, the focus on competencies has also found its way into universities' curricula. As a consequence, curricula were adapted in order to convey students both in-depth knowledge of a particular area as well as generic competences (Bologna Working Group on Qualifications Framework, 2005, Appendix 8). For example, students with a Master's degree should be able to "communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and

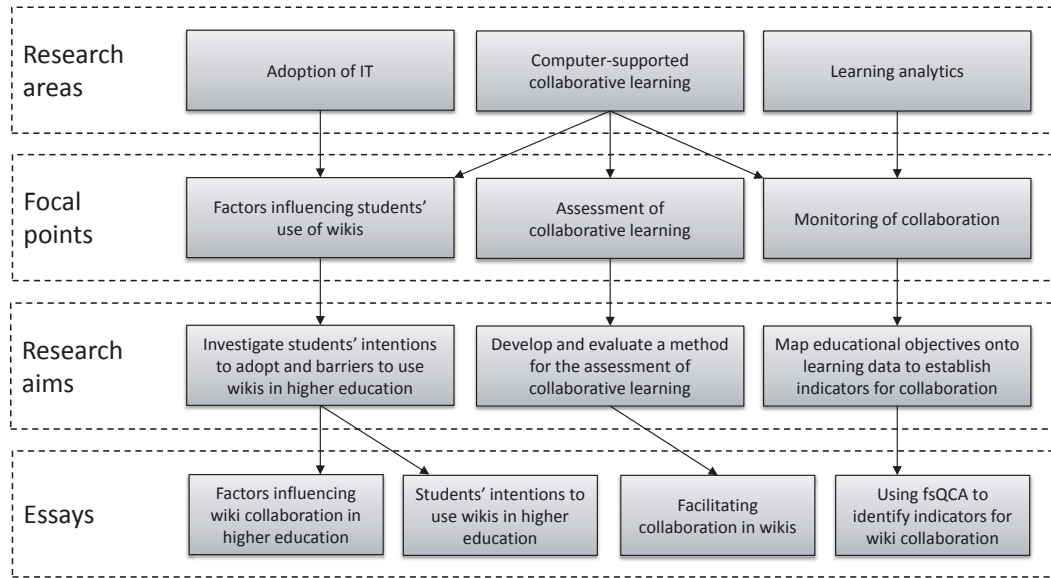
unambiguously” (p. 196). This shift has been supported by the demand of the labour market for students that have achieved social and personal competencies, in addition to in-depth knowledge (Heidenreich, 2011).

On course level, this placed emphasis on collaborative learning, which had led to “greater autonomy for the learner, but also to greater emphasis on active learning, with creation, communication and participation” (Downes, 2005). The shift to collaborative learning has been supported by existing learning theories and models (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991; Vygotsky, 1978), which could explain the educational advantages. For example, collaborative learning has proved to promote critical thinking and communications skills (Johnson & Johnson, 1994b; Laal & Ghodsi, 2012). As Haythornthwaite (2006) advocates: “collaborative learning holds the promise of active construction of knowledge, enhanced problem articulation, and benefits exploring and sharing information and knowledge gained from peer-to-peer communication” (p. 10). The term *collaboration* defies clear definition (Dillenbourg, 1999). In this article, cooperation is seen as the division of labour in tasks, which allows group members to work independently, whereas collaboration needs continuous synchronisation and coordination of labour (Dillenbourg, Baker, Blaye & O'Malley, 1996; Haythornthwaite, 2006). Therefore, cooperation allows students to subdivide task assignments, work relatively independent, and to piece the results together to one final product. In contrast, collaboration is seen as a synchronous and coordinated effort of all students to accomplish their task assignment resulting in a final product where “no single hand is visible” (Haythornthwaite, 2006, p. 12).

Due to the debate about *digital natives* (Prensky, 2001) and “students’ heavy use of technology” in private life (Luo, 2010, p. 32), teachers have started to explore possible applications of modern technology in teaching and learning. Especially wikis have become popular and gained reasonable attention in higher education. Wikis have been used to support collaborative learning (e.g. Cress & Kimmerle, 2008), collaborative writing (e.g. Naismith, Lee & Pilkington, 2011), and student engagement (e.g. Neumann & Hood, 2009). A *wiki* is a “freely expandable collection of interlinked Web ‘pages’, a *hypertext system* for storing and modifying information - a *database*, where each page is easily editable by any user” (Leuf and Cunningham, 2001, p. 14; italics in original). Thereby, wikis enable the collaborative construction of knowledge (Alexander, 2006).

With the intention to take advantage of the benefits connected with collaborative learning, this doctoral thesis focuses on the facilitation of collaboration in wikis to leverage collaborative learning.

Figure 1: Relationships within the doctoral thesis



This synopsis illustrates research aims, methods, and findings based on the text structure borrowed from Lovász-Bukvova (2012). The doctoral thesis was founded on a constructivist understanding of reality (see Section 2). The research is associated with three different research areas: adoption of IT, computer-supported collaborative learning, and learning analytics. After reviewing existing literature, three focal points were identified that correspond to my initial research impetus as well as to research gaps in these research areas: factors influencing students' use of wikis, assessment of collaborative learning, and monitoring of collaboration (see Section 3). The aims of this doctoral thesis were (1) to investigate students' intentions to adopt and barriers to use wikis in higher education, (2) to develop and evaluate a method for assessing computer-supported collaborative learning, and (3) to map educational objectives onto learning-related data in order to establish indicators for collaboration (see Section 4). Based on the research aims, four studies were carried out. The relationship between research areas, focal points, research aims, and essays is displayed in Figure 1. Each study raised unique research questions that has been addressed by different methods (see Section 5). Thereby, this doctoral thesis presents findings (see Section 6) covering the complete process of the use of wikis to support collaboration and thus provides a holistic view on the use of wikis in higher education.

2 Theoretical foundation

In this section, I explain my epistemic position that determines my understanding of reality and truth, and thus, is the theoretical foundation of my doctoral thesis.

The research was based on a constructivist understanding of reality. I used Lincoln and Guba (1985) constructivist paradigm as an underlying framework, which they introduced as a counterpart to the positivist paradigm¹. Positivists act on the assumption that reality is objective, tangible, and independent from the individual, whereas constructivists are convinced that reality is constructed in the minds of individuals and resides in their minds: “They do not exist outside of the persons who create and hold them; they are not part of some ‘objective’ world that exists apart from their constructors” (Guba & Lincoln, 1989, p. 143). Hence, there are multiple, divergent constructions that are bound to the individual, the context, the method of inquiry, and some point in time (Guba & Lincoln, 1982). Accordingly, truth is a “matter of best-informed and most sophisticated construction on which there is consensus at a given time” (Schwandt, 1998, p. 243). On this basis, the thesis uses the notion of internal and external consensus. Pörksen (2009) refers to internal consensus as the correspondence between what one communicates to others and what one holds to be real. External consensus describes the accordance with the others that they accept one’s statement as correct.

As a consequence, constructivist researchers cannot provide the truth, but they can try to achieve a consensual understanding with other researchers through discourse within the scientific community. An aggravating factor is that knowledge cannot be transferred easily, because everyone shares his own intangible construction of the reality, although some degree of co-construction is possible. However, “understanding” the construction of another researcher is not a straightforward process, because it demands to understand others’ understanding (Rusch, 2007). To facilitate understanding, Guba and Lincoln (1982) provided constructivist researchers with four criteria for judging – and therefore understanding – the trustworthiness of qualitative research: credibility, transferability, dependability, and confirmability. Within the thesis I applied these criteria by comparing findings with existing literature, discussing results with colleagues, and subjecting drafts to peer review processes for publication. Using criteria for judging about the quality of qualitative research did not limit myself to “qualitative, constructivist research”.

It is commonly claimed that research methods are bound to paradigms and cannot be mixed together with methods from other paradigms, because scientific paradigms are incommensurable (Mingers, 2001; Smaling, 1994). According to Smaling (1994), this thesis does not hold due to the underdetermination of paradigms and methods: “a research method, certainly a qualitative research method, does not unequivocally imply a particular paradigm” (p. 242). At best a method is linked to a paradigm

¹To ease the understanding, I distinguish between two paradigms: positivism (including empirical-analytic paradigm, objectivism, functionalism) and constructivism (including subjectivism, interpretivism).

in a kind of “Wahlverwandtschaft” (Weber, 1922 as cited in Smaling, 1994, p. 242). Rather, it is possible to use a particular method not in its ‘normal’ paradigm, but within another setting, and to interpret the results in the light of the paradigm in use (Mingers, 2001).

3 Research areas and focal points

This thesis is focused on the use of wikis in higher education for collaboration. Within my doctoral research, I narrowed the focus down to the use of wikis in formal learning processes and took the perspective of a teacher. This research focus has been studied in different research areas: adoption of IT, computer-supported collaborative learning, and learning analytics. In the following, I briefly introduce each research area. Based on the current state of research in these areas, three focal points were identified that influenced the research aims of this doctoral thesis.

Adoption of IT. Although research on information technology adoption uses qualitative research methods to explore new causal relationships, its ultimate goal is testing causal theories using quantitative research methods. Several theories explain the process of information technology adoption and use. The theoretical models most commonly used (Oliveira & Martins, 2011) are the Theory of Reasoned Action (Fishbein & Ajzen, 1975), the Theory of Planned Behaviour (Ajzen, 1991), the Decomposed Theory of Planned Behaviour (Taylor & Todd, 1995), the Technology Acceptance Model (Davis, Bagozzi & Warshaw, 1989), the Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis & Davis, 2003), the Diffusion of Innovations Theory (Rogers, 1995), as well as the Technology, Organization, and Environment Framework (Tornatzky & Fleischer, 1990). These models have been used to study pre-adoption and post-adoption beliefs on individual, group, firm, industrial, and societal level in nearly every field. Regarding the adoption of information technology in education, previous research has focused on analysing determinants of learner’s intention to use information technology for learning. In this vein, established theories have been extended by incorporating new causal relationships to better explain e-learning acceptance (Chen, 2011; Teo, 2010, 2011) or Web 2.0 acceptance of learners (Hartshorne & Ajjan, 2009) as well as faculty members (Ajjan & Hartshorne, 2008).

Computer-supported collaborative learning. Researchers from different disciplines like psychology, educational science, sociology, communication science, as

well as computer science study collaborative learning using unique theoretical perspectives and specific methods (Strijbos & Fischer, 2007). Research on computer-supported collaborative learning can be divided into three main areas (Resta & Lafferrière, 2007): (1) research on the context that focuses on instructor's role (Wallace, 2003), curriculum design (Strijbos, Martens & Jochems, 2004), learning environment (Kreijns, Kirschner & Jochems, 2002; Stahl, 2006), or learner characteristics (e.g. Bennett, Maton & Kervin, 2008; Prensky, 2001). (2) research on the process of computer-supported collaborative learning that focuses on interventions (Pea, 2004), interactions (Kreijns, Kirschner & Jochems, 2003), collaborative knowledge construction (Cress & Kimmerle, 2008), assessment (Strijbos, 2011), or the use of distance learning. And (3) research on learning outcomes (Laal & Ghodsi, 2012; Pearson, 2006).

Learning analytics. Online learning environments provide large sets of machine-readable data. Although the field of learning analytics emerged with the availability of data, its initial technological focus shifted towards an educational focus. Today, learning analytics is understood as the “measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs” (Ferguson, 2012, p. 305). Despite research on data collection, data extraction and data aggregation as well as research on techniques to handle big data (Baker & Yacef, 2009; Romero & Ventura, 2007), learning analytics focuses on stakeholders' (e.g. learners, teachers, system designers) needs by deriving indicators, profiling users' behaviour, or assessing users' achievement (e.g. Aviv, Erlich, Ravid & Geva, 2003; Chatti, Dyckhoff, Schroeder & Thüs, 2012; Ferguson, 2012; Wolpers, Najjar, Verbert & Duval, 2007).

Based on my research impetus and a review of the literature in these research areas, I identified three focal points to be addressed in the doctoral thesis, because they have been insufficiently covered by previous research.

Factors influencing students' use of wikis. This point was identified based on the study of literature on adoption of IT and computer-supported collaborative learning. Wikis are not a new phenomenon in higher education (cf. Guzdial, Rick & Kehoe, 2001), but there is still uncertainty among teachers on how to integrate wikis in teaching and promote collaboration effectively (Allwardt, 2011; Elgort, Smith & Toland, 2008; Naismith et al., 2011). And although much has been reported about how wikis should be used to support collaborative learning, there is no systematic study (approaches worth mentioning Hartshorne & Ajjan, 2009; Hew & Cheung, 2009) that discloses factors influencing students' use nor their intentions to use wikis

in higher education. As a result, some studies still report negative experiences (Cole, 2009; Ebner, Kickmeier-Rust & Holzinger, 2008).

Assessment of collaborative learning. This point was identified based on the study of literature on computer-supported collaborative learning as well as on my experience as a teacher. Without further instructions, students rather split work than engage in collaborative learning (Alyousef & Picard, 2011). But when students collaborate, there is the problem to assess collaboration. According to Strijbos (2011) the assessment of computer-supported collaborative learning faces three challenges: (1) the level of assessment, that is, should collaborative learning be assessed using individual grades or group grades, (2) the operationalisation of cognitive outcomes, and (3) the focus of assessment, that is, should assessment of collaborative learning solely focus on cognitive outcomes or should social and motivational perspectives obtain more attention.

Monitoring of collaboration. This point was identified based on the study of literature on computer-supported collaborative learning and learning analytics. Evaluating collaborative learning is difficult and time-consuming in general and in particular for teachers. As a consequence, the assessment of collaborative learning is still mostly summative and focused on cognitive outcomes (Strijbos, 2011). Although students would benefit from formative feedback on the process of collaborative learning, only few studies “involve the teacher by supporting the monitoring of students’ activities” (Chatti et al., 2012) and thus enable teachers to provide formative feedback – without investing extra time. However, previous studies were based on large sets of data (Bakharia & Dawson, 2011; Blikstein, 2011; Dringus & Ellis, 2005), but have not took pedagogical issues into account (Chatti et al., 2012; Ferguson, 2012).

In the next section, I formulate research aims and questions that address the research gaps which have been indicated by the focal points.

4 Research aims and questions

This doctoral thesis contributes to three research areas: adoption of IT, computer-supported collaborative learning, and learning analytics. In order to contribute to these areas, three focal points have been identified from literature: factors influencing students’ use of wikis, assessment of collaborative learning, and monitoring of collaboration. Based on the focal points, I selected research aims and posed research

questions in order to contribute to both research as well as practice. Therefore, I have set the following research aims for my doctoral research:

1. Contribute to the existing research on adoption of IT and computer-supported collaborative learning by investigating students' intentions to adopt and barriers to use wikis in higher education.
2. Contribute to the existing research on computer-supported collaborative learning by developing and evaluating a method for the assessment of computer-supported collaborative learning.
3. Contribute to the existing research on learning analytics by mapping educational objectives onto learning-related data in order to establish indicators for collaboration.

The research focus was on students' use of wikis in higher education in general. Thereby, I took the perspective of teachers on the use of wikis in formal learning processes. Specifically, this doctoral thesis investigated how collaborative learning can be facilitated.

The thesis includes results from four studies that have been described in four research essays, each contributing to the overall research aims and targeting specific research questions. In the following, I introduce the research objectives or questions of each study briefly.

Study 1: Factors influencing wiki collaboration in higher education

The first study was concerned with factors that influence wiki collaboration in higher education. The study has been documented in *Essay 1: Factors influencing wiki collaboration in higher education*. The findings in the study addressed the first research aim. The study had the following research objectives:

- Identify factors that influence collaboration in wikis within formal learning processes in higher education and
- Identify actions that have been used in this context to foster collaboration.

Study 2: Students' intentions to use wikis in higher education

The second study was concerned with the analysis of students' intentions to adopt and use wikis in higher education. The study has been documented in *Essay 2: Students' intentions to use wikis in higher education*. The findings in the study addressed the first research aim. The study had the following research objectives:

- Develop a causal model to explain students' intentions to adopt and use wikis in higher education and
- Test the model to a convenient sample of students studying at a German university.

Study 3: Facilitating collaboration in wikis

The third study was concerned with the iterative development of an educational setting and a method for assessing computer-supported collaborative learning. The study has been documented in *Essay 3: Facilitating collaboration in wikis*. The findings in the study addressed the first and the second research aim. The study had the following research objectives:

- Design an educational setting that facilitates wiki-based collaborative learning to promote critical thinking and communication skills,
- Iterate the educational setting to enhance its suitability to facilitate collaborative learning, and
- Develop an assessment method and evaluate its appropriateness in order to refine it.

Study 4: Using fuzzy set qualitative comparative analysis (fsQCA) to identify indicators for wiki collaboration

The fourth study was concerned with the derivation of indicators to support the evaluation of wiki-based collaborative learning. The study has been documented in *Essay 4: Using fuzzy set qualitative comparative analysis (fsQCA) to identify indicators for wiki collaboration*. The findings in the study addressed the third research aim. The study had the following research objectives:

- Introduce an approach suitable for the incorporation of educational objectives into learning analytics and
- Apply the approach to the data collected in Study 3 in order to derive indicators that can be used to monitor collaboration in wikis.

5 Methods

Although each of the four studies contributes to the general theme of this doctoral thesis – wikis in higher education, each study employed appropriate methods to answer

its research objectives or research questions. As a result, this doctoral thesis is a multi-method approach to study wikis in higher education. The methods used in each study are outlined below, a detailed description of the methods applied in each study can be found in the corresponding essays (see Essay 1, 2, 3, and 4).

Study 1: Factors influencing wiki collaboration in higher education

The study employed the *constant comparative method* to qualitative data analysis (Glaser & Strauss, 1967). Instead of using a pre-defined provisional start list of codes, *in vivo* coding was used to code information chunks of varying size until codes become stable. The initial codes were then aggregated into higher-level codes and categories (Miles & Huberman, 1994). Lincoln and Gubas (1985) constructivist paradigm served as an underlying framework reflecting the rather subjective character of the analysis.

The data were generated from a systematic literature review that queried electronic databases using Boolean searches. The database searches resulted in 550 hits, which have been narrowed down in three steps. First, search results were limited to articles in English language, that are peer-reviewed, and published in academic journals or at academic conferences. Additionally, duplicates were removed. Second, article abstracts were examined whether they fit the inclusion criteria. To be included in the analysis, the articles had to report about *empirical research* on the use of *wikis in courses for group collaboration in higher education*. And third, the remaining articles were examined using the full paper. Finally, 73 articles remained and were included in the analysis.

Study 2: Students' intentions to use wikis in higher education

The study employed partial least squares (PLS) path modelling to test a theoretical model explaining students' intentions to use wikis in higher education. The theoretical model was composed of nine constructs. It was based on existing theory (Taylor & Todd, 1995) and enhanced it by consolidating results from previous studies (Bock, Zmud, Kim & Lee, 2005; Chen, 2011; Hsu & Lin, 2008; Kang, Kim & Bock, 2010; Teo, 2011; Venkatesh & Bala, 2008). Thus the character of the study was explanatory and confirmatory. SmartPLS software (Ringle, Wende & Will, 2005) was used to assess scales validity and test the theoretical model.

The data were generated from a survey conducted among first semester students in an introductory course in information systems at one of the largest German universities. The survey consisted of a questionnaire developed from material discussed and

tested previously and included 27 items to measure the constructs. Participation in the survey was voluntary. 425 questionnaires were handed out at the beginning of the lecture and were collected afterwards. 245 questionnaires were returned, at least partly filled out. 133 data records remained after discarding incomplete questionnaires.

Causal models are seen as a representation of reality and statistically confirmed causal relationships as fact. Correspondingly, partial least square modelling implies positivism as a theoretical foundation. Essay 2 has been written in a manner that leaves no doubt to be positivistic and is therefore inconsistent with the theoretical foundation of this doctoral thesis. But at best a method is linked to a paradigm in a kind of “Wahlverwandtschaft” (Weber, 1922 as cited in Smaling, 1994, p. 242; see Section 2). In order to get Essay 2 published, it has been written in the predominant (positivist) manner. However, the findings of Essay 2 have been interpreted according to the constructivist paradigm in Section 6.

Study 3: Facilitating collaboration in wikis

The study employed action research. Due to its flexibility action research has been carried out in a variety of areas resulting in different “complex and multifacted” schools (Cohen, Manion & Morrison, 2007, p. 298 et seq.). Carr and Kemmis (2002, p. 162) defined action research as “a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out.” Hence, action research is suitable for improving direct practice. The study engaged in an action-reflection cycle to improve a learning arrangement iteratively and, thus, can be positioned as technical action research according to Grundy’s (1982) typology.

The ultimate goal of the action research project was to establish a learning arrangement and to facilitate collaboration among students. Collaboration was characterised by three criteria: *synchronicity*, *negotiation*, and *interaction* (Dillenbourg, 1999). The study evaluated the effects of actions based on social network analysis and qualitative data analysis. Social network analysis was used to evaluate synchronicity using *network density* (D) and *network degree centralisation* (C_D) (Harrer, Zeini & Pinkwart, 2005; Martínez et al., 2006). Negotiation and interaction were evaluated based on interviews. Interviews were semi-structured and lasted between 20-45 minutes each (Dicicco-Bloom & Crabtree, 2006). All interviews were transcribed and analysed using a pre-defined code schema to evaluate collaboration that has been developed within this action research project.

In four years the action research project ran through three iterations. In each iteration, data were retrieved from wiki log data using a script file that pre-processed the gathered data for social network analysis. Furthermore, seven interviewees were selected per iteration based on their position within the social network graph in order to achieve a purposeful sample with maximum variation (Coyne, 1997; Sandelowski, 1995).

Study 4: Using fuzzy set qualitative comparative analysis (fsQCA) to identify indicators for wiki collaboration

The study employed fuzzy set qualitative comparative analysis (fsQCA) (Ragin, 1987, 2000). fsQCA uses Boolean algebra for solving multiple, conjectural cases. The ultimate goal of fsQCA is to identify sufficient combinations for an outcome. For this purpose, cases are represented as sets according to set theory and *conditions* (variables) as well as *outcomes* (dependent variable) are assigned with membership scores between [0] full non-membership and [1] full membership (Berg-Schlosser, De Meur, Rihoux & Ragin, 2009). Therefore, a fuzzy membership score reflects the degree to which a condition belongs to a set. This is particularly useful when pinpointing to different qualitative states of a condition, but is also used for assigning “continuous” membership scores (Ragin, 2009). The assignment of membership scores is referred to as calibration and allows researchers to conceptualise their understanding of the research context. Thus, the qualitative nature of calibration reflects the theoretical foundation of the doctoral thesis. However, by using Boolean algebra, fsQCA bridges the gap between qualitative and quantitative methods (Rihoux, 2003).

Based on data retrieved from the educational setting developed in the third study, this study applied fsQCA in order to identify sufficient combinations of indices to be used as indicators for wiki collaboration. Therefore, the same operationalisation of collaboration was used, which made use of *synchronicity*, *negotiation*, and *interaction* as defining criteria for collaboration (Dillenbourg, 1999). Accordingly, indices from social network analysis and qualitative data analysis were used to derive conditions and assess outcomes.

6 Findings

The research object of this doctoral thesis was the use of wikis in higher education for collaborative learning. I studied the research object from three perspectives that can be mapped on the process of using wikis for teaching. The process starts with the clarification of (1) determining factors of the use of wikis, which is followed by

teachers (2) use of wikis to support collaborative learning within an educational setting. Finally, the process ends with (3) the evaluation of collaboration in wikis. Each of the four studies contributed to at least one of the research aims. In the following, the findings of each study and their contribution to the research aims are summarised.

Determining factors of the use of wikis

The thesis aimed to *contribute to the existing research on adoption of IT and computer-supported collaborative learning by investigating students' intentions to adopt and barriers to use wikis in higher education*. Essay 1 describes a systematic literature review in order to disclose factors influencing the use of wikis in teaching. Essay 2 presents a study of students' intentions towards using wikis in higher education.

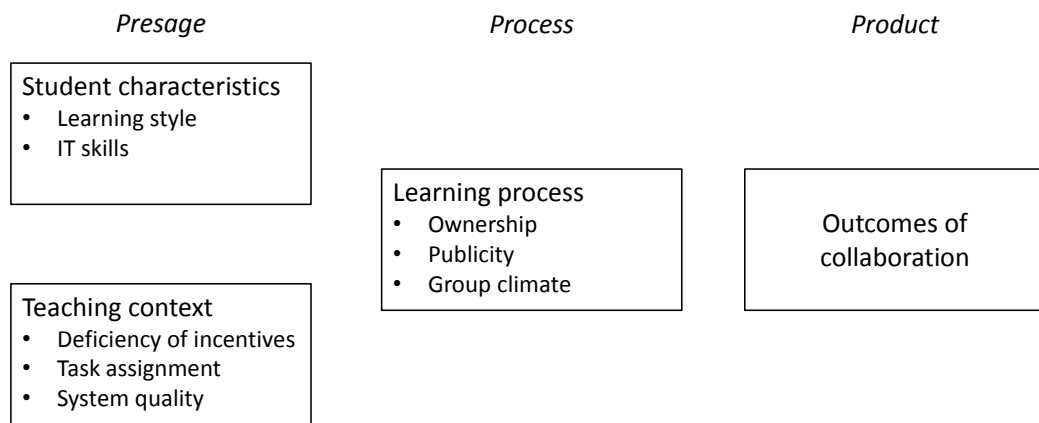


Figure 2: Factors influencing wiki collaboration

The first contribution to this research aim was the identification of factors that influence, or even hinder, collaboration in wikis (see Essay 1). Using Biggs (1989) *3P model* (presage, process, and product; see Figure 2) the factors were classified in three conceptual categories: student characteristics, teaching context, and learning process. *Student characteristics* are directly connected to a person. They comprise one's prior knowledge, abilities, and skills, but also certain preferences or the motivation to engage in collaboration. Although student characteristics can be addressed by teachers, they must not be affected immediately. *Teaching context* contains all those factors that are in control of the teacher (e.g. the quality of the wiki system). *Learning process* incorporates factors, which arise when collaboration takes place (e.g. group climate). The influencing factors are depicted in Figure 2 attached to their conceptual categories.

Furthermore, Essay 1 describes actions, which have been taken in previous studies to influence or to overcome these factors (e.g. reduce the effect of limited IT skills by providing wiki training courses).

While Essay 1 delivers an extensive overview about factors that have limited collaboration in previous research, Essay 2 investigates students' intentions to use wikis. As a result, a causal model that explains students' intentions to use wikis was introduced (see Figure 3). The causal model is based on the Decomposed Theory of Planned Behaviour (Taylor & Todd, 1995), but considers the context of wiki use in higher education by incorporating students' intrinsic and extrinsic motivation (see Figure 3 for related constructs perceived enjoyment and anticipated rewards) as well as by regarding the educational compatibility of wikis to support students' learning. All causal relationships were tested significant, except hypothesis H_8 ($SN \rightarrow BI$).

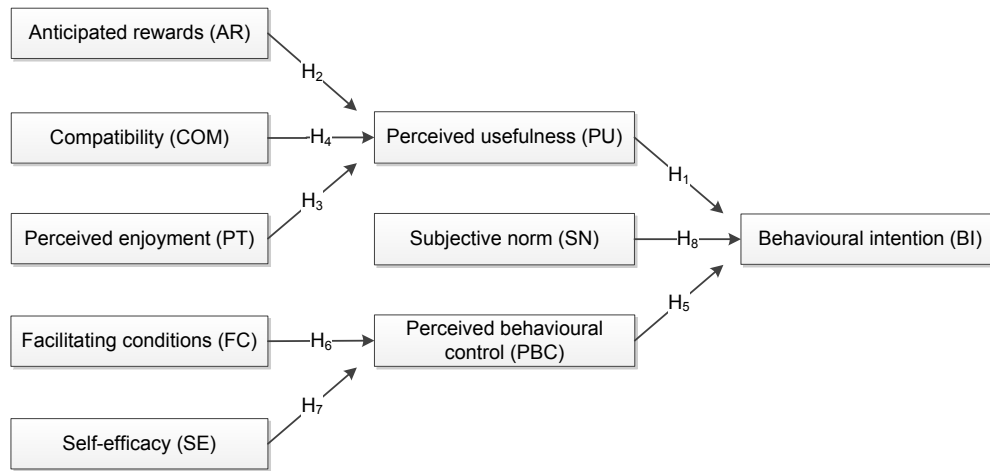


Figure 3: Research model

Both Essay 1 and 2 investigate determining factors of the use of wikis in higher education. Thus in combination, both essays form a multi-method approach to study the use of wikis in higher education. Although this has not been done with the intention to triangulate methods, data, and theory (cf. Denzin, 1970), some of the results are consistent in both studies. For example, the first study (Essay 1) identified students' learning style, which refers to a person's preference for a specific approach to learning, to have influence on the use of wikis. This is in accordance with the findings of the second study (see Essay 2), which showed a significant influence of educational compatibility on students' perceived usefulness. As a consequence, findings recurring in both studies "confirm" each other and hence increase the trustworthiness of both studies (cf. Guba and Lincoln, 1982; see also Section 2).

The thesis contributed two theoretical models to the existing research on the adoption and use of wikis in higher education: first, a theoretical model that classifies factors influencing wiki collaboration, and second, a theoretical model that discloses influences on students' intentions to use wikis in higher education.

Using wikis to support collaborative learning

The thesis aimed to *contribute to the existing research on computer-supported collaborative learning by developing and evaluating a method for the assessment of computer-supported collaborative learning*. Essay 3 describes an action research project in which an educational setting has been developed, evaluated, and improved in order to enhance a method to assess computer-supported collaborative learning. Indirectly, Essay 1 and 2 contribute to this research aim by identifying factors that determine the use of wikis in higher education.

Essay 3 presents an educational setting as the result of a four-year-long action research project that ran through three iterations. As a result, a task assignment was developed that involves all participants in the collaborative construction of a textbook. Also, a method to assess computer-supported collaborative learning was introduced and refined. To engage all participants in collaboration, the assessment focused on a group grade for *all* participants, but ensured individual accountability (cf. Slavin, 1996) by weighting the group grade with the individual contributions of a student. The findings show that students can be motivated to participate in collaboration when individual, extrinsic incentives are set; although participation remains heterogeneous (cf. Weinberger & Fischer, 2006). At the same time, the assessment method limits individualistic strategies (e.g. *social loafing*, Latané, Williams and Harkins, 1979; *free rider*, Kerr and Bruun, 1983) that undermine successful collaboration, as it interweaves task assignment with its assessment.

The thesis contributed to the existing research on computer-supported collaborative learning in two ways. First, the thesis provides an educational setting that facilitates collaboration in wikis and can be used in order to support critical thinking and communication skills. Second, an approach to assess collaborative learning was introduced and evaluated.

Evaluation of collaboration in wikis

The thesis aimed to *contribute to the existing research on learning analytics by mapping educational objectives onto learning-related data in order to establish indicators for collaboration*. Although Essay 3 is mainly concerned with the development of

an educational setting, it comprises also considerations on evaluating collaboration. Essay 3 introduces a content analysis coding scheme and investigates the explanatory power of social network indices to evaluate collaboration. Based on this preliminary work, a pedagogical perspective has been taken in Essay 4 in order to incorporate educational objectives in the analysis of learning-related data.

Table 1: Analysis of sufficient conditions for the outcome collaboration

<i>Solution</i>	DEN · DIS	+ cent · DEG · DIS	→ COLL
<i>Single case coverage</i>	2,6; 4,5,12; 9,10; 11	8; 11	
<i>Consistency</i>	.956	1	
<i>Raw coverage</i>	.722	.176	
<i>Unique coverage</i>	.606	.059	
<i>Solution consistency:</i>	.959	<i>Solution coverage:</i>	.781

Note. DEN – density, CENT – degree centralisation, DEG – median weighted degree, DIS – number of discussion posts, COLL – evaluation result for collaboration. Configurations were separated by semicolon, cases by comma. The consistency threshold has been set at 0.9. The next highest consistency score is 0.793. Case 11 is covered by both combinations. Lowercase abbreviation corresponds to the absence of a condition (0), whereas uppercase abbreviation refers to the presence of a condition (1).

Evaluating collaboration that took place in a wiki is a time-consuming job. Although previous research contributed feasible approaches to the evaluation of collaboration (e.g. Harrer et al., 2005; Martínez et al., 2006), only few studies “involve the teacher by supporting the monitoring of students’ activities” (Chatti et al., 2012) nor does previous research provide teachers with an easy-to-use evaluation method. Essay 3 contributes a lightweight coding scheme and evaluates social network indices. Essay 4 continues to simplify the evaluation of collaboration by employing an fuzzy set qualitative comparative analysis (fsQCA) to identify sufficient combinations of indices. These combinations can be used as indicators when implementing a dashboard to support teachers in monitoring students’ interaction. Table 1 depicts the solution of the fsQCA. The formula describes combinations of indices explaining successful group collaboration. For example, a high network density (DEN) and a large number of discussion posts (DIS) was in 60.6% (unique coverage of the term DEN · DIS) an indication for successful group collaboration (COLL).

The thesis contributed to the existing research on computer-supported collaborative learning by introducing a lightweight content analysis coding scheme to evaluate and indicators to monitor collaboration in wikis. Additionally, fsQCA was introduced into learning analytics providing researchers with the possibility to connect different academic fields, thus enabling them to integrate educational objectives into the analysis of learning-related data.

7 Conclusions

The doctoral thesis was motivated by the insufficiencies when using wikis for collaborative learning in higher education. Three research aims were proposed in order to contribute to the solution of these insufficiencies by (1) investigating students' intentions to adopt and barriers to use wikis in higher education, by (2) developing and evaluating a method for the assessment of computer-supported collaborative learning, and by (3) mapping educational objectives onto learning-related data in order to establish indicators for collaboration. These research aims were addressed by four studies forming together a comprehensive research project on the use of wikis for collaborative learning in higher education. Therefore, the doctoral thesis employed different research methods spanning from qualitative to quantitative as well as positivist to constructivist research. The studies have been documented in Essay 1, 2, 3, and 4.

The doctoral thesis contributed to the scientific discourse in three research areas by applying as well as advancing theory and methods. Four contributions to research have been made: first, the doctoral thesis contributed a theoretical model that classifies factors influencing collaboration in wikis. Second and complementing the first contribution, a theoretical model has been developed and tested in order to explain students' intentions to use wikis in higher education. The first two contributions provided the basis for the third contribution, which fostered the understanding of the use of wikis for collaborative learning by introducing an approach to the assessment of collaborative learning. Fourth, the fuzzy set qualitative comparative analysis was introduced to the field of learning analytics, thus allowing to incorporate educational objectives in the analysis of learning-related data.

This doctoral thesis made a contribution to practice, enabling teachers to use wikis effectively and to facilitate collaborative learning. Three contributions to practice have been made: first, this doctoral thesis provided a theoretical model classifying factors influencing wiki collaboration, but also identified actions taken in order to facilitate collaboration in wikis. Second, a ready-to-use educational setting has been provided that can be used by teachers interested in engaging their students in collaborative learning. Third, indicators for further use in teaching dashboards have been provided.

Based on the contributions to research and practice, this doctoral thesis forms the basis for further research in the respective research areas:

- The theoretical model presented in Essay 1 provides teachers with an overview about factors influencing wiki collaboration in higher education. While teachers

can use the theoretical model as a tool of the trade to facilitate collaboration in wikis, it facilitates research about the interdependencies between factors. In particular, further research should investigate the impact of different actions on different factors.

- The theoretical model introduced in Essay 2 explains students' intentions to use wikis, but was applied to first semester students only. In order to generalise the findings, this research should be replicated with students from different study courses and semesters. Likewise, the theoretical model can be used as a framework to study students' intentions depending on different educational technologies (e.g. blogs, social network services, forums).
- Both, Essay 1 and 2, investigate determining factors of the use of wikis in higher education. Whereas Essay 1 took a qualitative, constructivist view on factors influencing wiki collaboration, Essay 2 employed a quantitative, positivist approach. As I do not see both paradigms as incompatible, findings from both perspectives can be used to "correct or complement each other" (Smaling, 1994, p. 239). Correspondingly, findings from Essay 1 not covered by the theoretical model of Essay 2 can be used to theorise new constructs.
- Essay 3 introduced a method to assess computer-supported collaborative learning that is mainly focused on cognitive outcomes, but can be enhanced to incorporate social or motivational components. The incorporation of social and/or motivational components would allow teachers to realign the assessment (cf. Strijbos, 2011) in order to better fit the educational objectives associated with collaborative learning (e.g. development of communication skills or critical thinking; cf. Johnson and Johnson, 1994a).
- With fuzzy set qualitative comparative analysis, Essay 4 introduces a method into learning analytics that enables researchers to incorporate educational objectives into data analysis. Instead of relying on data-driven analysis like educational data mining, the method enables researchers to design meaningful indicators that connect challenging datasets (e.g. demographic characteristics or location-based data). Further research should connect such datasets to stimulate closer connections between learning analytics and learning sciences.
- Furthermore, the indicators established in Essay 4 should be implemented in a dashboard supporting teachers in monitoring students' activities in order to evaluate the stability of the indicators.

This doctoral thesis focused on collaboration in wikis in higher education. It employed descriptive, but also explanatory and design research and thus comprises of

multiple methods in order to thoroughly study the research object. As a result, this doctoral thesis presents findings covering the complete process of the use of wikis to support collaboration and thus provides a holistic view on the use of wikis in higher education.

References

- Ajjan, H. & Hartshorne, R. (2008). Investigating faculty decisions to adopt Web 2.0 technologies: Theory and empirical tests. *The Internet and Higher Education*, 11(2), 71–80. doi:10.1016/j.iheduc.2008.05.002
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. doi:10.1016/0749-5978(91)90020-T
- Alexander, B. (2006). Web 2.0: A new wave of innovation for teaching and learning? *EDUCAUSE Review*, 41(2), 32–44.
- Allwardt, D. E. (2011). Writing with wikis: A cautionary tale of technology in the classroom. *Journal of Social Work Education*, 47(3), 597–605. doi:10.5175/JSWE.2011.200900126
- Alyousef, H. S. & Picard, M. Y. (2011). Cooperative or collaborative literacy practices: Mapping metadiscourse in a business students' wiki group project. *Australasian Journal of Educational Technology*, 27(3), 463–480.
- Aviv, R., Erlich, Z., Ravid, G. & Geva, A. (2003). Network analysis of knowledge construction in asynchronous learning networks. *Journal of Asynchronous Learning Networks*, 7(3), 1–23.
- Baker, R. S. J. D. & Yacef, K. (2009). The state of educational data mining in 2009: A review and future visions. *Journal of Educational Data Mining*, 1(1), 3–17.
- Bakharia, A. & Dawson, S. (2011). SNAPP: A bird's-eye view of temporal participant interaction. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge - LAK '11* (pp. 168–173). doi:10.1145/2090116.2090144
- Barrie, S. C. (2004). A research-based approach to generic graduate attributes policy. *Higher Education Research & Development*, 23(3), 261–275. doi:10.1080/0729436042000235391
- Bennett, S., Maton, K. & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology*, 39(5), 775–786. doi:10.1111/j.1467-8535.2007.00793.x
- Berg-Schlosser, D., De Meur, G., Rihoux, B. & Ragin, C. C. (2009). Qualitative comparative analysis (QCA) as an approach. In B. Rihoux & C. C. Ragin (Eds.), *Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques* (Chap. 1, pp. 1–18). Thousand Oaks: Sage.

- Biggs, J. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research & Development*, 8(1), 7–25. doi:10.1080/0729436890080102
- Blikstein, P. (2011). Using learning analytics to assess students' behavior in open-ended programming tasks. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge - LAK '11* (pp. 110–116). doi:10.1145/2090116.2090132
- Bock, G.-W., Zmud, R. W., Kim, Y.-G. & Lee, J.-N. (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly*, 29(1), 87–111.
- Bologna Working Group on Qualifications Framework. (2005). The framework for qualifications of The European Higher Education Area. Copenhagen: Ministry of Science, Technology and Innovation, Denmark. Retrieved from http://www.ehea.info/Uploads/QF/050218_QF_EHEA.pdf
- Brown, J. S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32–42. doi:10.3102/0013189X018001032
- Carr, W. & Kemmis, S. (2002). *Becoming critical: Education, knowledge and action research*. London: RoutledgeFalmer.
- Chatti, M. A., Dyckhoff, A. L., Schroeder, U. & Thüs, H. (2012). A reference model for learning analytics. *International Journal of Technology Enhanced Learning*, 4(5/6), 318–331. doi:10.1504/IJTEL.2012.051815
- Chen, J.-L. (2011). The effects of education compatibility and technological expectancy on e-learning acceptance. *Computers & Education*, 57(2), 1501–1511. doi:10.1016/j.compedu.2011.02.009
- Cohen, L., Manion, L. & Morrison, K. (2007). *Research Methods in Education* (6th ed.). London: Routledge.
- Cole, M. (2009). Using wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141–146. doi:10.1016/j.compedu.2008.07.003
- Coyne, I. (1997). Sampling in qualitative research: Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing*, 26(3), 623–630. doi:10.1046/j.1365-2648.1997.t01-25-00999.x
- Cress, U. & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, 3(2), 105–122. doi:10.1007/s11412-007-9035-z
- Davis, F. D., Bagozzi, R. P. & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, 35(8), 982–1003. doi:10.1287/mnsc.35.8.982

- Denzin, N. K. (1970). *Sociological methods: A sourcebook*. Chicago, IL: Aldine.
- Dicicco-Bloom, B. & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, 40(4), 314–321. doi:10.1111/j.1365-2929.2006.02418.x
- Dillenbourg, P. (1999). What do you mean by ‘collaborative learning’? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (Chap. 1, pp. 1–19). Oxford: Elsevier. Retrieved from <http://halshs.archives-ouvertes.fr/docs/00/19/02/40/PDF/Dillenbourg-Pierre-1999.pdf>
- Dillenbourg, P., Baker, M., Blaye, A. & O’Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada & P. Rieman (Eds.), *Learning in Humans and Machine: Towards an interdisciplinary learning science* (pp. 189–211). Oxford: Elsevier.
- Downes, S. (2005). E-Learning 2.0. *eLearn magazine*. Retrieved from <http://elearnmag.acm.org/featured.cfm?aid=1104968>
- Dringus, L. P. & Ellis, T. (2005). Using data mining as a strategy for assessing asynchronous discussion forums. *Computers & Education*, 45(1), 141–160. doi:10.1016/j.compedu.2004.05.003
- Ebner, M., Kickmeier-Rust, M. & Holzinger, A. (2008). Utilizing wiki-systems in higher education classes: A chance for universal access? *Universal Access in the Information Society*, 7(4), 199–207. doi:10.1007/s10209-008-0115-2
- Elgort, I., Smith, A. G. & Toland, J. (2008). Is wiki an effective platform for group course work? *Australasian Journal of Educational Technology*, 24(2), 195–210.
- Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *International Journal of Technology Enhanced Learning*, 4(5/6), 304–317. doi:10.1504/IJTEL.2012.051816
- Fishbein, M. & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Boston, MA: Addison-Wesley.
- Glaser, B. G. & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick, NJ: AdlineTransaction.
- Grundy, S. (1982). Three modes of action research. *Curriculum Perspectives*, 2(3), 23–34.
- Guba, E. G. & Lincoln, Y. S. (1982). Epistemological and methodological bases of Naturalistic Inquiry. *Educational Technology Research and Development*, 30(4), 233–252.
- Guba, E. G. & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Newbury Park, CA: Sage.
- Guzdial, M., Rick, J. & Kehoe, C. (2001). Beyond adoption to invention: Teacher-created collaborative activities in higher education. *Journal of the Learning Sciences*, 10(3), 265–279. doi:10.1207/S15327809JLS1003_2

- Harrer, A., Zeini, S. & Pinkwart, N. (2005). The effects of electronic communication support on presence learning scenarios. In T.-W. Chan (Ed.), *The next 10 years!: Proceedings of the International Conference on Computer Support for Collaborative Learning 2005* (pp. 190–194). Morristown, NJ: Association for Computational Linguistics. doi:10.3115/1149293.1149317
- Hartshorne, R. & Ajjan, H. (2009). Examining student decisions to adopt Web 2.0 technologies: Theory and empirical tests. *Journal of Computing in Higher Education*, 21(3), 183–198. doi:10.1007/s12528-009-9023-6
- Haythornthwaite, C. (2006). Facilitating collaboration in online learning. *Journal of Asynchronous Learning Networks*, 10(1), 7–24.
- Heidenreich, K. (2011). *Erwartungen der Wirtschaft an Hochschulabsolventen*. Deutscher Industrie- und Handelskammertag e.V. Berlin. Retrieved from <http://www.dihk.de/themenfelder/aus-und-weiterbildung/schule-hochschule/hochschule/umfragen-und-prognosen/hochschulen-muessen-die-anforderungen-des-arbeitsmarktes-ernst-nehmen>
- Hew, K. F. & Cheung, W. S. (2009). Use of wikis in K-12 and higher education: a review of the research. *International Journal of Continuing Engineering Education and Life-Long Learning*, 19(2/3), 141. doi:10.1504/IJCEELL.2009.025024
- Hsu, C.-L. & Lin, J. C.-C. (2008). Acceptance of blog usage: The roles of technology acceptance, social influence and knowledge sharing motivation. *Information & Management*, 45(1), 65–74. doi:10.1016/j.im.2007.11.001
- Johnson, D. W. & Johnson, R. T. (1994a). *Learning together and alone: Cooperative, competitive, and individualistic learning* (4th ed.). Boston, MA: Allyn & Bacon.
- Johnson, R. T. & Johnson, D. W. (1994b). An overview of cooperative learning. In J. S. Thousand, R. A. Villa & A. I. Nevin (Eds.), *Creativity and collaborative learning*. Baltimore, MD: Brookes Press.
- Kang, M., Kim, Y.-G. & Bock, G.-W. (2010). Identifying different antecedents for closed vs open knowledge transfer. *Journal of Information Science*, 36(5), 585–602. doi:10.1177/0165551510375667
- Kerr, N. L. & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects. *Journal of Personality and Social Psychology*, 44(1), 78–94. doi:10.1037/0022-3514.44.1.78
- Kreijns, K., Kirschner, P. A. & Jochems, W. M. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society*, 5(1), 8–22.
- Kreijns, K., Kirschner, P. A. & Jochems, W. M. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior*, 19(3), 335–353. doi:10.1016/S0747-5632(02)00057-2

- Laal, M. & Ghodsi, S. M. (2012). Benefits of collaborative learning. *Procedia - Social and Behavioral Sciences*, 31, 486–490. doi:10.1016/j.sbspro.2011.12.091
- Latané, B., Williams, K. & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, 37(6), 822–832. doi:10.1037/0022-3514.37.6.822
- Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Learning in doing. Cambridge, MA: Cambridge University.
- Leuf, B. & Cunningham, W. (2001). *The Wiki Way: Quick collaboration on the web*. Upper Saddle River, NJ: Addison-Wesley.
- Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.
- Lovász-Bukvova, H. (2012). *Scientists' Self-presentation on the Internet* (Dissertation, Technische Universität Dresden). urn:nbn:de:bsz:14-qucosa-87592
- Luo, L. (2010). Web 2.0 integration in information literacy instruction: An overview. *The Journal of Academic Librarianship*, 36(1), 32–40. doi:10.1016/j.acalib.2009.11.004
- Martínez, A., Dimitriadis, Y., Gómez-Sánchez, E., Rubia-Avi, B., Jorrín-Abellán, I. & Marcos, J. A. (2006). Studying participation networks in collaboration using mixed methods. *International Journal of Computer-Supported Collaborative Learning*, 1(3), 383–408. doi:10.1007/s11412-006-8705-6
- Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.
- Mingers, J. (2001). Combining IS research methods: Towards a pluralist methodology. *Information Systems Research*, 12(3), 240–259. doi:10.1287/isre.12.3.240.9709
- Naismith, L., Lee, B.-H. & Pilkington, R. M. (2011). Collaborative learning with a wiki: Differences in perceived usefulness in two contexts of use. *Journal of Computer Assisted Learning*, 27(3), 228–242. doi:10.1111/j.1365-2729.2010.00393.x
- Neumann, D. L. & Hood, M. (2009). The effects of using a wiki on student engagement and learning of report writing skills in a university statistics course. *Australasian Journal of Educational Technology*, 25(3), 382–398.
- Oliveira, T. & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. *The Electronic Journal of Information Systems Evaluation*, 14(1), 110–121.
- Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *Journal of the Learning Sciences*, 13(3), 423–451. doi:10.1207/s15327809jls1303_6
- Pearson, J. (2006). Investigating ICT using problem-based learning in face-to-face and online learning environments. *Computers & Education*, 47(1), 56–73. doi:10.1016/j.compedu.2004.09.001

- Pörksen, B. (2009). The end of arbitrariness: The three fundamental questions of a constructivist ethics for the media. *Constructivist Foundations*, 4(2), 82–90.
- Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, 9(5), 1–6.
- Ragin, C. C. (1987). *The comparative method: Moving beyond qualitative and quantitative strategies*. Berkeley: University of California.
- Ragin, C. C. (2000). *Fuzzy-set social science*. Chicago: The University of Chicago.
- Ragin, C. C. (2009). Qualitative comparative analysis using fuzzy sets (fsQCA). In B. Rihoux & C. C. Ragin (Eds.), *Configurational comparative methods: qualitative comparative analysis (QCA) and related techniques* (Chap. 5, pp. 87–121). Thousand Oaks: Sage.
- Resta, P. & Laferrière, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review*, 19(1), 65–83. doi:10.1007/s10648-007-9042-7
- Rihoux, B. (2003). Bridging the gap between the qualitative and quantitative worlds? A retrospective and prospective view on qualitative comparative analysis. *Field Methods*, 15(4), 351–365. doi:10.1177/1525822X03257690
- Ringle, C. M., Wende, S. & Will, A. (2005). SmartPLS (Version 2.0 beta) [Computer software]. Hamburg. Retrieved from <http://www.smartpls.de>
- Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York, NY: The Free Press.
- Romero, C. & Ventura, S. (2007). Educational data mining: A survey from 1995 to 2005. *Expert Systems with Applications*, 33(1), 135–146. doi:10.1016/j.eswa.2006.04.005
- Rusch, G. (2007). Understanding: The mutual regulation of cognition and culture. *Constructivist Foundations*, 2(2-3), 118–128.
- Sandelowski, M. (1995). Sample size in qualitative research. *Research in Nursing & Health*, 18(2), 179–183. doi:10.1002/nur.4770180211
- Schwandt, T. A. (1998). Constructivist, interpretivist approaches to human inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *The landscape of qualitative research: Theories and issues* (Chap. 7, pp. 221–259). Thousand Oaks, CA: Sage.
- Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, 21(1), 43–69. doi:10.1006/ceps.1996.0004
- Smaling, A. (1994). The pragmatic dimension. *Quality & Quantity*, 28(3), 233–249. doi:10.1007/BF01098942
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
- Strijbos, J.-W. (2011). Assessment of (computer-supported) collaborative learning. *IEEE Transactions on Learning Technologies*, 4(1), 59–73. doi:10.1109/TLT.2010.37

- Strijbos, J.-W. & Fischer, F. (2007). Methodological challenges for collaborative learning research. *Learning and Instruction*, 17(4), 389–393. doi:10.1016/j.learninstruc.2007.03.004
- Strijbos, J.-W., Martens, R. & Jochems, W. M. (2004). Designing for interaction: Six steps to designing computer-supported group-based learning. *Computers & Education*, 42(4), 403–424. doi:10.1016/j.compedu.2003.10.004
- Taylor, S. & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research*, 6(2), 144–176. doi:10.1287/isre.6.2.144
- Teo, T. (2010). Examining the influence of subjective norm and facilitating conditions on the intention to use technology among pre-service teachers: A structural equation modeling of an extended technology acceptance model. *Asia Pacific Education Review*, 11(2), 253–262. doi:10.1007/s12564-009-9066-4
- Teo, T. (2011). Modeling the determinants of pre-service teachers' perceived usefulness of e-learning. *Campus-Wide Information Systems*, 28(2), 124–140. doi:10.1108/10650741111117824
- Tornatzky, L. G. & Fleischer, M. (1990). *The processes of technological innovation*. Lexington, MA: Lexington Books.
- Venkatesh, V. & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, 39(2), 273–315. doi:10.1111/j.1540-5915.2008.00192.x
- Venkatesh, V., Morris, M., Davis, G. & Davis, F. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478.
- Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University.
- Wallace, R. M. (2003). Online learning in higher education: A review of research on interactions among teachers and students. *Education, Communication & Information*, 3(2), 241–280. doi:10.1080/14636310303143
- Weber, M. (1922). *Gesammelte Aufsätze zur Wissenschaftslehre*. Tübingen: Mohr.
- Weinberger, A. & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education*, 46(1), 71–95. doi:10.1016/j.compedu.2005.04.003
- Wolpers, M., Najjar, J., Verbert, K. & Duval, E. (2007). Tracking actual usage: The attention metadata approach. *Educational Technology & Society*, 10(3), 106–121.

Factors influencing wiki collaboration in higher education

Christian Kummer

Abstract. Wikis are attractive tools for supporting collaboration and are widely used in higher education. Nevertheless, a collaborative tool does not necessarily lead to collaborative behaviour. This study addresses this shortcoming by analysing factors influencing the adoption of wiki collaboration in higher education. For this purpose, literature was systematically selected and analysed using a grounded approach to qualitative data analysis. As result, a framework that comprises factors influencing and actions fostering collaboration is presented. This allows instructors to better address obstacles to collaboration.

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1 Introduction

Wikis are not a new phenomenon in higher education (cf. Guzdial, Rick & Kehoe, 2001), but there is still uncertainty among instructors on how to integrate wikis into classroom and promote collaboration efficiently (Allwardt, 2011; Elgort, Smith & Toland, 2008; Naismith, Lee & Pilkington, 2011; Ramanau & Geng, 2009). Accordingly, instructors who are keen to use wikis for group collaboration cannot benefit from an existent body of knowledge, but have to learn by trial and error. As a result, some studies report negative experiences (Cole, 2009; Ebner, Kickmeier-Rust & Holzinger, 2008). The purpose of this paper is to identify factors that influence collaboration and actions that facilitate collaboration in wikis within higher education classrooms. I addressed the following research questions:

1. Which factors influence collaboration in wikis?
2. Which actions foster wiki collaboration in higher education classrooms?

To address the research questions, I selected research articles which report from the use of wikis in higher education classrooms. I analysed the selected literature using a grounded approach to qualitative data analysis. My goal was to isolate factors that hindered wiki adoption and factors that reduced the barriers of adoption. By classifying factors into Biggs' (1989) *3P model*, I provided instructors with a framework that points to obstacles of wiki collaboration. Additionally, actions were suggested to overcome these obstacles and to foster collaboration. Thereby, instructors can benefit from experience of many others without struggling through contradictory research findings. For researchers, the framework lays the foundation to thoroughly study the interdependencies between actions to foster collaboration and their impact on factors influencing collaboration.

The remainder of this article is structured as follows: within the next section, I give an overview why wikis are suitable for collaborative learning. Thereafter, I describe the literature search and selection, the analysis, and measures to ensure rigour in qualitative research. Afterwards I introduce and discuss my findings by giving examples and pointing out implications for both researchers and educational practitioners. Finally, I conclude with an outlook on further research.

2 Wikis and collaborative learning

Wikis have become popular with the emergence of Web 2.0 and have gained reasonable attention in higher education. Wikis have been used to support collaborative

learning (Carr, Morrison, Cox & Deacon, 2007; Cress & Kimmerle, 2008; Davies, Pantzopoulos & Gray, 2011; Elgort et al., 2008; Laru, Näykki & Järvelä, 2011; Wheeler, Yeomans & Wheeler, 2008), collaborative writing (Judd, Kennedy & Cropper, 2010; Kessler, 2009; Naismith et al., 2011), and student engagement (Davies et al., 2011; Neumann & Hood, 2009). A *wiki* is a “freely expandable collection of interlinked Web ‘pages’, a *hypertext system* for storing and modifying information - a *database*, where each page is easily editable by any user” (Leuf and Cunningham, 2001, p. 14; italics in original). Thereby wikis enable the collaborative construction of knowledge (Alexander, 2006), they are known as “intensely collaborative” (Godwin-Jones, 2003, p. 15). Regarding the use of wikis in higher education, this has led to “greater autonomy for the learner, but also to greater emphasis on active learning, with creation, communication and participation” (Downes, 2005). The shift to collaborative learning has been supported by existing learning theories and models (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991; Vygotsky, 1978), which could explain the educational advantages (Judd et al., 2010). As Haythornthwaite (2006) advocates: “collaborative learning holds the promise of active construction of knowledge, enhanced problem articulation, and benefits exploring and sharing information and knowledge gained from peer-to-peer communication” (p. 10).

The term *collaboration* defies clear definition (Dillenbourg, 1999). In this article, cooperation is seen as the division of labour in tasks, which allows group members to work independently, whereas collaboration needs continuous synchronisation and coordination of labour (Dillenbourg, Baker, Blaye & O’Malley, 1996; Haythornthwaite, 2006). Therefore, cooperation allows students to subdivide task assignments, work relatively independent, and to piece the results together to one final product. In contrast, collaboration is seen as a synchronous and coordinated effort of all students to accomplish their task assignment resulting in a final product where “no single hand is visible” (Haythornthwaite, 2006, p. 12).

Although the debate about *digital natives* (Prensky, 2001) appears to be a form of “moral panic” (Bennett, Maton & Kervin, 2008), educators have started to explore possible applications in teaching and learning due to “students’ heavy use of technology” in private life (Luo, 2010, p. 32; Pence, 2007). With the benefits of collaborative learning in mind, instructors started to use wikis for collaboration. But collaboration does not necessarily take place, when using a collaborative tool like a wiki (Kreijns, Kirschner & Jochems, 2003). As a result, some studies report negative experiences, where students were either reluctant to use the wiki (Cole, 2009; Ebner et al., 2008) or subdivided the assignment instead of collaborating (Naismith et al., 2011; Weaver, Viper, Latter & McIntosh, 2010; Witney & Smallbone, 2011).

3 Methods

In the following, I introduce my research methods. First, I provide a description of my literature search and unfold how I selected and how I analysed literature search results. Additionally, I introduce a descriptive summary of the articles included into analysis and disclose how I ensured rigour.

3.1 Literature search and selection

Guzdial et al. (2001) have written one of the first articles on using wikis in higher education. Since then, many articles have been published on this topic. Due to the overwhelming number of articles available, the search for relevant articles was conducted in a systematic manner. Therefore I queried electronic databases using Boolean searches with the term **wiki*** in combination with the terms **education***, **university**, and **teach***. To ensure quality, I limited the result list to display only articles that are English, peer-reviewed, and published in academic journals or at academic conferences. As of November 16th, 2011, the database searches revealed 550 hits. The specific number of hits per query and database is depicted in Table 1. The following databases were queried:

- EBSCOHost, with databases *Academic Search Complete*, *Business Source Complete*, *Communication and Mass Media Complete*, *Library, Information Science and Technology Abstracts*, and *PsycARTICLES* selected,
- Education Resources Information Center (ERIC), and
- ScienceDirect.

Because I regarded the number of retrieved articles as sufficient to represent the current state of research, I abstained from using a forward/backward search.

Table 1: Number of hits per query and database

Database	Search queries		
	wiki* AND education*	wiki* AND teach*	wiki* AND university
EBSCOHost	175	167	150
ERIC	192	127	86
ScienceDirect	36	22	24

The selection of articles to be included in the analysis was completed in three stages. First, I removed duplicate articles ($n = 66$) and those, which did not fulfil formal

requirements ($n = 45$; see above). Second, I examined the remaining 439 article abstracts whether they fit the inclusion criteria. To be included in the analysis, the articles had to report about *empirical research* on the use of *wikis in courses* for *group collaboration* in *higher education*. In the third stage, the remaining articles were examined using the full paper. Altogether, at the end of December 2011, 366 articles were discarded because they did not meet the inclusion criteria. 314 articles were screened out using the abstract (second stage), 52 articles based on the full paper (third stage). Finally, 73 articles remained and are included in the following analysis (see Appendix for a complete list of the included articles).

3.2 Analysis of articles

I used a grounded approach to answer the research questions, applying in particular the *constant comparative method* to analyse the articles (Glaser & Strauss, 1967). The basic unit of analysis were information chunks of varying size - phrases, sentences, or a whole paragraph - embedded in a case represented by an article (Miles & Huberman, 1994, p. 56). The selected articles were analysed and coded using the qualitative data analysis software *MaxQDA*, version 10. Instead of using a predefined provisional start list of codes, I used *in vivo* coding until codes became stable and patterns emerged from the articles (Miles & Huberman, 1994, p. 58/61). The initial codes were then aggregated into higher-level codes and categories. The coding was highly iterative. I compared each incident for a category with the previous incidents in the same and different groups coded in the same category (Glaser & Strauss, 1967, p. 106). After analysing the articles, fifteen codes with together 326 codings remained (for the number of codings per code refer to Figure 3 and Table 3). Furthermore, I generated a code co-occurrence matrix to check for interdependencies between codes (see Table 2).

3.3 Descriptive summary of the articles

In this section, I summarise the cases in which research on wikis in higher education classrooms was conducted. The article set comprises of 73 studies that had been published since 2006 (2006: 2; 2007: 3; 2008: 6; 2009: 23; 2010: 21; 2011: 18). One-third of the studies was conducted at universities in Europe (35.6%) another third in North America (32.9%), followed by Australia (13.7%), Asia (12.3%), Africa (2.7%), and South America (2.7%). If universities had teamed up for a wiki project, the reporting institution was counted. Some of the articles contained several descriptions of wiki adoption. This is reflected in the following descriptive statistics leading to 80 distinctive wiki implementations.

Past research had been carried out in different disciplines of study: *sciences* including mathematics and psychology, *engineering*, *medical sciences*, *humanities and social sciences* including economic sciences, *computer sciences* including information systems and educational technology, *law*, and *language* (see Figure 1). Decisive for assigning the article to a certain discipline was the course, not the participating students.

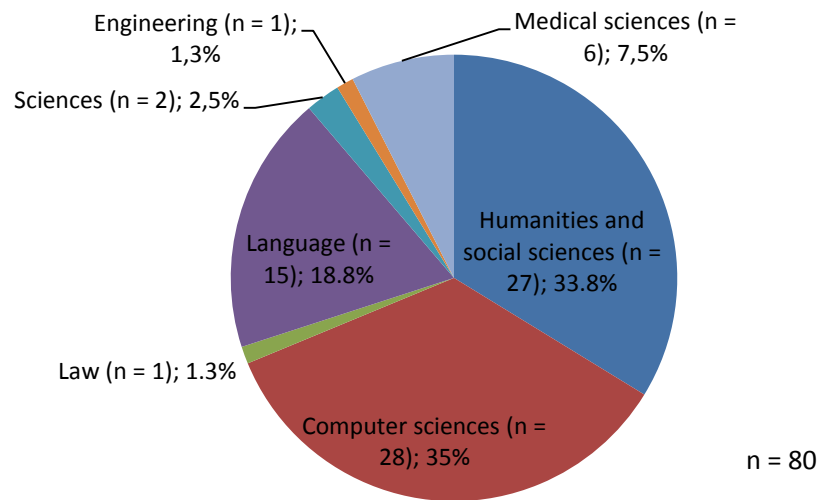


Figure 1: Discipline of study

Nearly three-quarters of the studies were conducted at Bachelor level ($n = 53$; 66.3%), followed by courses at Master ($n = 21$; 26.3%), and PhD level ($n = 2$; 2.5%). Four wiki implementations (5.0%) could not be allocated, because the study level was not clearly explicated. In case of mixed levels in one course, the lowest level was applied. Corresponding to the high proportion of courses at Bachelor level, courses with a large number of students were predominant (see Figure 2).

3.4 Measures to ensure rigour

Measures for ensuring scientific rigour of quantitative research cannot be applied to qualitative research. As this research was based on a constructivist understanding of reality, I used Lincoln and Gubas (1985) constructivist paradigm as an underlying framework. They suggest alternative criteria to establish trustworthiness for qualitative research: credibility, dependability, confirmability, and transferability.

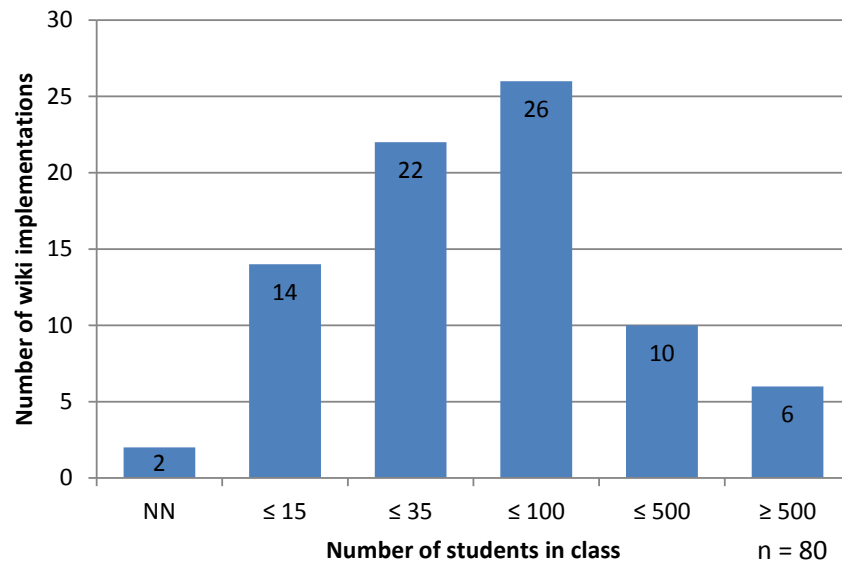


Figure 2: Distribution of number of students in classroom using wiki

3.4.1 Credibility/internal validity

Credibility relates to the concept of internal validity by positivist researchers (Miles & Huberman, 1994; Shenton, 2004). According to Lincoln and Guba (1985) credibility is one of the most important factors in establishing trustworthiness. It can be achieved by questioning whether a study is an authentic portrait of a research subject/area (Miles & Huberman, 1994, p. 278).

To achieve credibility I debriefed my findings to a colleague in order to examine my inquiry process (*peer debriefing*, Lincoln and Guba, 1985, p. 301). Although my coding structure was stable after the iterative analysis of 30 articles, the remaining articles were coded in order to *prolong* the *engagement* with the articles and identify potential *negative evidence* (Lincoln and Guba, 1985, p. 301; Miles and Huberman, 1994, p. 271).

3.4.2 Transferability/external validity

Transferability relates to the concept of external validity and is concerned with the applicability of the findings in other contexts (Lincoln and Guba, 1985, p. 124; Miles and Huberman, 1994, p. 279).

I provided a *thick description* of my inquiry, my findings, and the context (Lincoln & Guba, 1985, p. 125). I assume that a systematic approach provides a large variety of cases and thus results in a sufficient sample of the “population of contexts” (p.

124). Hence, it should lead to transferability. Although this is of limited relevance for my research methodology, it ensures robustness of my findings.

3.4.3 Dependability/reliability

The underlying issue of dependability (in place of reliability) is whether the process of the study is consistent and would lead to similar results (Miles & Huberman, 1994, p. 278), “if the work were repeated, in the same context, with the same methods and with the same participants” (Shenton, 2004, p. 71). Lincoln and Guba (1985, p. 316) argue that establishing credibility is a precondition for dependability. Therefore, I provided an in-depth coverage (*thick description*) to enable readers to comprehend my research approach (Shenton, 2004, p. 71).

3.4.4 Confirmability/objectivity

Confirmability aims at ensuring objectivity (Miles & Huberman, 1994, p. 278). For establishing confirmability I followed the advice of Lincoln and Guba (1985, p. 318-319) and wrote a reflexive journal during analysis to make potential biases clear to myself.

4 Findings and discussion

The result of the study is a conceptual framework, which can be used to address barriers to wiki implementation in higher education classrooms. The framework describes factors that influence collaboration and actions that help instructors to create facilitating conditions and promote wiki collaboration.

Within this section, I introduce the factors influencing wiki collaboration by giving examples and by outlining strategies to facilitate collaboration. Every description of an influencing factor points to possible actions to foster collaboration and concludes with a recommendation for educational practitioners. Altogether, seven actions remained after analysis that were frequently used by instructors to foster collaboration; Table 3 gives an overview of the actions.

After analysis, eight factors influencing, or even hindering, wiki collaboration remained. I have organised these factors in three conceptual categories on the basis of Biggs (1989) *3P model* (presage, process, and product; see Figure 3): student characteristics, teaching context, and learning process. *Student characteristics* are directly connected to a person. They comprise one’s prior knowledge, abilities, and skills, but also certain preferences or the motivation to engage in collaboration. Although

student characteristics can be addressed by instructors, they must not be affected immediately. *Teaching context* contains all those factors that are in control of the instructor. *Learning process* incorporates factors, which arise when collaboration takes place.

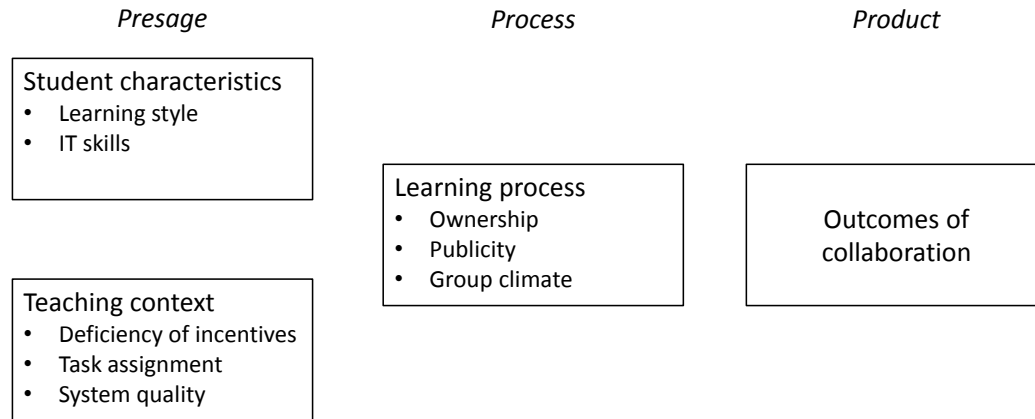


Figure 3: Factors influencing wiki collaboration

Note: Frequencies of codes: learning style (n = 29), IT skills (n = 39), deficiency of incentives (n = 7), task assignment (n = 12), system quality (n = 48), ownership (n = 29), publicity (n = 27), and group climate (n = 18). Total number of codings: 209.

4.1 Student characteristics

Following, I introduce how student characteristics influence a student's approach to collaboration by introducing two factors: student's *learning style* and his *IT skills*.

4.1.1 Learning style

A learning style is the preference of a person for a specific approach to learning. Matthew, Felvegi and Callaway (2009) state that wiki assignments are different from individual writing assignments, because students have to be aware of their peers' contribution. This requires a new way of working from students. As Carr et al. (2007) cite one student, "it's hard when you have been working alone for three years and then all of a sudden people want you to work together" (p. 275). Although students understood, that wikis are used to promote collaboration to engage students in shared meaning-making, they tend to be reluctant to work collaboratively (Karasavvidis, 2010; Su & Beaumont, 2010), because it is "time-consuming and sometimes not working" (Lin and Kelsey, 2009, p. 163, excerpt 43). Therefore students often favour cooperative learning over collaborative learning (Alyousef & Picard, 2011; Carr et al., 2007). Likewise, they prefer to work alone, because they do not have to

rely on the contributions of others (Lee, 2010). But following individual strategies and maximising personal reward has a negative impact on the overall collaboration. Due to the fact, that collaboration is the joint production of *one* product, willing students have to cope with late contributions. Hence, collaboration can barely take place. As one student put it:

“If people upload their page late (close to the due date) how I can edit it on time. I found that most of students write their assignment on MS Word first then later they upload it. I might not have enough time to do it” (Ruth & Houghton, 2009, p. 142).

While learning styles cannot be changed ad hoc (Biggs & Tang, 2007, p. 26), the choice of a wiki task can have an impact on learners approach to learning. Learners select their approach to a specific task depending on the requirements of the task and their previous success with a particular approach to this task. Although, learners do have preferences for one or another approach, the choice depends on the teaching context (Bennett et al., 2008; Biggs and Tang, 2007, p. 26). Accordingly, the teaching context must enable and promote collaboration. Thereby, learners’ approach to learning *could be* affected positively. First, prior research demonstrates that assignments have to be mandatory, otherwise participation is unlikely (cf. Cole, 2009; Ebner et al., 2008). Second, the assignment has to necessitate collaboration and is therefore impossible to be concluded by a single person. This can be supported with guidelines that describe the peer-to-peer interaction.

Recommendation: Promote collaboration through mandatory assignments that necessitate interaction with peers in order to conclude the assignment.

4.1.2 IT skills

Despite the alleged existence of so called *digital natives* (Bennett et al., 2008; Prensky, 2001), one major problem is still the lack of IT skills. While today’s students are interested in technology, their IT skills should not be overestimated (Ramanau & Geng, 2009). Some of the students still lack fundamental technology skills, such as “enabling cookies, working on shared documents, and clicking the refresh button in their Web browser” (Matthew et al., 2009, p. 65). As a result, they have problems to engage in virtual collaborative activities. Problems with IT skills can be subdivided in three main themes:

1. No prior experience with similar technology: “There are students like me who are new to wikis. We need time to explore the wiki system. If you want to

start a new topic, but just don't know how to do it ... you have to go back to the help menu to refresh your memory on how to use wiki. Because I don't post messages to wiki very often, I almost need to go to the help menu every time" (Choy & Ng, 2007).

2. Syntax problems: "At first it was hard to get it right. I didn't know how to write [in the wiki]" (Lin & Kelsey, 2009, p. 157).
3. Lost in hyperspace: "I haven't got used to the wiki's interface. Its structure seems a bit complicated. I sometimes get lost (don't know where I am)" (Choy & Ng, 2007).

Prior experience with similar technology affects the time required to engage in efficient wiki work (Guo & Stevens, 2011). Additionally, contributing to wikis is different from normal collaborative software, because markup syntax is used to format text in most wiki software. Learning the wiki syntax is sometimes a barrier (Naismith et al., 2011) that results in less intensive collaboration, because students are unable to create new content, post comments, or upload images. Familiarity and confidence with technology are therefore a precondition for productive collaborative engagement. In their absence, students waste much of their time to construct the wiki rather than to engage in collaboration and knowledge work. Previous research on barriers of wiki adoption refers to this problem as effort and time requirements (Karasavvidis, 2010). Experienced students perceive wiki collaboration as time-consuming, because they tend to overestimate their skills (Naismith et al., 2011).

Another problem of students who are not familiar with wikis is to be *lost in hyperspace* (Conklin, 1987). Students do not know "how [to] get to the one place" (Su & Beaumont, 2010, p. 420) and are confused by the structure of the wiki. Due to this, it is unlikely that collaboration will occur.

However, although a lack of IT skills limits collaboration at the beginning significantly, it is not a persistent obstacle. Guo and Stevens (2011) state, that most students learnt how to use wikis in less than a couple of days and only few did not learn it until the end of the semester. Previous research has shown many ways of providing students with the necessary skills (Guo & Stevens, 2011). Especially when the use of wikis is mandatory, sufficient initial training is necessary. This training should be integrated at the beginning of the course, acquainting the students with the most important wiki procedures. Furthermore, it is recommended to provide an experimental wiki installation (sandbox), where students can familiarise themselves with the wiki in a safe place. This should be supplemented with continuous technical support and instructional material on how to use wikis. Ideally, the complexity of the wiki task should be increased with caution to scaffold collaboration.

Recommendation: Provide initial training, continuous technical support and instructional material to familiarise students with wiki technology. Increase the complexity of wiki tasks carefully in order to scaffold collaboration.

4.2 Teaching context

In the following, I introduce three factors that can be controlled by the instructor: *incentives*, *task assignment*, and the *system quality* of the wiki.

4.2.1 Deficiency of incentives

Although “wikis are intensely collaborative” (Godwin-Jones, 2003, p. 15), they have to be integrated with the curriculum in a meaningful way. Otherwise, students will opt to not use them (Judd et al., 2010; Witney & Smallbone, 2011). Past research has shown that optional use of wikis is not purposeful when collaboration is desired (Allwardt, 2011; Carr et al., 2007; Cole, 2009; Ebner et al., 2008; Wheeler et al., 2008). Therefore, instructors have to offer incentives for participating in wikis, whether they are intrinsic or extrinsic (Kummer, 2013; Witney & Smallbone, 2011). This lack of interest can have different reasons. Firstly, students have little interest to participate in wikis due to the demands of their studies and their working life (Halcro & Smith, 2011). Secondly, the success of Wikipedia cannot be imitated in higher education easily. Wikipedians are already motivated for different reasons (Giles, 2005; Lerner & Tirole, 2002; Nov, 2007), but a comparable motivation has to be build up in higher education classrooms before collaboration takes place.

One precondition for wiki collaboration in higher education is that wiki assignments are integrated into the module in a reasonable way. Through mandatory and assessed wiki work, extrinsic incentives can be easily adopted. In comparison, creating intrinsic motivation is harder. Bonk, Lee, Kim and Lin (2009) have conferred certificates that certify students as Wikibookians after the end of the course. Others have tried to create beneficial tasks by engaging students in the collaborative authoring of a textbook.

“I enjoyed the experience since it gave me a feeling I am ‘teaching’ other users and sharing my knowledge with them” (Ravid, Kalman & Rafaeli, 2008, p. 1920).

“The traditional writing is somewhat boring. You only write for the instructor. [...] One thing I really liked about wikis is how we wrote collaboratively for multiple readers. Writing for a broad audience made me more serious about writing. I actually enjoyed it” (Lee, 2010, p. 265).

While most of the students found the presence of an audience outside the classroom already motivating (Baltzersen, 2010), a collaborative endeavour can foster a community-feeling that is in turn motivating (Bonk et al., 2009).

Recommendation: Integrate wiki assignments carefully into your course by providing intrinsic and extrinsic incentives.

4.2.2 Task assignment

A precondition for collaboration to occur is that the task assignment requires collaboration via wiki. It is not sufficient only to provide a collaborative technology, since this will not automatically lead to collaborative engagement (Guo & Stevens, 2011; Kreijns et al., 2003).

“Although wiki can engage students in collaborative work, this course does not require any collaborative work. If wiki is used in a business company which requires a group of people to develop something, I believe people can benefit from it. But this course does not maximise such a strength” (Choy & Ng, 2007).

“If there are projects that can have tutors and students develop collaboratively, I would think the collaborative aspects of wiki could be maximised” (Choy & Ng, 2007).

Hence, tasks have to be designed in such way that they cannot be easily subdivided and collaboration is therefore required. That stresses the importance of a fit between task and technology (Zigurs & Buckland, 1998): assignments should be designed for the use with wikis, as wikis do not necessarily fit traditional approaches (Kear, Woodthorpe, Robertson & Hutchison, 2010; Ruth & Houghton, 2009).

Nonetheless, students often do collaborate, but without using the wiki’s facilities (Allwardt, 2011; Zorko, 2009). To initiate collaborative activities within a wiki among students, instructors must scaffold collaboration. This can be achieved by synchronised, successive tasks (Cole, 2009; Snodgrass, 2011), which foster a “certain degree of knowledge asymmetry and resource interdependence” (Arnold, Ducate, Lomicka & Lord, 2009, p. 124). Additionally, clear expectations of the outcome and guidelines for participating in collaboration have to be formulated.

Recommendation: Design assignment tasks that are difficult to subdivide into cooperative tasks. Provide a clear expectation of how students can participate in collaboration.

4.2.3 System quality

In contrast to IT skills, the notion of system quality refers to the technical parameters of an information system like usability, availability, and response time (cf. DeLone & McLean, 2003). The choice of a stable information system influences the efficiency of the collaboration, because students with little IT skills experience more problems in case of poor system quality.

A prerequisite for group collaboration is a stable, easy to access system with no problems concerning security, availability, or reliability. Although this depends on the point of view, a wiki should be easy to use by providing students a clean and usable interface. Otherwise, inexperienced students will get into trouble:

“I disliked the disorganization and the difficulty of editing the pages. The boxes for entering new texts were somewhat messy and often skewed with the format of pasted examples” (Ramanau & Geng, 2009, p. 2623).

Beside usability concerns, the wiki syntax is sometimes experienced as “too complicated”, “frustrating”, and “not very standard” (Hughes & Narayan, 2009, p. 73). Accordingly, wikis are not seen as a “place to write” (p. 73) or as a place to collaborate. But this concern could be explained in part by lack of students’ IT skills.

Limited functionality can also hinder productive collaboration (Naismith et al., 2011; Varga-Atkins, Dangerfield & Brigden, 2010). This is especially the case for keeping up to date about the collaboration process.

“No immediate way of knowing if new messages are present, without opening the wiki up and searching all the headings - time-consuming. No history - can’t see who is present, who has read the messages - very frustrating” (Kear et al., 2010, p. 222).

Accordingly, students have to continually screen their classmates’ posting to react or to avoid reposting of information. This limits collaboration as students have to invest a considerable time and effort for gaining information (Baltzersen, 2010).

Also, students often express concern of limited possibilities to communicate in real-time (“have to wait for the students’ feedback”; Alyousef and Picard, 2011, p. 472), while wikis typically only offer asynchronous communication via discussion pages. Accordingly, students avoid the wiki and opt for alternatives (e.g. instant messaging, meeting face-to-face; Allwardt, 2011; Costa and Bondia, 2007). As a result, collaboration does not take place in the wiki.

Instructors should therefore carefully choose a system, which is easy to use, stable, and equipped with all necessary functionalities. To increase the usability for less IT skilled students, instructors should think about a visual editor, removing the need to write wiki syntax, and information streams, which automatically inform students about wiki updates.

Recommendation: Instructors should choose a wiki system which has been proven to be easy to learn and use.

4.3 Learning process

In the following, I introduce factors which arise during collaboration and can hinder or facilitate collaboration: the *ownership* of someone's work, the availability of the wiki to the *public*, and the *group climate* between collaborators.

4.3.1 Ownership

Editing someone's work is a challenge for students. Unless not absolutely necessary, students avoid to edit or delete contributions of fellow students.

"I think it was exciting to go in and edit something that others have made, it's not something one often does. I am used to writing texts from bottom, so going in and changing someone other's texts was demanding. One wants it to be as good as possible, but it's not so easy to know where to begin. I didn't either feel competent enough to correct others' work, I don't necessarily know more about the topic than the one who already has written about it. One thing is new hyperlinks and pictures, but going directly into the text and removing and adding was tough" (Baltzersen, 2010, p. 804).

Whilst the students are able to edit others work, they are hesitant out of a feeling of incompetence (Baltzersen, 2010). Hence, the ability to change others' work makes some students feel insecure. As a result, students tend to only add minor contributions to the work of "others" (Carr et al., 2007). This can also be influenced by cultural perceptions that regulate social interaction. Therefore, editing or modifying content created by others is perceived as a major offense (Alyousef & Picard, 2011; Twu, 2009). Additionally, some users do not like their work edited by others.

"I did have one unpleasant experience. I commented on one page and thought the comment was ok, but when I received an email from the

owner of the work saying she was getting annoyed and she was happy not to take any further part, I was disheartened. I didn't want her to lose marks for not participating. [...] I felt bad and returned the email with an apology. I also added to my comments on her page. I didn't mean to offend and we got on really well afterwards. In a way the experience has already helped me amend my ways. I have used what I learned in another situation by being more tactful with my comments instead of being as subtle as a brick in the face. I looked forward to having my work scrutinised and edited by my peers and I appreciated the comments that were left for me" (Weaver et al., 2010, p. 853).

This behaviour can be in part explained by the students' fear that others manipulate their work inappropriately. A feeling of ownership contradicts collaborative activities and has to be minimised. Instructors have different possibilities to deal with ownership problems. Firstly, instructors should provide training to introduce students to wikis, but also communicate clear and concise rules of engagement (Aborisade, 2009; Costa & Bondia, 2007). Additionally, netiquette guidelines should be published in order to foster a mutual understanding and resolve differences (Augar, Raitman & Zhou, 2006; Kear et al., 2010).

To promote a good start, collaboration can be scaffolded using mini-tasks that prepare students for the main assessment (Elgort et al., 2008). Once the wiki task was initiated, the instructor should keep his assistance to a minimum in order to encourage peer scaffolding. Consistent with the democratic nature of wikis, the role of the instructor becomes more that of a facilitator rather than a supervisor. Therefore, instructors should focus on facilitating collaboration by identifying group problems and moderating differences (Kessler, 2009; Lee, 2010; Matthew et al., 2009; Naismith et al., 2011).

Recommendation: Scaffold group collaboration by carefully introducing students to wiki work. Provide guidelines that establish a mutual understanding of ground rules of engagement. After start, moderate in case of difficulties and do not dominate group work in order to promote peer scaffolding.

4.3.2 Publicity

Wikis make the process of constructing text visible to everyone engaged in the wiki. While some students find it motivating to write not only for the instructor, others may feel a little bit scared.

"I am concerned someone will read it and think that it does not make sense" (Lin & Kelsey, 2009, p. 163).

“I was a little bit scared to actually write anything... ’cause I knew that there was surveillance. And I don’t like to be watched all the time” (Beames, Klenowski & Lloyd, 2010, p. 56).

Students were hesitant to share work in progress as they feared to expose messy or incomplete ideas (Beames et al., 2010; de Pedro et al., 2006; Su & Beaumont, 2010). They wanted to appear professional and did not want to be seen as “stupid” (Varga-Atkins et al., 2010). This is in conformance with the impression-management theory by Goffman (1959). According to Goffman (1959), individuals present a *front stage* version of themselves in public, if they perceive a *hidden audience*. Correspondingly, students could be interested only in presenting their *best side*, hence not collaborating via wiki but only uploading the final version (Allwardt, 2011; Carr et al., 2007; Zorko, 2009).

To promote collaboration, instructors should offer careful scaffolding. While students experiment with new technologies and new learning concepts, they need time to develop confidence in a safe environment (Kear et al., 2010; Varga-Atkins et al., 2010).

Recommendation: Explain the concept of open editing and public domain carefully to allay students’ fears. Provide students a safe, protected wiki to experiment and if necessary make it step by step public.

4.3.3 Group climate

Reluctance to engage in wiki collaboration can be due to a difficult group climate. To collaborate efficiently, students have to build up trust and familiarity with unknown group members (Beames et al., 2010). But an unresolved distrust, a lack of a common goal, and different learning styles can lead to reluctance or individualistic strategies.

“Collaboration was not easy. I think if I hadn’t had a reliable partner that was interested in the same subject or maybe assigned to do the work together, I’d like to work alone” (Lin & Kelsey, 2009, p. 162).

“I understand and like the idea of working on team projects. The reality is it is time-consuming and sometimes not working” (Lin & Kelsey, 2009, p. 162).

While team effectiveness is affected by team cohesion (Deeter-Schmelz, Kennedy & Ramsey, 2002), individualistic strategies undermine successful collaboration (e.g. *social loafing*, Latané, Williams and Harkins, 1979; *lone wolf*, Feldman Barr, Dixon and Gassenheimer, 2005; *free rider*, Kerr and Bruun, 1983).

The building of ties between group members could be facilitated with initial face to face meetings. To prevent social pitfalls, provide guidelines for social interaction and encourage students to develop an online identity. This can be achieved by scaffolding tasks to establish ties between fellow group members (Augar et al., 2006). Of course, instructors should keep track of the collaboration process and moderate if problems occur.

Recommendation: Provide possibilities to establish social connections between fellow students. Set clear netiquette guidelines for social interaction and conciliate in case of problems.

4.4 Interdependencies

I analysed interdependencies between influencing factors using a code co-occurrence matrix. Table 2 depicts the co-occurrences for each code-code relationship per document. While co-occurrence is not a standardised measure, relatively high co-occurrences can draw attention to interesting relationships between codes.

Table 2: Frequencies of code co-occurrence per document

		<i>Student characteristics</i>			<i>Teaching context</i>		<i>Learning process</i>	
		<i>LS</i>	<i>IT</i>	<i>DI</i>	<i>TA</i>	<i>SQ</i>	<i>O</i>	<i>P</i>
<i>SC</i>	<i>IT</i>	10***	-					
	<i>DI</i>	4*	5**	-				
<i>Teaching context</i>	<i>TA</i>	4*	8***	1*	-			
	<i>SQ</i>	11***	16***	2*	7**	-		
	<i>O</i>	8***	8***	3*	2*	10***	-	
<i>Learning process</i>	<i>P</i>	7**	7**	2*	2*	10***	6**	-
	<i>GC</i>	7**	6**	2*	2*	8***	4*	4*

Note: GC = group climate; O = ownership; P = publicity; IT = IT skills; LS = learning style; DI = deficiency of incentives; TA = task assignment; SC = student characteristics; SQ = system quality.

* = 0.33-quantile; ** = (0.66 - 0.33)-quantile; *** = (1 - 0.66)-quantile.

System quality has a high number of co-occurrences with almost every other factor. Problems with the wiki or using the wiki are present in nearly every wiki implementation. Accordingly, the highest number of co-occurrences has the relationship *system quality - IT skills*. Therefore, poor system quality seems to result in a greater number of problems using the system.

Also interesting is the relationship between *task assignment* and *IT skills*. If the assignment of tasks does not require the students to collaborate via the wiki, they seem to simultaneously experience problems using the wiki. Assuming that students are able to learn how to use wikis in a few days (cf. Guo & Stevens, 2011), this can be interpreted as a missing necessity to learn how to use them.

The strong relationship between prior *IT skills* and *learning style* emphasises the dependency of learning style on IT skills. This underscores the importance of exhaustive wiki training and continuous support, if wiki work is mandatory. Hence, diligent scaffolding is necessary in order to provide students with enough prerequisites for an efficient collaboration. This argument is borne by the high-ranking co-occurrence of the relationships between the codes of *student characteristic* and *learning process*. Sufficient IT skills and a learning style that allows collaboration could therefore be seen as characteristics that aid collaboration.

5 Conclusion

This paper presents a framework of factors influencing collaboration within a wiki in higher education. Using Biggs' (1989) *3P model*, these factors were subdivided into three categories: *student characteristics*, *teaching context*, and *learning process*. The framework gives instructors an overview, which factors are in their control, which ones are not. For example, the category *teaching context* consists of three factors that are in the responsibility of the instructor and can therefore be easily configured. In contrast, instructors cannot control *student characteristics* or the *learning process* directly, but influence them by taking certain actions such as offering training prior to the wiki assignment. Furthermore, actions to overcome factors that hinder collaboration were extracted from literature. Thereby, the framework allows instructors to benefit from experiences of previous wiki implementations without struggling through contradictory research findings. Therefore, the framework reveals starting points for interventions to foster wiki collaboration (see Table 3).

Table 3: Actions to facilitate collaboration

Action	Description	Applicable to
Community building	Foster community building by giving students the chance to build trust and familiarity with the group. Give them the chance to introduce themselves to each other.	Deficiency of incentives, Group climate
Facilitator	Facilitate collaboration, but do not dominate group work. Instead, point students to problems, anticipate difficulties, and give feedback. Focus on enabling peer to peer support and give control to the students.	IT skills, Ownership, Group climate
Incentives	Reward collaboration by integrating the task assignment into your module. Provide a meaningful task to motivate students intrinsically. Involve them as much as possible in construction of the wiki as they are inherently democratic.	Learning style, Deficiency of incentives
Netiquette	Provide clear and positive guidelines that foster a common understanding about how to engage in collaboration. Assure students, that editing is not correcting.	Ownership, Group climate
Roles	Consider to assign roles that establish responsibilities in order to foster collaboration.	Ownership, Deficiency of incentives
Scaffolding	Scaffold collaboration by providing a task that cannot be accomplished alone. Start with small and easy tasks and increase the complexity slowly. Provide samples and templates to make the start easy. Give your students space to practice wiki work and collaboration. Give feedback constantly in order to align collaboration.	Learning style, IT skills, Task assignment, Ownership, Publicity
Wiki training	Provide wiki trainings, continuous technical support, and provide instructional material that covers how to contribute to the wiki.	IT skills, System quality

Note: Frequencies of codes: community building (n = 7), facilitator (n = 36), incentives (n = 25), netiquette (n = 9), roles (n = 8), scaffolding (n = 28), and wiki training (n = 40). Total number of codings: 153.

While instructors can use the framework as a tool of the trade to foster collaboration within wikis in higher education, it facilitates research about the connections between factors that influence collaboration and actions that facilitate collaboration. In particular, further research should investigate the impact of different actions on different factors. For example, to what extent do instructors have to act as a facilitator to foster group collaboration? Is it possible to over-facilitate collaboration? Does over-

facilitation result in less interaction and less negotiation? Furthermore, when should instructors take actions to overcome a particular obstacle to collaboration: before the start, at the beginning, or in the meantime?

Furthermore, more research about the interdependencies among the factors that influence collaboration is necessary. The results shown in Table 2 suggest that interdependencies exist. For instance, *IT skills* appear to be a foundation for effective collaboration within wikis. Although this finding seems to be obvious, it is well suited to hypothesise correlations between obstacles based on code co-occurrences. Do students really have problems with task assignments or do they only lack IT skills?

While this paper introduced a framework of factors that influence collaboration, it has not considered the success of the wiki assignments in the analysis. Due to different types of assignment, assessment, and previous knowledge, research about wikis is hardly comparable with each other. Consequently, I agree with Resta's and Laferrière's(2007) proposal to use a generic model in order to assess the "added value of technology support for collaborative learning in higher education" (p. 68). As Resta and Laferrière (2007), I advise to use Biggs' (1989) *3P model* that I have enriched by factors that influence and actions that foster collaboration. Therefore, I provided a framework that can be used to describe the implementation of a wiki assignment holistically by incorporating actions that have been used to facilitate collaboration and by referring to factors that influenced collaboration.

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References

- Aborisade, P. (2009). Investigating a Nigerian XXL-cohort wiki-learning experience: Observation, feedback and reflection. *Electronic Journal of e-Learning*, 7(3), 191–202.
- Alexander, B. (2006). Web 2.0: A new wave of innovation for teaching and learning? *EDUCAUSE Review*, 41(2), 32–44.
- Allwardt, D. E. (2011). Writing with wikis: A cautionary tale of technology in the classroom. *Journal of Social Work Education*, 47(3), 597–605. doi:10.5175/JSWE.2011.200900126

- Alyousef, H. S. & Picard, M. Y. (2011). Cooperative or collaborative literacy practices: Mapping metadiscourse in a business students' wiki group project. *Australasian Journal of Educational Technology*, 27(3), 463–480.
- Arnold, N., Ducate, L., Lomicka, L. & Lord, G. (2009). Assessing online collaboration among language teachers: A cross-institutional case study. *Journal of Interactive Online Learning*, 8(2), 121–139.
- Augar, N., Raitman, R. & Zhou, W. (2006). Developing wikis to foster web-based learning communities: An iterative approach. *International Journal of Web Based Communities*, 2(3), 302–317. doi:10.1504/IJWBC.2006.011761
- Baltzersen, R. K. (2010). Radical transparency: Open access as a key concept in wiki pedagogy. *Australasian Journal of Educational Technology*, 26(6), 791–809.
- Beames, S., Klenowski, V. & Lloyd, M. (2010). Matching intention with agency: Lessons from practice. *Journal of Learning Design*, 3(2), 50–60.
- Bennett, S., Maton, K. & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology*, 39(5), 775–786. doi:10.1111/j.1467-8535.2007.00793.x
- Biggs, J. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research & Development*, 8(1), 7–25. doi:10.1080/0729436890080102
- Biggs, J. & Tang, C. (2007). *Teaching for quality learning at university: What the student does* (3rd ed.). New York, NY: Open University Press.
- Bonk, C. J., Lee, M. M., Kim, N. & Lin, M.-F. G. (2009). The tensions of transformation in three cross-institutional wikibook projects. *Internet and Higher Education*, 12(3-4), 126–135. doi:10.1016/j.iheduc.2009.04.002
- Brown, J. S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32–42. doi:10.3102/0013189X018001032
- Carr, T., Morrison, A., Cox, G. & Deacon, A. (2007). Weathering wikis: Net-based learning meets political science in a South African university. *Computers and Composition*, 24(3), 266–284. doi:10.1016/j.compcom.2007.06.001
- Choy, S. O. & Ng, K. C. (2007). Implementing wiki software for supplementing online learning. *Australasian Journal of Educational Technology*, 23(2), 209–226.
- Cole, M. (2009). Using wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141–146. doi:10.1016/j.compedu.2008.07.003
- Conklin, J. (1987). Hypertext: An introduction and survey. *IEEE Computer*, 20(9), 17–41.
- Costa, A. G. & Bondia, A. G. (2007). Design of a wiki-based collaborative working strategy within the context of legal sciences. *European Journal of Legal Education*, 4(1), 105–114.

- Cress, U. & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, 3(2), 105–122. doi:10.1007/s11412-007-9035-z
- Davies, A., Pantzopoulos, K. & Gray, K. (2011). Emphasising assessment ‘as’ learning by assessing wiki writing assignments collaboratively and publicly online. *Australasian Journal of Educational Technology*, 27(5), 798–812.
- de Pedro, X., Rieradevall, M., López, P., Sant, D., Piñol, J., Núñez, L. & Llobera, M. (2006). Writing documents collaboratively in higher education using traditional vs. wiki methodology (I): Qualitative results from a 2-year project study. In *4th International Congress of University Teaching and Innovation*. Barcelona.
- Deeter-Schmelz, D. R., Kennedy, K. N. & Ramsey, R. P. (2002). Enriching our understanding of student team effectiveness. *Journal of Marketing Education*, 24(2), 114–124. doi:10.1177/0273475302242004
- DeLone, W. H. & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, 19(4), 9–30.
- Dillenbourg, P. (1999). What do you mean by ‘collaborative learning’? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (Chap. 1, pp. 1–19). Oxford: Elsevier. Retrieved from <http://halshs.archives-ouvertes.fr/docs/00/19/02/40/PDF/Dillenbourg-Pierre-1999.pdf>
- Dillenbourg, P., Baker, M., Blaye, A. & O’Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada & P. Rieman (Eds.), *Learning in Humans and Machine: Towards an interdisciplinary learning science* (pp. 189–211). Oxford: Elsevier.
- Downes, S. (2005). E-Learning 2.0. *eLearn magazine*. Retrieved from <http://elearnmag.acm.org/featured.cfm?aid=1104968>
- Ebner, M., Kickmeier-Rust, M. & Holzinger, A. (2008). Utilizing wiki-systems in higher education classes: A chance for universal access? *Universal Access in the Information Society*, 7(4), 199–207. doi:10.1007/s10209-008-0115-2
- Elgort, I., Smith, A. G. & Toland, J. (2008). Is wiki an effective platform for group course work? *Australasian Journal of Educational Technology*, 24(2), 195–210.
- Feldman Barr, T., Dixon, A. L. & Gassenheimer, J. B. (2005). Exploring the ‘Lone Wolf’ phenomenon in student teams. *Journal of Marketing Education*, 27(1), 81–90. doi:10.1177/0273475304273459
- Giles, J. (2005). Internet encyclopaedias go head to head. *Nature*, 438(7070), 900–901. doi:10.1038/438900a
- Glaser, B. G. & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick, NJ: AdlineTransaction.

- Godwin-Jones, R. (2003). Emerging technologies. *Language Learning & Technology*, 7(2), 12–16.
- Goffman, E. (1959). *The presentation of self in everyday life*. New York, NY: Doubleday.
- Guo, Z. & Stevens, K. J. (2011). Factors influencing perceived usefulness of wikis for group collaborative learning by first year students. *Australasian Journal of Educational Technology*, 27(2), 221–242.
- Guzdial, M., Rick, J. & Kehoe, C. (2001). Beyond adoption to invention: Teacher-created collaborative activities in higher education. *Journal of the Learning Sciences*, 10(3), 265–279. doi:10.1207/S15327809JLS1003_2
- Halcro, K. & Smith, A. M. J. (2011). Wikis: Building a learning experience between academe and businesses. *Reflective Practice*, 12(5), 679–693. doi:10.1080/14623943.2011.601559
- Haythornthwaite, C. (2006). Facilitating collaboration in online learning. *Journal of Asynchronous Learning Networks*, 10(1), 7–24.
- Hughes, J. E. & Narayan, R. (2009). Collaboration and learning with wikis in post-secondary classrooms. *Journal of Interactive Online Learning*, 8(1), 63–82.
- Judd, T., Kennedy, G. & Cropper, S. (2010). Using wikis for collaborative learning: Assessing collaboration through contribution. *Australasian Journal of Educational Technology*, 26(3), 341–354.
- Karasavvidis, I. (2010). Wiki uses in higher education: Exploring barriers to successful implementation. *Interactive Learning Environments*, 18(3), 219–231. doi:10.1080/10494820.2010.500514
- Kear, K., Woodthorpe, J., Robertson, S. & Hutchison, M. (2010). From forums to wikis: Perspectives on tools for collaboration. *The Internet and Higher Education*, 13(4), 218–225. doi:10.1016/j.iheduc.2010.05.004
- Kerr, N. L. & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects. *Journal of Personality and Social Psychology*, 44(1), 78–94. doi:10.1037/0022-3514.44.1.78
- Kessler, G. (2009). Student-initiated attention to form in wiki-based collaborative writing. *Language Learning & Technology*, 13(1), 79–95.
- Kreijns, K., Kirschner, P. A. & Jochems, W. M. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior*, 19(3), 335–353. doi:10.1016/S0747-5632(02)00057-2
- Kummer, C. (2013). Students' intentions to use wikis in higher education. In R. Alt & B. Franczyk (Eds.), *Proceedings of the 11th International Conference on Wirtschaftsinformatik (WI2013)* (Vol. 2, pp. 1493–1508). Leipzig.

- Laru, J., Näykki, P. & Järvelä, S. (2011). Supporting small-group learning using multiple web 2.0 tools: A case study in the higher education context. *The Internet and Higher Education*, 15(1), 29–38. doi:10.1016/j.iheduc.2011.08.004
- Latané, B., Williams, K. & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, 37(6), 822–832. doi:10.1037/0022-3514.37.6.822
- Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Learning in doing. Cambridge, MA: Cambridge University.
- Lee, L. (2010). Exploring wiki-mediated collaborative writing: A case study in an elementary Spanish course. *CALICO Journal*, 27(2), 260–276.
- Lerner, J. & Tirole, J. (2002). Some simple economics of open source. *The Journal of Industrial Economics*, 50(2), 197–234.
- Leuf, B. & Cunningham, W. (2001). *The Wiki Way: Quick collaboration on the web*. Upper Saddle River, NJ: Addison-Wesley.
- Lin, H. & Kelsey, K. D. (2009). Building a networked environment in wikis: The evolving phases of collaborative learning in a wikibook project. *Journal of Educational Computing Research*, 40(2), 145–169. doi:10.2190/EC.40.2.a
- Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.
- Luo, L. (2010). Web 2.0 integration in information literacy instruction: An overview. *The Journal of Academic Librarianship*, 36(1), 32–40. doi:10.1016/j.acalib.2009.11.004
- Matthew, K. I., Felvegi, E. & Callaway, R. A. (2009). Wiki as a collaborative learning tool in a language arts methods class. *Journal of Research on Technology in Education*, 42(1), 51–72.
- Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.
- Naismith, L., Lee, B.-H. & Pilkington, R. M. (2011). Collaborative learning with a wiki: Differences in perceived usefulness in two contexts of use. *Journal of Computer Assisted Learning*, 27(3), 228–242. doi:10.1111/j.1365-2729.2010.00393.x
- Neumann, D. L. & Hood, M. (2009). The effects of using a wiki on student engagement and learning of report writing skills in a university statistics course. *Australasian Journal of Educational Technology*, 25(3), 382–398.
- Nov, O. (2007). What motivates Wikipedians? *Communications of the ACM*, 50(11), 60–64. doi:10.1145/1297797.1297798
- Pence, H. E. (2007). Preparing for the real web generation. *Journal of Educational Technology Systems*, 35(3), 347–356.
- Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, 9(5), 1–6.

- Ramanau, R. & Geng, F. (2009). Researching the use of wiki's to facilitate group work. *Procedia - Social and Behavioral Sciences*, 1(1), 2620–2626. doi:10.1016/j.sbspro.2009.01.463
- Ravid, G., Kalman, Y. M. & Rafaeli, S. (2008). Wikibooks in higher education: Empowerment through online distributed collaboration. *Computers in Human Behavior*, 24(5), 1913–1928. doi:10.1016/j.chb.2008.02.010
- Resta, P. & Laferrière, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review*, 19(1), 65–83. doi:10.1007/s10648-007-9042-7
- Ruth, A. & Houghton, L. (2009). The wiki way of learning. *Australasian Journal of Educational Technology*, 25(2), 135–152.
- Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22, 63–75.
- Snodgrass, S. (2011). Wiki activities in blended learning for health professional students: Enhancing critical thinking and clinical reasoning skills. *Australasian Journal of Educational Technology*, 27(4), 563–580.
- Su, F. & Beaumont, C. (2010). Evaluating the use of a wiki for collaborative learning. *Innovations in Education and Teaching International*, 47(4), 417–431. doi:10.1080/14703297.2010.518428
- Twu, H.-L. (2009). Effective wiki strategies to support high-context culture learners. *Tech Trends*, 53(5), 16–22. doi:10.1007/s11528-009-0318-2
- Varga-Atkins, T., Dangerfield, P. & Brigden, D. (2010). Developing professionalism through the use of wikis: A study with first-year undergraduate medical students. *Medical Teacher*, 32(10), 824–829. doi:10.3109/01421591003686245
- Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University.
- Weaver, D., Viper, S., Latter, J. & McIntosh, P. C. (2010). Off campus students' experiences collaborating online, using wikis. *Australasian Journal of Educational Technology*, 26(6), 847–860.
- Wheeler, S., Yeomans, P. & Wheeler, D. (2008). The good, the bad and the wiki: Evaluating student-generated content for collaborative learning. *British Journal of Educational Technology*, 39(6), 987–995. doi:10.1111/j.1467-8535.2007.00799.x
- Witney, D. & Smallbone, T. (2011). Wiki work: Can using wikis enhance student collaboration for group assignment tasks? *Innovations in Education and Teaching International*, 48(1), 101–110. doi:10.1080/14703297.2010.543765
- Zigurs, I. & Buckland, B. K. (1998). A theory of task/technology fit and group support systems effectiveness. *MIS Quarterly*, 22(3), 313–334.
- Zorko, V. (2009). Factors affecting the way students collaborate in a wiki for English language learning. *Australasian Journal of Educational Technology*, 25(5), 645–665.

Appendix

- Aborisade, P. (2009). Investigating a Nigerian XXL-cohort wiki-learning experience: Observation, feedback and reflection. *Electronic Journal of e-Learning*, 7(3), 191–202.
- Allwardt, D. E. (2011). Writing with wikis: A cautionary tale of technology in the classroom. *Journal of Social Work Education*, 47(3), 597–605. doi:10.5175/JSWE.2011.200900126
- Alyousef, H. S. & Picard, M. Y. (2011). Cooperative or collaborative literacy practices: Mapping metadiscourse in a business students' wiki group project. *Australasian Journal of Educational Technology*, 27(3), 463–480.
- Arnold, N., Ducate, L., Lomicka, L. & Lord, G. (2009). Assessing online collaboration among language teachers: A cross-institutional case study. *Journal of Interactive Online Learning*, 8(2), 121–139.
- Augar, N., Raitman, R. & Zhou, W. (2006). Developing wikis to foster web-based learning communities: An iterative approach. *International Journal of Web Based Communities*, 2(3), 302–317. doi:10.1504/IJWBC.2006.011761
- Baltzersen, R. K. (2010). Radical transparency: Open access as a key concept in wiki pedagogy. *Australasian Journal of Educational Technology*, 26(6), 791–809.
- Beames, S., Klenowski, V. & Lloyd, M. (2010). Matching intention with agency: Lessons from practice. *Journal of Learning Design*, 3(2), 50–60.
- Bonk, C. J., Lee, M. M., Kim, N. & Lin, M.-F. G. (2009). The tensions of transformation in three cross-institutional wikibook projects. *Internet and Higher Education*, 12(3-4), 126–135. doi:10.1016/j.iheduc.2009.04.002
- Bradley, L., Lindstrom, B. & Rystedt, H. (2010). Rationalities of collaboration for language learning in a wiki. *ReCALL*, 22(2), 247–265.
- Carr, T., Morrison, A., Cox, G. & Deacon, A. (2007). Weathering wikis: Net-based learning meets political science in a South African university. *Computers and Composition*, 24(3), 266–284. doi:10.1016/j.compcom.2007.06.001
- Chao, Y.-C. J. & Lo, H.-C. (2011). Students' perceptions of wiki-based collaborative writing for learners of English as a foreign language. *Interactive Learning Environments*, 19(4), 395–411. doi:10.1080/10494820903298662
- Cheng, G. & Chau, J. (2011). A comparative study of using blogs and wikis for collaborative knowledge construction. *International Journal of Instructional Media*, 38(1), 71–78.
- Choy, S. O. & Ng, K. C. (2007). Implementing wiki software for supplementing online learning. *Australasian Journal of Educational Technology*, 23(2), 209–226.

- Cole, M. (2009). Using wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141–146. doi:10.1016/j.compedu.2008.07.003
- Costa, A. G. & Bondia, A. G. (2007). Design of a wiki-based collaborative working strategy within the context of legal sciences. *European Journal of Legal Education*, 4(1), 105–114.
- Cronin, J. J. (2009). Upgrading to web 2.0: An experiential project to build a marketing wiki. *Journal of Marketing Education*, 31(1), 66–75.
- Davies, A., Pantzopoulos, K. & Gray, K. (2011). Emphasising assessment ‘as’ learning by assessing wiki writing assignments collaboratively and publicly online. *Australasian Journal of Educational Technology*, 27(5), 798–812.
- Davis, F. F. & Loasby, I. D. (2009). I love legal history: Web 2.0 and the teaching of law. *Journal of Commonwealth Law & Legal Education*, 7(1), 19–36. doi:10.1080/14760400903195116
- de Wever, B., Keer, H. V., Schellens, T. & Valcke, M. (2011). Assessing collaboration in a wiki: The reliability of university students’ peer assessment. *The Internet and Higher Education*, 14(4), 201–206. doi:10.1016/j.iuheduc.2011.07.003
- Dobson, T. M. (2006). The love of a good narrative: Textuality and digitality. *English Teaching: Practice and Critique*, 5(2), 56–68.
- Dymoke, S. & Hughes, J. (2009). Using a poetry wiki: How can the medium support pre-service teachers of English in their professional learning about writing poetry and teaching poetry writing in a digital age? *English Teaching: Practice and Critique*, 8(3), 91–106.
- Elgort, I., Smith, A. G. & Toland, J. (2008). Is wiki an effective platform for group course work? *Australasian Journal of Educational Technology*, 24(2), 195–210.
- Elola, I. & Oskoz, A. (2010). Collaborative writing: Fostering foreign language and writing conventions development. *Language Learning & Technology*, 14(3), 51–71.
- Ertmer, P. A., Newby, T. J., Yu, J. H., Liu, W., Tomory, A., Lee, Y. M., ... Sendurur, P. (2011). Facilitating students’ global perspectives: Collaborating with international partners using Web 2.0 technologies. *The Internet and Higher Education*, 14(4), 251–261. doi:10.1016/j.iuheduc.2011.05.005
- Ertmer, P., Newby, T., Liu, W., Tomory, A., Yu, J. & Lee, Y. (2011). Students’ confidence and perceived value for participating in cross-cultural wiki-based collaborations. *Educational Technology Research & Development*, 59(2), 213–228.
- Foulger, T. S., Williams, M. K. & Wetzel, K. (2008). We innovate: The role of collaboration in exploring new technologies. *International Journal of Teaching and Learning in Higher Education*, 20(1), 28–38.

- Guo, Z. & Stevens, K. J. (2011). Factors influencing perceived usefulness of wikis for group collaborative learning by first year students. *Australasian Journal of Educational Technology*, 27(2), 221–242.
- Halcro, K. & Smith, A. M. J. (2011). Wikis: Building a learning experience between academe and businesses. *Reflective Practice*, 12(5), 679–693. doi:10.1080/14623943.2011.601559
- Hazari, S., North, A. & Moreland, D. (2009). Investigating pedagogical value of wiki technology. *Journal of Information Systems Education*, 20(2), 187–198.
- Huang, W.-H. D. & Nakazawa, K. (2010). An empirical analysis on how learners interact in wiki in a graduate level online course. *Interactive Learning Environments*, 18(3), 233–244. doi:10.1080/10494820.2010.500520
- Hughes, J. E. & Narayan, R. (2009). Collaboration and learning with wikis in post-secondary classrooms. *Journal of Interactive Online Learning*, 8(1), 63–82.
- Judd, T., Kennedy, G. & Cropper, S. (2010). Using wikis for collaborative learning: Assessing collaboration through contribution. *Australasian Journal of Educational Technology*, 26(3), 341–354.
- Karasavvidis, I. (2010a). Understanding wikibook-based tensions in higher education: An activity theory approach. *E-Learning and Digital Media*, 7(4), 386–394. doi:10.2304/elea.2010.7.4.386
- Karasavvidis, I. (2010b). Wiki uses in higher education: Exploring barriers to successful implementation. *Interactive Learning Environments*, 18(3), 219–231. doi:10.1080/10494820.2010.500514
- Kear, K., Woodthorpe, J., Robertson, S. & Hutchison, M. (2010). From forums to wikis: Perspectives on tools for collaboration. *The Internet and Higher Education*, 13(4), 218–225. doi:10.1016/j.iheduc.2010.05.004
- Kessler, G. (2009). Student-initiated attention to form in wiki-based collaborative writing. *Language Learning & Technology*, 13(1), 79–95.
- Kessler, G. & Bikowski, D. (2010). Developing collaborative autonomous learning abilities in computer mediated language learning: Attention to meaning among students in wiki space. *Computer Assisted Language Learning*, 23(1), 41–58. doi:10.1080/09588220903467335
- Kuteeva, M. (2011). Wikis and academic writing: Changing the writer-reader relationship. *English for Specific Purposes*, 30(1), 44–57. doi:10.1016/j.esp.2010.04.007
- Lai, Y. C. & Ng, E. M. W. (2011). Using wikis to develop student teachers' learning, teaching, and assessment capabilities. *The Internet and Higher Education*, 14(1), 15–26. doi:10.1016/j.iheduc.2010.06.001

- Lambert, J., Kalyuga, S. & Capan, L. A. (2009). Student perceptions and cognitive load: What can they tell us about e-learning Web 2.0 course design? *E-Learning*, 6(2), 150–163. doi:10.2304/elea.2009.6.2.150
- Laru, J., Näykki, P. & Järvelä, S. (2011). Supporting small-group learning using multiple web 2.0 tools: A case study in the higher education context. *The Internet and Higher Education*, 15(1), 29–38. doi:10.1016/j.iuheduc.2011.08.004
- Lee, L. (2010). Exploring wiki-mediated collaborative writing: A case study in an elementary Spanish course. *CALICO Journal*, 27(2), 260–276.
- Lin, H. & Kelsey, K. D. (2009). Building a networked environment in wikis: The evolving phases of collaborative learning in a wikibook project. *Journal of Educational Computing Research*, 40(2), 145–169. doi:10.2190/EC.40.2.a
- Ma, W. W. & Yuen, A. H. (2008). News writing using wiki: Impacts on learning experience of student journalists. *Educational Media International*, 45(4), 295–309. doi:10.1080/09523980802571564
- Matthew, K. I., Felvegi, E. & Callaway, R. A. (2009). Wiki as a collaborative learning tool in a language arts methods class. *Journal of Research on Technology in Education*, 42(1), 51–72.
- Meishar-Tal, H. & Gorsky, P. (2010). Wikis: What students do and do not do when writing collaboratively. *Open Learning: The Journal of Open and Distance Learning*, 25(1), 25–35. doi:10.1080/02680510903482074
- Meyer, K. A. (2010). A comparison of Web 2.0 tools in a doctoral course. *The Internet and Higher Education*, 13(4), 226–232. doi:10.1016/j.iuheduc.2010.02.002
- Mirk, S. M., Burkiewicz, J. S. & Komperda, K. E. (2010). Student perception of a wiki in a pharmacy elective course. *Currents in Pharmacy Teaching and Learning*, 2(2), 72–78. doi:10.1016/j.cptl.2010.01.002
- Miyazoe, T. & Anderson, T. (2010). Learning outcomes and students' perceptions of online writing: Simultaneous implementation of a forum, blog, and wiki in an EFL blended learning setting. *System*, 38(2), 185–199. doi:10.1016/j.system.2010.03.006
- Morley, D. A. (2011). Enhancing networking and proactive learning skills in the first year university experience through the use of wikis. *Nurse Education Today*, 32(3), 261–266. doi:10.1016/j.nedt.2011.03.007
- Naismith, L., Lee, B.-H. & Pilkington, R. M. (2011). Collaborative learning with a wiki: Differences in perceived usefulness in two contexts of use. *Journal of Computer Assisted Learning*, 27(3), 228–242. doi:10.1111/j.1365-2729.2010.00393.x
- Neumann, D. L. & Hood, M. (2009). The effects of using a wiki on student engagement and learning of report writing skills in a university statistics course. *Australasian Journal of Educational Technology*, 25(3), 382–398.

- Otter, M. E., Whittaker, S. & Spriggs, S. (2009). Using wikis and peer evaluation to teach medical students how to find and assess evidence based resources: A pilot study. *New Review of Academic Librarianship*, 15(2), 187–205. doi:10.1080/13614530903240502
- Park, C. L., Crocker, C., Nussey, J., Springate, J. & Hutchings, D. (2010). Evaluation of a teaching tool - wiki - in online graduate education. *Journal of Information Systems Education*, 21(3), 313–321.
- Pombo, L., Loureiro, M. J. & Moreira, A. (2010). Assessing collaborative work in a higher education blended learning context: Strategies and students' perceptions. *Educational Media International*, 47(3), 217–229. doi:10.1080/09523987.2010.518814
- Ramanau, R. & Geng, F. (2009). Researching the use of wiki's to facilitate group work. *Procedia - Social and Behavioral Sciences*, 1(1), 2620–2626. doi:10.1016/j.sbspro.2009.01.463
- Ras, E. & Rech, J. (2009). Using wikis to support the Net Generation in improving knowledge acquisition in capstone projects. *Journal of Systems and Software*, 82(4), 553–562. doi:10.1016/j.jss.2008.12.039
- Ravid, G., Kalman, Y. M. & Rafaeli, S. (2008). Wikibooks in higher education: Empowerment through online distributed collaboration. *Computers in Human Behavior*, 24(5), 1913–1928. doi:10.1016/j.chb.2008.02.010
- Ren, Z., Baker, P. & Zhang, S. (2009). Effects of student-written wiki-based textbooks on pre-service teachers' epistemological beliefs. *Journal of Educational Computing Research*, 40(4), 429–449.
- Ruth, A. & Houghton, L. (2009). The wiki way of learning. *Australasian Journal of Educational Technology*, 25(2), 135–152.
- Snodgrass, S. (2011). Wiki activities in blended learning for health professional students: Enhancing critical thinking and clinical reasoning skills. *Australasian Journal of Educational Technology*, 27(4), 563–580.
- Su, F. & Beaumont, C. (2010). Evaluating the use of a wiki for collaborative learning. *Innovations in Education and Teaching International*, 47(4), 417–431. doi:10.1080/14703297.2010.518428
- Thompson, J. R., Hess, G. R., Bowman, T. A., Magnusdottir, H., Stubbs-Gipson, C. E., Groom, M., ... Stokes, D. L. (2009). Collaborative graduate education across multiple campuses. *Journal of Natural Resources and Life Sciences Education*, 38, 16–26.
- Trentin, G. (2009). Using a wiki to evaluate individual contribution to a collaborative learning project. *Journal of Computer Assisted Learning*, 25(1), 43–55. doi:10.1111/j.1365-2729.2008.00276.x

- Tsai, W.-T., Li, W., Elston, J. & Chen, Y. (2011). Collaborative learning using wiki web sites for computer science undergraduate education: A case study. *IEEE Transactions on Education*, 54(1), 114–124. doi:10.1109/TE.2010.2046491
- Varga-Atkins, T., Dangerfield, P. & Brigden, D. (2010). Developing professionalism through the use of wikis: A study with first-year undergraduate medical students. *Medical Teacher*, 32(10), 824–829. doi:10.3109/01421591003686245
- Vratulis, V. & Dobson, T. M. (2008). Social negotiations in a wiki environment: A case study with pre-service teachers. *Educational Media International*, 45(4), 285–294. doi:10.1080/09523980802571531
- Weaver, D., Viper, S., Latter, J. & McIntosh, P. C. (2010). Off campus students' experiences collaborating online, using wikis. *Australasian Journal of Educational Technology*, 26(6), 847–860.
- Wheeler, S. & Wheeler, D. (2009). Using wikis to promote quality learning in teacher training. *Learning, Media and Technology*, 34(1), 1–10. doi:10.1080/17439880902759851
- Wichadee, S. (2010). Using wikis to develop summary writing abilities of students in an EFL class. *Journal of College Teaching & Learning*, 7(12), 5–10.
- Witney, D. & Smallbone, T. (2011). Wiki work: Can using wikis enhance student collaboration for group assignment tasks? *Innovations in Education and Teaching International*, 48(1), 101–110. doi:10.1080/14703297.2010.543765
- Xiao, Y. & Lucking, R. (2008). The impact of two types of peer assessment on students' performance and satisfaction within a wiki environment. *The Internet and Higher Education*, 11(3-4), 186–193. doi:10.1016/j.iuheduc.2008.06.005
- Zorko, V. (2009). Factors affecting the way students collaborate in a wiki for English language learning. *Australasian Journal of Educational Technology*, 25(5), 645–665.

Students' intentions to use wikis in higher education

Christian Kummer

Abstract. Although wikis have gained considerable attention in higher education, students are often reluctant to use wikis in formal learning processes. Unlike company employees, students are not often rewarded for their participation in wiki-based assignments. Therefore, students seem to be opportunistic and decide to adopt wikis if they fit their current situation and preferences. This paper adapts the Decomposed Theory of Planned Behaviour to examine the situation in higher education classrooms. To better understand students' decision to use wikis, we introduced an intrinsic and extrinsic motivation construct. A survey was conducted with 133 first semester students to test the proposed model. The results provide support for the importance of an intrinsic and extrinsic motivation construct to explain influence on students' wiki use.

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1 Introduction

The Web 2.0 has attracted considerable attention over the past few years. Social networking sites, blogs, wikis, podcasts, and more have changed the way that people search for, obtain, and share information. This change has had a substantial impact not only on our private lives but also on higher education (Downes, 2005). Many educators have started to adapt and incorporate technology into their classrooms. Wikis especially have become popular with the development of the Web 2.0 and have gained reasonable attention in higher education. A wiki is a “freely expandable collection of interlinked web pages, a hypertext system for storing and modifying information – a database where each page is easily editable by any user” (Leuf & Cunningham, 2001, p. 14). Wikis have been used to support collaborative learning (Wheeler, Yeomans & Wheeler, 2008), collaborative writing (Kessler, 2009), and student engagement (Neumann & Hood, 2009). Although wikis are not a new phenomenon in higher education (Guzdial, Rick & Kehoe, 2001), there is still uncertainty about how to integrate wikis into classroom efficiently. As a consequence, instructors are struggling with students that are reluctant to use wikis (Cole, 2009; Ebner, Kickmeier-Rust & Holzinger, 2008). At the same time, there is a lack of empirically tested research (Guo & Stevens, 2011; Liu, 2010) about the students' perception of using wikis in formal learning processes within higher education.

The goal of this paper is to address this research gap by exploring factors that influence students' decision to adopt wikis within formal learning processes in higher education. Our research is distinctive for three reasons: first, we use the Decomposed Theory of Planned Behaviour (DTPB) (Taylor & Todd, 1995) as a theoretical background for this study, which has not been previously tested in this context. Prior research only investigated students' intentions towards the whole software category, Web 2.0 (Hartshorne & Ajjan, 2009), and is therefore limited. Students' decisions to adopt particular software depend on the context: e.g. the intention to voluntarily use social bookmarks in a classroom is different from the intention to write a graded assignment in a wiki. Second, we adapt the DTBP to suit the specific context of using wikis within formal learning processes in higher education. This is necessary because the motivation to use wikis is different from other contexts. Therefore, we included two constructs that represent the influence of intrinsic and extrinsic motivation on students' intention to use wikis. Based on literature, we integrate perceived enjoyment (Hsu & Lin, 2008) and anticipated rewards (Bock, Zmud, Kim & Lee, 2005). In combination, these constructs allow us to understand the different motivations that are crucial for the adoption of a particular technology. Third, by modelling perceived usefulness as an influence on behavioural intention and by removing attitude, we take previously reported substitution effects from studies (Teo, 2009; Venkatesh,

Morris, Davis & Davis, 2003) into account for the DTPB. The revised model was tested using a survey of first semester students in an introductory course on information systems. We then examined the proposed hypotheses using the partial least square approach to data analysis.

The paper is structured as follows: in the second section, we propose an adapted model of technology acceptance of wikis in higher education. Within the third section, we explain the methodology of our study. The results of the study are presented in the fourth chapter. The fifth chapter discusses the results and shows how instructors could benefit from these results. Finally, the next research steps are outlined.

2 Theoretical model

The theoretical framework used in this study is based on the Decomposed Theory of Planned Behaviour (Taylor & Todd, 1995). The DTPB has its origin in the Theory of Planned Behaviour (Ajzen, 1991). The TPB asserts that an individual's usage behaviour is a direct function of perceived behavioural usefulness and behavioural intention that in turn is a function of attitude, subjective norm, and perceived behavioural control. The DTPB extends the TPB by adding further influence factors on attitude and perceived behavioural control, resulting in more explanatory power (Taylor & Todd, 1995). As this study did not test a particular wiki implementation, we omitted usage behaviour because it cannot be measured without using a wiki. Therefore, behavioural intention is used as the strongest predictor of actual use (cf. Wilhelm, Strahringer & Smolnik, 2012). For this reason, we favoured the DTPB over the Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw, 1989) because the DTPB allows a better prediction of the behavioural intention than the TAM (Taylor & Todd, 1995). The proposed model (see Figure 1) can be used to test influences on wiki adoption without relying on a specific wiki implementation.

As a consequence, we removed perceived ease of use as an influence on perceived usefulness for three reasons. First, we did not test a particular wiki implementation. Although different wiki implementations have basis functionality in common, ease of use is dependent on a particular wiki implementation. Second, today's students are comfortable with nearly every form of technology (Pence, 2007). Perceived ease of use is moderated by experience. Therefore, perceived ease of use is not that important in forming behavioural intention if the users are already familiar with the technology (Venkatesh, 2000; Venkatesh & Bala, 2008). Third, a wiki is web-based application. Perceived ease of use did not appear as a significant determinant when access to a system is provided by a graphical front-end and a browser (Agarwal & Prasad, 1997). Therefore, we removed perceived ease of use in order to get a model

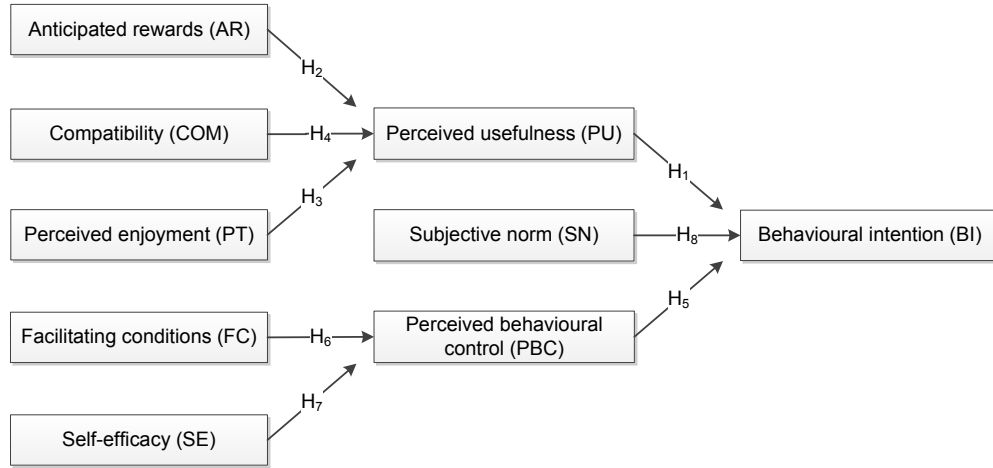


Figure 1: Research model

that is as parsimonious as possible, but facilitates the understanding of students' decision to adopt wikis (Bagozzi, 1992; Taylor & Todd, 1995).

In the following, we introduce an adapted DTPB that is used to study factors influencing students' behavioural intention to use wikis if they are provided within formal learning processes in higher education classrooms.

2.1 Perceived usefulness

In contrast to the DTPB, we replaced attitude with perceived usefulness because attitude is not always a reliable predictor of behavioural intention. Attitude is not significant if constructs related to performance and effort expectancies are included in the model (Venkatesh et al., 2003). Research results suggest that attitude can be substituted with perceived usefulness (Teo, 2009; Venkatesh et al., 2003).

Perceived usefulness (PU) is defined as the "prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context" (Davis et al., 1989, p. 985). Previous studies have shown strong empirical support that perceived usefulness positively influences behavioural intention (Taylor & Todd, 1995; Venkatesh & Bala, 2008). In the context of wikis in formal learning processes, perceived usefulness is viewed as the degree to which students believe that using wikis will help them learn better. Hence, perceived usefulness is hypothesised to positively influence the behavioural intention.

Hypothesis 1: Perceived usefulness will positively influence students' intentions to use wikis.

The situation in higher education classrooms is different than the situation in small and medium-sized companies, for example. Unlike company employees, students are often not rewarded for their participation in wiki-based assignments if they are not mandatory (Ebner et al., 2008). Therefore, students seem to be opportunistic, and they will decide to adopt wikis in formal learning processes only if they fit their current situation and preferences. Students choose an approach to learning by interpreting the “teaching context in the light of their own preconceptions and motivations” (Biggs, 1989, p. 12). Although the DTPB already takes individual preconceptions (e.g. perceived usefulness) and context (e.g. facilitating conditions) into account, motivations to adopt a particular technology are disregarded. The motivation to use a particular technology depends on their application; e.g. a student’s motivation when using wikis for a graded assignment is probably different from his motivation when commenting on a lecture via a social network service.

Taking this situation into account, we integrated anticipated rewards (Bock et al., 2005) and perceived enjoyment (Hsu & Lin, 2008) as new constructs that explain students’ extrinsic and intrinsic motivation. Extrinsic motivation refers to something that is done because it results in a nameable outcome, whereas intrinsic motivation refers to something that is done because it is “inherently interesting or enjoyable” (Ryan & Deci, 2000, p. 55).

Anticipated rewards

Different studies have shown that students do not use wikis unless it is mandatory or if they are rewarded for their work (Cole, 2009; Ebner et al., 2008). Hence, we argue that *anticipated extrinsic rewards* (AR) like graded assignments cause a higher degree of perceived usefulness of wikis (Witney & Smallbone, 2011). Anticipated rewards are defined as the “degree to which one believes that one will receive extrinsic incentives” (Bock et al., 2005, p. 107) for using wikis within formal learning processes. Therefore, anticipated rewards reflect the reward-based superior influence on students’ intentions.

Hypothesis 2: Anticipated rewards will positively influence perceived usefulness.

Perceived enjoyment

The variety of motives to contribute to Wikipedia shows (Nov, 2007) that people do not only participate if they are rewarded. Therefore, there are students who are intrinsically motivated to use wikis. In formal learning processes, these students enjoy using wikis because every participant can read their contributions. This gave

them the feeling of “teaching other users and sharing knowledge” (Ravid, Kalman & Rafaeli, 2008, p. 1920). These students “enjoy the process and do not perceive it as being effortful compared to those who have less intrinsic motivation” (Venkatesh, Speier & Morris, 2002, p. 301). Due to its facilitating effect, we included *perceived enjoyment* (PT) as an intrinsic motivator construct that positively influences perceived usefulness.

Hypothesis 3: Perceived enjoyment will positively influence perceived usefulness.

Compatibility

Conformant to the DTPB, we included the *compatibility* (COM) of an information system in the theoretical model. Compatibility is generally regarded as the degree to which an information system is congruous with the potential user's existing values, previous experiences, and current needs (Taylor & Todd, 1995). In this study, we used Chen's definition of educational compatibility as the degree to which a wiki “complies with the overall learning expectancy of students, including the current learning situation, the learning style, and the preference of conducting learning activities” (Chen, 2011, p. 1504). Hence, it is expected that an increasing compatibility of the learning style and learning situation with wikis will positively influence the perceived usefulness of wikis in formal learning processes.

Hypothesis 4: Compatibility will positively influence perceived usefulness.

2.2 Perceived behavioural control

Individuals do not have complete control over their behaviour in some circumstances. *Perceived behavioural control* (PBC) reflects the level of control individuals feel they have over their own behaviour. It is an important determinant of intention because individuals' behavioural intention is strongly influenced by their perception of the ability to perform it (Ajzen, 1991; Taylor & Todd, 1995). Regarding students' use of wikis in formal learning processes, perceived behavioural control reflects the students' feeling about their confidence in using wikis and the availability of resources needed to use them.

Hypothesis 5: Perceived behavioural control over wikis will positively influence students' intentions to use wikis.

Facilitating conditions

The first component influencing perceived behavioural control describes the necessary resources to engage in a behaviour (Ajzen, 1991; Taylor & Todd, 1995). These

facilitating conditions (FC) influence the behavioural intentions and the actual use of the technology. In our context, missing resources such as time and technology hinder the use of wikis for formal learning processes.

Hypothesis 6: The availability of facilitating conditions will positively influence perceived behavioural control.

Self-efficacy

Self-efficacy (SE) beliefs can influence individuals' behavioural intentions and therefore their actions. This describes an individual's confidence in the ability to perform a behaviour (Ajzen, 1991; Bandura, 1982). In the context of wikis in formal learning processes, self-efficacy defines the students' perception of their abilities to use a wiki in higher education classrooms.

Hypothesis 7: Self-efficacy will positively influence perceived behavioural control.

2.3 Subjective norm

Subjective norm (SN) is defined as the degree to which an "individual perceives that most people who are important to him think he should or should not use the system" (Venkatesh & Bala, 2008, p. 277). With regard to wikis in formal learning processes, the students' perception of the use of wikis can be influenced by persons important to them. In contrast to the DTPB, we have not distinguished between peer and superior influence because previous studies showed no significant influence of superior influence on students' intentions and perceptions (Sun, Tsai, Finger, Chen & Yeh, 2008; van Raaij & Schepers, 2008).

Hypothesis 8: Subjective norm will positively influence students' intentions to use wikis.

3 Method

To test the model, a survey was conducted to investigate students' intentions to use wikis in higher education classrooms. The survey consisted of a questionnaire developed from material discussed and tested previously (Bock et al., 2005; Chen, 2011; Hsu & Lin, 2008; Kang, Kim & Bock, 2010; Taylor & Todd, 1995; Teo, 2011; Venkatesh & Bala, 2008); see Table 1 for a list of the items. Because this study did not focus on a particular wiki implementation, the students were told to imagine a learning scenario where they collaboratively contribute information to a wiki with

their fellow students. The items were slightly modified to suit the context and translated into German. We gave the German items to a peer for back-translation into English to check whether they result in items similar to the originals. Afterwards, wording and translation changes were included in the questionnaire. Each construct was measured using a five-point Likert scale, ranging from “strongly disagree” to “strongly agree”.

The study was conducted January 2012 among first semester students enrolled in an introductory course in information systems at a large German university. Participation in the survey was completely voluntary. 425 questionnaires were handed out at the beginning of the lecture and were collected afterwards. 245 questionnaires were returned, at least partly filled out. 133 data records remained after discarding incomplete questionnaires. The participants included 76 males (57.1%) and 57 females (42.9%). Most of the participants were between 18 and 23 years of age ($n = 124$; 93.2%), and the remaining students ($n = 9$; 6.8%) were under 29 years of age. The participants were students of economics with a focus on business administration ($n = 89$; 66.9%), business informatics ($n = 20$; 15%), engineering management ($n = 23$; 17.3%), or business economics and education ($n = 1$; 0.8%). The dataset has been published in a persistent public data repository (Kummer, 2013).

The collected data was analysed using the partial least squares (PLS) path modelling to assess scales validity and test the hypotheses. This was done using SmartPLS software (Ringle, Wende & Will, 2005). PLS is a component-based structural equation modelling technique that has minimal demands on measurements scales, sample size, and residual distributions (Chin, 1998). We chose PLS because of its minimal requirements regarding sample size and prediction capability (Gefen & Rigdon, 2011). However, the “10 times rule” is fulfilled, specifying the minimum sample size as “10 times the largest number of predictors for any dependent variable in the model” (Gefen & Rigdon, 2011, p. A4). As the “10 times rule” is only a minimum requirement, we calculated the statistical power according to Cohen using G*Power (Cohen, 1988; Faul, Erdfelder, Buchner & Lang, 2009). The number of cases is sufficient to detect relationships of a medium effect size with a power of 95% ($n = 119$). This statistical power is regarded as sufficient because the hypotheses were previously tested in other contexts. It is therefore likely that small effect sizes were discovered.

4 Results

PLS path models are interpreted in two-steps process, encompassing (1) the assessment of the reliability and the validity of the measurement model, and afterwards, (2) the evaluation of the structural model that explains hypothesized causal paths.

Table 1: Summary of items and factor loadings

<i>Construct</i>	<i>Item</i>		<i>Loading</i>
Anticipated rewards (Bock et al., 2005)	AR1	I will receive a better grade in return for my participation in wikis.	.93
	AR2	I will receive a chance for a better grading in return for my participation in wikis.	.94
Behavioural intention (Venkatesh & Bala, 2008)	BI1	Assuming I had access to wikis, I intend to use them.	.94
	BI2	Given that I had access to wikis, I predict that I would use them.	.97
	BI3	I plan to use wikis in my studies if they are provided.	.97
Compatibility (Chen, 2011)	COM1	Using wikis is compatible with all aspects of my learning.	.90
	COM2	Using wikis is completely compatible with my current learning situation.	.93
	COM3	I think using wikis its well with the way I like to conduct learning activities.	.93
	COM4	Using wikis fits into my learning style.	.89
Facilitating conditions (Teo, 2011)	FC1	When I need help to use wikis, guidance is available to me.	.92
	FC2	When I need help to use wikis, specialized instruction is available to help me.	.89
	FC3	When I need help to use wikis, a specifc person is available to provide assistance.	.91
Perceived behavioural control (Taylor & Todd, 1995)	PBC1	I would be able to use wikis.	.93
	PBC2	Using wikis is entirely within my control.	.91

	PBC3	I have the resources and the knowledge and the ability to make use of wikis.	.94
Perceived enjoyment (Hsu & Lin, 2008)	PT1	While participating in wikis, I experienced pleasure.	.91
	PT2	The process of participating in wikis is enjoyable.	.86
	PT3	I have fun using wikis.	.88
Perceived usefulness (Venkatesh & Bala, 2008)	PU1	Using wikis improves my learning efficiency/performance.	.88
	PU2	Using wikis in increases my productivity.	.89
	PU3	Using wikis enhances my effectiveness.	.93
	PU4	I find the system to be useful in my tasks.	.82
Self-efficacy (Kang et al., 2010)	SE1	I have confidence in my ability to provide knowledge that other students consider valuable.	.92
	SE2	I have the expertise needed to provide valuable knowledge for other students.	.94
	SE3	Most fellow students think that the knowledge I transfer is valuable to them.	.86
Subjective norm (Venkatesh & Bala, 2008)	SN1	People who are important to me think that I should participate in wikis.	.96
	SN2	People who influence my behaviour encourage me to participate in wikis.	.96

4.1 Measurement model

Each construct was measured using reflective indicators. To evaluate the reliability and validity of the measurement model, we assessed the convergent validity and the discriminant validity of the scale items.

Convergent validity was assessed using three criteria: internal consistency, indicator reliability, and average variance extracted (AVE). To ensure internal consistency,

Cronbach's alpha α_C and internal composite reliability ρ_c should be greater than .70 (Chin, 1998); both thresholds were exceeded for all constructs, see Table 2. Table 1 lists the constructs, the related items, and the factor loadings. Indicator reliability can be assumed because each indicator loads high ($> .80$) on the related construct (Chin, 1998). Finally, every AVE exceeded the suggested threshold of .50 (Chin, 1998).

Discriminant validity is achieved if the conceptually different constructs exhibit sufficient difference. Therefore, the factor loading of each indicator is expected to be greater than all of its cross loadings (Chin, 1998), and the AVE of a construct should be higher than the constructs' highest squared correlation with any other construct (Fornell & Larcker, 1981), as shown in Table 2 (refer to Appendix for cross loadings). Both criteria satisfactorily fulfilled the requirements, demonstrating discriminant validity.

The results of the model evaluation demonstrated that satisfactory reliability, convergent validity, and discriminant validity were achieved. Therefore, all scales in this study sufficiently measured the related constructs.

Finally, we addressed concerns regarding common method bias by using a statistical approach suggested by Podsakoff, MacKenzie, Lee and Podsakoff (2003) and by following a method proposed by Liang, Saraf, Hu and Xue (2007). The average of indicator variance caused by substantive constructs (0.85) was substantially greater than the method-based variance (0.01). Additionally, most of the method factor loadings were insignificant. Common method bias is thus not a serious concern of this study.

4.2 Structural model

The hypotheses were tested with SmartPLS (Ringle et al., 2005). We used the bootstrapping method to determine the significance of the paths among the constructs. As recommended, we used the number of valid observations ($n = 133$) as the number of bootstrap cases, 5,000 bootstrap samples, and selected the individual sign changes option (Hair, Sarstedt, Ringle & Mena, 2011). Therefore, we derived significance for item loadings and path coefficients β by using the t-statistic.

Table 2: Descriptive statistics, correlation of constructs, composite reliability ρ_c , Cronbach's alpha α_C , and AVE values

	M	SD	ρ_c	α_C	Inter-construct correlations									
					AR	BI	COM	FC	PBC	PT	PU	SE	SN	
AR	2.46	1.16	.93	.85	.87 (.93)									
BI	3.36	1.18	.97	.96	.22	.92 (.96)								
COM	3.17	1.04	.95	.93	.37	.72	.83 (.91)							
FC	2.77	1.04	.94	.90	.45	.43	.56	.83 (.91)						
PBC	3.47	1.15	.95	.92	.27	.67	.74	.41	.86 (.93)					
PT	2.55	1.04	.92	.86	.37	.36	.51	.53	.41	.78 (.89)				
PU	3.14	1.00	.93	.90	.52	.70	.80	.59	.68	.66	.78 (.88)			
SE	2.68	1.06	.93	.89	.50	.39	.47	.49	.52	.57	.56	.82 (.91)		
SN	2.40	1.15	.96	.91	.46	.29	.48	.50	.34	.53	.51	.44	.92 (.96)	

Note: Diagonal elements are the average variance extracted (AVE) and in parenthesis the square root of the AVE.

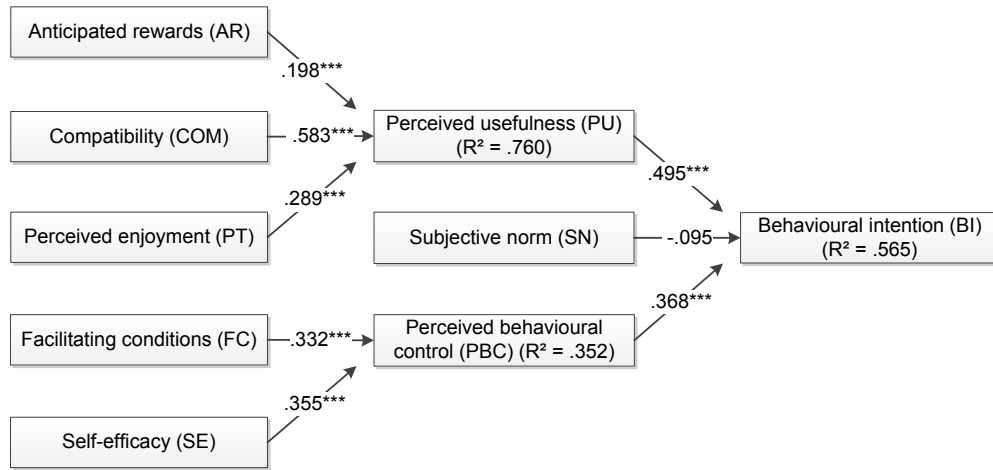


Figure 2: PLS path analysis model (***) $p < .001$

The R^2 values of the endogenous constructs indicate the percentage of variance explained by the model and therefore give information about the explanatory power of the structural model. According to the thresholds denoted by Chin (1998), the R^2 of behavioural intention ($R^2 = .565$) and perceived behavioural control ($R^2 = .352$) is moderate, though perceived usefulness ($R^2 = .760$) had a substantial level (Chin, 1998). All structural paths were found to be significant except one. The R^2 values of the endogenous variables and the significance of the modelled paths are depicted in Figure 2. Additionally, we calculated the effect size f^2 , which can be explored to see the impact of an exogenous variable on an endogenous variable. The impact at the structural model can be considered a small ($f^2 = .02$), medium ($f^2 = .15$), or large ($f^2 = .35$) effect (Chin, 1998); for effect sizes of the paths see Table 3. The predictive capabilities of the proposed model were tested using cross-validated redundancy measure Q^2 . Each Q^2 value was greater than zero; therefore, the model can be seen to have predictive relevance (Chin, 1998).

As expected, perceived usefulness had a significant and positive influence on the behavioural intention to use a wiki in formal learning processes. The effect size on the intention was medium ($f^2 = .202$). Therefore, hypothesis H_1 ($\beta = .495$; $p < .001$) was supported. The proposed positive influence of anticipated rewards on perceived usefulness (H_2 , $\beta = .198$; $p < .001$) was significant, the effect was on a good small level ($f^2 = .114$), and therefore the hypothesis was supported. The proposed positive influence of perceived enjoyment on perceived usefulness (H_3 , $\beta = .289$; $p < .001$) was significant and had a medium effect ($f^2 = .195$). Thus, hypothesis H_3 was supported. The positive influence of compatibility on perceived usefulness (H_4 , $\beta = .583$; $p < .001$) was supported significantly. Hence, a high compatibility with the

Table 3: Path coefficient β , t-statistic and effect size f^2

Hypotheses		β	t-statistic	f^2
H ₁	PU→BI	.495***	5.586	.202
H ₂	AR→PU	.198***	3.393	.114
H ₃	PT→PU	.289***	5.006	.195
H ₄	COM→PU	.583***	10.405	.497
H ₅	PBC→BI	.368***	4.072	.166
H ₆	FC→PBC	.332***	4.162	.114
H ₇	SE→PBC	.355***	4.223	.128
H ₈	SN→BI	- .095	1.606	

Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

students' learning situation increases the perceived usefulness. The effect size had a large effect ($f^2 = .497$) as well as the highest influence on perceived usefulness.

Consistent with the DTPB, hypotheses H₅, H₆, and H₇ were supported. The influence of perceived behavioural control on behavioural intention is positive, significant (H₅, $\beta = .368$; $p < .001$), and had a medium effect ($f^2 = .166$) on behavioural intention. The hypothesised positive influence of facilitating conditions on perceived behavioural control was significant (H₆, $\beta = .332$; $p < .001$). However, the effect size was only small ($f^2 = .114$). Finally, the proposed positive influence of self-efficacy on perceived behavioural control was also significant (H₇, $\beta = .355$; $p < .001$), but has only a small effect ($f^2 = .128$). Unexpectedly, subjective norm had no significant influence on behavioural intention. Hence, hypothesis H₈ was not supported.

To ensure that no significant paths have been left out of the model, we compared it to the saturated model. A saturated model connects all exogenous variables with the endogenous variable, whereas the theoretical model only includes the hypothesised paths. Both models were compared with each other in order to verify "(1) that the significant paths in the theoretical model also remain significant in the saturated model, and (2) that adding the paths via the saturated model does not significantly increase the f^2 " (Gefen & Rigdon, 2011, p. viii). We compared the adjusted R^2 of the proposed theoretical model (adjusted $R^2 = .555$) with the saturated one (adjusted $R^2 = .606$). All relationships stayed significant, and the effect size of the additional paths was small ($f^2 = .129$). Therefore, it is unlikely that any significant path has been left out in the theoretical model.

5 Discussion

5.1 Overall results

In this study, we adapted the DTPB to explore the factors that influence students' decision to adopt wikis within formal learning processes in higher education. Consistent with previous research, perceived usefulness (e.g. Davis et al., 1989) and perceived behavioural control (e.g. Taylor & Todd, 1995) had significant influence on behavioural intention. In conjunction with subjective norm, perceived usefulness and perceived behavioural control explain 56% of the variance of behavioural intention. In contrast to previous studies (e.g. Venkatesh & Bala, 2008), subjective norm had no significant influence on behavioural intention. This finding is counterintuitive as students are spending a lot of time together while studying. Accordingly, it seems reasonable to expect them to influence each other's attitude towards technology for learning. However, the argument may not be relevant for first semester students, as there may not have formed personal relationships and learning habits yet. The lack of mutual influence could explain why subjective norm had no influence on students' behavioural intention. Accordingly, instructors' influence on first semesters should also be limited.

By integrating anticipated rewards and perceived enjoyment as constructs that represent intrinsic and extrinsic motivation, the proposed model considers the specific situation in higher education classrooms. The results show that both constructs were antecedents of perceived usefulness. In conjunction with compatibility, anticipated rewards and perceived enjoyment explain 76% of the variance of perceived usefulness. As hypothesised, anticipated rewards and perceived enjoyment had a positive influence on perceived usefulness. Therefore, students perceive wiki assignments as more useful if they are rewarded (e.g. with grades) or if they enjoy working with wikis. Compatibility had a large and significant effect on perceived usefulness. This is consistent with findings by Chen (2011), who shows that educational compatibility is more important than the perceptions regarding technology usage. Therefore, the larger the compatibility with the learning situation, the larger is the perceived usefulness.

Consistent with the DTPB (Taylor & Todd, 1995), facilitating conditions and self-efficacy both had a small, significant influence on perceived behavioural control.

5.2 Practical implications

The underlying question of this study is what can we do as instructors to explain our students' lack of motivation? What can we do to engage our students and encourage them to use wikis? In the following, we outline some implications of the results.

Anticipated rewards, perceived enjoyment, and compatibility were strong determinants of perceived usefulness. The large influence of compatibility calls attention to students' learning preferences and learning style. Instructors have to think carefully about how wikis can support students' learning styles rather than changing them. While someone's learning style does not change in a short time, instructors can accommodate students with a course assignment that fits their learning situation. Students use wikis if they fit their goals, whether they are intrinsically or extrinsically motivated. But in either case, a wiki assignment must fit the learning situation of the student. Therefore, wikis should be an integral part of the course assignment rather than just an additional duty. Thereby, it is more likely that students will engage with a wiki if the course assignment necessitates it. As a consequence, instructors should ask themselves if a wiki is beneficial for a certain task assignment – and opt for an alternative if the task does not benefit from using a wiki.

While instructors cannot change their students' learning style, they can abet wiki adoption by targeting students' motivation. One precondition for the students to use wikis in class is that wiki assignments are integrated into the course in a reasonable and rewarding way. Otherwise, students will abstain from using the wiki (Cole, 2009; Ebner et al., 2008). Through mandatory and assessed wiki work, extrinsic rewards can be set easily. Alternatively, instructors can try to motivate students by conferring certificates after taking part in a wiki-based course, instead of forcing them into wiki use by rewarding them with a grade (Bonk, Lee, Kim & Lin, 2009).

Ideally, students are motivated extrinsically and intrinsically. Perceived enjoyment refers to one's intrinsic motivation. As perceived enjoyment had a significant influence on perceived usefulness, students seem to like the idea of working together within a wiki. This is consistent with previous qualitative research about the use of wikis in higher education. Students like the feeling of teaching others and sharing their knowledge (Ravid et al., 2008). And although intrinsic motivation cannot be built by instructors, they can design task assignments that stimulate intrinsic motivation. For example, working for a greater audience can motivate students: like writing a textbook together that will be published as an open educational resource.

Independent of students' source of motivation, instructors should consider students' learning preferences and learning styles by seamlessly integrating wikis into the course. Thereby, instructors would not only lower barriers of adoption and invite

students' participation and engagement in the wiki, but would also provide facilitating conditions. As facilitating conditions and self-efficacy had a significant influence on perceived behavioural control, accompanying wiki training and continuous support to lower technology barriers is recommended.

5.3 Limitations and further research directions

From a research perspective, the study results indicate the suitability of the proposed model to explain the influences on the use of wikis in formal learning processes within higher education by students. However, this study has some limitations.

First, we did not have the opportunity to collect data from a random sample of students. A convenience sample was used to test the model (first semester students in an introductory course in information systems). In order to generalize the findings, this study should be replicated with students from different study courses and semesters.

Second, the explanatory power of this model regarding the influence of subjective norm on behavioural intention has to be further examined. Although subjective norm has been proven as a reliable influence in various acceptance models (Taylor & Todd, 1995; Venkatesh & Bala, 2008), this was not the case in this study. Perhaps this is due to the fact that the subjective norm was measured with only two reflective indicators and without distinguishing between different influence groups (e.g. peer influence, superior influence). An alternative explanation is that peers do have little influence on students' intentions and superior influence was substituted by anticipated rewards. Therefore, more qualitative and quantitative research is necessary to explore further social influences on technology adoption in the context of higher education.

Third, we refrained from including wiki characteristics in the model, but provided contextual information as a preamble to the questionnaire. While some will see this as a limitation, it facilitates the comparison of different educational technologies by shifting technology-specific characteristics into the background and focusing on the adoption of a form of technology in a particular setting. Further research should therefore investigate whether the proposed model yields different results with other Web 2.0 applications (e.g. social networking services, weblogs).

6 Conclusion

The results of this study provide a foundation for future research about factors that influence student use of wikis in higher education. We show that intrinsic and

extrinsic motivation plays an important role in students' decision to participate and engage in wiki assignments. Based on these findings, researchers should examine methods to foster support for student use of wikis, as well as for other Web 2.0 applications. This would enable instructors to better address students' needs and preferences.

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References

- Agarwal, R. & Prasad, J. (1997). The role of innovation characteristics and perceived voluntariness in the acceptance of information technologies. *Decision Sciences*, 28(3), 557–582. doi:10.1111/j.1540-5915.1997.tb01322.x
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. doi:10.1016/0749-5978(91)90020-T
- Bagozzi, R. P. (1992). The self-regulation of attitudes, intentions, and behavior. *Social Psychology Quarterly*, 55(2), 178. doi:10.2307/2786945
- Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, 37(2), 122–147. doi:10.1037/0003-066X.37.2.122
- Biggs, J. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research & Development*, 8(1), 7–25. doi:10.1080/0729436890080102
- Bock, G.-W., Zmud, R. W., Kim, Y.-G. & Lee, J.-N. (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly*, 29(1), 87–111.
- Bonk, C. J., Lee, M. M., Kim, N. & Lin, M.-F. G. (2009). The tensions of transformation in three cross-institutional wikibook projects. *Internet and Higher Education*, 12(3-4), 126–135. doi:10.1016/j.iheduc.2009.04.002
- Chen, J.-L. (2011). The effects of education compatibility and technological expectancy on e-learning acceptance. *Computers & Education*, 57(2), 1501–1511. doi:10.1016/j.compedu.2011.02.009

- Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research* (Chap. 10, pp. 295–336). Mahwah, NJ: Lawrence Erlbaum.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale: Lawrence Erlbaum.
- Cole, M. (2009). Using wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141–146. doi:10.1016/j.compedu.2008.07.003
- Davis, F. D., Bagozzi, R. P. & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, 35(8), 982–1003. doi:10.1287/mnsc.35.8.982
- Downes, S. (2005). E-Learning 2.0. *eLearn magazine*. Retrieved from <http://elearnmag.acm.org/featured.cfm?aid=1104968>
- Ebner, M., Kickmeier-Rust, M. & Holzinger, A. (2008). Utilizing wiki-systems in higher education classes: A chance for universal access? *Universal Access in the Information Society*, 7(4), 199–207. doi:10.1007/s10209-008-0115-2
- Faul, F., Erdfelder, E., Buchner, A. & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149–60. doi:10.3758/BRM.41.4.1149
- Fornell, C. & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research*, 18(3), 382–388. doi:10.2307/3150980
- Gefen, D. & Rigdon, E. E. (2011). An update and extension to SEM guidelines for administrative and social science research. *MIS Quarterly*, 35(2), iii–xiv.
- Guo, Z. & Stevens, K. J. (2011). Factors influencing perceived usefulness of wikis for group collaborative learning by first year students. *Australasian Journal of Educational Technology*, 27(2), 221–242.
- Guzdial, M., Rick, J. & Kehoe, C. (2001). Beyond adoption to invention: Teacher-created collaborative activities in higher education. *Journal of the Learning Sciences*, 10(3), 265–279. doi:10.1207/S15327809JLS1003_2
- Hair, J. F., Sarstedt, M., Ringle, C. M. & Mena, J. A. (2011). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*. doi:10.1007/s11747-011-0261-6
- Hartshorne, R. & Ajjan, H. (2009). Examining student decisions to adopt Web 2.0 technologies: Theory and empirical tests. *Journal of Computing in Higher Education*, 21(3), 183–198. doi:10.1007/s12528-009-9023-6
- Hsu, C.-L. & Lin, J. C.-C. (2008). Acceptance of blog usage: The roles of technology acceptance, social influence and knowledge sharing motivation. *Information & Management*, 45(1), 65–74. doi:10.1016/j.im.2007.11.001

- Kang, M., Kim, Y.-G. & Bock, G.-W. (2010). Identifying different antecedents for closed vs open knowledge transfer. *Journal of Information Science*, 36(5), 585–602. doi:10.1177/0165551510375667
- Kessler, G. (2009). Student-initiated attention to form in wiki-based collaborative writing. *Language Learning & Technology*, 13(1), 79–95.
- Kummer, C. (2013). Students' intentions to use wikis in higher education (ZA5683 data file, version 1.0.0) [Data file and questionnaire]. Köln: GESIS Data Archive. doi:10.4232/1.11514
- Leuf, B. & Cunningham, W. (2001). *The Wiki Way: Quick collaboration on the web*. Upper Saddle River, NJ: Addison-Wesley.
- Liang, H., Saraf, N., Hu, Q. & Xue, Y. (2007). Assimilation of enterprise systems: The effect of institutional pressures and the mediating role of top management. *MIS Quarterly*, 31(1), 59–87.
- Liu, X. (2010). Empirical testing of a theoretical extension of the technology acceptance model: An exploratory study of educational Wikis. *Communication Education*, 59(1), 52–69. doi:10.1080/03634520903431745
- Neumann, D. L. & Hood, M. (2009). The effects of using a wiki on student engagement and learning of report writing skills in a university statistics course. *Australasian Journal of Educational Technology*, 25(3), 382–398.
- Nov, O. (2007). What motivates Wikipedians? *Communications of the ACM*, 50(11), 60–64. doi:10.1145/1297797.1297798
- Pence, H. E. (2007). Preparing for the real web generation. *Journal of Educational Technology Systems*, 35(3), 347–356.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y. & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879–903. doi:10.1037/0021-9010.88.5.879
- Ravid, G., Kalman, Y. M. & Rafaeli, S. (2008). Wikibooks in higher education: Empowerment through online distributed collaboration. *Computers in Human Behavior*, 24(5), 1913–1928. doi:10.1016/j.chb.2008.02.010
- Ringle, C. M., Wende, S. & Will, A. (2005). SmartPLS (Version 2.0 beta) [Computer software]. Hamburg. Retrieved from <http://www.smartpls.de>
- Ryan, R. M. & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54–67. doi:10.1006/ceps.1999.1020
- Sun, P.-C., Tsai, R. J., Finger, G., Chen, Y.-Y. & Yeh, D. (2008). What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education*, 50(4), 1183–1202. doi:10.1016/j.compedu.2006.11.007

- Taylor, S. & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research*, 6(2), 144–176. doi:10.1287/isre.6.2.144
- Teo, T. (2009). Is there an attitude problem? Reconsidering the role of attitude in the TAM. *British Journal of Educational Technology*, 40(6), 1139–1141. doi:10.1111/j.1467-8535.2008.00913.x
- Teo, T. (2011). Modeling the determinants of pre-service teachers' perceived usefulness of e-learning. *Campus-Wide Information Systems*, 28(2), 124–140. doi:10.1108/10650741111117824
- van Raaij, E. M. & Schepers, J. J. (2008). The acceptance and use of a virtual learning environment in China. *Computers & Education*, 50(3), 838–852. doi:10.1016/j.compedu.2006.09.001
- Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating perceived behavioral control, computer anxiety and enjoyment into the technology acceptance model. *Information Systems Research*, 11(4), 342–365. doi:10.1287/isre.11.4.342.11872
- Venkatesh, V. & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, 39(2), 273–315. doi:10.1111/j.1540-5915.2008.00192.x
- Venkatesh, V., Morris, M., Davis, G. & Davis, F. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478.
- Venkatesh, V., Speier, C. & Morris, M. G. (2002). User acceptance enablers in individual decision making about technology: Toward an integrated model. *Decision Sciences*, 33(2), 297–316. doi:10.1111/j.1540-5915.2002.tb01646.x
- Wheeler, S., Yeomans, P. & Wheeler, D. (2008). The good, the bad and the wiki: Evaluating student-generated content for collaborative learning. *British Journal of Educational Technology*, 39(6), 987–995. doi:10.1111/j.1467-8535.2007.00799.x
- Wilhelm, D. B., Strahringer, S. & Smolnik, S. (2012). Die Nutzungsintention als Prädiktor der realen Systemnutzung: eine quantitative Analyse. In D. C. Mattfeld & S. Robra-Bissantz (Eds.), *Multikonferenz Wirtschaftsinformatik 2012* (pp. 825–836). Berlin: Gito.
- Witney, D. & Smallbone, T. (2011). Wiki work: Can using wikis enhance student collaboration for group assignment tasks? *Innovations in Education and Teaching International*, 48(1), 101–110. doi:10.1080/14703297.2010.543765

Appendix

Table A1: Factor and cross loadings

	<i>AR</i>	<i>BI</i>	<i>COM</i>	<i>FC</i>	<i>PBC</i>	<i>PT</i>	<i>PU</i>	<i>SE</i>	<i>SN</i>
<i>AR1</i>	.93	.21	.35	.39	.24	.41	.47	.57	.42
<i>AR2</i>	.94	.20	.35	.44	.26	.27	.50	.38	.45
<i>BI1</i>	.20	.94	.67	.42	.63	.30	.62	.33	.29
<i>BI2</i>	.21	.97	.72	.40	.66	.37	.69	.40	.26
<i>BI3</i>	.22	.97	.69	.41	.65	.36	.69	.38	.28
<i>COM1</i>	.34	.63	.90	.5	.70	.38	.69	.37	.40
<i>COM2</i>	.31	.66	.93	.54	.67	.47	.72	.44	.40
<i>COM3</i>	.39	.68	.93	.53	.70	.50	.76	.46	.48
<i>COM4</i>	.33	.65	.89	.49	.63	.48	.75	.44	.45
<i>FC1</i>	.42	.44	.51	.92	.49	.46	.54	.45	.38
<i>FC2</i>	.41	.33	.47	.89	.39	.47	.50	.43	.49
<i>FC3</i>	.39	.40	.55	.91	.49	.52	.56	.46	.50
<i>PBC1</i>	.23	.66	.70	.51	.93	.34	.64	.44	.24
<i>PBC2</i>	.29	.57	.69	.44	.91	.41	.60	.49	.41
<i>PBC3</i>	.23	.64	.67	.45	.94	.38	.65	.51	.31
<i>PT1</i>	.36	.28	.40	.45	.36	.91	.56	.54	.43
<i>PT2</i>	.29	.27	.41	.47	.29	.86	.54	.51	.43
<i>PT3</i>	.33	.40	.52	.49	.42	.88	.64	.47	.53
<i>PU1</i>	.44	.61	.76	.56	.60	.59	.88	.48	.50
<i>PU2</i>	.51	.54	.67	.45	.53	.60	.89	.50	.48
<i>PU3</i>	.53	.60	.71	.51	.57	.63	.93	.56	.50
<i>PU4</i>	.36	.70	.69	.55	.69	.48	.82	.43	.32
<i>SE1</i>	.40	.36	.43	.42	.48	.49	.53	.92	.36
<i>SE2</i>	.47	.38	.44	.43	.52	.55	.54	.94	.39
<i>SE3</i>	.52	.30	.41	.50	.40	.51	.45	.86	.45
<i>SN1</i>	.48	.28	.47	.49	.37	.57	.53	.49	.96
<i>SN2</i>	.41	.27	.44	.47	.29	.44	.46	.35	.96

Facilitating collaboration in wikis

Christian Kummer

Abstract. Wikis are widely used in higher education, because they are said to stimulate collaborative writing and learning. But using a collaborative tool does not necessarily result in collaboration. Although wikis are not a new phenomenon, educators are still struggling to facilitate collaboration within wikis. This article reports from an action research project that examined the influence of task assignment and grading on collaboration. For this purpose, the task assignment and grading of a Master programme module were altered within three iterations. Collaboration was evaluated using social network analysis and content analysis. As a result, a learning arrangement is presented that facilitates collaborative learning and introduces an approach to the assessment of collaboration that takes group achievement into account but does not invite social loafing.

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1 Introduction

For many years universities have communicated generic graduate attributes their students have acquired after studying. Graduate attributes are skills and competencies that are relevant for both employability and other aspects of life (Barrie, 2004). Over the past years and due to the Bologna Process, the focus on graduate outcomes has found its way into universities curricula. As a consequence, curricula were adapted in order to convey students both in-depth knowledge of a particular area as well as generic competences (Bologna Working Group on Qualifications Framework, 2005, Appendix 8). For example, students with a Master's degree should be able to "communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously" (p. 196). This shift has been supported by the demand of the labour market for students that have achieved social and personal competencies, in addition to in-depth knowledge (Heidenreich, 2011).

In 2009 the curricula at my faculty were restructured to meet the requirements formulated by the framework for qualifications of The European Higher Education Area (Bologna Working Group on Qualifications Framework, 2005). I was involved in the planning of a Master's programme module. Part of this module is a project-based course, in which I wanted to engage students in collaboration, as collaborative learning is well-suited to promote critical thinking and communication skills (Johnson & Johnson, 1994b; Laal & Ghodsi, 2012). In order to prepare my students for the labour market, I simulated a collaboration situation based on a report that documents a best practice (Bukvova & Kalb, 2010).

In this article, I introduce how I developed a learning arrangement within a four-year-long action research project that ran through three iterations. I report how I established a learning arrangement that facilitates collaboration and how I evaluated my efforts to assess collaborative learning. The result of my research is a ready-to-use learning arrangement that facilitates collaborative learning.

In the following section, I describe how I focused my research to suit my situation, before I introduce my research method. Afterwards, I detail every project iteration and report from the development of the learning arrangement. After discussing themes that emerged through iterations, I provide a description of the learning arrangement and point to limitations of this research. Finally, I conclude with an outlook on further research.

2 Context and focus

I am a researcher and lecturer in the field of economics at a German university. As part of the Bologna Process, Bachelor and Master degrees were introduced at my university in 2009. Curricula had to be restructured in order to be comparable and compatible with the framework of qualifications of the European Higher Education Area. The qualification framework describes generic learning outcomes and competences for each qualification cycle (e.g. Bachelor, Master, Doctorate) (Bologna Working Group on Qualifications Framework, 2005, Appendix 8). At this point, my faculty realigned existing courses to focus more on competences than before.

I was involved in the planning of a Master programme module on knowledge management that consists of three parts: a lecture, an exercise course, and a project work. Lecture and exercise course are assessed together in an oral exam, the project work is graded separately. The lecture comprises of case study work in groups accompanied by an electronic lecture, the course work focuses on the application of knowledge. After the first half of the semester, the lecture course finishes and groups are remixed for project work using jigsaw puzzle. A detailed description of the module design has been published in Bukvova, Meyer and Schoop (2010; for jigsaw puzzle refer to Aronson, 1978; Pozzi, 2010).

Complementary to lecture and course work, the project work should allow students to collaboratively construct new knowledge and solve complex problems in order to facilitate the constitution of graduate skills. I wanted to incorporate collaborative learning into project work, because "collaborative learning holds the promise of active construction of knowledge, enhanced problem articulation, and benefits exploring and sharing information and knowledge gained from peer-to-peer communication" (Haythornthwaite, 2006, p. 10). The benefits of collaborative learning have been well documented (Johnson, Johnson & Stanne, 2000; Laal & Ghodsi, 2012; Slavin, 1996): among others, "perspective-taking, interpersonal attraction, social support, friendships, reduction of stereotypes and prejudice, valuing differences, psychological health, self-esteem, social competencies" (Johnson et al., 2000, p. 3). Therefore, collaborative learning is well suited to convey the competences demanded by the labour market (Heidenreich, 2011) and the framework of qualifications of the European Higher Education Area (Bologna Working Group on Qualifications Framework, 2005).

But the term collaboration defies clear definition (Dillenbourg, 1999; Haythornthwaite, 2006). In this article, collaboration is seen as a synchronous and coordinated effort to create one final product. In contrast, cooperation "refers to a more fixed division of labour generally made explicit at the outset" (Dillenbourg, 1999, p. 8). As

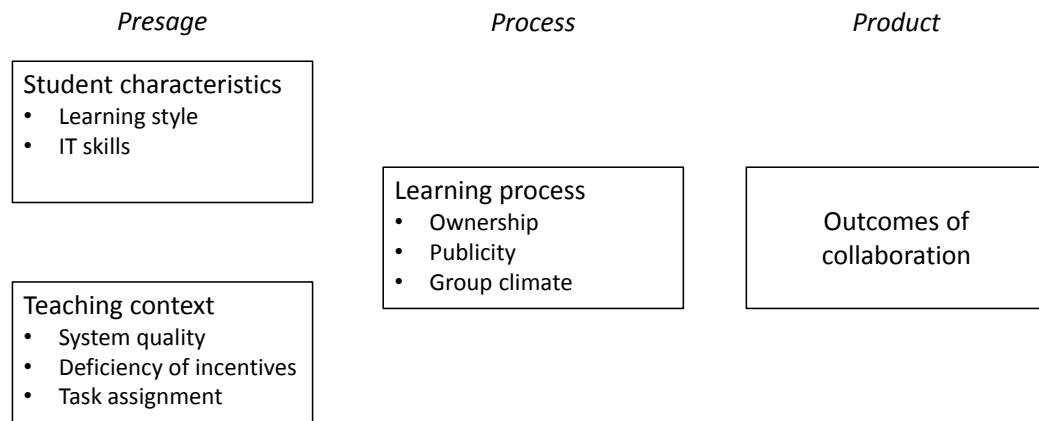
I particularly wanted to promote social skills, I focused on collaborative learning as it necessitates continuous synchronisation, negotiation, and interaction (Dillenbourg, 1999, p. 8). Thus, to reach project work's goals, that is, convey competences, collaboration is better suited than cooperation.

To facilitate collaboration and shared knowledge construction, I wanted to integrate a wiki assignment into the project work, because wikis are said to be “intensely collaborative” (Godwin-Jones, 2003). Although wikis have been widely used in higher education to support collaborative learning (e.g. Carr, Morrison, Cox & Deacon, 2007; Cress & Kimmerle, 2008; Davies, Pantzopoulos & Gray, 2011; Elgort, Smith & Toland, 2008; Laru, Näykki & Järvelä, 2011; Wheeler, Yeomans & Wheeler, 2008), lecturers are still struggling to facilitate collaboration within wikis (Choy & Ng, 2007; Cole, 2009; Ebner, Kickmeier-Rust & Holzinger, 2008). This can be explained partially by two reasons: the little consensus on *how to facilitate collaborative learning* within wikis (Allwardt, 2011; Cubric, 2007; Elgort et al., 2008; Ramanau & Geng, 2009) and the problem on *how to assess collaborative learning* in general (Strijbos, 2011) and for wikis in particular (Naismith, Lee & Pilkington, 2011; Miyazoe & Anderson, 2010).

Because I consider wikis to have great potential to facilitate collaborative learning, I started to investigate how wikis can be successfully integrated into classroom to facilitate collaboration. As I struggled to engage students in wiki collaboration in previous courses, I drew on a literature review that identified factors influencing collaboration in wikis (Kummer, 2013). The factors are categorised in *student characteristics*, *teaching context*, and *learning process* using Biggs' (1989) *3P model* (see Figure 1). Every factor of the category *teaching context* can be controlled by the lecturer, but the other categories contain factors that are not in lecturer's control and can therefore be influenced at best (e.g. by giving training courses to improve students IT skills). Therefore, I concentrated on category teaching context, which consists of three factors that can be modified to facilitate collaboration: system quality, deficiency of incentives, and task assignment.

System quality refers to problems that arise when wiki systems are not usable, not accessible, or slow in their reaction on user input (Kummer, 2013). I have not focused on system quality, as I was not limited to use a particular wiki system. Therefore, in case of any problems that arise from poor system quality, the wiki system can be replaced with another one that fits the needs.

Deficiency of incentives. One precondition for collaboration within wikis is that they are integrated into courses in a meaningful way and provide students with intrinsic (e.g. community-feeling) and extrinsic (e.g. mandatory and assessed assignments) incentives (Kummer, 2013). Otherwise, students will opt to not use wikis (Ebner



Source: Adapted from Kummer (2013)

Figure 1: Factors influencing wiki collaboration

et al., 2008; Judd, Kennedy & Cropper, 2010). In my case, this was not the problem as the project work on knowledge management had to be graded. More interesting is the connection between grading and task assignment.

A precondition for collaboration are *task assignments* that necessitate collaboration (Kummer, 2013). But at the same time, the assessment of collaboration must assure individual accountability (Slavin, 1980). As a consequence, each student should receive an individual grade. In contrast, group grades should never be used (Kagan, 1995), because they violate individual accountability and therefore invite limited individual efforts like social loafing (Latané, Williams & Harkins, 1979) and free-riding (Kerr & Bruun, 1983). Although these problems are evident, there is no generic set of acknowledged indicators that can be used to assess collaborative learning (Strijbos, 2011). Strijbos (2011) infers from previous findings that the assessment of (computer-supported) collaborative learning faces three challenges: (1) the level of assessment, that is, should collaborative learning be assessed using individual grades or group grades, (2) the operationalisation of cognitive outcomes, and (3) the focus of assessment, that is, should assessment of collaborative learning solely focus on cognitive outcomes?

I wanted to contribute to the solution of these problems by exploring a new approach to the assessment of collaborative learning within the project work. I had two aims: first, I wanted the students to collaborate with each other. Second, I wanted to ensure individual accountability *and* consider collaboration by taking group achievement into account. By doing so, I suggested an approach that contributes to the solution of the challenges, which the assessment of collaborative learning is facing.

Based on Johnson and Johnson (1994b) who argue that collaboration takes only place when students perceive individual accountability and feel themselves respons-

ible to achieve group’s goals, my idea was to interweave the task assignment with its grading by assessing it in two steps. Firstly, the quality of the collaborative product (see Section 4 for criteria that have been used to evaluate the quality of the collaborative product), secondly, the quantity of individual contributions measured with a point system. Individual grades were calculated by weighting the group grade with the proportion of the amount of individual contributions to the average amount of contributions (see Equation 1).

$$Grade_{Individual} = Grade_{Group} \cdot \frac{Contribution_{Individual}}{Contribution_{Average}} \quad (1)$$

Thereby, individual accountability was achieved by taking the number of individual contributions into account, whereas personal responsibility was considered by using the group grade as a basis for assessment. As a consequence, participants cannot rely on their own contributions, but must contribute to the group’s goal in order to meet their personal goals (Slavin, 1996; see also Johnson and Johnson, 1994a, who introduced individual grades based on group performance).

Summarised, the ultimate goal of this action research project is to implement the approach outlined above in order to develop a task assignment that facilitates collaboration. Before I introduce how I implemented and improved the task assignment during three iterations, I disclose my research method.

3 Methods

I used action research as the underlying research method and chose the constructivist paradigm by Lincoln and Guba (1985), assuming that reality is constructed in the minds of individuals and bound to the individual. Therefore, objectivity does not exist and truth cannot be achieved, but consensus between what others accept as correct can be reached (Pörksen, 2009).

3.1 Action research

My research project is embedded within the context of reorganisation of the curriculum structure at my faculty. My research project can therefore be positioned as technical action research according to Grundy’s (1982) typology, because it was aimed at making a situation more efficient and effective.¹ Nevertheless, I reflected

¹Because I adjusted and improved my interventions and the learning arrangement iteratively, my research could have been classified as *design-based research*. Anderson and Shattuck (2012) referred to design-based research as “research through mistakes” (p. 17) and outline the similarities to

my own behaviour in facilitating collaboration (*reflection-on-action*; Schön, 1983) and changed it in following iterations when necessary. Hence, this research project had also impact on my development as a teacher.

There is much emphasis on action research as being a cooperative or collaborative activity (e.g. Hult & Lennung, 1980), because individualism would “destroy the critical dynamic of the group” (Kemmis & McTaggart, 1992, p. 15). However, relating action research to Stenhouse’s (1975) notion of a *teacher as researcher*, it can be an individualistic matter as well. In Germany, educational action research in higher education is often carried out by a single person, because most of the university employees do both researching and teaching students. This particularly reflects my research situation. Whitehead (1989) mentioned statements in form of an action-reflection cycle which help teacher-researchers to improve their practice: “I experience problems when my educational values are negated in my practice; I imagine ways of overcoming my problems; I act on a chosen solution; I evaluate the outcomes of my actions; I modify my problems, ideas and actions in the light of my evaluation... (and the cycle continues)” (p. 43). While I already introduced my problem and an idea of overcoming it (see previous section), I will describe in the following how I evaluated my efforts to implement the solution. For the description how I modified my actions during the cycles see Section 4.

3.2 Evaluation

The overall goal of this research project was to implement a task assignment that facilitates collaboration. Dillenbourg (1999, p. 5) describes collaboration as a “situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms, but there is no guarantee that the expected interactions will actually occur.” In my case, the situation is designed by the educational setting, mainly defined by the task assignment, whereas interaction can be characterised by three criteria: *synchronicity*, *interaction*, and *negotiation*. In contrast to hierarchical situations, collaboration is characterised by synchronous work (*synchronicity*) and *negotiation* of procedure, which results in mutual affection of participants’ cognitive processes (*interaction*) (Dillenbourg, 1999). To evaluate collaboration, I concentrated on these three criteria.

action research. Finally, Sein, Henfridsson, Purao, Rossi and Lindgren (2011) introduced a research method called *action design research* that combines both research methods (see also Cole, Purao, Rossi & Sein, 2005). As they introduced very strict principles for their method to differentiate themselves from action research, design research and design-based research, I refrained from using their method. However, the term action design research describes well the orientation of this research.

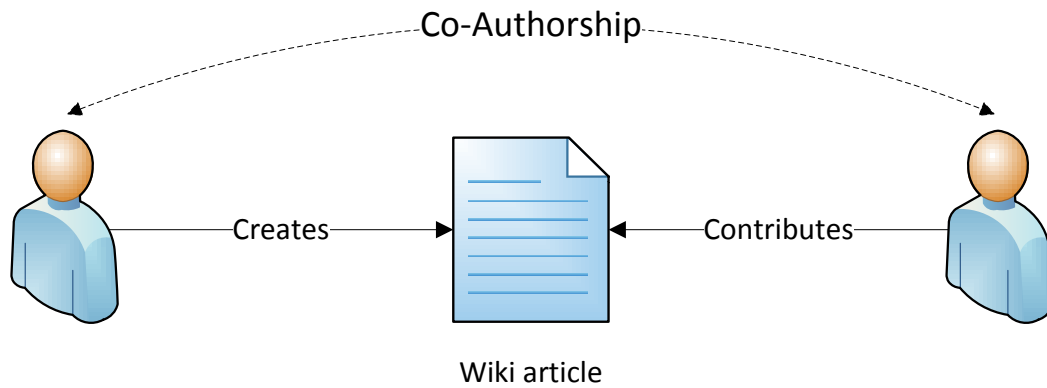


Figure 2: Collaboration as co-authorship between two participants

Previous research had shown that social network analysis in combination with interviews is appropriate to study collaboration (Harrer, Zeini & Pinkwart, 2005; Martínez et al., 2006). Based on this approach, I evaluated *synchronicity* using social network analysis. Although social network indices provide an insight into collaboration, it is only a quantitative one that cannot differentiate between collaboration and cooperation. For this reason, I interviewed participants to further investigate the manner in which they worked with other students within the project work. Furthermore, I invited voluntary and anonymous feedback. Results from the analysis of both interviews and feedback were used to investigate *synchronicity*, *negotiation*, and *interaction*.

Data collection

Data were collected from wiki log data using a script file that pre-processed the data for social network analysis. Participants that authored a wiki article together were treated as co-authors (see Figure 2). Therefore, I hypothesised co-authorship as collaboration. By analysing every article, an indirect co-authorship network (Martínez et al., 2006) emerged from the log files that maps collaboration.

Based on their position within the social network graph and based on actor-based social network indices, I selected participants to achieve a purposeful sample with maximum variation (Coyne, 1997; Sandelowski, 1995). Therefore, each sample contained students with a peripheral, an average and a central position within project work (see Figure 3). As participation in an interview was voluntarily, I asked each of the selected students whether he/she wants to participate in an interview. Everyone I asked agreed to participate. I interviewed seven participants after the second and after the third iteration. The interviews lasted between 20-45 minutes each and were semi-structured (Dicicco-Bloom & Crabtree, 2006).

Additionally, I invited students to send me feedback via e-mail, but also provided them with a link to an online service where they can give feedback anonymously. I received six times feedback (partially anonymous); once for the first, twice for the second, and three times for the third iteration. Furthermore, I surveyed discussion pages, but they were not included into qualitative data analysis. Instead, I used discussion pages to back up my interpretation of the social network indices.

Data analysis

The data retrieved from the wiki were analysed with *Pajek* version 3.10, a software for network analysis and network visualisation. I used *network density* (D) and *network degree centralisation* (C_D) following Martínez et al. (2006) as indicators to assess if collaboration took place.

Mathematically, the density D is the average of the standardised node degrees ($d(n_i)$) with values between $[0, 1]$. The degree represents the number of connections a network node (in this case the student) has with other nodes. Correspondingly, the density is the proportion of possible connections of a network to the connections that are actually present in a network (Wasserman & Faust, 1994). Therefore, a high value of density provides an indication for collaboration among students. Furthermore, I took network degree centralisation C_D into account to investigate the overall activity within the wiki. Centralisation C_D is a group-level index that “records the extent to which a single actor has high centrality, and the others, low centrality. It also can be viewed as a measure of how unequal the individual actor values are. It is (roughly) a measure of variability, dispersion, or spread” (Wasserman & Faust, 1994, p. 176). With values between $[0, 1]$, a high value of centralisation would mean that a low number of students were active, whereas a moderate value indicates that some students acted as a hub. Therefore, a low value of centralisation indicates a balanced collaboration among students (cf. Martínez et al., 2006; Wasserman & Faust, 1994, p. 177).

All interviews were transcribed and analysed with the qualitative data analysis software *MaxQDA* version 10 by applying *constant comparative method* (Glaser & Strauss, 1967). Following the “all is data” paradigm (Glaser, 2001), feedback data were included in the qualitative data analysis. Problems regarding the design of the task assignment were coded *in vivo* and afterwards connected to stable problem sets through iteration. In contrast, a pre-defined code schema was used to evaluate collaboration (refer to Appendix B for a description of the codes). A situation was assessed as collaborative if it was *synchronous* and characterised by an *interactive* communication in which participants affected their cognitive processes mutually by

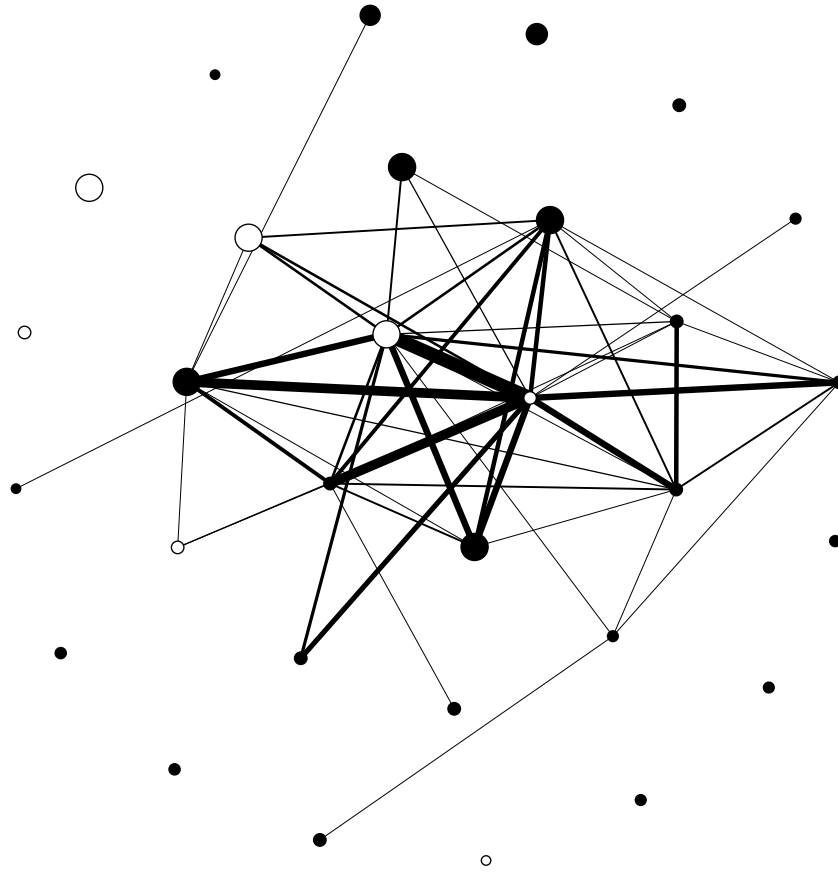


Figure 3: Network visualisation of the selection of interviewees for the 2nd iteration

Note: Size of nodes represents betweenness centrality of an actor $C_B(n_i)$ and therefore indicates the importance of the actor for communication in the project (Wasserman & Faust, 1994, pp. 188-191). White coloured nodes mark interviewees. Only edges with a minimum weight of 10 ($w_{ij} \geq 10$) are depicted. The thickness of edges indicates the strength of co-authorship between participants.

negotiating meaning. The unit of analysis were in both complete arguments that could comprise single sentences or even several paragraphs.

4 Process

In the following, I describe the three iterations of my action research project and disclose how I directed and influenced the project work. After each iteration, I evaluated my goals and planned modifications for the next iteration. I assessed the success of an iteration based on

1. Values of the social network indices (see Table 2),
2. Results from the analysis of the interviews,

3. Observation of collaboration on discussion pages and wiki articles, and
4. Quality of the collaborative outcome.

Values of social network indices and qualitative analysis were used to evaluate collaboration based on three criteria *negotiation*, *synchronicity*, and *interaction* (see Section 3.2 and Appendix B for the codebook). In addition to the results from data analysis, I used my observations to interpret the results. In conclusion, I evaluated the quality of the collaboration based on collaborative outcomes. In my understanding, the quality of the outcomes of collaboration reflects the quality of collaboration between participants (Kreijns, Kirschner & Jochems, 2002). Related to wikis, collaboration is reflected in articles that are without mistakes with regards to content, share a consistent form, and are granular and not redundant to each other. Furthermore, all articles are covered by a consistent conceptualisation of the subject.

4.1 Iteration 1

The first iteration took place during the transition from Diploma to Master degree programmes at my faculty. Accordingly, composition of participating students were different to following iterations. Meaning, the majority of students were enrolled in the Diploma programme. Additionally and in contrast to following iterations, I accompanied the project work as an observer only. For a brief summary of the iterations refer to Table 1.

Table 1: Descriptive data of the project iterations

		Iteration		
		1	2	3
Year		2009	2011	2012
Project duration	total	11 weeks	9 weeks	10 weeks
	self-directed	11 weeks	5 weeks	5 weeks
Participants	students	17	29	38
	teacher	2	1	1
Gender	female	4	18	22
	male	15	12	17
Degree programme	Diploma	12	5	1
	Master	5	24	37

Design

In the first iteration of the project work², I wanted my students to extend an existing knowledge base about knowledge management. The knowledge base was implemented as a wiki within the university's learning management system.³ The wiki was private and only accessible to the participants. Furthermore, I provided a forum that could be used for communication. The existing content had been created by students from former courses and needed improvement with regard to quality and coverage of the topic. The students' task was to collaboratively improve and extend content in order to create a knowledge base that is easy to use, motivating, and informative for people (e.g. students, practitioners) interested in knowledge management. The students were free to add any information to the wiki that contributes to the main objective. Apart from some examples of possible contributions, I abstained from giving initial structure and guidance. Therefore, the students were responsible for the organisation of content creation.

At the beginning of the project, the students were informed that the knowledge base will be assessed as a whole and graded according to quality. Individual grades were calculated by weighting the group grade with the proportion of the amount of individual contributions to the average amount of contributions (see Equation 1). Every student was free to contribute *when*, *what*, *where* and *how much* he wanted. At the same time, almost everything could be a contribution: revisions of existing content, new content, an idea for future improvement of the wiki, etc. Each contribution had to be recorded in a document. This was necessary because wiki and forum provided insufficient capabilities to retrace contributions per student. The protocols were used to check the extent and quality of the contribution as each contribution was rewarded with a point.

Evaluation

In contrast to subsequent iterations, I evaluated whether students collaborated based on my observations and data retrieved from anonymous feedback, discussion forum, and wiki. The network shows a high *network density* ($D = .971$) for the complete network and a distinctive difference when separating articles ($D_A = .965$) from discussion threads ($D_D = .532$) into dedicated networks. Refer to Table 2 for an overview of the network indices across iterations.

²This section contains findings from the first iteration that were previously published as Kalb, Kummer and Schoop (2011).

³The learning management system OPAL (Online Plattform für akademisches Lehren und Lernen) is the central platform for several Saxon universities. It is available at <http://bildungsportal.sachsen.de/opal/dmz/>.

Table 2: Network indices and wiki statistics

	Iteration		
	1	2	3
Network density D	.971	.929	.927
Articles only D_A	.965	.926	.923
Discussion pages only D_D	.532	.211	.281
Network degree centralisation C_D	.033	.076	.077
Articles only C_{DA}	.039	.079	.081
Discussion pages only C_{DD}	.034	.217	.314
Wiki pages (incl. files, categories, etc.)	209	585	628
Articles only	165	201	146
Discussion pages only	44	121	142
Page edits	1,510	5,596	8,212

The high value of density D indicates that students collaborated intensely, especially when compared to densities of other asynchronous learning networks reported in other studies (Aviv, Erlich, Ravid and Geva, 2003, $D \in [.150, .360]$; de Laat, 2002, $D = .570$; de Laat, Lally, Lipponen and Simons, 2007, $D \in [.360, .460]$). Therefore, almost everybody edited at least one article with any other participant. This is supported by a *network degree centralisation* ($C_D = .033$) at a low level, meaning that the amount of work invested is balanced between participants. The moderate value for D_D can be interpreted as a sign for collaboration also, as it means that every participant discussed with every second participant.

Whilst working on this project, students met each other weekly at the accompanying exercise courses. Due to the relatively small number of participants ($n = 17$), students took advantage of their meetings to coordinate their efforts. Finally, one student was coordinating nearly all tasks and acted as a leader within a student-agreed hierarchy. Consequently, they specialised in particular tasks or worked independently on an article. However, the efforts invested by the students are remarkable, resulting in a collaborative product of high quality with regard to form and content. Due to the hierarchical coordination, all wiki articles are perfectly integrated within *one* conceptualisation of the subject area.

Although students worked synchronously, they limited *interaction* to a minimum. From my observation and the analysis of discussion forum, there is little evidence for *negotiation* of meaning as students limited their collaborative efforts e.g. to agree upon a standard template for wiki articles. As a consequence, the good values for C_D and D must be put into perspective. Although they indicate intensive group work, they are of limited suitability to provide evidence for collaboration. As a consequence, researchers cannot rely on good social network indices. However, C_D and D are well-suited to indicate the intensity and balance of group work. Therefore,

I continued to use them in the following iterations to get an impression how intense collaboration was.

Apart from the evaluation of collaboration, some issues with the task assignment needed to be taken into account for the next iteration. First, although students started early to coordinate themselves, most students did not start editing until the first half of the project was over. Students had difficulties to understand their task. They were used to have a quantifiable goal (e.g. a ten-page term paper), but not the complexity to have a goal that is bound to quality. Students could hardly accept that they will not know if they had done enough. Therefore, it needed an additional presentation and discussion to clarify project's objective and questions arisen.

Second, the assessment of the contributions was difficult as the granularity of the protocols differed. To ensure that all students were treated equally, they were standardised by the lecturer. Therefore, from case to case, it was necessary to reward two contributions with just one point, or the other way around.

With regard to my aims, this project was a first step in creating a task assignment that facilitates collaboration. Surprisingly, most students were comfortable with being assessed based on their engagement. But although students coordinated themselves, they seemed to have worked together more than in comparison to traditional paper-based assignments. However, students divided work and refrained from negotiating and interacting with each other. Therefore and apart from the good project outcome, in terms of form and content, this project holds potential for improvements, as students avoided to challenge each others opinion, but simply ran for *a* solution that must not necessarily be the *best* solution. As a consequence, it is unlikely that they benefited from different viewpoints, exhausting discussions, and subsequent light-bulb moments, or summarised, they potentially developed less competencies (e.g. social skills) from collaboration than possible.

However, the idea to interweave task assignment with its grading seems to have facilitated collaboration. Therefore, I followed this approach and identified need for modification.

Need for modification

In the following, I derive changes to the task assignment from the evaluation in order to refine the task assignment to necessitate collaboration.

First, I had not expected students coordinating themselves so rigorously that they did not have to rely on others assistance. The possibility to meet weekly, the small number of participants, and the project duration could have been reasons for the development of a more or less hierarchical structure. To prevent the emergence of

hierarchical coordination, next iterations should complicate consensual coordination and division of labour in order to necessitate negotiation of meaning. This could be facilitated by taking various action (Kalb et al., 2011):

1. Increasing the number of students in order to make the coordination of timetables and decisions difficult.
2. Reducing the project time to circumvent the evolution of a hierarchy.
3. Restricting communication to electronic media by task assignment or locally dispersed participants.
4. Increasing the complexity of the task assignment in order to make it impossible to be subdivided into smaller tasks.

Second, at the beginning, students had difficulties to understand what they were expected to do. Scaffolding tasks could prevent problems and ease collaboration at the beginning, as scaffolds reduce the cognitive load. Increasing the complexity slowly will allow students to adapt to new challenges regarding collaboration easily (Rienties et al., 2012).

Third, the point-based assessment system was insufficient and too simplistic. Students' motivation to deal with larger tasks was limited as smaller tasks were rewarded with the same number of points. Therefore, the point system should differentiate between tasks by rewarding them according to their complexity.

4.2 Iteration 2

At the time of the second iteration, transition from Diploma to Master degree programmes was completed. As an effect, only a few of the participating students were enrolled in the Diploma programme, but the number of Master students has increased clearly (see also Table 1).

Design

Before the second iteration, I modified the task assignment in order to improve it. In the first iteration, students were asked to enhance and extend an already existing knowledge base. Different than I expected, students concentrated on a superficial make-over by harmonising format, layout, and language instead of extending it. Therefore, the task assignment did not necessitated collaboration, or to put it practically, allowed the identification and division of tasks.

For this reason, I increased the complexity of the task assignment for the second iteration. Students were told to create a wiki about knowledge management that can be linearised into a textbook structure. Therefore, students had to start with an empty wiki and were forced to agree upon a shared conceptualisation.

As a textbook is also worthwhile for students after finishing the course, I was hoping that students will be motivated by co-authoring it. For the purpose of linearisation, I switched to *MediaWiki*, whose *Collection*⁴ extension is capable of providing PDF export functionality. Additionally, I introduced a WYSIWYG⁵ editor to alleviate the editing of wiki articles.

With 29 participants for the second iteration, the number of participants had nearly doubled, which made it more difficult for the participants to coordinate themselves in a hierarchical manner, as the evolution of a hierarchy needs time. Additionally, I reduced the time to work self-directed to five weeks. As this is a short time period to collaborate effectively, I scaffolded collaboration by adding a phase in which students will have the chance to make themselves familiar (1) with each other, (2) with the wiki, and (3) with the new type of assignment. Within this phase, I increased the complexity of the tasks slowly to reduce the initial cognitive load (Rienties et al., 2012; see also Sweller and Chandler, 1991, for *cognitive load theory*). Within two-and-a-half weeks, students were obliged to log into the wiki, create a profile page with at least one image, a short note about oneself, and a hyperlink (see e.g. Hughes, 2010 for the importance of digital profiles in virtual learning environments). Students could have done this task on their own or guided within an optional course that introduced wiki's functionality. Additionally, I installed a second wiki that gave students the chance to play with wiki functionality in a safe place without fearing to "destroy" something by mistake. The second task within this scaffolding phase was to familiarise with each other. Divided into groups, students were asked to create a table of contents from a set of approximately 50 knowledge management terms. Again, I provided students with material, this time from the first iteration, to reduce cognitive load at the beginning. Students were familiar with most of the concepts from module's lecture and exercise course. They were free to make improvements to the given set by narrowing down complex concepts into less complex terms. Distinguishing concepts and classifying them into an outline, requires students to negotiate a shared understanding. Although only one outline was chosen as the table of contents for the textbook, every student was accustomed in discussing terminology.

⁴Extension Collection: <http://www.mediawiki.org/wiki/Extension:Collection>.

⁵WYSIWYG: what you see is what you get; a WYSIWYG editor displays the content on screen like its appearance when printed.

After this scaffolding phase, all students worked five weeks toward filling the textbook with content. The role of the groups was to write an answer to a real-life knowledge management problem (e.g. One of your employees will leave your company in the near future: How do you save his knowledge?). By this, I did not reduce the wiki to a content management system for a textbook, but preserved the benefits of using a wiki by providing different pathways to explore it. Although students stuck to their groups, they were responsible for themselves (Johnson & Johnson, 1994a). As the point-based assessment system was insufficient in the first iteration, I enhanced the point system. Within the first iteration, students were not motivated to engage in larger tasks, because tasks were not differentiated according to their complexity. Therefore, I introduced a point system that takes the complexity of a task into account. Writing an article was a complex task as prior research is necessary before the article can be written, formatted, categorised and linked to other wiki articles. Hence, writing an article was rewarded with 10 points. In contrast, small corrections (e.g. misspelling, formatting) are not complex, but necessary and are therefore rewarded with 1 point. Some of the tasks were thought as a motivation for students to collaborate. For example, instead of rewarding only complete articles, I set motivation to enhance other's articles by adding content (e.g. new citation, 2 points; illustrative figure, 5 point) or by peer reviewing an article (10 points; e.g. pointing to similarities with or redundancy to other articles, proposing improvements). For a description of the point system refer to Appendix A.

In the first iteration, students started late with their assignment. As self-coordinated work lasted only five weeks, I introduced a rule to continuously engage students in collaboration. Students were obliged to make 20 points per week minimum.

Evaluation

Evaluation was based on data retrieved from interviews and the wiki as well as on my observations and invited anonymous feedback. In comparison with the first iteration, the network density was slightly lower ($D = .929$). The relation between network densities when separated into article ($D_A = .926$) and discussion network ($D_D = .211$) is similar, but larger compared to the first iteration. In conjunction with network degree centralisation C_{DD} (.217), a small density D_D indicates a moderate debate on the discussion pages that is balanced among all participants, meaning that no participant dominated the discussion. The high density D_A reveals that group work took mainly place on article pages and was balanced among participants ($C_D = .076$).

As shown in the first iteration, social network indicators cannot be used to evaluate collaboration without further analysis. Accordingly, the good values have to

be set into perspective after qualitative analysis of interactivity, synchronicity, and negotiation. While students agreed that they have worked synchronously towards a common goal and felt themselves as part of a larger community, they admitted that they have worked more in an individualist than in a collaborative manner.

“I liked the collaboration because I could do something independent from the others. I was not always dependent on the others. In normal project work we have often the problem that one half of the group is not coming to meetings and the other half has not been prepared. In this project, I have indeed done something in the team, but I could also do a lot alone. This was very positive for me because I could divide my time better.”⁶

“Some have worked only for themselves without paying attention to the others or their contributions. The motivation to collaborate is simply different.”

“In part, it was so that an article, which I have begun the day before, was finalised on the next day. That was amazing.”

Although students worked synchronously, they did not negotiate procedure and meaning. As a consequence, collaboration took only place by chance or in small groups of students who already knew each other. Accordingly, students negotiated their work not or very rarely with their friends or within their groups.

“I have worked with only a few others that I already knew. We told us: look at that, there can be made something, or, I have now started there, can you contribute something?”

“I have not communicated that much. At best when peer reviewing others’ article or receiving others’ peer reviews.”

“I find it easier to work alone than to work in a group. In this project, it was difficult too, because group members have not communicated with each other.”

Consequently, students have not perceived group work as interactive, that is, working within this project has not influenced students conception toward the subject area or wiki collaboration.

The quality of the collaborative product was quite good. Articles were accurate in form and content, granular, and shared a consistent conceptualisation of the subject

⁶ All quotes were translated by the author, according to their meaning, from German into English.

area. However, some redundancies were not dissolved and students failed at linearising the articles into a textbook structure. This could be due to efforts necessary to agree upon one structure.

Apart from the evaluation of collaboration were some issues with the task assignment. In contrast to the first iteration, the scaffolding phase of this iteration ensured that each student had the possibility to get familiar with the wiki, his/her group, and the task assignment. Students had no difficulties to understand the task assignment, but were irritated about the point system. Students were unsure how many points they will receive for certain activities. Overall, students liked the point system as it gave them the possibility to keep track of their progress and enabled them to compare their own efforts with the efforts of other students. Students accepted the obligation to add 20 points minimum per week, but were unsure how many points they have to make each week.

“The point system and assessment formula made me a little unsure. I did not know, whether 20 points per week are sufficient, or how many points the others are doing, and how many points I should do to get a good grade. So I think I have made more points than were necessary. But I found the project so perfectly.”

“At first I was skeptical about the grading system. But looking back, I must say that it has promoted motivation definitely. In any case, for me personally.”

“Without the 20-points-rule I would have postponed the project work, because you have indeed many other things to do during the semester.”

But using a differentiated point system had also negative effects. Some students acted strategic and tried to maximise their own benefits.

“The point system also had a negative effect. Some have produced a lot of crap. Some mistakes were made on purpose to be later repaired for points. I thought that was stupid.”

“Some had the strategy ‘quantity, not quality’, that is, maximise the own number of points without paying attention to the big picture.”

Students had different strategies to gain points. Some students focused on producing articles of high quality, others just copied content from Wikipedia or from the previous iteration that was made available to the students. And yet others concentrated on formatting and hyperlinking articles. Some students complained that some have not added anything substantial, as they focused on easy tasks like formatting.

Independent from issues related to the point system, I noticed that students dogmatically stuck to sample material or to answers I gave to questions, which arose during self-coordinated work. This was not intended. For example, although students perceived the need to agree upon a standard layout for wiki articles, they were too hesitant to create wiki pages that can be used for coordination.

Although students were sceptical at the beginning, most of them liked the task assignment afterwards, as they benefited from project work for the preparation of their oral exams. Independent from the issues outlined above, students edited the wiki 5,596 times, created 201 articles (see Table 2), and therefore developed a textbook about knowledge management that comprises of 135 pages (in its linearised form). Therefore, I followed this approach up to facilitate collaboration and identified need for modification.

Need for modification

In the following, I derived changes to the task assignment from the evaluation in order to refine the task assignment to necessitate collaboration.

First, I had not expected students to maximise their reward by neglecting quality. Therefore, future task assignments should prevent such behaviour. This could be facilitated by taking various action:

1. Adapt grading in order to assess one's contributions with regard to content.
2. Simplify the point system to prevent strategic behaviour.
3. Limit content from previous iterations that was made available to facilitate content production.

Second, although students got into a synchronous way of working together, following iterations should try to facilitate more negotiation and interaction between students. In relation to this task assignment, further iterations should scaffold collaboration to a lesser extent than within this iteration to provide less structure and necessitate negotiation about procedure and goal. Furthermore, the teacher should minimise his engagement in order to allow self-coordination. Thus, students could perceive a "sense of autonomy in performing a task or action", which could also have a positive impact on students intrinsic motivation (Rienties et al., 2012; as this is in line with self determination theory, see Ryan and Deci, 2000).

4.3 Iteration 3

Design

Before the third iteration, I adapted the assessment in order to prevent strategic behaviour that maximises individual rewards. Within the second iteration, some students maximised their rewards by contributing content of low quality, or even making mistakes intentionally to correct them afterwards. The rationale behind my approach was to assess a collaborative artefact with a single grade. To calculate an individual grade, the relation of the individual amount of points is set in proportion to the average number of points (see also Equation 1 on page 6). Therefore, individual contributions were independent from quality. In the third iteration, I split the grade into two components: one half of the grade will be calculated like in previous iterations, whereas the other half will be based on the quality of student's contributions. The grade for the quality of student's contribution will be based on the articles initiated and the reviews written by the student. Additionally, I adapted the point system (see Table A1) to complicate individual strategies by removing points for actions that have been used to maximise the number of points in the second iteration.

With 38 participants for the third iteration, at the beginning students had the opportunity to get familiar with the wiki. Therefore, they were obliged to log into the wiki, create a profile page with at least one image, a short note about oneself, and a hyperlink. Students could have done this task on their own or guided within an optional course that introduced wiki's functionality. I refrained from installing a separate sandbox wiki, as it has not been used by a single student within the previous iteration.

After getting familiar with the wiki, students engaged in self-directed work. Divided into groups, students were asked to create a textbook that comprises of concepts from module's lecture and exercise course. I highlighted that the linearisation of the content (using MediaWiki's Collection extension) will be the foundation for the group grade. Therefore, the project group's task was the structuring of the textbook. Like in the second iteration, each group had to write a group essay that answers a real-life knowledge management problem (e.g. How can knowledge-intensive processes be identified, supported, and measured?). This was intended to provide an indication for the structuring of the textbook. Additionally, this was meant to make benefit of wiki functionalities by providing different pathways to explore wiki contents. Beside the group task, each student had to initiate at least two articles and had to write two reviews. I did not provided students with material from previous iterations to force students to study the subject area on their own.

In contrast to the second iteration, I provided a community portal within the wiki that could be used for discussions with the whole group. At the same time, I limited my online presence in the wiki to create a need for negotiation.

The project work was bound to the accompanying lecture and started afterwards. As the lecture was delayed due to cancellation, the project work overlapped with exam time. Students complained about the overlap. For this reason, I decided to extend the duration of the project work to ten weeks, but committed students to participate five weeks minimum. Correspondingly, students were free to choose the weeks within which they wanted to participate.

Evaluation

Evaluation was based on data retrieved from interviews and the wiki as well as on my observations and invited anonymous feedback. The network indices differ negligibly from the second iteration (see Table 2). Network density ($D = .927$) and network degree centralisation ($C_D = .077$) were slightly weaker compared to the second iteration, except the density ($D_D = .281$) and centralisation ($C_{DD} = .314$) of the discussion network that were slightly greater. Therefore, the group work on discussion pages was little more intense. This indication can be backed up by the results of the qualitative analysis. Interviewees refer more often to negotiation than in the previous iteration. Students also worked in a synchronous manner, but with little cognitive influence on each other (dimension *interaction*, see Appendix B).

“The fewer is given, the more you will have to discuss, and the harder it is to come to a solution. In the project, few was given, but this was not bad. This had the advantage that you are very free in the way you work, but the disadvantage that it takes longer to coordinate.”

“I have worked with 3-4 people at random intervals. We have tried to come to an understanding about issues and ideas, but we rarely discussed effective enough to make a decision. After all, you usually put your own idea. I thought that was a pity, because a wiki should be used to incorporate the ideas of others.”

Although students reported from negotiation, discussion led to small achievements only. This can be explained by two reasons. First, although this project work had 38 active participants (see Table 2), only a few participated in discussion about procedure. Most students limited their collaborative efforts to their group’s task, but the majority kept away from general discussion about, for example, the structuring of the textbook, consistent formatting criteria, or resolution of conflicting articles.

Second, the few students who engaged in discussion, had a problem with decision-making. Collaboration demands decision-making by consensus, but participants did not get beyond exchanging ideas. Coming to a decision is a laborious process that needs discussion and negotiation. As nobody felt responsible to moderate the discussion, students dropped out of discussion and decided on their own. This was partly due to an overlap of the project with the exam time. As students were obliged to participate five weeks only, not all students were active at once. This complicated decision-making for students. This had also effects on the outcomes of the project work. Although students discussed (142 discussion pages; see Table 2 for details) and edited wiki pages more frequently (8,212 page edits) than in previous iterations, the quality of the wiki was weaker: the wiki contained page conflicts (e.g. two articles of the same topic), was not structured consistently, and missed granularity of the topics, at least partly. In summary, students were unable to cope the complexity of negotiating about every organisational aspect. This is also reflected by the fact, that more students produced less content (146 articles) than in previous iterations.

Regarding the modifications I made to the task assignment, I rated this iteration as a success. The incorporation of a qualitative assessment resulted in fewer students with strategies that maximise individual reward. However, one problem emerged from the task assignment. With every iteration, the task assignment got more sophisticated. As a consequence, communicating the task assignment was a tough job. Students felt overwhelmed by regulations and were anxious that they have to work more than rewarded (within the credit point system).

Irrespective of minor problems, the task assignment facilitated collaboration, but not thoroughly, namely without creating interaction that had an influence on students cognitive processes. However, the interviewees revealed that the project work was a new and intensive experience for most of the students.

Need for modification

In the following, I derive changes to the task assignment from the evaluation in order to refine the task assignment to necessitate collaboration. After an analysis of this iteration, two main problems were identified.

First, although project work had collaborative qualities, students failed at discussing topics and decision-making. Interviewees reported that this was due to missing incentives to participate in discussion. As students' contributions accounted for one half of the grade, students undervalued the overall task to create a textbook and concentrated on their individual contributions. Therefore, following iterations should question the high proportion of individual contributions or should create

incentives for students to participate in discussion. Furthermore, the teacher should provide facilities that support students in negotiation and decision-making as well as explicitly advise students that they have to engage in negotiation in order to accomplish project's goals.

Second, the outcome of this iteration was of lower quality in comparison to previous iterations. While students edited the wiki frequently and discussed a lot, it seems that students lost potential in negotiating shared norms and practices. Therefore, following iterations should provide students with pre-defined practices and tools to support collaboration in order to eliminate the need to agree upon every single aspect.

5 Discussion

In the following, I will discuss findings of project iterations with regard to my research aims. I had two aims: first, I wanted students to collaborate with each other; second, I wanted to ensure individual accountability and emphasise collaboration by taking group achievement into account.

Within three iterations, I improved the task assignment in order to facilitate collaboration better. Although the learning arrangement appears to have changed fundamentally over iterations, I adapted two dimensions only: task assignment (see Section 5.1) and assessment (see Section 5.2).

In contrast to the previous section, which had laid open how I adjusted the learning arrangement, I will discuss in Section 5.1 how changes to the *task assignment* affected my aim to facilitate collaboration. Afterwards, I will discuss the suitability of my new approach to assess collaboration (see Equation 1). Therefore, I will discuss in Section 5.2 whether intrinsic and extrinsic *incentives* were considered through the task assignment in order to overcome obstacles to collaboration (see Section 2). Finally, I will point to limitations of this research (see Section 5.3).

5.1 Task assignment

In the following, I discuss the modifications to the task assignments and evaluate their influence on collaboration.

Project duration

Although project duration changed with each iteration, it cannot be evaluated without looking at the surrounding circumstances. During the first iteration, the project

work took place as an assignment within the exercise course and was not coupled with the lecture. After the first iteration, degree programmes of my faculty were changed over to Bachelor/Master degrees. Starting with the second iteration, the project work was coupled with the lectures. The lecture comprises of case study work in groups, whereas these groups are remixed in project work using jigsaw (for a detailed description of the educational setting see Bukvova et al., 2010).

During the third iteration, the coupling of lecture and project work caused an overlap of project work with the exam time, which resulted in a prolonged project duration. However, if the surrounding circumstances were not taken into account, the modifications to the task assignment were limited (see Table 3).

Table 3: Modifications to the task assignment

	Iteration		
	1	2	3
Course structure and content			
Duration of self-directed collaboration	10 weeks	5 weeks	5 weeks
Duration of scaffolded collaboration	No scaffolding	~3 weeks	~1 week
Tasks completed during scaffolding	Not applicable	Familiarisation with the wiki; structuring for a textbook	Familiarisation with the wiki
Amount of material provided at the beginning	Wiki with pre-existing content that should be revised	Content from previous iteration could have been used; pre-defined set of terms	No content provided
Assessment			
Point system	One point per contribution	Differentiated point system	Differentiated point system
Individual grade	Calculated with regard to group grade	Calculated with regard to group grade	Calculated with regard to group grade plus individual component
Obligation to contribute every week	No	Yes	Yes

The length of the time that students should collaborate with each other changed once. After the first iteration, I shortened the duration of the project in order to complicate hierarchical coordination. However, the duration of the project seems to have had limited impact on the outcome of project work. Although students of the first iteration could have worked 10 weeks on the project work, they started editing the wiki late, resulting in an effective working time of five weeks only. As a consequence, the time students have worked on the project can be assessed as similar for all three iterations.

Summarised, five weeks of self-direct collaboration were sufficient to engage students in collaborative learning, given the number of students and the size of the task. And although work load was quite fair, students perceived the project as very intense due to the novel and demanding task assignment. However, these five weeks should be complemented with a well-balanced scaffolding phase.

Scaffolding

Problem solving becomes ineffective when learners are not sufficiently experienced (Kirschner, Sweller & Clark, 2006; Rienties et al., 2012). Especially at the beginning of the project work, I made many demands on students. I scaffolded collaboration to reduce cognitive load and to facilitate an efficient beginning. For this reason, I provided students with (1) wiki trainings, (2) pre-existing content, and (3) tips how to approach problems.

Contributing to wikis is not always easy. Many students struggle at contributing to a wiki, as editing often requires them to use wiki text (e.g. Lin & Kelsey, 2009). Wiki text is a simple markup language that is used to format text. For this reason, I provided a WYSIWYG editor to ease editing. Unexpected, students opted for the plain text editor and used wiki text, as it gave them more control.

“I have not used the text editor, but instead wikitext. It requires you to read in for half an hour, but gives you more control.”

This is consistent with previous research, which has shown that wikis are easy to use and required skills are acquired within few days (e.g. Guo & Stevens, 2011). However, students valued the optional wiki trainings, even a few voted for mandatory wiki trainings, because they demanded that all participants achieve the same skills in using wikis. This request is interesting as it points to a problem that instructors are facing when facilitating collaboration in classrooms: although students' IT skills have limited effect on the outcomes of collaboration, missing IT skills hinder efficient collaboration (Kummer, 2013). Therefore, IT skills appear to act as a hygiene factor

(Herzberg, 1987) – when absent, problems arise, but when present, they do not add to success.

Providing structure, either in terms of pre-existing content or scaffolded collaboration, had a positive effect on the quality of the project outcome. In the first and second iteration, I provided students with material from previous projects. As a consequence, students could focus on quality with regard to contents. In the second iteration, this was even more facilitated by scaffolding collaboration and moderating project work. As a result, the quality of the wiki in the first two iterations was better in form and content than in the last iteration. In the third iteration, I have not provided material. Consequently, students had to invest more time to negotiate rules of interaction, formal requirements, and structuring of content. As a result, the project outcome of the third iteration was poorer with regard to contents than in previous iterations. Although this seems to be an argument for providing structure, this must be seen in connection with the learning objectives of the underlying learning arrangement. In this case, the goal of the project work was to facilitate collaboration in order to take advantage of the benefits of collaborative learning. Therefore, engaging students in interaction could be rated as a success.

However, students rated interactions only as successful, if they had the feeling that they achieved in-depth knowledge of the subject area. In contrast, students undervalued the benefits of critical reflection and interaction with others. As a consequence, they have not benefited from discussing different viewpoints and engaging in collaborative knowledge construction.

“The wiki is a help, it’s short and sweet. The breakdown of essential knowledge management issues has helped me gaining an overview about the knowledge.” (2nd iteration – central position)

“The link between individual issues has not helped me as much as I would have expected.” (2nd iteration – peripheral position)

Interviewer: “Has the wiki helped you, to put topics in relationship?”
– Interviewee: “I could not put topics into relationship better. In this sense, the wiki had no benefit for me.” (3rd iteration)

Figure 4 shows six visualisations of the co-authorship network filtered according to the weight of an edge w_{ij} , that is, number of articles co-authored by two students. Within this figure, each edge represents collaborative activities between two participants, whereat the frequency of these activities is indicated by the thickness of the edge. Using the example of the second iteration, this figure depicts the heterogeneity of participation, that is, the unequal participation of learners (Weinberger & Fischer, 2006). The visualisation shows that students’ participation is heterogeneous.

This is reflected by the decrease of connections between learners when comparing the unfiltered network $w_{ij} \geq 1$ and the network with edges $w_{ij} \geq 10$. While few collaborated intensely $w_{ij} \geq 20$, that is, these few have worked together on minimum 20 articles, the whole group failed at collaborating as a wiki community. Interestingly, this participation behaviour seems to be similar to the inequality of participation in online communities, also known 90-9-1 principle – “90% of contribute never, 9% of users contribute a little, and 1% of users account for almost all the action” (Nielsen, 2006). However, interviewees that had a more central position within the network seem to have benefited more from project work, in terms of a holistic understanding of the subject area, than peripheral interviewees.

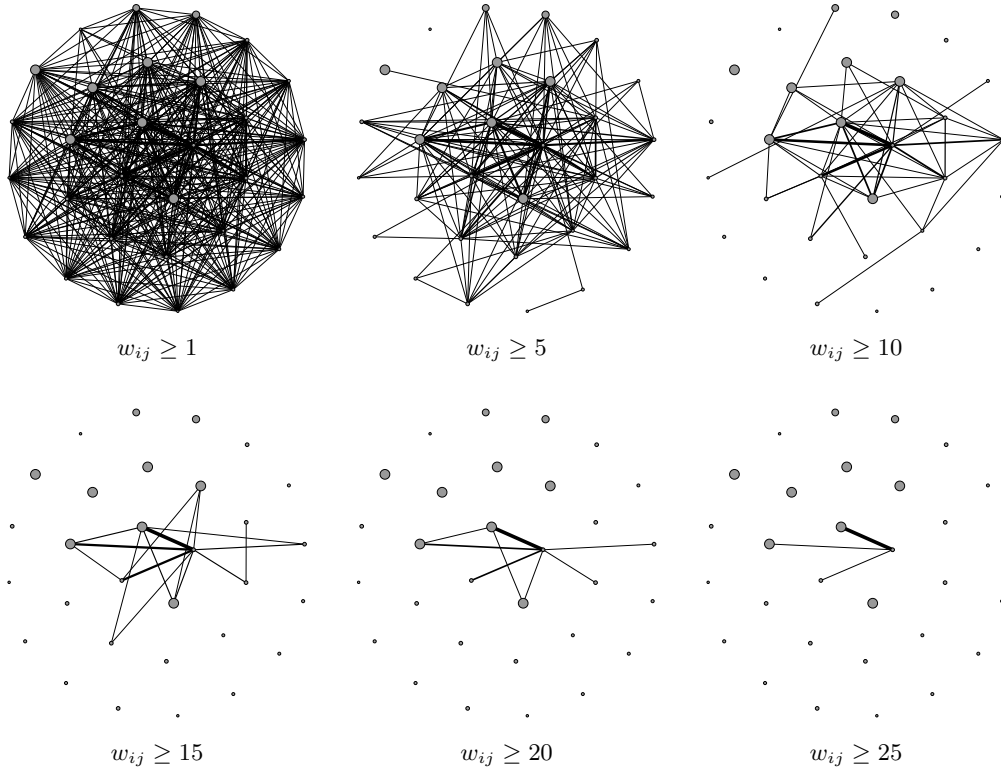


Figure 4: Heterogeneity of participation within the 2nd iteration

Note: Size of nodes represents betweenness centrality of an actor $C_B(n_i)$ and therefore indicates the importance of the actor for communication in the project (Wasserman & Faust, 1994, pp. 188-191). The thickness of edges indicates the strength of co-authorship between participants based on the weight of an edge w_{ij} .

Summarised, the degree of structure provided reflects the educational alignment of the project work. Low structured projects will probably result in self-guided collaboration, whereas high-structured projects are more likely to result in over-scripted collaboration (Kollar, Fischer & Hesse, 2006). Personally, I see my learning arrange-

ment at the borderline between self-guided and scripted collaboration. The first iteration followed more or less a laissez-faire policy, which resulted not in collaboration, but in hierarchical coordination. In the subsequent iterations, I chose to provide more structure, but have not found the right mix yet, to leave students enough space for self-organisation and engage them in collaboration.

Regardless of the degree of structure provided, the task assignment got more and more sophisticated. And although I got better in guiding students, how to start collaboration, it took me more and more time to prepare students for collaboration. This problem was due to the point-based assessment (e.g. How many points do I receive for ...?) or regulations to foster collaboration (e.g. 20-points-per-week-rule).

5.2 Incentives

The key component of the learning arrangement was the point system that gave students an incentive to contribute to the project work, and as a consequence, gave them a reason to engage in collaboration. Although the point system and assessment system, or rather the extrinsic incentives, changed over the iterations, intrinsic motivators stayed the same. Independent from the iteration, students were motivated by creating a resource on knowledge management that will be used in future courses. Beginning with the second iteration, I added the possibility to linearise the wiki to allow students to create their own textbook on knowledge management.

“I was fascinated by the idea. The motivation was to create something that remains at the end. The motivation was created by the task or by the whole project itself.”

Although not all of the participants were that enthusiastic as the one quoted above, feedback on the task assignment were positive. Students appear to have liked the task assignment due to its novelty (this is in line with previous research on collaborative learning; see Laal and Ghodsi, 2012). For this reason, I adjusted the extrinsic rewards during the three iterations only.

By interweaving task assignment with its grading, I wanted to ensure individual accountability *and* consider collaboration by taking group achievement into account. Associated with the point system and the assessment of the group achievement were two problems:

1. Students prioritised achieving points over contributing high-quality material or engaging in time-consuming collaboration.

2. Finding accurate indicators for the assessment of group achievement is difficult, in particular when the outcome of the collaboration is a wiki.

In the first iteration, students complained about the unfair, unbalanced point system that rewards complex contributions with only one point. In retrospective, and surprisingly, the point system of the first iteration was the most robust. Although students complained about unrewarded tasks, they handled them. With the second iteration, I introduced a point system that rewarded tasks according to their complexity. Therefore, small tasks that can be dispatched easily were rewarded with points (e.g. creating a hyperlink, 1 point; see Table A1 for a complete list of rewarded tasks). Unfortunately, some students acted strategical and maximised their personal reward by concentrating on tasks with a profitable ratio of time and effort to points rewarded. Although I adjusted the point system in the third iteration to avoid strategic behaviour, the point system incited students to prioritise points over quality slavishly. By introducing the 20-points-per-week-rule (see Section 4.2), I amplified this effect. Nevertheless, I kept with this rule, because it fostered continuous activity in the wiki and therefore facilitated collaboration.

“I think it would have been few in the wiki after free weeks without the 20-points-rule. However, if nothing stands in it, nobody else can add something.”

“I simply knew, do more than 20 points a week, and then it’s okay.”

As the quote above reveals, the 20-points-per-week-rule gave students an idea of my expectations towards an average amount of points per week. However, the amount of points achieved by students spread strongly. This was a severe problem, because individual grades were dependent from the average number of points of all students (see Equation 1). Students who contributed less than average were not the problem, but the few students who engaged heavily in project work distorted the average amount of points considerably. This had two consequences, (1) students with an average amount of points were penalised and (2) the calculation failed for students with a superior amount of points.⁷ I solved this problem by excluding outliers to the top from the calculation of the average number of points contributed that were the basis for the calculation of individual grades. If the calculation still yielded some impossible grade points, I cut them off by the best grade that was possible. However, this is a mathematical problem, that is accompanied with the inequality of participation, but not a problem with the underlying pedagogical rationale.

⁷Supposed that the average amount of points of all students is 100 points, the group grade is 90 grade points and students can achieve 100 grade points at best. Given a student will have 150 points, the student would receive 135 grade points ($135 = 90 \cdot (150/100)$; see Equation 1 for the calculation formula), which is out of the grade scale.

The second problem, to find accurate indicators to evaluate the group achievement, was complex. The assessment of group's achievement depends on the educational objective of the course. In this case, students should deepen their expertise in knowledge management by collaboratively creating a resource on knowledge management. Therefore, the project work should also foster the development of graduate skills. For example, information literacy, communication skills according to the generic graduate attributes policy introduced by (Barrie, 2004). But the main objective was on in-depth knowledge in knowledge management. But over the iterations, I started to incorporate indicators that reflected collaboration.

The first two iterations were based on a group grade that assessed the quality of the whole wiki. But what is the quality of a wiki? I communicated to students that the grade for the wiki will be based on its granularity, its internal structuring (e.g. through categorisation), the interconnectedness of its articles, and of course, based on the quality of its articles in form and content. As a consequence, evaluation was limited to an assessment of the cognitive outcomes from collaboration. Therefore, assessment lacked *constructive alignment* (Biggs & Tang, 2007), meaning that processes and outcomes associated with collaboration played no role in assessment (Boud, Cohen & Sampson, 1999; Strijbos, 2011). Nonetheless, by calculating individual grades based on students' individual contributions, I took student's share on the collaborative product, and implicitly on collaborative processes, into account.

However, assessing the quality of the wikis was difficult, as they were not homogeneous in terms of quality. For example, how to assess a wiki with some pages that are plagiarised? Victimise innocent students for one black sheep? In the first two iterations, I struggled with myself how to cope this situation. Because outcomes of both iterations were quite impressive, I abstained from disciplining students for plagiarism and valued their efforts. In the third iteration, I changed the calculation of individual grades: 50% of the grade were calculated based on the quantity of student's contributions to the wiki, the other 50% were based on the quality of student's contributions to the wiki. As this focused even more on cognitive outcomes than in previous iterations, I refocused the grade, that was given for the wiki, on collaborative outcomes only. Therefore, the quality of (1) the structuring of the textbook and of (2) the wiki articles became the basis for the assessment. Against my expectation, students undervalued the group grade and concentrated on contributions of high quality or on a high number of contributions. As a result, the structuring of the textbook was of average quality, meaning inconsistencies in structuring as well as redundant and overlapping articles. I gave a benevolent group grade to avoid penalising students for participating in a learning arrangement that is still in development. However, future research should investigate whether a more weighted group grade increases the incentive to contribute to the overall result. An alternative

explanation for insufficient group achievement is a potential lack of awareness with regard to the quality of the wiki. Accordingly, providing participants with formative feedback could increase their efforts (Shute, 2008).

Summarised, the assessment based on an individual grade that is calculated according to the overall grade and students' average amount of contributions has prevented students from social loafing or free-riding, but has ensured individual accountability.

5.3 Limitations

From a research perspective, this study introduced a novel learning arrangement to foster collaboration, which was continuously improved over three iterations. However, this study has some limitations.

First, research based on interventions is rarely completed, as there is “always room for improvements in the design and subsequent evaluation” (Anderson & Shattuck, 2012, p. 17). Therefore, this research is on a preliminary stage; thus the “final” learning arrangement is stable after three iterations, but has still room for improvements.

Second, the combination of social network analysis with interviews is problematic to study collaboration. This is not in line with previous research (Harrer et al., 2005; Martínez et al., 2006). Social network indicators are of limited explanatory power, as they are only capable of indicating intensive group work (see Section 4.1, subheading *Evaluation*).

Hence, qualitative analysis was the key component for the evaluation of collaboration. Therefore, I introduced three codes (see Appendix B) to evaluate collaboration based on three dimensions: negotiation, synchronicity, and interaction (Dillenbourg, 1999). Although the codes allow to evaluate collaboration, they cannot be used to measure different degrees of collaboration; i.e., a situation can be evaluated as collaborative or not collaborative.

Third and connected to the previous limitation, I evaluated collaboration based on the assumptions of interviewees. As a consequence, only explicit comments could have been taken into account when evaluating collaboration. This is in particular limiting, when examining the affection of cognitive processes (see code *interaction* in Appendix B; for more sophisticated content analysis schemes see de Wever, Schellens, Valcke and Van Keer, 2006; Strijbos, Martens, Prins and Jochems, 2006). However, this was a pragmatic decision to reduce time needed for evaluation, as teacher and researcher were the same person.

6 Conclusion

This article reported from a four-year-long action research project that iteratively developed a learning arrangement. Although I have not finished my action research yet, a stable learning arrangement evolved from an initial idea that can be used to engage students in collaboration. As a result, I completed with a learning arrangement that facilitates collaboration for most of participating students and very intensive work for all others. Based on my action research project, I compiled my findings in a description for the fourth iteration (see Appendix C). This description can also be used by other teachers to provide an established learning arrangement that facilitates collaboration, prevents social loafing and free-riding, and assures individual accountability. Furthermore, the learning arrangement is outcome-oriented in three ways. First, the result of the learning arrangement is a wiki that can be linearised into a textbook. Second, the learning arrangement fosters the development of graduate skills (e.g. social skills, IT skills), as defined by the framework for qualifications of The European Higher Education Area (Bologna Working Group on Qualifications Framework, 2005) or as demanded by the labour market (Heidenreich, 2011). Third and connected to second, the learning arrangement is also well-suited to teach in-depth knowledge, as students will discuss the topics of the regrading subject area intensely.

For these reasons, I rate my efforts to design a learning arrangement that engages students in collaboration as a success. But although I achieved my aim to facilitate collaboration, future research is necessary to continue improving the learning arrangement. Future research should investigate alternative approaches to assess collaboration, as the point-based assessment system is vulnerable to strategic behaviour. Related to the problems identified in Section 5.2, I see two research directions.

First, as students undervalue the impact of a group grade on their individual grade, future research should investigate ways of establishing an awareness for the actual quality of project work. Possibly, student tutors could point students to open problems, deficiencies, or inconsistencies and provide them with strategies to solve their problems. Therefore, students would perceive further possibilities that could have an influence on the quality of the project outcome. Beside this, student tutors would reduce effects that are due to a superior influence of an instructor, as student tutors are more on a par with students (Dolmans et al., 2002).

Second, instead of optimising a point-based reward system, an alternative could be to assess based on peer-rewarded grades. That would allow students to evaluate others' effective contribution to an collaborative assignment.

Despite issues related to assessment, future research is necessary to ease the evaluation of collaboration, as the combination of social network analysis with qualitative data analysis based on codes is not reliable enough. Instead of refining codes, an alternative could be to adjust metadiscourse markers to map collaboration (Alyousef & Picard, 2011; Hyland, 2005). This approach would have the potential to computer-supported wiki analysis. Although this would not enable automatic assessment of collaboration, results from automatic analysis could be used within a learning dashboard that can direct lecturers to problems in collaboration.

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References

- Allwardt, D. E. (2011). Writing with wikis: A cautionary tale of technology in the classroom. *Journal of Social Work Education*, 47(3), 597–605. doi:10.5175/JSWE.2011.200900126
- Alyousef, H. S. & Picard, M. Y. (2011). Cooperative or collaborative literacy practices: Mapping metadiscourse in a business students' wiki group project. *Australasian Journal of Educational Technology*, 27(3), 463–480.
- Anderson, T. & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher*, 41(1), 16–25. doi:10.3102/0013189X11428813
- Aronson, E. (1978). *The jigsaw classroom*. Beverly Hills, CA: Sage.
- Aviv, R., Erlich, Z., Ravid, G. & Geva, A. (2003). Network analysis of knowledge construction in asynchronous learning networks. *Journal of Asynchronous Learning Networks*, 7(3), 1–23.
- Barrie, S. C. (2004). A research-based approach to generic graduate attributes policy. *Higher Education Research & Development*, 23(3), 261–275. doi:10.1080/0729436042000235391

- Biggs, J. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research & Development*, 8(1), 7–25. doi:10.1080/0729436890080102
- Biggs, J. & Tang, C. (2007). *Teaching for quality learning at university: What the student does* (3rd ed.). New York, NY: Open University Press.
- Bologna Working Group on Qualifications Framework. (2005). The framework for qualifications of The European Higher Education Area. Copenhagen: Ministry of Science, Technology and Innovation, Denmark. Retrieved from http://www.ehea.info/Uploads/QF/050218_QF_EHEA.pdf
- Boud, D., Cohen, R. & Sampson, J. (1999). Peer learning and assessment. *Assessment & Evaluation in Higher Education*, 24(4), 413–426. doi:10.1080/0260293990240405
- Bukvova, H. & Kalb, H. (2010). *T-Systems Multimedia Solutions: Vernetztes Arbeiten im Team Web*, Enterprise 2.0 Fallstudien. München. urn : nbn : de : 101 : 1 - 201004211305
- Bukvova, H., Meyer, S. & Schoop, E. (2010). eLectures: Vom Nebenprodukt zum strukturierten Blended Learning Arrangement. In M. Schumann, L. M. Kolbe, M. H. Breitner & A. Frerichs (Eds.), *Multikonferenz Wirtschaftsinformatik 2010* (pp. 1425–1436). Göttingen: Universitätsverlag Göttingen.
- Carr, T., Morrison, A., Cox, G. & Deacon, A. (2007). Weathering wikis: Net-based learning meets political science in a South African university. *Computers and Composition*, 24(3), 266–284. doi:10.1016/j.compcom.2007.06.001
- Choy, S. O. & Ng, K. C. (2007). Implementing wiki software for supplementing online learning. *Australasian Journal of Educational Technology*, 23(2), 209–226.
- Cole, M. (2009). Using wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141–146. doi:10.1016/j.compedu.2008.07.003
- Cole, R., Purao, S., Rossi, M. & Sein, M. (2005). Being proactive: Where action research meets design research. In *Proceedings of the 26th International Conference on Information Systems*.
- Coyne, I. (1997). Sampling in qualitative research: Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing*, 26(3), 623–630. doi:10.1046/j.1365-2648.1997.t01-25-00999.x
- Cress, U. & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, 3(2), 105–122. doi:10.1007/s11412-007-9035-z
- Cubric, M. (2007). Wiki-based process framework for blended learning. In *Proceedings of the 2007 International Symposium on Wikis - WikiSym '07* (pp. 11–24). New York, NY: ACM Press. doi:10.1145/1296951.1296953

- Davies, A., Pantzopoulos, K. & Gray, K. (2011). Emphasising assessment ‘as’ learning by assessing wiki writing assignments collaboratively and publicly online. *Australasian Journal of Educational Technology*, 27(5), 798–812.
- de Laat, M. (2002). Network and content analysis in an online community discourse. In *Networked Learning 2002 Conference, Sheffield*.
- de Laat, M., Lally, V., Lipponen, L. & Simons, R.-J. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for social network analysis. *International Journal of Computer-Supported Collaborative Learning*, 2(1), 87–103. doi:10.1007/s11412-007-9006-4
- de Wever, B., Schellens, T., Valcke, M. & Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education*, 46(1), 6–28. doi:10.1016/j.compedu.2005.04.005
- Dicicco-Bloom, B. & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, 40(4), 314–321. doi:10.1111/j.1365-2929.2006.02418.x
- Dillenbourg, P. (1999). What do you mean by ‘collaborative learning’? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (Chap. 1, pp. 1–19). Oxford: Elsevier. Retrieved from <http://halshs.archives-ouvertes.fr/docs/00/19/02/40/PDF/Dillenbourg-Pierre-1999.pdf>
- Dolmans, D. H. J. M., Gijselaers, W. H., Moust, J. H. C., de Grave, W. S., Wolfhagen, I. H. a. P. & van der Vleuten, C. P. M. (2002). Trends in research on the tutor in problem-based learning: Conclusions and implications for educational practice and research. *Medical Teacher*, 24(2), 173–180. doi:10.1080/01421590220125277
- Ebner, M., Kickmeier-Rust, M. & Holzinger, A. (2008). Utilizing wiki-systems in higher education classes: A chance for universal access? *Universal Access in the Information Society*, 7(4), 199–207. doi:10.1007/s10209-008-0115-2
- Elgort, I., Smith, A. G. & Toland, J. (2008). Is wiki an effective platform for group course work? *Australasian Journal of Educational Technology*, 24(2), 195–210.
- Glaser, B. G. (2001). *The grounded theory perspective: Conceptualization contrasted with description*. Mill Valley, CA: Sociology Press.
- Glaser, B. G. & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick, NJ: AdlineTransaction.
- Godwin-Jones, R. (2003). Emerging technologies. *Language Learning & Technology*, 7(2), 12–16.
- Grundy, S. (1982). Three modes of action research. *Curriculum Perspectives*, 2(3), 23–34.

- Guo, Z. & Stevens, K. J. (2011). Factors influencing perceived usefulness of wikis for group collaborative learning by first year students. *Australasian Journal of Educational Technology*, 27(2), 221–242.
- Harrer, A., Zeini, S. & Pinkwart, N. (2005). The effects of electronic communication support on presence learning scenarios. In T.-W. Chan (Ed.), *The next 10 years!: Proceedings of the International Conference on Computer Support for Collaborative Learning 2005* (pp. 190–194). Morristown, NJ: Association for Computational Linguistics. doi:10.3115/1149293.1149317
- Haythornthwaite, C. (2006). Facilitating collaboration in online learning. *Journal of Asynchronous Learning Networks*, 10(1), 7–24.
- Heidenreich, K. (2011). *Erwartungen der Wirtschaft an Hochschulabsolventen*. Deutscher Industrie- und Handelskammertag e.V. Berlin. Retrieved from <http://www.dihk.de/themenfelder/aus-und-weiterbildung/schule-hochschule/hochschule/umfragen-und-prognosen/hochschulen-muessen-die-anforderungen-des-arbeitsmarktes-ernst-nehmen>
- Herzberg, F. (1987). One more time: How do you motivate employees? *Harvard Business Review*, 46(1), 53–62.
- Hughes, G. (2010). Identity and belonging in social learning groups: The importance of distinguishing social, operational and knowledge-related identity congruence. *British Educational Research Journal*, 36(1), 47–63. doi:10.1080/01411920902834167
- Hult, M. & Lennung, S.-Å. (1980). Toward a definition of action research: a note and bibliography. *Journal of Management Studies*, 17(2), 241–250. doi:10.1111/j.1467-6486.1980.tb00087.x
- Hyland, K. (2005). *Metadiscourse: Exploring interaction in writing*. London: Continuum International.
- Johnson, D. W., Johnson, R. T. & Stanne, M. B. (2000). *Cooperative learning methods: A meta-analysis*. Retrieved from <http://www.tablelearning.com/uploads/File/EXHIBIT-B.pdf>
- Johnson, D. W. & Johnson, R. T. (1994a). *Learning together and alone: Cooperative, competitive, and individualistic learning* (4th ed.). Boston, MA: Allyn & Bacon.
- Johnson, R. T. & Johnson, D. W. (1994b). An overview of cooperative learning. In J. S. Thousand, R. A. Villa & A. I. Nevin (Eds.), *Creativity and collaborative learning*. Baltimore, MD: Brookes Press.
- Judd, T., Kennedy, G. & Cropper, S. (2010). Using wikis for collaborative learning: Assessing collaboration through contribution. *Australasian Journal of Educational Technology*, 26(3), 341–354.
- Kagan, S. (1995). Group grades miss the mark. *Educational Leadership*, 52(8), 68–71.

- Kalb, H., Kummer, C. & Schoop, E. (2011). Implementing the ‘Wiki Way’ in a course in higher education. In H. Rohland, A. Kienle & S. Friedrich (Eds.), *DeLFI 2011 - Die 9. e-Learning Fachtagung Informatik der Gesellschaft für Informatik e. V.* (pp. 231–242). Lecture Notes in Informatics. Bonn: Gesellschaft für Informatik e. V. urn:nbn:de:bsz:14-qucosa-97529
- Kemmis, S. & McTaggart, R. (1992). *The action research planner* (3rd ed.). Geelong: Deakin University.
- Kerr, N. L. & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects. *Journal of Personality and Social Psychology*, 44(1), 78–94. doi:10.1037/0022-3514.44.1.78
- Kirschner, P. A., Sweller, J. & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, 41(2), 75–86. doi:10.1207/s15326985ep4102_1
- Kollar, I., Fischer, F. & Hesse, F. W. (2006). Collaboration scripts: A conceptual analysis. *Educational Psychology Review*, 18(2), 159–185. doi:10.1007/s10648-006-9007-2
- Kreijns, K., Kirschner, P. A. & Jochems, W. M. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society*, 5(1), 8–22.
- Kummer, C. (2013). *Factors influencing wiki collaboration in higher education*. doi:10.2139/ssrn.2208522
- Laal, M. & Ghodsi, S. M. (2012). Benefits of collaborative learning. *Procedia - Social and Behavioral Sciences*, 31, 486–490. doi:10.1016/j.sbspro.2011.12.091
- Laru, J., Näykki, P. & Järvelä, S. (2011). Supporting small-group learning using multiple web 2.0 tools: A case study in the higher education context. *The Internet and Higher Education*, 15(1), 29–38. doi:10.1016/j.iheduc.2011.08.004
- Latané, B., Williams, K. & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, 37(6), 822–832. doi:10.1037/0022-3514.37.6.822
- Lin, H. & Kelsey, K. D. (2009). Building a networked environment in wikis: The evolving phases of collaborative learning in a wikibook project. *Journal of Educational Computing Research*, 40(2), 145–169. doi:10.2190/EC.40.2.a
- Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.
- Martínez, A., Dimitriadis, Y., Gómez-Sánchez, E., Rubia-Avi, B., Jorrín-Abellán, I. & Marcos, J. A. (2006). Studying participation networks in collaboration using mixed methods. *International Journal of Computer-Supported Collaborative Learning*, 1(3), 383–408. doi:10.1007/s11412-006-8705-6

- Miyazoe, T. & Anderson, T. (2010). Learning outcomes and students' perceptions of online writing: Simultaneous implementation of a forum, blog, and wiki in an EFL blended learning setting. *System*, 38(2), 185–199. doi:10.1016/j.system.2010.03.006
- Naismith, L., Lee, B.-H. & Pilkington, R. M. (2011). Collaborative learning with a wiki: Differences in perceived usefulness in two contexts of use. *Journal of Computer Assisted Learning*, 27(3), 228–242. doi:10.1111/j.1365-2729.2010.00393.x
- Nielsen, J. (2006). Participation inequality: Encouraging more users to contribute. Retrieved April 8, 2013, from <http://www.nngroup.com/articles/participation-inequality/>
- Pörksen, B. (2009). The end of arbitrariness: The three fundamental questions of a constructivist ethics for the media. *Constructivist Foundations*, 4(2), 82–90.
- Pozzi, F. (2010). Using jigsaw and case study for supporting online collaborative learning. *Computers & Education*, 55(1), 67–75. doi:10.1016/j.compedu.2009.12.003
- Ramanau, R. & Geng, F. (2009). Researching the use of wiki's to facilitate group work. *Procedia - Social and Behavioral Sciences*, 1(1), 2620–2626. doi:10.1016/j.sbspro.2009.01.463
- Rienties, B., Giesbers, B., Tempelaar, D., Lygo-Baker, S., Segers, M. & Gijssels, W. (2012). The role of scaffolding and motivation in CSCL. *Computers & Education*, 59(3), 893–906. doi:10.1016/j.compedu.2012.04.010
- Ryan, R. M. & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54–67. doi:10.1006/ceps.1999.1020
- Sandelowski, M. (1995). Sample size in qualitative research. *Research in Nursing & Health*, 18(2), 179–183. doi:10.1002/nur.4770180211
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books.
- Sein, M. K., Henfridsson, O., Purao, S., Rossi, M. & Lindgren, R. (2011). Action design research. *MIS Quarterly*, 35(1), 37–56.
- Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, 78(1), 153–189. doi:10.3102/0034654307313795
- Slavin, R. E. (1980). Cooperative learning in teams: State of the art. *Educational Psychologist*, 15(2), 93–111. doi:10.1080/00461528009529219
- Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, 21(1), 43–69. doi:10.1006/ceps.1996.0004

- Stenhouse, L. (1975). *An introduction to curriculum research and development*. London: Heinemann.
- Strijbos, J.-W. (2011). Assessment of (computer-supported) collaborative learning. *IEEE Transactions on Learning Technologies*, 4(1), 59–73. doi:10.1109/TLT.2010.37
- Strijbos, J.-W., Martens, R. L., Prins, F. J. & Jochems, W. M. (2006). Content analysis: What are they talking about? *Computers & Education*, 46(1), 29–48. doi:10.1016/j.compedu.2005.04.002
- Sweller, J. & Chandler, P. (1991). Evidence for cognitive load theory. *Cognition and Instruction*, 8(4), 351–362. doi:10.1207/s1532690xc0804_5
- Wasserman, S. & Faust, K. (1994). *Social network analysis: Methods and applications*. Structural analysis in the social sciences. Cambridge, MA: Cambridge University.
- Weinberger, A. & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education*, 46(1), 71–95. doi:10.1016/j.compedu.2005.04.003
- Wheeler, S., Yeomans, P. & Wheeler, D. (2008). The good, the bad and the wiki: Evaluating student-generated content for collaborative learning. *British Journal of Educational Technology*, 39(6), 987–995. doi:10.1111/j.1467-8535.2007.00799.x
- Whitehead, J. (1989). Creating a living educational theory from questions of the kind, ‘How do I improve my practice?’ *Cambridge Journal of Education*, 19(1), 41–52. doi:10.1080/0305764890190106

Appendix A

Point system. Within each iteration, the point-based assessment was improved. The number of points per task is listed in Table A1 for the second and third iteration. The point system had two purposes. On the one hand, it was used to measure students' contributions, on the other hand, it set incentives to collaborate. For example, by reviewing other students' articles, students get into contact with each other.

Within the first iteration every contribution was rewarded with one single point and were not further subdivided into specific tasks. For this reason, the first iteration was not described in Table A1 as the specific tasks did not apply to it.

Table A1: Point system

<i>Task</i>	<i>Iteration</i>	
	2	3
Create new page	0.5	-
Small correction (e.g. spelling mistake, formatting)	1	1
Transferred article	1	-
New link	1	1
Larger correction (e.g. substantial correction of spelling mistakes or formatting)	2	5
New citation	2	1
Idea	2	2
Transferred and revised article	5	-
New paragraph	5	-
Graphic	5	5
Review	10	5
Complete new article	10	10

Appendix B

Collaborative learning takes place in *situations* where people *interact* in a particular form (Dillenbourg, 1999). Within these situations people work together, are at the same level, take similar actions and share a common goal. The type of interaction that constitutes collaboration can be characterised as interactive, synchronous, and negotiable. Using these attributes, I operationalised collaboration with three codes. The definition of the operational criteria were took from Dillenbourg (1999) and adapted to suit this research's context. In the following, I define the codes and give information on how to use them.

Codebook

Code INTERACTIVE

Brief definition Mutual influence on cognitive processes

Full definition The interactivity of a collaborative situation is characterised by “the extent to which these interactions influence the peers’ cognitive processes” (Dillenbourg, 1999, p. 8).

When to use Apply this code to all text passages that report from a change in someone’s understanding of a thing (e.g. conception of a theory) due to interaction with someone else.

When not to use Do not use this code for reference for negotiation of procedure.

Example “In my group, we have phoned, we have written emails, we have chatted via video, simply because we had to, but also because we wanted to. It was a very collaborative process, stronger than I would expect from a conventional project now. There I would not do that.”

Code SYNCHRONOUS

Brief definition Doing something together

Full definition While doing something synchronously is often referred to as a technical attribute (e.g. wikis as a mean for asynchronous communication), that is, doing something at the same time, a synchronous effort is the mutual process of working together towards a common goal.

When to use Apply this code to all occurrences that report from joint work on the project.

When not to use Do not use this code for reference for discussions.

Example “Some articles have really developed. Someone has written a section, then someone else has reviewed it. There were people who were specialized to begin new sections. And then there were people who could extend an article well.”

Code NEGOTIABLE

Brief definition Negotiate meaning or procedure

Full definition Collaborative interaction affords negotiation of meaning, procedure, and goals. In contrast to hierarchical decision making, collaborators have to discuss, to negotiate, and to argue in order to create a shared conceptualisation.

When to use Apply this code to all occurrences that report from situations where collaborators negotiate procedure.

When not to use Do not use this code for reference for negotiations about peer reviews.

Example “I have worked with only a few others that I already knew. We told us: look at that, there can be made something, or, I have now started there, can you contribute something?”

Appendix C

In the following, I disclosed my design for a fourth iteration of the learning arrangement that will take place in the summer semester of 2013. First, I introduce design changes, second, I present a step-by-step guide that will enable other teachers to use this learning arrangement.

Design

Following the criteria defined within Table 3, I have not changed the duration of the self-directed project work (5 weeks) nor the duration of preliminary scaffolding (3 weeks). But as participants of the third iteration had problems to coordinate internal processes, I modified the tasks to be completed within project work preparation. As in each iteration, the first task will be to familiarise with the wiki software. Therefore, students will be told to register for the wiki, to create a profile page, and to connect to group members. I will keep also up voluntary wiki trainings wherein students will get a short introduction in using MediaWiki.

Within every iteration, students had many questions (e.g. how to quote references in an article) and many problems (e.g. how to linearise all wiki articles into one textbook structure). Answering these questions and helping students to solve their problems was every time a balance between guidance and instruction. On the one hand, I held back, as I wanted students to take responsibility, on the other hand, I wanted to facilitate the creation of a well-crafted wikibook. For this reason, I wanted to raise students awareness for problems that have to be solved within a collaborative project. Therefore, each group will be responsible to negotiate an approach to solve one of these problems that will be binding for the whole project group. Groups will discuss a solution for the following points:

Structuring of the textbook Create a preliminary structuring for a textbook on knowledge management. Create guidelines for wiki articles in terms of granularity, freedom of redundancy, and disambiguation.

Formatting guidelines Create formatting guidelines for wiki articles including rules for references, pictures (e.g. copyright), links (e.g. frequency of links), and categorisation of articles.

Peer review Create a peer review policy that regulates how articles go into peer review, which criteria are reviewed, and how feedback has to be considered.

Point system Create criteria for the awarding of points (e.g. minimum requirements for an article). Also, if necessary, introduce new rewarded task in coordination with teacher.

Negotiation procedure Create rules which enable participants to discuss a problem and to decide about this problem.

Netiquette Create a netiquette that regulates social conventions within wiki work (e.g. tone of the reviews, revising articles vs. discussing possible article revisions).

Each group will communicate their proposal in order to allow the community to comment. Furthermore, each group will help the community at implementing these guidelines during project work and to mediate in case of problems.

Regarding the point system, I will remove small tasks that have been rewarded with one or two points only, as they invited strategic behaviour in previous iterations.

Step-by-step instruction manual

As the project work is part of a complex educational setting (see Bukvova et al., 2010 for a detailed description of the setting), the project work is planned to be carried out with six groups. In best case, each group consists of 6 members, but this can be adjusted to the number of participants.

Plan the project work

- Organise students into six groups.
- Assign each group a problem area (see previous section, e.g. formatting guidelines).
- Define the subject area of the textbook.
- Develop a question for each group that can be used to make the topic accessible to beginners, practitioners, and researchers within the respective subject area. For example, the following question can be used to open up the subject area knowledge management: “One of your employees will leave your company in the near future: How do you save his knowledge?”
- Plan project schedule including introductory course, wiki tutorials, and due dates.

- Prepare an introductory course on the project work that briefly introduces group membership, assessment (calculation of individual grade, point system, assessment criteria), and general conditions (20-points-rule, record keeping).
- Prepare a wiki tutorial that introduces major wiki concepts and gives students the opportunity to practice oneself in wiki functionalities and wiki text syntax.

Install MediaWiki software

- Install a WYSIWYG-editor.⁸
- Install extension Collection⁹ for providing export functionality.
- Allow the sign up of new users and require them to enter their e-mail address. Limit the display of wiki articles to registered users only.

Prepare the wiki for project work

- Create a category named *Organisation* and provide information about project's schedule and students' group membership on the category page. In the following, assign every article that contains information about the project work with category *Organisation*.
- Create an article per group that contains information about group's tasks.
- Create an article that describes how project work will be assessed and introduce assessment criteria for the individual grade as well as for the group grade.
 - 50% based on an individual grade
 - 50% based on a discounted group grade using the assessment formula (see Equation 1) and the point system
- Create an article that introduces the point system: larger correction (substantial revision; 5 points), new citation (2 points), graphic (5 points), new article (10 points).
- Create an article that describes general conditions.
 - Minimum requirements: 20 points per week (in the following: 20-points-rule), two new articles, and two reviews.

⁸E.g. Extension WikiEditor: <http://www.mediawiki.org/wiki/Extension:WikiEditor>

⁹Extension Collection: <http://www.mediawiki.org/wiki/Extension:Collection>

- Keep records of own activities and self-award points based on the point system.
- Every article of the resulting wiki has to be peer reviewed and, if necessary, revised.

Project schedule

Week 1

- Give an introductory course on the project work and a wiki tutorial.
- Give students the task to register for the wiki and to create a profile page that includes at least a picture, a short bio, and a hyperlink. This task is due to second week.
- Give students the task to provide a proposal for their problem (e.g. formatting guidelines). This task is due to third week.
- The 20-points-rule is ineffective until week 3.

Week 2

- Close wiki registration.
- Provide “problem” groups with tips and point them to possible problems that can take place in collaboration.

Week 3

- Point groups to open topics or flaws within their “problem” proposals.
- Give students the chance to comment group’s “problem” proposals.

Week 4-8

- Harmonised proposals turn effective.
- Self-directed work starts, the 20-points-rule turns effective.
- Give weekly feedback and answer questions.

Using fuzzy set qualitative comparative analysis (fsQCA) to identify indicators for wiki collaboration

Christian Kummer

Abstract. The evaluation of collaborative learning is often difficult and time-consuming. As a consequence, teachers' assessment of collaboration is mostly summative and focused on cognitive outcomes. Based on data that was gathered from a project-based, unscripted course, collaboration was evaluated using social network analysis and qualitative data analysis. In order to support teachers in monitoring of students' activities and enable them to give formative feedback on the collaborative process, this article introduces how fuzzy set qualitative comparative analysis (fsQCA) can be used to derive meaningful indicators. As a result, indices have been derived that can be used to point teachers to groups that experience problems in collaboration.

1 Introduction

As a teacher, I like wikis, because they are particularly suitable for collaborative learning, as they allow students to construct, share, and explore information and knowledge gained from peer-to-peer communication (Haythornthwaite, 2006). And although I already used wikis to facilitate collaboration, I am dissatisfied with the situation, as adopting collaboration in teaching confronted me with a problem: how to assess collaborative learning? Assessing collaboration that took place in wikis is a time-consuming endeavour, reconstructing the collaborative process by looking up page revisions, hyperlinks, and reading the final result. As in my case, assessment of collaboration is mostly summative and focused on cognitive outcomes (Strijbos, 2011). But as students benefit from the process of collaborative learning (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991; Vygotsky, 1978), and not from a final grade, I would like to give formative feedback on the process. But so far, I refrained from giving formative feedback due to the time and effort necessary for feedback. This was the impetus for this research that questions how teachers, like me, can be supported in evaluating group collaboration within a wiki. Consequently, the ultimate goal of this article is to derive meaningful indicators that can be used to provide teachers with dashboard functionality and support them in monitoring students' collaborative activities.

Prior studies have shown that a mixed method using *social network analysis* (SNA) and interviews can be used to study collaboration (Harrer, Zeini & Pinkwart, 2005; Martínez et al., 2006). But evaluating collaboration is difficult and time-consuming in general and in particular for teachers, as teachers still lack tools that signal problems in collaboration. Only few studies “involve the teacher by supporting the monitoring of students' activities” (Chatti, Dyckhoff, Schroeder & Thüs, 2012), but these studies (Bakharia & Dawson, 2011; Blikstein, 2011; Dringus & Ellis, 2005) rely primarily on large sets of learning-related data and do not take pedagogical issues into account (Chatti et al., 2012; Ferguson, 2012).

Starting from an educational objective, this paper introduces a case-based approach that takes pedagogical issues into account and allows researchers to derive meaningful indicators. Based on data that was gathered from a project-based, unscripted course on master level (Kummer, 2013), I evaluated the educational objective of this course. The educational objective of this course was to engage students in collaborative learning in order to promote critical thinking and communications skills (Johnson & Johnson, 1994; Laal & Ghodsi, 2012). In this article, collaboration is seen as a synchronous and coordinated effort to create one final product. In contrast to that, cooperation “refers to a more fixed division of labour generally made explicit at the outset” (Dillenbourg, 1999, p. 8).

To prove whether students engaged in collaborative learning, I employed SNA to analyse indirect co-authorship networks (Martínez et al., 2006) and used a pre-defined list of codes to analyse discussion pages qualitatively (Kummer, 2013). Indices from both quantitative and qualitative analysis were used to employ a *qualitative comparative analysis* (QCA) using *fuzzy sets* (fsQCA) (Ragin, 1987). As a result, sufficient combinations of these indices were identified that indicate group collaboration. Subsequently, I show how sufficient combinations can be used to provide lecturers with dashboard functionality and point them to deviating groups that might have problems collaborating with each other. As the goal of this research is to deliver actionable data about learners for the purpose of understanding their learning, this research can be situated within the research area of learning analytics.

My research is distinctive for three reasons: first, with QCA, I introduce an approach that has not been used before in learning analytics, but is capable of working with challenging combinations of datasets (e.g. demographic characteristics or location-based data). Second, starting with an educational problem, I take a pedagogical issue into account, instead of relying on an approach that is driven by data. As a result, I present indicators that are sufficient to provide evidence for collaboration. Third, by showing how these indicators can be used to support teachers in evaluation, I focus on perspectives of learners, as reduced time and effort for evaluation could “realign work on grading and marking, moving it away from summative assessment” (Ferguson, 2012, p. 314). In a nutshell, in this paper I address three out of four current challenges of learning analytics (Ferguson, 2012): (1) “develop methods of working with a wide range of datasets in order to optimise learning environments” (p. 313), (2) “build strong connections with the learning sciences” (p. 312), and (3) “focus on the perspectives of learners” (p. 313).

In the following, I present my approach to identify sufficient combinations of indicators for collaboration. Therefore, I detail how I employed fsQCA. Afterwards, I show how results of this approach can be used to constantly monitor group collaboration in wikis. Finally, I conclude with limitations of this study as well as with an outlook on further research.

2 Methods

I chose the constructivist paradigm by Lincoln and Guba (1985), assuming that reality is constructed in the minds of individuals and bound to the individual. Therefore, objectivity does not exist and truth cannot be achieved, but consensus between what others accept as correct (Pörksen, 2009).

Finding meaningful indicators is one of the challenges that learning analytics is facing (Chatti et al., 2012). Based on data gathered in a project-based course, this research used *qualitative comparative analysis with fuzzy sets* (fsQCA) to identify indicators linked to a desired outcome. My goal was to identify meaningful indicators for collaboration that can be used to support teachers in evaluating group collaboration.

In the next section, I detail the educational setting and describe how I collected data and pre-processed it, using SNA and *qualitative data analysis* (QDA), for fsQCA. As fsQCA is currently nearly unrecognised within the field of Information Systems (Wendler, Bukvova & Leupold, 2013), I give a brief introduction into fsQCA to ease the understanding of the method and its requirements. Afterwards, I introduce how I evaluated collaboration using indicators derived from SNA and QDA and I describe how I used these as explanatory factors for collaboration.

2.1 Setting and data collection

This paper is based on data gathered from an educational setting that facilitates collaboration within a wiki. Subsequently, I describe the educational setting briefly, for a detailed description refer to Kummer (2013).

The educational setting is part of a Master programme module that consists of a lecture, an exercise course, and a project-based course. The goal of the project work is to engage students in collaboration and shared knowledge construction with the educational objective to facilitate the development of competencies like communication skills (Johnson & Johnson, 1994; Laal & Ghodsi, 2012). While students are divided into groups of six, all of them are responsible to work towards one common goal. Students' task is to collaboratively construct a wiki on the topic of knowledge management that can also be linearized into a textbook. Apart from that each group has to write an article and find a solution to a current knowledge management issue (e.g. One of your employees will leave your company in the near future: How do you save his knowledge?).

Data was collected from two iterations of the project-based course that took place in the summer terms of 2011 (29 participants; 18 female; 11 male) and 2012 (38 participants; 22 female; 16 male). All participants were enrolled in a Master's degree programme at the faculty of economics of a German university. Only wiki data was collected, i.e., log data and entries in discussion pages, as results are to be used as indicators for group collaboration that can operate on the basis of wiki data. Data was retrieved from the wiki in two ways. First, I wrote a script that queried the wiki database, pre-processed information about co-authorship in groups, and exported one dataset for each group that can be read using the SNA software *Pajek*, version

3.10. As a result, 12 datasets comprising information about 12 groups resulted from data collection. Second, discussion pages were copied by hand into one document per group for further QDA.

The qualitative comparative analysis is well suited for addressing questions about outcomes resulting from multiple and conjectural cases (Ragin, 1987). For this reason, I selected QCA for this research, as I wanted to explore factors that can be used to explain group collaboration based on two cases with six groups per case as embedded units of analysis. Correspondingly, this research can also be seen as an exploratory case study (Yin, 2009).

2.2 Qualitative comparative analysis (QCA) and fuzzy set QCA

In this section, I introduce QCA and fuzzy set QCA in order to give a bit of background before going into the topic in depth, but due to space restrictions I describe basic concepts only. However, the application of fsQCA regarding this research is detailed within the next section (see Identifying Sufficient Conditions for Collaboration Using Fuzzy Set QCA). Readers interested in a comprehensive description of the method may be referred to (Ragin, 1987, 2000).

QCA as a technique was developed by Charles C. Ragin in the 1980s, but its logical foundations trace back to the work of John Stuart Mill (Berg-Schlosser, De Meur, Rihoux & Ragin, 2009; Ragin, 1987). Originating in the field of Comparative Politics, it has been applied also in Sociology, Management Science, Business and Economics, among others. Lately QCA has been introduced in Information Systems/Wirtschaftsinformatik (Wendler et al., 2013). QCA uses Boolean algebra for solving multiple, conjectural cases. The ultimate goal of QCA is to identify sufficient combinations for an outcome. For this purpose, *conditions* (variables) are dichotomised into 0 (false or absent) or 1 (true or present), and cases are represented as sets according to set theory and are assigned with an *outcome* (dependent variable) coded as 0 or 1 (Berg-Schlosser et al., 2009). Based on dichotomised (raw) data, a truth table has to be constructed that displays a list of all possible *configurations* (combinations). A configuration is the combination of conditions with a particular outcome, which may be represented by several of the observed cases. In the following step, the Boolean expression that consists of the description of the truth table is reduced to the minimal formula. This step is called Boolean minimisation and reveals regularities within the data that can be interpreted by the researcher (Rihoux, 2006). For an introduction in QCA that includes a detailed example see Rihoux and De Meur (2009).

QCA combines several strengths from qualitative and quantitative research; for example, familiarity with cases, complex causality, generalisation based on small-N (Ragin, 1987; Rihoux, 2006). However, dichotomisation of data limits the applicability of QCA, as some data cannot be dichotomised in an appropriate way (e.g. think of a meaningful threshold to code temperature into cold [0] and hot [1]). As a consequence, several configurational comparative methods have evolved as an alternative to QCA (also referred to as crisp set QCA), namely multi-value, fuzzy set, and temporal QCA.

Fuzzy set QCA extends conventional Boolean sets by permitting membership scores between [0] full non-membership and [1] full membership. Therefore, a fuzzy membership score reflects the degree to which a condition belongs to a set. This is particularly useful when pinpointing to different qualitative states of a condition, but is also used for assigning “continuous” membership scores (Ragin, 2009). For example, a country (e.g. Iran) might receive a membership score of 0.6 within a set of democratic countries, when it shares several characteristics with other democracies (e.g. right to vote for every citizen), but also has non-democratic characteristics (e.g. no freedom of press). Membership scores are not assigned according to their comparative rank, but guided by the use of theoretical and substantive knowledge. This process is called calibration and defines “three qualitative breakpoints: full membership (1), full nonmembership (0), and the crossover point, where there is maximum ambiguity regarding whether a case is more in or out of a set (0.5)” (Ragin, 2009, p. 90). After calibration, fuzzy membership scores are dichotomised for Boolean minimisation. Based on the frequency of a configuration, that is, number of similar cases, and the consistency of the configuration, the researcher decides upon their inclusion within Boolean minimisation (Ragin, 2009). The complete application of this procedure is detailed in the next section (see Section 3).

In the next section, I introduce explanatory factors for collaboration. Explanatory factors are causal conditions that were used to *describe* an outcome. In this case, I used indices from social network analysis and qualitative data analysis. In the subsequent section, I show how indices have been calculated and were used to *explain* the outcome.

2.3 Explanatory factors for collaboration

Dillenbourg (1999, p. 5) refers to collaborative learning as a “situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms.” According to Dillenbourg (1999) a collaborative situation has three defining characteristics: *synchronicity*, *negotiation*, and *interaction*. A situation is *synchronous*, when participants do more or less simultaneously something

together. In addition to that a collaborative interaction is also characterised by equal participants that *negotiate* procedure based on their point of view. As a consequence, collaborative *interaction* should influence peers cognitive processes. With regard to this research, two questions arise. First, how can be evaluated whether a group has collaborated or not using these characteristics? And second, which indicators seem to be suitable to reflect the characteristics?

Previous research has shown that a mixed method approach using SNA and qualitative analysis of interviews is appropriate to study collaboration in groups (Harrer et al., 2005; Martínez et al., 2006). In the following, I illustrate how I adapted this approach to evaluate collaboration. Additionally, I propose indices for further use as explanatory factors for collaboration in fsQCA. Ragin (2009) suggests to select three to eight causal conditions. I selected four indices from SNA to be used as causal conditions to describe the dimension *synchronicity*. The dimensions *negotiation* and *interaction* are integrated in the outcome – collaboration – and are introduced in the next section (see Section 2.3.2).

2.3.1 Social network analysis

I examined *synchronicity* (see next section for *negotiation* and *interaction*) using wiki log data, as log data reveals how students communicated through discussion threads. Data was collected from the wiki using a script that pre-processed wiki log data by creating one dataset per group. Each of these datasets contains group's discussions. Connections between group members were constructed by hypothesising co-authorship of discussion pages as collaboration (see Figure 1). As a result, an undirected co-authorship network emerged from the log files (Martínez et al., 2006). As groups were obliged to write at least one article collaboratively in order to pass the assignment, I included discussion pages only. Thereby I reduced a potential bias in values of social network indices. Including every type of wiki page (e.g. article, discussion, and category) would have resulted in perfectly interlinked group members due to their co-authored group article.

Previous research used network density (D ; DEN) and network degree centralisation (C_D ; CENT) as indicators for collaboration (Aviv, Erlich, Ravid & Geva, 2003; Harrer et al., 2005; Lally & de Laat, 2002; de Laat, Lally, Lipponen & Simons, 2007; Martínez et al., 2006). As both indices have proved value for evaluating collaboration, I used them as explanatory factors for collaboration.

Mathematically, the density D is the average of the standardised node degrees $d(n_i)$ with values between 0 and 1. The degree represents the number of connections a network node (in this case the student) has with other nodes. Correspondingly, the

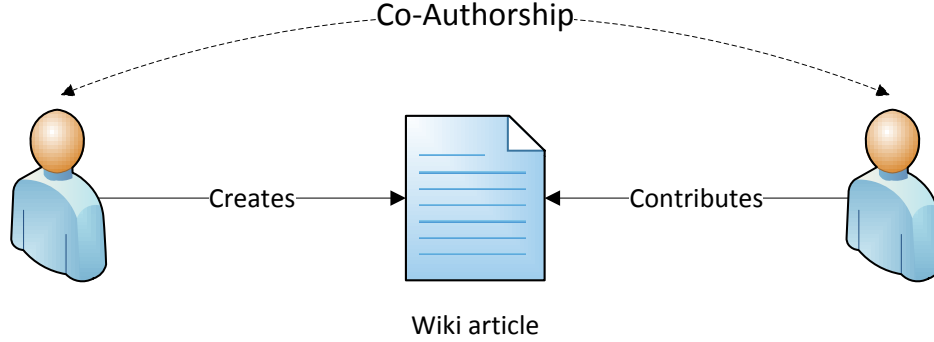


Figure 1: Collaboration as co-authorship of participants

density is the proportion of possible connections of a network to the connections that are actually present in a network (Wasserman & Faust, 1994, p. 178). Therefore, a high value of density provides an indication for collaboration among students, as it shows how group members worked together. For example, in case 12 from Table 1, the density DEN is 1, that is, all group members are perfectly connected with each other. Consequently, it is likely that they collaborated with each other.

Furthermore, I took group's degree centralisation C_D into account to investigate the group activity. Centralisation C_D is a group-level index that "records the extent to which a single actor has high centrality, and the others, low centrality. It also can be viewed as a measure of how unequal the individual actor values are. It is (roughly) a measure of variability, dispersion, or spread" (Wasserman & Faust, 1994, p. 176). With values between 0 and 1, a high value of centralisation would mean that only few of the group members contributed in group's assignment. In contrast, a low value of centralisation indicates a balanced collaboration among students (Martínez et al., 2006; Wasserman & Faust, 1994, p. 177). For example, in case 12 from Table 1, the centrality CENT is 0, indicating that no single member of group 12 dominated the group, but instead all group members have made equal efforts and thus collaborated.

Exact values for both indices are specified for each group in Table 1 within columns DEN and CENT under raw data. Beside these established indices, I propose another index to be used as an explanatory factor: the median weighted degree (DEG) (see Table 1). The weighted degree extends the node degree $d(n_i)$, which is the number of links attached to a node, by the weight of the links attached to this node. Therefore, the median of weighted node degrees ($\tilde{d}(n_i)$, DEG) is an indicator for the intensity of collaboration within a group. A high median of weighted degrees is therefore a

sign that group members discussed on various pages with each other, whereas a low value indicates that the group has limited discussion to the absolutely necessary.

Table 1: Raw and calibrated data

Case	Raw data					Calibrated data				
	DEN	CENT	DEG	DIS	COLL	DEN	CENT	DEG	DIS	COLL
1	.500	.417	3	16	1	.100	.104	0	.417	.700
2	1	0	5	25	2	1	1	0	.792	1
3	1	.583	2	6	1	1	0	0	0	.700
4	1	0	10	56	2	1	1	1	1	1
5	1	0	9	32	2	1	1	.833	1	1
6	1	0	6	21	1	1	1	.250	.625	.700
7	.048	.167	0	8	0	.100	.417	0	.083	.100
8	.400	.300	12.500	20	1	.100	.250	1	.583	.700
9	.667	.500	5.500	24	1	.700	0	.125	.750	.700
10	.667	.200	5.500	33	1	.700	.375	.125	1	.700
11	.619	.300	12	27	2	.700	.250	1	.875	1
12	1	0	7.500	39	1	1	1	.583	1	.700

Note. DEN – density, CENT – degree centralisation, DEG – median weighted degree, DIS – number of discussion posts, COLL – assessment of collaboration.

2.3.2 Qualitative data analysis

Although previous research introduced sophisticated methods to analyse collaborative processes (Strijbos, Martens, Prins & Jochems, 2006; de Wever, Schellens, Valcke & Van Keer, 2006), I preferred an easy to use code scheme that operationalizes collaboration with the aid of three dimensions: *synchronicity*, *interaction*, and *negotiation* (Kummer, 2013). As the key focus of this research is not the in-depth study of collaborative processes, but the incorporation of an educational objective in order to provide meaningful indices, I regarded the evaluation of collaboration (= *outcome*) using this code scheme as sufficient.

For the same reason, I refrained from interviewing group members, but analysed group discussion pages to evaluate collaboration. The selected discussion pages were coded using QDA software *MaxQDA*, version 10. Using the pre-defined list of codes, information chunks of varying sizes – sentences, a paragraph, or a whole discussion post – were used as the basic unit of analysis embedded in a case that was represented by a document covering all discussions of a group. I coded *negotiation* and *interaction* only, as I already analysed *synchronicity* using SNA. Table 1 illustrates the results of my evaluation of collaboration per group. Due to the task assignment, all groups have worked together in a synchronous manner on at least one article. Therefore,

I evaluated collaboration based on the coding of *negotiation* and *interaction* only, as all groups met my criteria for a positive evaluation for *synchronicity*. In Table 1 (column COLL under raw data) the occurrence of one dimension is reflected by 1 and of both dimensions by 2. Finally, a 0 indicates that groups worked synchronous, but discussion pages showed no accordance for codes *negotiation* and *interaction*.

Apart from the evaluation of collaboration, I propose another index to be used as an explanatory factor: the number of discussion posts per group (DIS) (see Table 1). Negotiating procedure and meaning is a complex and time-consuming tasks when relying on wiki-based communication (Lin & Kelsey, 2009). Consequently, it should necessitate a large number of discussion posts to come to a mutual agreement. And although a large number must not necessarily indicate collaborative activities, it provides an indication for it. For this reason, I counted the number of discussion posts per group.

3 Identifying sufficient conditions for collaboration using fuzzy set QCA

In the previous section, I described how I evaluated collaboration (COLL) using the density (DEN) and the degree centralisation (CENT) of a network together with QDA. Additionally, I proposed two other indices as explanatory factors for collaboration: the median weighted degree (DEG) and the number of discussion posts (DIS). Summarised, I used four *conditions* (= explanatory factors) to describe an *outcome* (= collaboration).

In the following, I describe how I applied fsQCA with *R*, version 2.15.2. Specifically, I used *R*'s package *QCA* (Thiem & Duşa, 2013), version 1.0-4, to (1) calibrate raw data into fuzzy set membership scores, (2) to construct the truth table, (3) to reduce the Boolean expression to a minimal formula, and to (4) test for necessity and sufficiency of the conditions.

3.1 Data calibration

The process of transforming raw data (= base variable values) into fuzzy membership scores is referred to as calibration. There are two methods of assigning fuzzy membership scores: direct assignment and transformational assignment (Thiem & Duşa, 2013, p. 51). On the one hand direct assignment is used when fuzzy membership scores refer to qualitative states. On the other hand transformational assignment is used when differentiation in qualitative states is difficult. This is the case for continuous base variables that are assigned fuzzy set membership scores based on specific

Table 2: Calibration of data into fuzzy set membership scores

<i>Transformational assignment based on end-point concept</i>			
	Full membership (1)	Crossover point (0.5)	No membership (0)
CENT	0	.100	1
DEG	10	7	5
DIS	30	18	6
<i>Direct assignment</i>			
DEN	$\mu_{\text{DEN}}(x) = \begin{cases} 0.1 & \text{if } x_i < 0.6 \\ 0.7 & \text{if } x_i < 1 \\ 1 & \text{if } x_i = 1 \end{cases}$		
COLL	$\mu_{\text{COLL}}(x) = \begin{cases} 0.1 & \text{if } x_i = 0 \\ 0.7 & \text{if } x_i = 1 \\ 1 & \text{if } x_i = 2 \end{cases}$		

functions (e.g. linear, logistic) that make use of three qualitative breakpoints: no membership (0), the crossover point (0.5), and full membership (1) (Ragin, 2009; Thiem and Duşa, 2013, p.55). In this study, I employed both methods (see Table 2). Following, I disclosed the rationale for calibration of raw data into fuzzy set membership scores. The calibrated data is depicted within Table 1

I calibrated the density of groups' network (DEN) and evaluation of groups' collaboration performance (COLL) using direct assignment with a three-value fuzzy set (see Table 2). Three values were possible for COLL: 0, 1, and 2. Based on my conceptualisation of collaboration, a zero reflects that a group worked together on an article, but has not engaged in a wiki-based discussion in order to negotiate procedure or meaning. Therefore, the group limited their collaborative efforts to a minimum – this is reflected by a membership score of 0.1. In contrast, a two indicates that the discussion indicated signs of negotiation and interaction, that is, all three dimensions are present that is reflected by a full membership (1). As negotiation and interaction are either indicating activities or consequences that are connected with intensive collaboration, I rated the appearance of one of these codes with a membership score of 0.7.

The density was also assigned a membership score based on a three-value fuzzy set. DEN refers to the synchronicity of group work and is therefore regarded as a precondition of effective collaboration. Consequently, I assigned a membership score of 0.1 if the density dropped below $D < 0.6$. However, densities greater-than-or-equal to $D = 0.6$ and below $D = 1$ were assigned a membership score of 0.7. Thereby, I considered groups that engaged in collaboration, but had to deal with unresponsive peers. For example, if only one group member refrained from collaboration, the density dropped clearly (see DEN of case 9-12 in Table 1, column raw data). But if

all group members took an active part in collaboration, the density is equal to one. Consequently, I assigned a full membership (1) if density is $D = 1$.

The network degree centralisation (CENT) per group, the median of weighted degree (DEG), and the number of discussion post per group were assigned a fuzzy set membership score using transformational assignment. As CENT is a standardised index and was transformed using a negative end-point concept with 0 and 1 as endpoint. Collaboration is characterised by working together having equal rights. Consequently, full membership is awarded for low CENT, as low values for CENT indicate networks with balanced participation among group members. I selected a low crossover point (0.1) in order to assign a low membership score to groups that have been dominated by one group member.

DEG and DIS were assigned fuzzy set membership scores based on a positive end-point concept. In both cases, I selected the crossover point based as well as the membership on educational considerations. For example, the crossover point for DEG is 18, that is, in five weeks each group member posted three times only, as each group consisted of 6 group members. Accordingly, the value for full membership (1) represented my expectations towards group activities.

3.2 Boolean minimisation

In the following, I introduce how I constructed a truth table using the calibrated data and applied Boolean minimisation. Prior I analysed for necessary conditions that could be removed before constructing the truth table (Ragin, 2009). Given a minimum sufficiency inclusion score (0.965) and a minimum coverage (0.6) none of the potential $3^k - 1$ combinations showed an inclusion score that was sufficiently high to indicate necessity. Therefore, all conditions were involved into truth table construction (Ragin, 2000). Based on the fuzzy membership score, each case's conditions are dichotomised. With four causal conditions (e.g. DEN), the truth table lists the $2^4 (= 16)$ configurations that refer to the fuzzy set corners (see Table 3). In contrast to crisp set QCA, each of the truth table rows correspond to one of the vector space corners that can be constructed from fuzzy sets (Ragin, 2009). Table 3 contains the truth table that clearly lists both empirically evident and non-evident configurations (see column Cases).

Wagemann and Schneider (2007) recommend that both solution formulas, the parsimonious and the complex, should be reported. Therefore, Boolean minimisation has been carried out in two steps. First, I derived the complex solution that incorporates all fundamental products into the canonical sum that correspond to true configur-

Table 3: Truth table

Configuration	DEN	CENT	DEG	DIS	COLL	n	Incl	PRI	Cases
1	0	0	0	0	0	2	.659	.370	1, 7
2	0	0	0	1	R	0	1	1	
3	0	0	1	0	R	0	1	1	
4	0	0	1	1	1	1	1	1	8
5	0	1	0	0	R	0	.392	0	
6	0	1	0	1	R	0	1	-	
7	0	1	1	0	R	0	1	1	
8	0	1	1	1	R	0	1	1	
9	1	0	0	0	0	1	.793	.571	3
10	1	0	0	1	1	2	1	1	9, 10
11	1	0	1	0	R	0	1	1	
12	1	0	1	1	1	1	1	1	11
13	1	1	0	0	R	0	1	1	
14	1	1	0	1	1	2	1	1	2, 6
15	1	1	1	0	R	0	1	1	
16	1	1	1	1	1	3	1	1	4, 5, 12

Note. PRI- proportional reduction in inconsistency, R – logical remainder, Incl – sufficiency inclusion score, n – number of cases in configuration.

ations (Thiem & Duşa, 2013, p. 71). Second, I incorporated logical remainder to derive the parsimonious solution.

The complex solution was derived from all configurations that exceed the sufficiency inclusion score of 0.9 using Boolean minimisation. No restrictions were made regarding the minimum number of cases per configuration due to the small number of cases. As a result, the complex solution for the analysis of the sufficient conditions for the outcome *collaboration* is $DEN \cdot DIS + cent \cdot DEG \cdot DIS \rightarrow COLL$ (see Table 4).

Table 4: Analysis of sufficient conditions for the outcome collaboration

<i>Solution</i>	$DEN \cdot DIS$	$+ \quad cent \cdot DEG \cdot DIS$	$\rightarrow \quad COLL$
<i>Single case coverage</i>	2,6; 4,5,12; 9,10; 11		8; 11
<i>Consistency</i>	.956		1
<i>Raw coverage</i>	.722		.176
<i>Unique coverage</i>	.606		.059
<i>Solution consistency:</i>	.959	<i>Solution coverage:</i>	.781

Note. Configurations were separated by semicolon, cases by comma. The consistency threshold has been set at 0.9. The next highest consistency score is 0.793. Case 11 is covered by both combinations. Lowercase abbreviation corresponds to the absence of a condition (0), whereas uppercase abbreviation refers to the presence of a condition (1).

To derive the parsimonious solution, logical remainders have to be incorporated into Boolean minimisation. Logical remainder are configurations for which “no case possesses a membership score above 0.5, or which have been judged to contain too few cases in relation to the total number of cases” (Thiem & Duşa, 2013, p. 73). Incorporating logical remainders allows researchers to consider potential counterfactual cases that are not present in the data (Ragin & Sonnett, 2004) (e.g. configuration 2 and 3, see Table 3). I approached the problem of limited diversity, that is, not all logically possible configurations exist in my data (Ragin, 1987, pp. 104-113), by incorporating both easy and difficult counterfactuals (Ragin & Sonnett, 2004). As a result, the parsimonious solution is derived from Boolean minimisation: $DIS \rightarrow COLL$.

Ragin (2009, p. 111) points out that logical remainders have to be evaluated whether they are “implausible and should be excluded from a solution.” Therefore, I examined whether contradictory simplifying assumptions, that is, logical remainders that has been used both “in the minimisation of the [1] outcome configurations *and* in the minimisation [0] outcome configurations” (Yamasaki & Rihoux, 2009, p. 136), were used to derive the parsimonious solution. I used the procedure suggested by Yamasaki and Rihoux (2009, pp. 136-138). Within two iterations, I assigned an outcome to five contradictory simplifying assumptions based on theoretical considerations (first iteration: configurations 2, 6, and 8; second iteration: configurations 3 and 11; each configuration was assigned an [0] outcome). After eliminating the contradictory simplifying assumptions, the minimal sum equalled the complex solution. In the following section, I discuss the result, where I focus on the complex solution, as it provides the most meaningful solution.

4 Discussion

In the following, I discuss the results of my analysis briefly, first, with regard to the solution formula of fsQCA (see Table 4). Secondly, I discuss how the results can be used to provide a teachers dashboard.

4.1 Overall results

The results of the analysis of the sufficient conditions for the outcome collaboration are displayed in Table 4. While solution consistency is very high (0.959), solution coverage is satisfying (0.781). Figure 2 also depicts the results graphically. A combination of conditions is sufficient, when all cases are around or above the bisecting line (Ragin, 2000, p. 236) (see Figure 2, triangles A3 and A4). Two combinations of conditions, $DEN \cdot DIS$ and $cent \cdot DEG \cdot DIS$, lead to the outcome *collaboration*. This

result is interesting, as it points to several regularities and distinctive differences in how groups succeed in group collaboration.

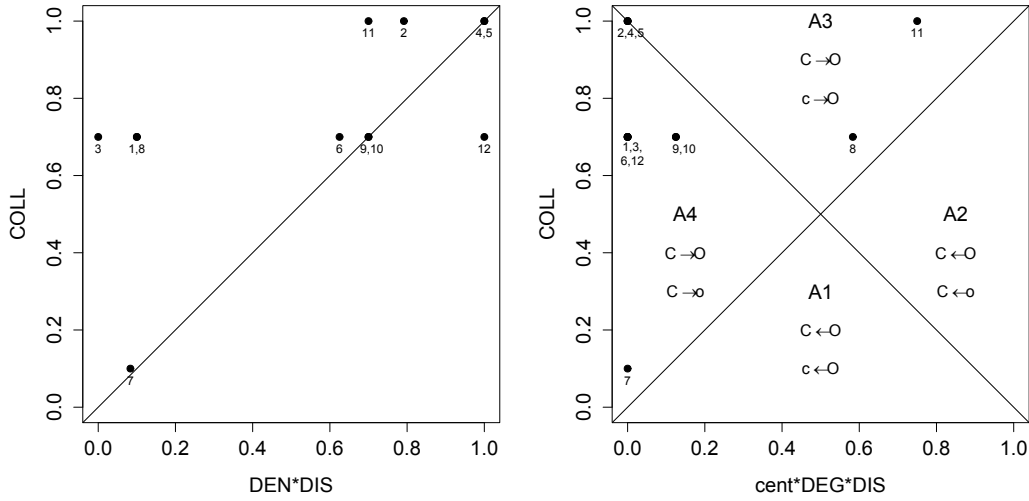


Figure 2: Sufficient conditions for the outcome collaboration

Note: Uppercase letters refer to presence, lowercase to absence of condition (C) or outcome (O). Arrow indicates implication.

First, the first combination of conditions, DEN · DIS, refers to groups, whose network density and number of discussion posts were high. Therefore, the group members were tightly linked with each other and discussed frequently. This combination covers 8 cases within 4 configurations (see Table 4). For example, configuration 16 with cases 4, 5 and 12 – notably is the large number of discussion post that can be seen as characteristic for this configuration as well as for this combination of conditions. I refer to this combination of conditions as *Balanced Collaboration*, as these groups collaborated – with regard to my conceptualisation – and worked synchronously in an equal manner.

Second, the second combination of conditions, cent · DEG · DIS, refers to groups, whose network showed less balanced collaboration than the previous combination. Instead, these groups showed a higher median of weighted degrees and less discussion posts. This combination covers 2 cases within 2 configurations (see Table 4). When using discussion posts to back up interpretation of this combination, it becomes obvious that in both cases groups had one member that took responsibility for collaboration. For example: in case 8, one member left a message on each group member's personal wiki page, wherein the member was called to get in touch with other members on the discussion page. Furthermore, the message prompted group members to give feedback to an initial draft, to adjust schedules and communication channels. I refer to this type as *Primus Inter Pares Collaboration*, as these groups collaborated, but

were directed by one group member who organised collaboration acting as *primus inter pares*.

Third, the number of discussion posts (DIS) is present in both combinations of conditions and therefore points to the importance of communication for collaboration. This is also highlighted by the parsimonious solution $\text{DIS} \rightarrow \text{COLL}$, even though it was derived using contradictory simplifying assumptions. However, this result is consistent with theories of collaborative learning that stress the importance of communication for collaboration (e.g. Dillenbourg, 1999).

In the following, I discuss how the sufficient combinations of conditions for the outcome *collaboration* (see Table 4) can be used to provide actionable data for teachers.

When the social network indices and the number of discussion posts of a group comply with one of the combinations above, the group has collaborated, in the majority of cases. Correspondingly, each group that has not met one of the combinations is likely to have failed in group collaboration. Using this knowledge, a teachers' dashboard can be implemented that calculates these indices in real-time and thus allows teachers to monitor group collaboration. But although the solution formula (Table 4) cover a large percentage of all observed cases, both combinations are only sufficient. Therefore, when used as indicators, they are not immune against false positives and vice versa. As a consequence, a dashboard can provide assistance only, but does not substitute the teacher. Additionally, both combinations can be used to indicate collaboration only, which is not necessarily correlated with high quality in form and content. However, by reducing time and effort necessary, a dashboard enables teachers to assist groups in overcoming problems.

4.2 Limitations and further research directions

From a research perspective, the identified combinations can be used to implement a tutors' dashboard. Also, fuzzy set QCA has been introduced as a method that is able to incorporate pedagogical considerations into the subject area of learning analytics. However, this study has some limitations that point to further research directions.

First, I evaluated collaboration based on three dimensions: synchronicity, negotiation, and interaction. While synchronicity was assessed using SNA, negotiation and interaction were evaluated using a pre-defined coding scheme for content analysis based on discussion pages (Kummer, 2013). This had two consequences: first, only collaboration that took place in the wiki was included in the analysis, second, the simple coding scheme reduced the time needed for evaluation, but limited the

meaningfulness of the evaluation result. However, I refrained from using more sophisticated content analysis schemes (Strijbos et al., 2006; de Wever et al., 2006), as the in-depth study of collaborative processes is not the main focus of this research.

Second, I selected conditions that can be calculated in real-time, as sufficient combinations should be used for real-time monitoring of group collaboration performance. In order to create a comprehensive picture of group collaboration, further research should investigate whether results from different analyses can be incorporated into fsQCA. For example, Alyousef and Picard (2011) mapped meta-discourse markers to collaboration. Meta-discourse markers can be used to detect interaction in written text (Hyland, 2005) and can be evaluated by using text mining algorithms automatically.

Third, despite the potential benefits of using both combinations as indicators, the results presented are based on an ex post analysis. All conditions could have been collected, apart from the outcome. According to my conceptualisation of collaboration, collaboration emerges from shared practice and becomes manifest in interaction, negotiation, and synchronicity (Dillenbourg, 1999). As interaction and negotiation develop over time, I refrained from continuous evaluation of collaboration. Therefore, further analysis is necessary to examine whether both combinations remain sufficient at any moment of the project duration. Although this limits the validity of this research's sufficient combinations, it reveals the powerfulness of the approach presented.

5 Conclusion

In this study, I derived meaningful indicators for collaboration by using multiple research methods. In the first step, QDA and SNA were used to evaluate wiki data resulting in the assessment of collaboration for 12 groups. In the second step, social network indices (e.g. DEN), a descriptive measure (DIS), and my evaluation of collaboration (COLL) were used for fsQCA. As a result, sufficient conditions for collaboration were identified that point to two strategies that have been used by groups to succeed in collaboration: *Balanced Collaboration* and *Primus Inter Pares Collaboration*. As both strategies represent successful collaboration, they can be used as a reference indicating effective collaboration. Therefore, they can be used as indicators when implementing a dashboard that supports the teacher in monitoring students' interaction.

With fsQCA, I introduced a method to derive indicators that enable researchers to incorporate educational objectives into learning analytics. However, this method is not limited to learning analytics and has several benefits.

First, researchers become less reliant on relations within data, as calibration gives researchers the possibility to interpret data based on their conceptualisation. Thereby, QCA in general and my approach in specific combine both strengths from qualitative and quantitative research. In this study, for example, I was able to reproduce my conceptualisation of collaboration based on the calibration of data. While the calibration of data is a highly interpretative process, consistency and coverage of the solution formula can provide evidence for researcher's conceptualisation in data.

Second, QCA can work with small sets of data. It can be used by researchers to hypothesise or test theories, develop indicators, or to analyse data in detail, before they evaluate the robustness of their findings on big sets of data. Thereby, researchers can take challenging sets of data into account that can either be retrieved from an information system or be the result of a previous analysis like in this study. As a consequence, researchers can include diverse data sets into analysis, e.g., demographic characteristics or location-based data.

Summarised, I derived meaningful indicators for collaboration and presented a method that has proven to be capable of connecting different academic fields: Educational Science and Information Systems.

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References

- Alyousef, H. S. & Picard, M. Y. (2011). Cooperative or collaborative literacy practices: Mapping metadiscourse in a business students' wiki group project. *Australasian Journal of Educational Technology*, 27(3), 463–480.
- Aviv, R., Erlich, Z., Ravid, G. & Geva, A. (2003). Network analysis of knowledge construction in asynchronous learning networks. *Journal of Asynchronous Learning Networks*, 7(3), 1–23.
- Bakharia, A. & Dawson, S. (2011). SNAPP: A bird's-eye view of temporal participant interaction. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge - LAK '11* (pp. 168–173). doi:10.1145/2090116.2090144
- Berg-Schlosser, D., De Meur, G., Rihoux, B. & Ragin, C. C. (2009). Qualitative comparative analysis (QCA) as an approach. In B. Rihoux & C. C. Ragin (Eds.), *Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques* (Chap. 1, pp. 1–18). Thousand Oaks: Sage.

- Blikstein, P. (2011). Using learning analytics to assess students' behavior in open-ended programming tasks. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge - LAK '11* (pp. 110–116). doi:10.1145/2090116.2090132
- Brown, J. S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32–42. doi:10.3102/0013189X018001032
- Chatti, M. A., Dyckhoff, A. L., Schroeder, U. & Thüs, H. (2012). A reference model for learning analytics. *International Journal of Technology Enhanced Learning*, 4(5/6), 318–331. doi:10.1504/IJTEL.2012.051815
- de Laat, M., Lally, V., Lipponen, L. & Simons, R.-J. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for social network analysis. *International Journal of Computer-Supported Collaborative Learning*, 2(1), 87–103. doi:10.1007/s11412-007-9006-4
- de Wever, B., Schellens, T., Valcke, M. & Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education*, 46(1), 6–28. doi:10.1016/j.compedu.2005.04.005
- Dillenbourg, P. (1999). What do you mean by 'collaborative learning'? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (Chap. 1, pp. 1–19). Oxford: Elsevier. Retrieved from <http://halshs.archives-ouvertes.fr/docs/00/19/02/40/PDF/Dillenbourg-Pierre-1999.pdf>
- Dringus, L. P. & Ellis, T. (2005). Using data mining as a strategy for assessing asynchronous discussion forums. *Computers & Education*, 45(1), 141–160. doi:10.1016/j.compedu.2004.05.003
- Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *International Journal of Technology Enhanced Learning*, 4(5/6), 304–317. doi:10.1504/IJTEL.2012.051816
- Harrer, A., Zeini, S. & Pinkwart, N. (2005). The effects of electronic communication support on presence learning scenarios. In T.-W. Chan (Ed.), *The next 10 years!: Proceedings of the International Conference on Computer Support for Collaborative Learning 2005* (pp. 190–194). Morristown, NJ: Association for Computational Linguistics. doi:10.3115/1149293.1149317
- Haythornthwaite, C. (2006). Facilitating collaboration in online learning. *Journal of Asynchronous Learning Networks*, 10(1), 7–24.
- Hyland, K. (2005). *Metadiscourse: Exploring interaction in writing*. London: Continuum International.

- Johnson, D. W. & Johnson, R. T. (1994). *Learning together and alone: Cooperative, competitive, and individualistic learning* (4th ed.). Boston, MA: Allyn & Bacon.
- Kummer, C. (2013). *Facilitating collaboration in wikis*. doi:10.2139/ssrn.2250367
- Laal, M. & Ghodsi, S. M. (2012). Benefits of collaborative learning. *Procedia - Social and Behavioral Sciences*, 31, 486–490. doi:10.1016/j.sbspro.2011.12.091
- Lally, V. & de Laat, M. (2002). Cracking the code: Learning to collaborate and collaborating to learn in a networked environment. In G. Stahl (Ed.), *Proceedings of the Conference on Computer Support for Collaborative Learning: Foundations for a CSCL Community* (pp. 160–168).
- Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Learning in doing. Cambridge, MA: Cambridge University.
- Lin, H. & Kelsey, K. D. (2009). Building a networked environment in wikis: The evolving phases of collaborative learning in a wikibook project. *Journal of Educational Computing Research*, 40(2), 145–169. doi:10.2190/EC.40.2.a
- Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.
- Martínez, A., Dimitriadis, Y., Gómez-Sánchez, E., Rubia-Avi, B., Jorrín-Abellán, I. & Marcos, J. A. (2006). Studying participation networks in collaboration using mixed methods. *International Journal of Computer-Supported Collaborative Learning*, 1(3), 383–408. doi:10.1007/s11412-006-8705-6
- Pörksen, B. (2009). The end of arbitrariness: The three fundamental questions of a constructivist ethics for the media. *Constructivist Foundations*, 4(2), 82–90.
- Ragin, C. C. (1987). *The comparative method: Moving beyond qualitative and quantitative strategies*. Berkeley: University of California.
- Ragin, C. C. (2000). *Fuzzy-set social science*. Chicago: The University of Chicago.
- Ragin, C. C. (2009). Qualitative comparative analysis using fuzzy sets (fsQCA). In B. Rihoux & C. C. Ragin (Eds.), *Configurational comparative methods: qualitative comparative analysis (QCA) and related techniques* (Chap. 5, pp. 87–121). Thousand Oaks: Sage.
- Ragin, C. C. & Sonnett, J. (2004). Between complexity and parsimony: Limited diversity, counterfactual cases, and comparative analysis. In S. Kropp & M. Minkenberg (Eds.), *Vergleichen in der Politikwissenschaft* (pp. 180–197). Wiesbaden: VS Verlag für Sozialwissenschaften.
- Rihoux, B. (2006). Qualitative comparative analysis (QCA) and related systematic comparative methods: Recent advances and remaining challenges for social science research. *International Sociology*, 21(5), 679–706. doi:10.1177/0268580906067836
- Rihoux, B. & De Meur, G. (2009). Crisp-set qualitative comparative analysis. In B. Rihoux & C. C. Ragin (Eds.), *Configurational comparative methods: Qualitat-*

- ive comparative analysis (QCA) and related techniques* (Chap. 3, pp. 33–68). Thousand Oaks, CA: Sage.
- Strijbos, J.-W. (2011). Assessment of (computer-supported) collaborative learning. *IEEE Transactions on Learning Technologies*, 4(1), 59–73. doi:10.1109/TLT.2010.37
- Strijbos, J.-W., Martens, R. L., Prins, F. J. & Jochems, W. M. (2006). Content analysis: What are they talking about? *Computers & Education*, 46(1), 29–48. doi:10.1016/j.compedu.2005.04.002
- Thiem, A. & Duşa, A. (2013). *Qualitative comparative analysis with R*. New York, NY: Springer. doi:10.1007/978-1-4614-4584-5
- Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University.
- Wagemann, C. & Schneider, C. (2007). *Standards of good practice in qualitative comparative analysis (QCA) and fuzzy-sets*. Retrieved from <http://www.compasss.org/wpseries/WagemannSchneider2007.pdf>
- Wasserman, S. & Faust, K. (1994). *Social network analysis: Methods and applications*. Structural analysis in the social sciences. Cambridge, MA: Cambridge University.
- Wendler, R., Bukvova, H. & Leupold, S. (2013). Qualitative comparative analysis in Information Systems and Wirtschaftsinformatik. In R. Alt & B. Franczyk (Eds.), *Proceedings of 11th International Conference on Wirtschaftsinformatik (WI2013)* (Vol. 2, pp. 1457–1471). Leipzig.
- Yamasaki, S. & Rihoux, B. (2009). A commented review of applications. In B. Rihoux & C. C. Ragin (Eds.), *Configurational comparative methods: qualitative comparative analysis (QCA) and related techniques* (Chap. 6, pp. 123–145). Thousand Oaks, CA: Sage.
- Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.