Development and Evaluation of a Behavior Change Support System Targeting Learning Behavior

A Technology-Based Approach to Complement the Education of Future Executives Using Persuasive Systems in Higher Education

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Note: All essays in this dissertation have been slightly modified compared to their published version to facilitate readability. Modifications include a continuous page count, adjusted formatting of headings, tables, and figures, adapted references to other sections, and a central list of references at the end of this dissertation.

List of Essays

This dissertation is based on eight scientific essays. The essays are introduced with the corresponding outlet alongside its current ranking in the "WI-Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik im Verband der Hochschullehrer für Betriebswirtschaft e.V. (WKWI) und des Fachbereichs Wirtschaftsinformatik der Gesellschaft für Informatik (GI-FB WI)" as well as the "VHB-JOURQUAL 3 des Verbands der Hochschullehrer für Betriebswirtschaft e.V. (VHB)". In addition, the research highlights of each essay are presented, and for essays with multiple authors, the share contributed by the author of this dissertation is mentioned.

This dissertation is structured according to a three-cycle view of design science research formulated by Hevner (2007). Design science research is a methodology that aims to improve the environment by introducing new and innovative artifacts. The generic structure of the three cycles is presented in the following:

Design science research approaches typically 1) start with an analysis of opportunities and problems in the addressed environment. From this, requirements for the artifact can be derived. In addition to the environment, design science research also 2) integrates the knowledge base. The knowledge base provides insights for selecting and applying appropriate theories and methods for designing, structuring, and evaluating the artifact. At the center of design science research is 3) the construction of an artifact, its evaluation, and subsequent feedback to further refine its design (Hevner 2007).

In order as mentioned in the thesis and structured according to design science research (Hevner 2007):

Essays Addressing the Environment

1. Vay, Christian; Steinherr, Vanessa Maria (2023). Leadership in a Digitalized and Crisis-ridden World: Towards a Comprehensive Overview of Relevant Competencies for Leaders. In: 56th Hawaii International Conference on System Sciences (HICSS). Lahaina, USA, January 2-6.

   Highlights:
   - We conduct a systematic literature review on competencies within the digital leadership and crisis leadership literature.
   - We identify 38 articles and synthesize 288 mentions of competencies within both research fields.
   - Clustering the identified 288 mentions of competencies leads to 21 competence areas.
   - We present these 21 competence areas by categorizing the competencies according to self-management, people management, and business management.
   - Divided into self-management, people management, and business management the article depicts the extent to which the identified competencies of digital leadership and crisis leadership overlap or complement each other.
   - This resulting overview provides guidance for educators on what competencies are important when developing training programs for future leaders.

   Ranking (Share: 50%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked C

   available online:
   https://hdl.handle.net/10125/103194
   urn:nbn:de:bvb:384-opus4-1015907

2. Steinherr, Vanessa Maria; Vay, Christian (2021). Personal Skills in the BISE Curriculum: An Integrative Approach. Research-in-Progress. In: 17. Internationale Tagung Wirtschaftsinformatik (WI). Research in Progress. Nürnberg, Germany / Virtual Conference, February 21-23.

   Highlights:
   - We highlight and verify the relevance of soft skill training for future executives who are currently attending universities based on literature.
   - We summarize the defined requirements for higher education formulated in the "Guidelines for Education in Business Information Systems Engineering at Tertiary Institutions" and the findings of the theoretical background of self-leadership (Neck and Houghton 2006) as well as the experiential learning theory (Kolb 1984).
   - Based on a complementary systematic review investigating the literature on soft skill training in the context of higher education for techno-economic courses we derive concrete needs for successful soft skill training.
   - Considering these insights, we present an approach that systematically integrates the training of personal skills into a basic Business Information Systems Engineering lecture for first-semester students, in form of an interactive video.

   Ranking (Share: 50%)
   WI-Orientierungslisten: Ranked A
   VHB-JOURQUAL 3: Ranked C

   available online:
   https://aisel.aisnet.org/wi2022/digital_education/digital_education/5/
   urn:nbn:de:bvb:384-opus4-962176

3. Steinherr, Vanessa Maria; Reinelt, Ramona (2022). Using Hexad User Types to Identify Motivational Preferences among Learners. In: 28th Americas Conference on Information Systems (AMICIS). Minneapolis, USA, August 10-14.

   Highlights:

   - The study examines the potential of the Hexad framework (Marczewski 2013) to characterize students according to their motivational preferences.
   - Since the Hexad framework was developed to distinguish between six motivational preferences of users of gamified information systems, but the authors suggest a broad potential field of application, we conduct a systematic literature review on the current application context of the Hexad framework.
   - The literature review reveals application contexts such as health, sustainability, warehouse management, or education. This indicates that the Hexad framework is only used in combination with information systems.
   - According to the literature review, this study is the first to examine the context shift of the Hexad framework outside information systems into the environment of educational settings such as lectures or seminars.
   - To initially determine the fit between the defined motivational preferences within the Hexad framework and the motivational preferences of higher education students, we conducted a role play with 63 participants. In this role-play we assigned students to personas that were characterized according to the previously identified Hexad user types of students.
   - Students' reflections on their experiences with their assigned motivational preferences in the role play show that the Hexad framework can identify different motivational preferences within the learners.

   Ranking (Share: 50%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked D

   available online:
   https://aisel.aisnet.org/amcis2022/sig_ed/sig_ed/6/
   urn:nbn:de:bvb:384-opus4-962151

Essays Addressing the Knowledge Base

4. Merz, Marieluise; Steinherr, Vanessa Maria (2022). Process-based Guidance for Designing Behavior Change Support Systems - Marrying the Persuasive Systems Design Model to the Transtheoretical Model of Behavior Change. Communications of the Association for Information Systems. 50, 337-357.

   Highlights:
   - We develop a model that combines the findings of the persuasive systems design model (Oinas-Kukkonen 2013) and the transtheoretical model of behavior change (Prochaska and DiClemente 1983).
   - By combining the technical perspective of the persuasive systems design model (Oinas-Kukkonen 2013) and the psychological needs along the stages of change (Prochaska and DiClemente 1983), the developed model provides a guide for selecting effective design principles for developing behavior change support systems.
   - Based on theory and a systematic literature review, we identify 85 links between the design principles of the persuasive systems design model and the stages of change.
   - The resulting model defines 11 design principles as basic requirements and categorizes 17 design principles into four levels of recommendation along users' behavior change stages.

   Ranking (Share: 50%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked C

   available online:
   https://doi.org/10.17705/1CAIS.05014
   urn:nbn:de:bvb:384-opus4-961688

5. Steinherr, Vanessa Maria; Merz, Marieluise (2023). Design Principles for Persuasive Systems: Towards a Design Framework for Developing Behavior Change Support Systems. Under review in: ACM Transactions on Computer-Human Interaction (TOCHI).

   Highlights:

   - We develop a model that specifies the persuasive systems design model and provides a guideline for developing behavior change support systems.
   - We synthesize existing design knowledge from theoretical and practical studies to systematically derive 14 design principles.
   - Following the process for design principle development of Möller et al. (2020) and the design principles schema of Gregor et al. (2020), we aggregate 125 concepts of design knowledge into 14 design principles.
   - We evaluate the set of new design principles in terms of their ability to clearly articulate design knowledge, using the interrater reliability of two independent persuasive systems designers coding 43 descriptive statements.
   - The resulting Cohen's Kappa of $\kappa = 0.99$ for a total of 602 coded variables indicates almost perfect interrater reliability, suggesting that the set of design principles developed clearly codifies prescriptive design knowledge in the context of behavior change support systems.
   - The 14 formulated design principles provide researchers and developers with explicitly formulated prescriptive knowledge about how to design, evaluate, and develop behavior change support systems.

   Ranking (Share: 65%):
   WI-Orientierungslisten: Ranked A
   VHB-JOURQUAL 3: Ranked B

Essays Addressing the Design and Evaluation of the Central Artifact

6. Steinherr, Vanessa Maria (2021). LANA: A Behavior Change Support System towards Self-regulated Learning. In: 27th Americas Conference on Information Systems (AMCIS). Montreal, Canada / Virtual Conference, August 9-13.

   Highlights:
   - We conducted a literature review on behavior change support systems in the context of higher education, which identified the need for behavior change support systems in higher education that target student learning behaviors.
   - We present the process for developing a new behavior change support system, including a detailed context analysis, following the persuasive systems design model (Oinas-Kukkonen 2013).
   - We explain and depict the modes of action and functionalities of the newly developed behavior change support system targeting self-regulated learning.
   - The evaluation of the behavior change support system is based on the technology acceptance model by Davis (1986) and emphasizes users' acceptance and the potential to support students in improving their learning behavior.
   - Complementing qualitative feedback from the user group identifies concrete improvement ideas for the behavior change support system towards self-regulated learning.

   Ranking (Share: 100%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked D

   available online:
   https://aisel.aisnet.org/amcis2021/is_education/sig_education/5
   urn:nbn:de:bvb:384-opus4-962185

7. Steinherr, Vanessa Maria (2023). Design Requirements for Behavior Change Support Systems with High Use Continuance: Insights for the Target Group of Students. In: 56th Hawaii International Conference on System Sciences (HICSS). Lahaina, USA, January 2-6.

   Highlights:

   - First, we present the second iteration of the prototype of a behavior change support system towards self-regulated learning and its evaluation through its target group of higher education students.
   - We surveyed 54 students using the perceived persuasiveness questionnaire and open fields for students' qualitative feedback.
   - Based on students' answers 19 design requirements were identified that can promote students' use continuance.
   - In order to make the design requirements identified through the evaluation of a concrete behavior change support systems transferable to other behavior change support systems targeting students, we derive ten more general meta-requirements.

   Ranking (Share: 100 %):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked C

   available online:
   https://hdl.handle.net/10125/102995
   urn:nbn:de:bvb:384-opus4-1015883

8. Steinherr, Vanessa Maria (2023). Development of a Behavior Change Support System that Targets Learning Behavior: Examining the Effect of Rewards and Social Comparison. Under review for: Proceedings of the 44th International Conference on Information Systems (ICIS), Hyderabad, India, December 10-13.

   Highlights:
   - We initially present the third prototype of a behavior change support system towards self-regulated learning and its evaluation by its target group of higher education students.
   - Addressing the identified needs and demands formulated by the target group, as well as considering the model of motivation by Richter et al. (2015), we describe two versions of the third prototype, eighter fostering external motivation or social motivation.
   - The paper presents application examples of the design principle of social comparison, targeting social motivation, and the design principle of rewards, targeting extrinsic motivation.
   - The comparison of the two prototype versions shows that the design principle of social comparison leads to significantly higher perceived effectiveness and social support among students compared to the design principle of rewards.
   - We identify positive significant effects of perceived effectiveness and primary task support on students' use continuance of the behavior change support system.

   Ranking (Share: 100 %):
   WI-Orientierungslisten: Ranked A
   VHB-JOURQUAL 3: Ranked A

In addition to the essays included in this dissertation, the following essays were contributed during the dissertation project:

9. Steinherr, Vanessa Maria; Graeber, Simon; Rudenko, Sasha (2022). Persuasive systems to support behavior change in the context of higher education. In: 17th International Conference on Design Science Research in Information Systems and Technology (DESRIST), St. Petersburg, FL, USA, June 1–3.

   Ranking (Share: 90 %):
   WI-Orientierungslisten: not listed
   VHB-JOURQUAL 3: Ranked C

   available online:
   https://www.usf.edu/business/documents/desrist/paper_107.pdf
   urn:nbn:de:bvb:384-opus4-962131

10. Steinherr, Vanessa Maria; Vay, Christian (2023). Leadership Education in a Technology-enhanced Learning Environment: The Relation between Self-regulated Learning and Self-Leadership. In: Proceedings of the 31st European Conference on Information Systems (ECIS). Kristiansand, Norway, June 11-16.

    Ranking (Share: 50 %):
    WI-Orientierungslisten: Ranked A
    VHB-JOURQUAL 3: Ranked B

    available online:
    https://aisel.aisnet.org/ecis2023_rp/370/
    urn:nbn:de:bvb:384-opus4-1051159

1 Introduction

There is a growing demand for a comprehensive, low-barrier support that guides students in higher education to build and maintain learning competencies throughout the course of their academic careers (Selvi 2022; Oliveira et al. 2021; Edisherashvili et al. 2021; Taranto and Buchanan 2020; Wong et al. 2019).

Learning competencies are essential for students' academic careers and can be attributed to self-regulated learning, as both researchers and educators identify self-regulated learning as the most effective learning behavior (Boekaerts 1999). Self-regulated learning refers to learners taking responsibility for their own learning outcomes by metacognitively, motivationally, and behaviorally shaping their own learning process (Zimmerman 1990; Zimmerman and Schunk 2011). This is particularly important in higher education, where learning is characterized by a high degree of freedom (Steh and Saric 2020). With the rise of hybrid and digital learning environments in higher education, students' responsibility for their own learning process is even increasing, and so is the demand for self-regulated learning (Edisherashvili et al. 2021). Moreover, the importance of self-regulated learning goes beyond students' academic education, as it also affects students' future careers (Sitzmann and Ely 2011; Steinherr and Vay 2023), particularly if students aspire to leadership roles competencies in learning are crucial (Vay and Steinherr 2023). Consequently, self-regulated learning competencies are understood as effective and necessary competencies to prepare students for the current learning societies of today's technologically complex and economically competitive environments (Taranto and Buchanan 2020).

While research shares a clear understanding of self-regulated learning promoting academic as well as professional development, inadequate self-regulated learning increases students' risk of entering a "cycle of failure" (Patel et al. 2015). Poor self-regulated learning competencies are associated with lower task value and self-efficacy beliefs, but greater anxiety, frustration, and boredom among students (Artino et al. 2011). This is alarming, because struggling students are often unable to overcome their difficulties on their own. Reasons include an inappropriate choice of learning strategies, poor handling of failure, and external attribution of arising problems (Patel et al. 2015). Learners with low levels of self-regulation also typically perceive high barriers to support, such as help from instructors or peers (Patel et al. 2015).

Given the increasing demand for self-regulated learning competencies and the reluctance of struggling students to seek support, easily accessible self-regulated learning support

systems are a promising solution (Wong et al. 2019). In particular, Behavior Change Support Systems (BCSS) have shown success in helping users change their habits to the desired behavior in multiple contexts (Merz and Ackermann 2021). Some BCSS are often already integrated into people's daily lives, such as smartphone apps that track users' physical activity and help them become healthier (Schneider et al. 2016). However, recent literature reviews could not identify a BCSS for self-regulated learning, indicating a research gap: From a technical perspective, the application context of BCSS is constantly evolving, but there is still a lack of research on BCSS that target student learning behaviors (Merz and Ackermann 2021; Steinherr 2021). From a pedagogical perspective, supportive systems to promote self-regulated learning are on the rise, but research on self-regulated learning addressed by a BCSS is deficient (Wong et al. 2019).

The success of the support systems strongly depends on their concrete design, students' perception and their intention to engage with the systems (Wong et al. 2019; Merz and Steinherr 2022). When designing BCSS, the Persuasive Systems Design (PSD) model provides guidelines and 28 design principles (Oinas-Kukkonen 2013). However, while the PSD model emphasizes the importance of the contextual and user-centric design of BCSS, it lacks instructions on how to do so (Merz and Steinherr 2022). With the aim of generating knowledge about BCSS in the context of higher education, targeting the learning behavior of higher education students, this dissertation investigates the design and students' perception of a BCSS targeting self-regulated learning. Addressing the current research gap, we raise the superordinate question: *How should a BCSS be designed to support higher education students in changing their behavior towards self-regulated learning?*"

This dissertation answers this research question following a design science research (DSR) approach according to Hevner (2007) and Hevner and Chatterjee (2010) that combines essays about 1) the environment, studying required competencies and students' needs so that universities can prepare their graduates for work environments, 2) the knowledge base, developing theoretical knowledge that guides designing BCSS, and 3) the specific design of the central artifact, a BCSS towards self-regulated learning including its evaluation. The central artifact is called LANA (= Learning ANAlysis) and will be further iteratively revised based on feedback from the target group.

Figure 1 provides an overview of the essays in the dissertation and categorizes them according to the three research areas following DSR by Hevner (2007). The essays can each be clearly assigned to one category based on their thematic focus and their contributions

to the dissertation. However, each essay in this dissertation is designed on a foundation of practical relevance and academic rigor.

Environment	Information Systems Design	Knowledge Base
Essay 1: Personal Skills in the BISE Curriculum: An Integrative Approach **Essay 2:** Leadership in a Digitalized and Crisis-ridden World: Towards a Comprehensive Overview of Relevant Competencies for Leaders **Essay 3:** Using Hexad User Types to Identify Motivational Preferences among Learners	**Essay 6:** LANA: a Behavior Change Support System towards Self-regulated Learning **Essay 7:** Design Requirements for Behavior Change Support Systems with High Use Continuance: Insights for the Target Group of Students **Essay 8:** Development of a Behavior Change Support System Targeting Learning Behavior: Examining the Effects of the Design Principles Rewards and Social Comparison	**Essay 4:** Process-based Guidance for Designing Behavior Change Support Systems **Essay 5:** Design Principles for Persuasive Systems: Towards a Design Framework for Developing Behavior Change Support Systems

Figure 1: Design Science Research Framework (Hevner 2007) and Essays of the Dissertation

The first three essays analyze the environment of the target group of the developed BCSS LANA fostering self-regulated learning. The target group is defined as higher education students. The aim of these essays is to identify the requirements for an effective and comprehensive education program at universities. The results of these essays contribute to the target group-oriented design of the BCSS as a method of training higher education students in the required competencies to prepare them as future executives. This is based on the conviction that higher education institutions should fulfill their responsibility to develop future leaders (Chunoo and Osteen 2016). In order to develop a valuable support system for higher education students, the first step is to identify relevant content for the support system and effective approaches to reach the target group.

Against this background, **Essay 1** investigates relevant competencies future executives need in order to operate in the current crisis-ridden and digitalized environment. A literature review of the competencies described in the research areas of crisis leadership and digital leadership reveals 38 articles with a total of 288 individual mentions of competencies. Clustering these 288 mentions results in 21 different competence areas. To explore different perspectives of these 21 competence areas, they are categorized considering the perspectives of business-, people- and self-management. The literature review identifies competencies that are frequently mentioned in both the crisis leadership and digital leadership literature, such as learning, communication, and decision making. In addition, some identified competencies, for example, situational awareness, are only mentioned in

one research area, crisis leadership or digital leadership. We understand that all the identified competencies are relevant to the comprehensive education of future leaders. However, we suggest that the most frequently mentioned competencies, such as learning, should be addressed with high priority.

Building on this, **Essay 2** investigates the current state of teaching at higher education institutions. As identified in Essay 1, in the increasingly complex and dynamic world, the education of higher education students should include subject-specific content but also requires training of soft skills in order to equip higher education students with competencies required in future work environments. The Business and Information Systems Engineering (BISE) society is aware of the need for a holistic education during the student's academic career, covering both technical and soft skills. However, existing approaches to soft skill training for students are often inadequate and integrate soft skills development mostly implicitly, usually without quantitatively measuring the impact on students. Based on a systematic literature review, we identified concrete requirements for effective soft skill training in higher education contexts for BISE students. For example, it is crucial for students to take an active role in soft skill training.

Following insights based on what competencies are important (Essay 1) and what is needed for effective training of the soft skills required for future leaders (Essay 2), **Essay 3** explores the motivational preferences of the target group. The goal is to find out how to design courses for higher education students that motivate them to participate and engage. The knowledge base on motivational theories provides various concepts that address students' motivation. These theories often explain motivation within the individual in a rather abstract form or focus on complex cause-and-effect relationships, while concrete and tangible strategies for motivating students based on individual preferences are lacking. One framework that provides tangible advice on how to motivate students based on their individual motivational preferences is the Hexad framework. There are reports of positive effects on motivation when the framework is considered in the design of information systems, but there is no research on the use of the framework outside of information systems. Essay 3 examines the changing application context of the Hexad farmwork outside information systems to learning in higher education. The fit between students' motivational preferences of their Hexad user types and their motivational preferences as learners shows a high rate of identification, based on qualitative feedback from 63 students. Regardless of the students' corresponding Hexad user type, all students show high levels of learning orientation and social orientation. Overall, Essay 3 suggests that in higher education, it is valuable not to present a one-size-fits-all solution, but to consider

the different motivational preferences of students and to integrate elements that foster motivation according to the Hexad user types, such as social support for the socializer user type or a reward system for the externally motivated player user type.

The following essays (Essays 4 - 5) focus on the theory of designing BCSS. Their results contribute to the knowledge base on how to design BCSS and how to communicate the design knowledge generated in the context of persuasive systems.

When designing BCSS the PSD model by Oinas-Kukkonen and Harjumaa (2009) guides developers in implementing the systems. However, while the framework lists and defines 28 integrable design principles, it lacks information on how and when to select these principles. To address this, **Essay 4** presents a new model with recommendations for selecting appropriate PSD design principles considering users' progress in behavior change. We enrich the technological perspective of the PSD model with the psychological insights of the transtheoretical model of Prochaska and DiClemente (1983). The transtheoretical model defines stages of change that people progress when changing behavior: precontemplation, contemplation, preparation, action, and maintenance (maintenance further leads to termination) (Prochaska and Norcross 2001). Combining the design principles of the PSD model with the needs to advance the stages of behavior change of the transtheoretical model, we mapped the 28 design principles to the stages of change based on their potential to address users' needs along the behavior change process. Based on this mapping, we identify 11 design principles that act as basic requirements for BCSS because they are important along all stages of change. We then categorize the remaining 17 design principles into four levels of recommendation based on their potential to address the underlying needs of users along the four stages of behavior change. Our mapping is then validated through a systematic literature review. The resulting model provides a specification of the PSD model and guidance for selecting effective design principles for BCSS development.

Essay 5 addresses the need for a clear codification of design knowledge in the research field of persuasive systems. The essay, therefore, presents our approach to systematically derived design principles for BCSS. Following the framework for the development of design principles by Möller et al. (2020), we apply the supportive approach to systematically derive design principles. We synthesize existing design knowledge based on a state-of-the-art analysis of theoretical and practical studies to systematically aggregate 125 design concepts. The identified 125 design concepts form the basis for deriving a concise and comprehensive set of 14 design principles for BCSS. To ensure a clear codification

of design knowledge, the formulation of the design principles follows the design principles schema of Gregor et al. (2020). These newly formulated design principles include specifications of design principles provided by the PSD model, such as *praise* and *rewards*, but also introduce additional concepts, such as *goal setting*. The resulting set of 14 design principles provides explicitly formulated, prescriptive knowledge for designing, evaluating, and developing BCSS.

Based on the findings of the investigation of the environment and theoretical knowledge base, Essays 6 - 9 address the practical implementation of a BCSS towards self-regulated learning.

Essay 6 presents the initial development process of the BCSS for self-regulated learning. For the initial approach of designing a BCSS for self-regulated learning, we conduct a wide systematic literature review including eight databases with economic, technical, educational, and psychological backgrounds: AISel, Ebscohost, ERIC, IEEE, Pro-quest, PubPsych, Web of Science, and WISO. Searching in titles and abstracts using the search string ("Behavior Change Support System*" OR "Persuasive Technolog*" OR "Persuasive System*") AND (learn* OR education OR student*) revealed 70 articles. Out of these, 18 articles describe persuasive technology in the context of higher education. The literature review reveals the needs and potential of BCSS for students but also reveals the research gap regarding BCSS for self-regulated learning. The consecutive development of the BCSS is based on the theoretical foundation of the PSD model including a context analysis to consider the target users. To ensure an easily accessible character, we implemented the BCSS as a Flutter-based web application. Flutter is an open-source UI software development kit that allows a single code base to be used for both iOS and Android applications. To build, test, and deploy the Flutter-based BCSS, we used Android Studio as our development environment with Dart as the corresponding programming language. After the implementation phase, we evaluate the developed BCSS. Since BCSS in general are not yet established in the higher education context, Essay 6 investigates the acceptance among the target user group as a required precondition of BCSS' impact. Thus, the evaluation of the BCSS is based on the Technology Acceptance Model (TAM) (Davis 1986) and emphasizes user acceptance as well as the potential to support students in improving their learning behavior. It identifies students' perceived usefulness as having a positive and significant influence on their intention to use the system. Incorporating the theoretical background of self-regulated learning appeals to be relevant and is emphasized by stu-

dents, and thus promoting their perceived usefulness. Furthermore, the students' qualitative feedback reveals concrete improvement ideas for BCSS towards self-regulated learning.

Following the iterative nature of DSR, we built on these findings to substantially revise the artifact to incorporate students' feedback, while maintaining the theme of self-regulated learning. In **Essay 7**, we present the second iteration of the BCSS towards self-regulated learning. The resulting prototype of the second iteration is again designed according to the PSD model but also incorporates students' feedback gathered in Essay 6. As Essay 6 identified a high level of acceptance and appreciation among students of the BCSS towards self-regulated learning, Essay 7 investigates design features that influence students' use continuance. Use continuance is a necessary precondition for long-term behavioral outcomes. Based on qualitative feedback from 54 students and quantitative data from 25 students, we identified 19 design requirements for high use continuance. These include, for example, students' desire for a reward system or social support when using the BCSS. In addition, to make the identified design requirements transferable to other BCSS with the target group of students, we derive ten more generally applicable meta-requirements.

Based on these findings of the first and second iterations**, Essay 8** presents the third iteration of the BCSS towards self-regulated learning. It is guided by the findings of the previous evaluation cycles (Essay 6 and Essay 7) and additionally incorporates findings on the motivational preferences of learners and users of information systems (Essay 3). Considering these findings, we address the need for motivational elements that address the different motivational preferences of students, more specifically, we consider external and social motivation to promote students' use continuance. Consequently, the third prototype incorporates the design principle of rewards to address external motivation as well as the design principle of social comparison to address social motivation. In order to compare the effects of each incorporated design principle (rewards vs. social comparison) we implemented two versions of the prototype, each version incorporating one design principle. The comparison of the two versions shows that the design principle of social comparison leads to significantly higher perceived effectiveness and social support among students compared to the design principle of rewards.

In the following, each essay included in this dissertation is presented in detail. As mentioned earlier, please note that all essays have been slightly modified compared to their published version to facilitate readability. Modifications include a continuous page count,

adjusted formatting of headings, tables, and figures, adapted references to other sections, and a central list of references at the end of this dissertation.

2 Essays Investigating the Environment of Higher Education Students

2.1 Essay 1: Leadership in a Digitalized and Crisis-ridden World: Towards a Comprehensive Overview of Relevant Competencies for Leaders

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Published in:	51st Hawaii International Conference on System Sciences (HICSS). Lahaina, USA, January 2-6 2023.

2.1.1 Abstract

Our environment is increasingly characterized by digitalization and crisis. Consequently, the competence requirements for executives are changing. Since they are critical to the success of companies, identifying talents and developing necessary leadership competencies is essential. To accomplish this in a targeted manner, a competency overview is needed that considers digitalization and crisis. However, current literature indicates that digital and crisis leadership are investigated separately. To address this research gap, this study develops a competence overview based on a systematic literature review considering both research streams. The analysis of 38 studies reveals 21 competency areas. For a structured analysis, these competency areas are considering the competence categories of self-, people-, and business management. The literature review shows that there is an overlap in the two areas regarding competencies related to decision-making, communication, and learning. Differences occur, for example, regarding leaders' health awareness or technical literacy, which are only addressed in digital leadership.

2.1.2 Introduction

For a target-oriented talent identification as well as education and skill development of executives in a digital and crisis-ridden environment, a state-of-the-art overview of relevant competencies is necessary. Leadership competencies can be critical success factors for companies. Research on leadership competencies has therefore been conducted for decades (Muir 2014), but the world is changing rapidly as it becomes increasingly digitized (Schiuma et al. 2021) and crisis-ridden (Hertelendy et al. 2021). Accordingly, the required competencies of leaders have also changed significantly (Dirani et al. 2020) and the need for leadership development might has never been more urgent than in the current volatile, uncertain, complex, and ambiguous world (Moldoveanu and Narayandas 2019).

In response to this development, two research streams have been established and have gained importance: 1) Digital Leadership (DL), which takes up the demand to counter the challenges of the progressing digitalization. 2) Crisis Leadership (CL), which addresses the increase in crises and their effects. The current state-of-the-art reviews highlight the importance of DL (Eberl and Drews 2021) or CL (Wu et al. 2021) and call for further research on required leadership competencies to counter current and future challenges. However, current research projects on DL and CL are so far addressed stand-alone without considering each other (Eberl and Drews 2021; Wu et al. 2021). Given the current environment, this paper explores the need to no longer consider the research streams of DL and CL separately. Therefore, this paper aims to systematically analyze the literature of both research streams to provide a more holistic overview of the required leadership competencies. Using a systematic literature review, we address the research question: *Which insights regarding required competencies for executives in a digitized and crisis-ridden world emerge from the state-of-the-art literature on DL and CL?*

By answering this question, this study contributes in three ways. It 1) provides an overview of required leadership competencies; 2) presents starting points for target-oriented recruitment as well as education and training of executives; 3) offers inspiration for future development and research on both DL and CL by considering identified competencies of each other.

2.1.3 Theoretical Background

2.1.3.1 Digital Leadership

DL is not clearly defined (Zeike et al. 2019). The first understanding relates to DL as a term for "doing the right things for the strategic success of digitalization for the enterprise and its business ecosystem" (El Sawy et al. 2016). The focus in this context is primarily on business-related management aspects (e.g., defining a new business strategy, business model, or workplace design) and their adaptation for a successful digitalization strategy of an organization (El Sawy et al. 2016). Furthermore, this understanding includes the ability to create a vision for the digitalization process, competencies leaders need in the digital age, and that drive digital transformation (Zeike et al. 2019). A second understanding focuses more on the influence of digital technologies on the leader-follower interaction, as technology affects the way leaders and followers are connected (Pabst von Ohain 2019). In this regard, skills, roles, and leadership styles are seen as important characteristics of digital leaders (Eberl and Drews 2021). Since the focus of this paper is on individual leadership competencies rather than on the digital transformation of an organization, for the purpose of this paper we define DL as the skills, roles, and leadership styles that leaders use to fulfill their leadership function in a digitized organizational environment.

2.1.3.2 Crisis Leadership

CL is used in different contexts like in the healthcare, military, critical infrastructure, or aviation domain and addresses the challenges of leaders in crisis situations (Deitchman 2013). In the current literature, different opinions on the appropriate leadership style in crises exist. Especially the context (e.g., lack of time) influences the appropriateness of a rather authoritarian, transformational, collaborative (Heide and Simonsson 2021; Kapucu and Ustun 2018), or situational leadership style (Wisittigars and Siengthai 2019). Kapucu and Ustun (2018) state that task-oriented leadership styles increase CL effectiveness. However, the lack of appropriate CL competencies can cause poor crisis management (Kapucu and Ustun 2018). In contrast to CL, crisis management focuses on preparation strategies and making organizations ready for crises (Grissom and Condon 2021) and is a top-down process how to organize and solve certain problems (Heide and Simonsson 2021).

A systematic framework on leadership competencies with a focus on crisis situations is defined by Savanevičienė et al. (2014). The framework defines 1) self-management (SM) competencies which help leaders to "be stable in unspecified environment and to adapt to rapidly changing circumstances" on an individual level and 2) people management (PM) competencies "which allow warranting of efficient people management". Furthermore, the framework also differentiates 3) business management (BM) competencies that ensure "business decision-making and efficient business communication". To enable a systematic analysis in this paper, we rely on this framework.

2.1.3.3 Competencies

To define competencies, the definition of El Asame and Wakrim (2018) is valid for this paper. They define competencies as "a set of personal characteristics (skills, knowledge, attitudes, etc.) that a person acquires or needs to acquire, in order to perform an activity inside a certain context with a specific performance level".

2.1.4 Systematic Literature Review

Our systematic literature review follows Vom Brocke et al. (2015): The process of our literature review is sequential, as the literature search is the defined initial step at the beginning of our reviewing process. To identify intersubjectively comprehensible and quality-assured articles, we choose five bibliographic databases as sources: ABIinform, ACM, AISel, PubPsych, EBSCOhost. By applying our search string in abstracts, we aim for comprehensive coverage: "abstract: ("digital leadership" OR "crisis leadership") AND abstract: (skill* OR competenc* OR abilit*)".

The search in March 2022 revealed 62 articles, with 7 of these being duplicates. Applying the inclusion criteria *derivable conclusions of the leadership competencies,* 17 studies are excluded, resulting in 4 conference and 34 journal articles. In the resulting sample of 38 articles, all studies can be clearly distinguished between DL (19 studies) and CL (19 studies). No study addresses both. Figure 2 depicts the number of published studies by year and shows that research on CL and DL has increased significantly over the past decade.

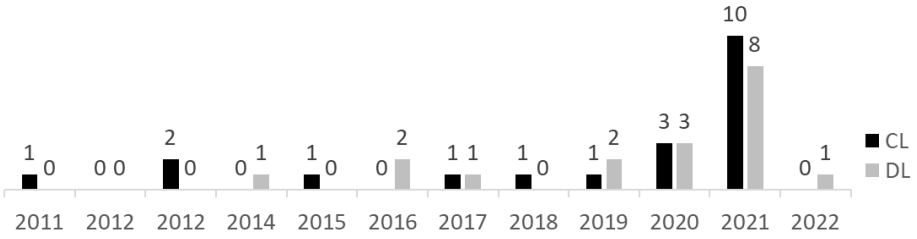

Figure 2: Identified Studies per Year

2.1.5 Analysis of Leadership Competencies

Based on the analysis of the 38 articles, we identified 288 individual mentions of required leadership competencies and categorized them according to the competence categories SM, PM, and BM. Table 1 provides an overview of identified mentions on competencies and their distribution.

Table 1: Number of Topics Mentioned

	SM	PM	BM	Total
DL	43	87	39	169
CL	24	54	41	119
Total	67	141	80	288

After categorizing the identified leadership competencies, we clustered the topics resulting in 21 competence areas. Table 2 shows two examples of the clustering assignment in the competence category PM.

Table 2: Exemplary Cluster Assignment "Emotional Intelligence"

Competence area "communication"
Sample of supporting quotes CL: "In general, during a crisis, leaders who demonstrated […] the ability to make and engage in consistent and responsible […] communications, and a transparent communication process were able to inspire and influence change." (Sriharan et al. 2021) DL: "It is important for leaders that during virtual communication, he or she is well organized, the message is clear, and feedback mechanism can avoid mistake and ambiguity."(Soon and Salamzadeh 2021)
Competence area "emotional intelligence"
Sample of supporting quotes CL: "Emotional intelligence enables the leaders to motivate followers by changing and moderating their own and teams' emotions to function effectively and be efficient in crisis situations." (Wisittigars and Siengthai 2019) DL: "Displaying empathy provides leaders with knowledge of how to understand follower feelings, influence follower emotions and anticipate employee behavior. (Pabst von Ohain 2019)

Table 3 presents the resulting competence overview of the identified competence areas and shows which competencies are addressed in which research stream (DL/CL) and competence category (SM/PM/BM).

Table 3: Identified Competence Categories

Competence areas	DL			CL		
	SM	PM	BM	SM	PM	BM
Communication		■	■		■	■
Decision-Making		■	■	■	■	■
Learning	■	■		■	■	
Collaboration		■	■		■	
Agility	■	■		■		
Emotional Intelligence		■		■	■	
Sense-Making		■		■	■	
Situational Awareness				■	■	■
Global Thinking		■	■			
Influence Others		■			■	
Innovation Management			■			■
Digital Transformation		■	■			
Problem Solving	■					■
Self-Regulation	■			■		
Building Trust		■			■	
Social Media Usage	■	■				
Technical Literacy	■					
Open Mindset	■					
IS Governance			■			
Infrastructure		■				
Health Awareness	■					

2.1.5.1 Self-Management in Digital Leadership

The thinking and behavior of digital leaders require **agility**, corresponding adaptability, and flexibility when conditions change. This helps digital leaders e.g., to switch leadership styles, take over new tasks, lead from remote, reshape existing capabilities, and adapt to changing processes (Claassen et al. 2021; Pabst von Ohain 2019), or perform multiple tasks (Freitas Junior et al. 2020). In this regard, digital leaders use digital solutions to recognize business opportunities or to choose appropriate actions (Pabst von Ohain 2019). Moreover, digital leaders need **problem-solving** competencies and therefore skills related to critical thinking and to creativity (Karakose et al. 2021), e.g., to evaluate new business opportunities. Digital leaders know how to use **social media** to build up knowledge and to use its transformational effect (Ahlquist 2014; Prince 2017) to foster change and improvement (Moorley and Chinn 2016). Furthermore, an **open mindset**, e.g., toward new digital concepts is necessary to adapt to the digitalization-induced changes in leadership processes, tasks, or styles (Pabst von Ohain 2019). Digital leaders are explicitly open to **learning** (Karakose et al. 2021). Digital leaders' **health awareness** summarizes competencies in establishing personal virtual boundaries concerning privacy, time management, and leaders' overall wellness (Ahlquist 2014). This is also related to the requirement to be resilient (Freitas Junior et al. 2020). Self-leadership skills help to deal with challenges like the dissolution of boundaries between work and private life, distractions, constant accessibility, information overload, and work intensification (Mander et al. 2021). In this regard, digital leaders need competencies in **self-regulation** in general (Prince 2017; Saputra and Hindriari 2021). This includes the ability to take care of oneself based on self-confidence and a responsible approach to trust-based working time and time off compensation. Digital leaders need self-discipline and a good way of dealing with disruptions, especially in the home office (Mander et al. 2021). Furthermore, digital leaders need a broad scope of **technical literacy** (Ahlquist 2014; Freitas Junior et al. 2020; Prince 2017; Soon and Salamzadeh 2021) including the ability to analyze digital content (Ahlquist 2014). These competencies comprise digital knowledge and technical literacy (Claassen et al. 2021; Karakose et al. 2021; Zeike et al. 2019) but also enjoy using technology and digital tools (Zeike et al. 2019). By doing so, digital leaders can encourage digital technology usage (Karakose et al. 2021) and thereby improve performance (Prince 2017). Digital leaders represent digital and technology experts (Zeike et al. 2019; Abbu et al. 2020). This is associated with the demand to keep up to date regarding technologies and further development (Ahlquist 2014; Zeike et al. 2019).

2.1.5.2 Self-Management in Crisis Leadership

Leadership in crisis situations demands **agility** to work across organizational functions (Wicker 2021) and flexibility to respond to different situations (Kapucu and Ustun 2018). **Emotional intelligence** is important in crisis situations (Kim 2021; Joniaková et al. 2021; Kostić-Bobanović and Bobanović 2013) to maintain clear judgement and decision-making by recognizing, regulating, managing, (Grissom and Condon 2021), acknowledging, and addressing own emotions (Standiford et al. 2020). Emotional intelligence can be trained, e.g., for speaking clearly and with confidence during crisis situations (Balwant 2021). **Situational awareness** includes integrating internal and external information in decision-making to create a comprehensive picture of the situation (Deitchman 2013; Dixon et al. 2017). Situational awareness can be an integral part of **sense-making**. On an individual level, this is a key task to get an understanding of a crisis and take appropriate action (Tham et al. 2020; Wicker 2021) in every stage of a crisis (Dixon et al. 2017) by analyzing also high volumes of gathered information (Grissom and Condon 2021). After a crisis, leaders should make sense of decisions and events during the crisis to improve future leadership (Dixon et al. 2017). The willingness to **make decisions** is important in CL (Kapucu and Ustun 2018) and includes seeking information from various sources to make decisions on time and based on a broad base of information (Deitchman 2013). In crises, **self-regulation** is important including having a new vision as well as self-confidence (Joniaková et al. 2021). Leaders need to **learn** from crises and see them as an opportunity to learn from others and themselves also by reflecting on experiences and adapting findings to future leadership (Standiford et al. 2020). Wicker (2021) states that the ability to learn from crisis situations is critical.

2.1.5.3 People Management in Digital Leadership

Digital leaders foster **collaboration** (Karakose et al. 2021; Pabst von Ohain 2019). In doing so, digital leaders shape teams into coherent and integrated work units (Soon and Salamzadeh 2021). They encourage employees to embrace a culture of collaboration and experimentation (Prince 2017) and foster knowledge sharing and exchange (El Sawy et al. 2016). Digital leaders recognize the benefits of platforms that enable collaboration and knowledge sharing and promote and support their launch and use (El Sawy et al. 2016; Ahlquist 2014). They also strengthen the employees' possibilities of collaboration regardless of place, time, and culture (Claassen et al. 2021). Moreover, digital leaders create a structure where responsibility can be shared among team members (Karakose et al. 2021).

Communication and human relations competencies are central components of digital leaders' interpersonal skills (Moorley and Chinn 2016; Prince 2017; Karakose et al. 2021; Soon and Salamzadeh 2021). Digital leaders have the ability to use different means of communication (Freitas Junior et al. 2020) and use social media to listen to followers on a micro-level as well as for data exploration and crowdsourcing (Moorley and Chinn 2016). By clear communication and listening (Moorley and Chinn 2016), digital leaders appear sympathetic (Pabst von Ohain 2019) and provide clear messages and feedback mechanisms to reduce mistakes and ambiguity. They are not afraid to share information on a personal level (Moorley and Chinn 2016). On a professional level, digital leaders communicate the essence of digital transformation (Schiuma et al. 2021). When receiving information, they focus on the meaning of the message, not the message itself (Prince 2017). Through communicating shared purpose and meaning, they integrate diverse employees and partners (El Sawy et al. 2016). Thereby, digital leaders focus on **sense-making** (Prince 2017). Furthermore, they communicate adequately concerning different cultures (Rüth and Netzer 2020). In this regard, DL includes **global thinking**. This requires a conscious commitment at the global level (Moorley and Chinn 2016). With the help of digital platforms, digital leaders overcome restrictions such as location or time and promote collaboration between employees, even from different cultures (Claassen et al. 2021). If necessary, digital leaders make their ideas and visions palatable to followers in different countries (Rüth and Netzer 2020). They also take into account cultural heterogeneity and are aware of different values and beliefs (Karakose et al. 2021). PM in the context of DL includes adequate **decision-making** and decisiveness: By promoting and deploying flat hierarchies, digital leaders delegate decision-making authority (El Sawy et al. 2016). They consider democratic principles and encourage employer participation in decision-making (Karakose et al. 2021). When making decisions, digital leaders take digital transformation into account and consider ethical aspects of **digital transformation** (Schiuma et al. 2021). DL includes the ability to shape a knowledge-creating context for the digital transformation, e.g., by creating virtual and real opportunities for knowledge exchange (Schiuma et al. 2021). Furthermore, leaders are able to make the digital transformation to everyone's job. This includes, e.g., empowering followers and being a role model (Schiuma et al. 2021). This means engaging people to act with the digital transformation, e.g., by inspiring and giving a common purpose, but also fostering dialectic thinking about certain solutions and showing empathy (Schiuma et al. 2021). Digital leaders need **emotional intelligence** to understand and influence followers' emotions, e.g., to foster motivation towards the digital transformation goals. Furthermore, they need to build

up and establish **trust** among their followers rather than to impose control (Pabst von Ohain 2019; Karakose et al. 2021). In this regard, it is important for digital leaders to know how to influence followers (e.g., by being an authentic role model) rather than using hierarchical power (Prince 2017). This includes establishing an adaptive and willing mindset, e.g., by engaging employees to join digitalization events (El Sawy et al. 2016) and also taking ethical considerations into account (Phillips 2021). Digital leaders consider the training of competencies related to cyber conflict recognition among followers and its mediation (Ahlquist 2014). Empathy allows leaders to act as a coach, to guide followers on the challenges of digitalization, to support employees' well-being, and to motivate them to be innovative (Pabst von Ohain 2019). In this regard, digital leaders need to recognize, for example, the right time to lead or coach a follower (Prince 2017). Digital leaders lead in an authentic and transparent way, as this reduces follower resistance and increases their willingness to follow digitalization goals (Pabst von Ohain 2019; Prince 2017). Trust helps digital leaders to identify and reduce followers' negative emotions and strengthens collaboration (Pabst von Ohain 2019). Furthermore, it influences the effectiveness of digital collaboration in teams (Soon and Salamzadeh 2021). Digital leaders are honest and transparent towards their followers, which means to show an open and comprehensible behavior to increase their trust and support (Pabst von Ohain 2019).

DL means offering followers an adequate **infrastructure**. This includes investing in digital platforms which make remote work possible, provide a constant technology support service, and provide personalized and user-friendly apps. These technologies allow followers to decide when and how to work and make access to information independent of followers' location (El Sawy et al. 2016). The usage of **social media** allows leaders to make their behavior visible and to act as role models as well as mentors (Moorley and Chinn 2016). This means, that digital leaders use social media for social good (Ahlquist 2014). Digital leaders are aware of the potential of social media for crowd-sourcing (e.g., for innovation purposes) or articulating a vision, and can leverage its benefits (Moorley and Chinn 2016). Moreover, digital leaders have a certain degree of online self-awareness and reflect their digital profile (Ahlquist 2014). Digital leaders implement a fail-fast **learning** culture where followers learn from their mistakes (Abbu et al. 2020) and set up a personal learning network (Ahlquist 2014). They train followers to accept failures and encourage them to share these (El Sawy et al. 2016). Moreover, they provide adequate

opportunities to develop new skills (El Sawy et al. 2016). This includes supporting a digital learning culture and followers' technology-based professional development (Karakose et al. 2021). Digital leaders **influence** by demonstrating an entrepreneurial mindset (Abbu et al. 2020) and showing passion for their business domain (Moorley and Chinn 2016). **Agility** in DL not only refers to the flexibility of leaders, but is also important for managing employees: Digital leaders use agile principles and promote transparent communication of project progress to all relevant employees (Abbu et al. 2020).

2.1.5.4 People Management in Crisis Leadership

Adequate **communication** competencies of leaders are important before and during crisis situations (Kapucu and Ustun 2018; Wisittigars and Siengthai 2019; Zhuravsky 2015). Leaders promote the exchange of information, create and maintain an open atmosphere, clarify communication (Deitchman 2013), and know when to delegate communication tasks to ensure rapid decision-making and also a quick decision conversion (Wisittigars and Siengthai 2019). They need skills in negotiation, authority delegation, and relationship building (Wisittigars and Siengthai 2019), e.g., to use effective communication as a means to build a team and enhance its task performance in critical situations (Zhuravsky 2015). Effective communication skills are necessary to communicate a clear vision for creating a shared sense of purpose (Sriharan et al. 2021). Leaders avoid a negative impact on organizational performance (e.g., caused by rumors) through clear, fast, and frank communication (Kim 2021). Openness in communication has a positive effect on employees' feelings of safety and satisfaction (Wisittigars and Siengthai 2019). Leaders in crisis situations should be able to communicate internally and externally (Zhuravsky 2015), whereby internal communication is not just a message service, but also a means to make sense of ambiguous situations (Heide and Simonsson 2021) to reduce anxiety among followers (Kim 2021), to move people to action and to enable followers to act as a sender for receivers outside the organization (Heide and Simonsson 2021). To enable effective communication with stakeholders (Ladak et al. 2021), leaders need adequate communication systems and should be trained in communication and media usage (Grissom and Condon 2021) to create a precise and constant flow of information (Kapucu and Ustun 2018). In crisis situations, leaders use different means of communication (e.g., social media) to alter behavior or establish new social norms (McGuire et al. 2020). Instant messaging allows a rapid reorganization of the workforce, e.g., by creating chat groups (Tham et al. 2020). Crisis situations demand a high degree of leadership competencies in

collaboration (Kim 2021; Kapucu and Ustun 2018). Leaders need to accept information input from followers and promote information sharing (Deitchman 2013). The ability to enable collaboration by cultivating interpersonal relationships is essential for making information exchange and consensus on crucial decisions possible (Suhadianto et al. 2021; Ladak et al. 2021). The team-building behavior of leaders enhances collaboration. Leaders take also the potential of team members into account, motivate them, and communicate with them (Kapucu and Ustun 2018). **Decision-making** and decisiveness are key competencies in crisis management as strong and timely decision-making processes have an impact on employees' abilities (Kim 2021; Kapucu and Ustun 2018). Leaders need the ability to stay self-aware in crisis situations and subjugate distressing feelings (Dixon et al. 2017). Participatory decision-making is an important leadership skill during a crisis as it can foster quick decisions (Joniaková et al. 2021). Furthermore, active requests for follower assistance create collaborative and active team decisions, even in the case of leaders' absence (Dixon et al. 2017). Leaders analyze different alternatives also by considering ethical aspects and follow a value consistency to give followers a feeling of certainty and transparency (Joniaková et al. 2021). **Emotional intelligence** is a key component of CL and involves recognizing, regulating, and managing the emotions of followers (Grissom and Condon 2021; Joniaková et al. 2021; Wisittigars and Siengthai 2019). Leaders need the ability to show interpersonal warmth and sensitivity (Deitchman 2013), recognize stress, and create a positive, reassuring, and courageous attitude to promote coping among team members (Grissom and Condon 2021). They need to listen actively, develop authentic relationships, and accept criticism (Grissom and Condon 2021). To engage others for collective action, demonstration of empathy, emotional presence, and caring also of the well-being of others is essential (Sriharan et al. 2021; Caringal-Go et al. 2021). Emotional intelligence enables leaders to motivate followers by changing and moderating teams' emotions to function effectively and be efficient in crisis situations. It allows influencing self-confidence, courage, and the stress- and conflict-management capabilities of followers (Wisittigars and Siengthai 2019). Ignoring negative emotions could risk the ability of a team to work together (Standiford et al. 2020). **Learning** is included in different CL tasks (e.g., for sense-making or decision-making processes) and has therefore a central role (Tham et al. 2020). During a crisis, leaders need to make sure that theoretical CL practices support the cognitive skills and processes of team members and foster their learning ability regards the improvement of crisis strategies during and after a crisis (Schulman and Roe 2011). After a crisis, leaders need learning competencies to reflect

critically on past crisis preparation as well as their own decision-making and communication during the crisis to be better prepared for the next crisis (Grissom and Condon 2021). The **sense-making** ability of leaders is crucial in crisis situations. It enables the transformation of complex situations into comprehendible and actionable information (Dixon et al. 2017; Heide and Simonsson 2021; Henning et al. 2011). Leadership is also about influencing the sense-making of team members. This process is called sense-giving and in crisis situations, it can occur simultaneously with the leaders sense-making (Dixon et al. 2017). Sense-making is thereby not just providing more information, but addressing questions, making sense of them, and initiating actions (Heide and Simonsson 2021). Leaders need to know how to use digital information technologies, e.g., for collective sensemaking, but also with a sense of avoiding an "infodemic", which is an overload of accurate and inaccurate information (Tham et al. 2020). The ability to build **trust** is a core competence in CL (Kim 2021). In the context of decision-making processes in crisis situations, leaders can build trust by leveraging cognitive diversity and considering the different knowledge and perspectives of team members with different professional backgrounds (Joniaková et al. 2021). Behaving with integrity is important for leaders in crisis situations (Joniaková et al. 2021). Leaders need competences in the business domain to make decisions based on professional judgement and to earn the trust of colleagues and followers (Deitchman 2013). Leaders inspire followers to trust in their colleagues and leaders also in difficult circumstances (Deitchman 2013). The determination, courage, and responsibility leaders show influence the ability of followers to manage a crisis and their willingness to follow a leader. Respect for employee concerns and acceptance of responsibility by leaders builds trust and encourages employees to act proactively (Kim 2021). Creating transparency with information in common and also with own emotional vulnerabilities in uncertain environments can increase trust and credibility among followers (Standiford et al. 2020). Moreover, leaders need **situational awareness** including the ability to act with respect to the crisis contexts. This means, that leaders need the ability to recognize the phase of the crisis, e.g., to adapt framing and tone of messaging in different crisis stages. Otherwise, leaders could be unaware of their actions' risk (Schulman and Roe 2011). Leaders should be able to **influence** and inspire others (Sriharan et al. 2021). This includes to show authenticity and charisma, to use an appropriate leadership style, to respect the diversity of skills, and to create a motivating culture for systematic thinking (Joniaková et al. 2021; Buhagiar and Anand 2021). In doing so, leaders show the way forward and thus sustain the spirit in the team even in difficult situations (Buhagiar and Anand 2021).

2.1.5.5 Business Management in Digital Leadership

In a BM context, digital leaders need competencies in open and customer-oriented **communication**, e.g., to develop new products and services or digital processes (Claassen et al. 2021; El Sawy et al. 2016; Abbu et al. 2020). They are able to **think globally**, e.g., by addressing different customer needs across cultures (Karakose et al. 2021; Rüth and Netzer 2020), and have distinctive competencies in **innovation management** (Prince 2017). They exploit and implement digital innovation, are aware of possible limitations (Pabst von Ohain 2019; Brunner et al. 2021), and foster communication for innovation purposes (Soon and Salamzadeh 2021; Erhan et al. 2022). Furthermore, they **collaborate** cross-functional with business counterparts (Schiuma et al. 2021) and share good employees with the whole organization (El Sawy et al. 2016). To **make decisions** in an evidence-based way, digital leaders have competencies in data analysis (Abbu et al. 2020; Moorley and Chinn 2016). They take possible side-effects of their decisions into account (Ahlquist 2014). To lead and define **digital transformation** (Prince 2017) they provide and promote (Abbu et al. 2020) a clear and comprehensive strategy and vision (Dewi and Sjabadhyni 2021; Zeike et al. 2019). Digital leaders need competencies related to **IS governance** (Brunner et al. 2021). This summarizes the ability to implement digital strategies (e.g., bring your own device) (El Sawy et al. 2016) and digital visions (Prince 2017). In addition, they shape their organizations so that both digital natives and older team members make digital technology an integral and valuable part of their work environment (Phillips 2021).

2.1.5.6 Business Management in Crisis Leadership

Leadership in crisis situations from a BM point of view demands competencies in **communication**, especially with external stakeholders, as this influences the perceived effectiveness of CL (Balwant 2021). This includes networking and partnering to cultivate interpersonal relationships among organizations (Kapucu and Ustun 2018; Sriharan et al. 2021). Competencies in **decision-making** are central to CL (Tham et al. 2020). Leaders should make quick, accurate, and time-critical decisions without having all information (Kapucu and Ustun 2018) also under high pressure (Zhuravsky 2015). Competencies in **situational awareness** like knowledge of different crisis stages (Grissom and Condon 2021), the ability to evaluate information on their importance (Kapucu and Ustun 2018), or the recognition of emerging crises (Wisittigars and Siengthai 2019) including crisis preparation (Wisittigars and Siengthai 2019) are essential. Competencies in **problem-**

solving (e.g., simplifying complexity) enable quick responses to problems (Wisittigars and Siengthai 2019). Furthermore, leaders in crisis need competencies in **innovation management** to foster the innovation abilities of staff as well as also external stakeholders (Kapucu and Ustun 2018).

2.1.6 Discussion

In general, it can be stated that the number of publications concerning the research streams of DL and CL increased steadily over the last years (see Figure 2). This goes in line with an increasingly digitized but also crisis-ridden environment and emphasizes the need for a holistic overview of leadership competencies. The analysis also further indicates that DL and CL are research streams, that are so far not considered together. However, by combining both research streams, this study identified commonalities and differences regarding required leadership competencies.

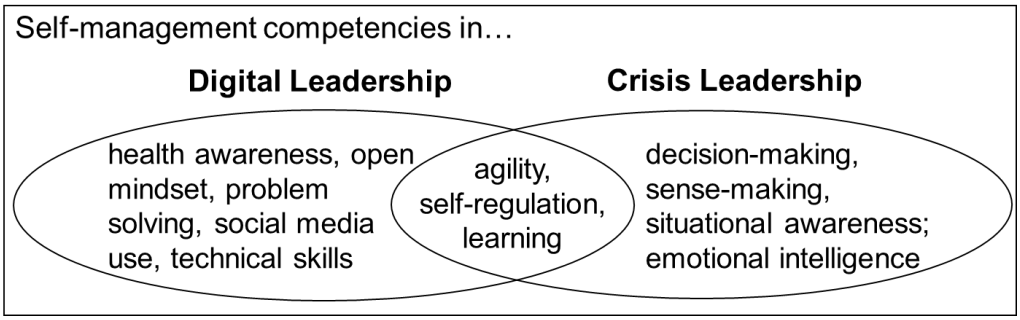

Figure 3: Self-Management Competencies

Looking at the competencies in terms of the leader's SM (Figure 3) revealed that several competencies are considered in both research streams: Competencies related to agility (e.g., multi-task execution), self-regulation (e.g., self-discipline), and learning (e.g., learning from past situations). In contrast to these three competencies, health awareness (e.g., creating virtual boundaries), open mindset (e.g., acceptance of new technologies), problem-solving (e.g., critical thinking), social media use (e.g., building up new knowledge), and technical skills (e.g., data analysis) are exclusively thematized in the DL literature. In CL literature competencies related to decision-making (e.g., considering information from multiple sources), sense-making (e.g., acting appropriately in different crisis stages), situational awareness (e.g., developing a comprehensive picture of the current situation), and emotional intelligence (e.g., managing own emotions) are addressed.

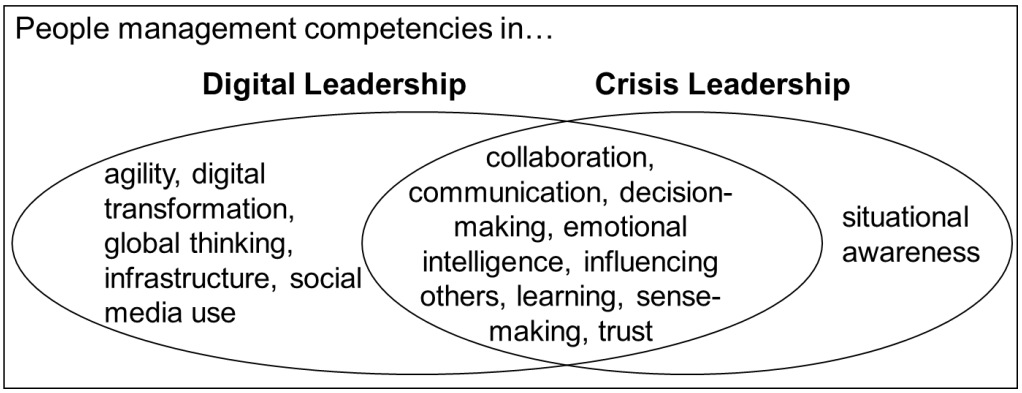

Figure 4: People Management Competencies

Relating to the leader's PM (Figure 4) both research streams address competencies in collaboration (e.g., promotion of information exchange), communication (e.g., communication of a shared sense of purpose); decision-making (e.g., promoting and deploying flat hierarchies), as well as emotional intelligence. (e.g., understanding followers' emotions), influencing others (e.g., creating passion), learning (e.g., implementing a fail-fast culture), sense-making (e.g., transformation of complex decision-situations into actionable tasks), and building trust (e.g., among followers).

Competencies in agility (e.g., using agile principles), digital transformation (e.g., engaging followers to act with digital transformation), global thinking (e.g., promoting collaboration between different cultures), infrastructure (e.g., enabling remote work), and social media use (e.g., act as a role model) are addressed exclusively in the DL literature. Competences on situational awareness (e.g., recognizing a certain crisis stage) are mentioned exclusively in the CL literature.

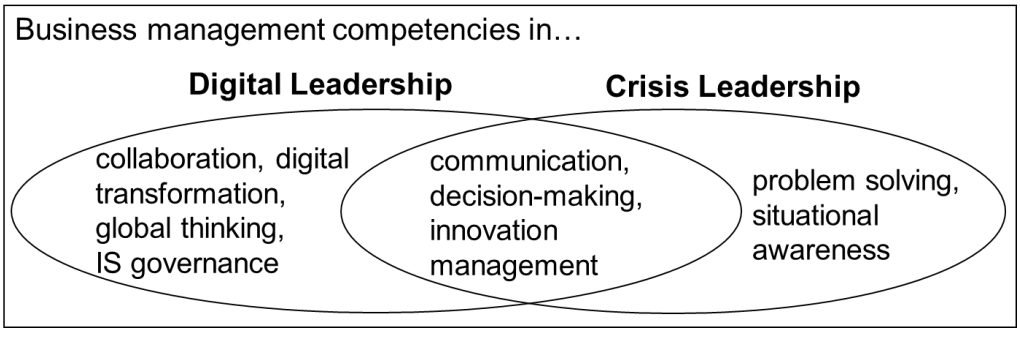

Figure 5: Business Management Competencies

From a BM perspective (Figure 5), there is an overlap of the competencies regarding innovation management (e.g., fostering creativity), decision-making (e.g., using data analysis), and communication (e.g., networking). Competencies in collaboration (e.g.,

cross-functional working), digital transformation (e.g., providing digital strategy), global thinking (e.g., addressing customer needs across different cultures), and IS governance (e.g., implementing digital strategies) are addressed in DL literature only. In contrast, competencies in problem-solving (e.g., simplifying complexity) and situational awareness (e.g., knowledge of crisis stages) are mentioned exclusively in CL literature.

These findings can be used as a foundation for several managerial/educational implications. Competence areas resulting from the overlap between DL and CL can serve as a starting point in leadership competence development or as a basic requirement for the recruitment of executives. Depending on the focus of the leadership education or the assessment center, competence areas specializing in CL or DL can be added, e.g., to adapt to the requirements of a certain job. The competence overview provided in this work can give orientation for the relevant competence areas needed to be assessed or trained, e.g., for virtual talent development solutions organizations are heavily investing in (Mahapatra and Dash 2022).

2.1.7 Conclusion and Future Research

DL and CL are two young research streams, that have gained relevance in recent years. While the two research streams have so far mostly been considered separately, this study provides a higher-level overview of relevant competence areas required of leaders in a world characterized by digitalization and crises. It is noticeable that there is an overlap regarding addressed leadership competencies in CL and DL. Nevertheless, the comparison also shows clear differences and points out topics where the other research stream can benefit. Furthermore, the strength of the overlap of CL and DL is different between SM, PM, and BM, where PM has the largest overlap.

Certain limitations are associated with this systematic literature review. By including additional databases, new studies, and findings could be identified. There is also a certain subjectivity in the explorative approach to identifying relevant competencies. However, since the findings of the work are already based on a search of abstracts in five databases, a reasonable breadth of the search is given. In addition, the exploratory approach was carried out by two researchers, which gives a certain intersubjectivity.

Merging DL and CL was identified as novel in this study. Further research can pick up on this point and go into more detail about the interactions between DL and CL compe-

tencies. Since this study is based purely on research contributions, it would also be enriching if the practice is also considered. Interviews with leaders in companies, consulting firms, or coaches could yield insightful new findings.

2.2 Essay 2: Personal Skills in the BISE Curriculum: An Integrative Approach

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2.2.1 Abstract

In an increasingly complex and dynamic world, young executives need certain soft skills to be forearmed for the challenges of their job. The need for training of these personal skills in higher education is recognized among the business and information systems engineering (BISE) society. Yet, existing approaches often integrate the development of soft skills implicitly, usually without quantitively measuring the impact on students. However, an initial literature review identified a demand for an explicit and systematic integration of personal skills in basic lectures. We present an approach that systematically integrates the training of personal skills in a basic BISE lecture for first-semester students. To exemplify this approach, we describe the integration of the self-leadership strategy self-observation in a lecture on process modeling. Our research project follows the Design Science Research methodology. The outlook previews the completion of the first design cycle by describing the planned evaluation and further research ideas.

2.2.2 Introduction

Soft skills are crucial for business and information systems engineering (BISE) students to become successful young executives in an increasingly complex business environment (Torres et al. 2020) and employers strongly expect skills related to a positive attitude, self-motivation, and self-direction (Majid et al. 2019; Grudzdev et al. 2018). The need for soft skill development in higher education is well known in the BISE domain and worldwide discussions regarding the lack of soft skill training amongst graduates are going on for decades (Idrus 2014). For German-speaking countries, the “Wissenschaftliche Kommission Wirtschaftsinformatik” (WKWI) and the “Gesellschaft für Informatik” (GI) formulated guidelines for BISE education, including relevant personal skills (Jung and Lehrer 2017). Currently, lectures or seminars typically foster soft skills implicitly (Idrus 2014). Explicitly, soft skills are mostly offered as voluntary add-on courses for small groups of students (Sampl et al. 2017). These offers are often not well-attended by business students (Majid et al. 2012) and taught content might not be learned sustainably (Goh et al. 2012). Furthermore, the soft skill development is inhibited by students’ focus on subject-oriented content, a large number of students in one classroom, and lecturers’ limited time to cover the syllabus content (Idrus and Abdullah 2009, p. 73; Mitchell and Bexyon 2018). As a result, the gap between the actual soft skill level of graduates and the soft skill level expected by employers is increasing (Majid et al. 2019; Osmani et al. 2016; Liu and Murphy 2018). Integrative teaching approaches within basic BISE lectures could counteract these problems (Beard et al. 2008; Idrus 2014). Basic lectures, which are a mandatory part of the study program, have the advantage of providing a reliable platform to reach students. In particular, BISE methods, which are rather abstract and often relevant for exams (e.g., EPC modeling), could serve as a "carrier" for soft skill integration. To build on insights into existing approaches and to identify already defined requirements, we conducted an initial systematic literature review. Based on the results, we suggest a “2 in 1” concept fostering relevant soft skills more explicitly in a first-semester BISE lecture. To take up the need for a systematic approach, we use an established framework in the soft skill context: Self-leadership (SL). SL addresses relevant personal skills as it enables people to gain the needed self-direction and self-motivation to perform (Goldsby et al. 2021). As a theoretically grounded concept, validated questionnaires to measure effects are available (Houghton and Neck 2002). Our integrative approach enriches subject-specific lectures with soft-skill content in form of interactive videos. These videos deepen students’ subject-specific knowledge by using typical BISE methods within a SL context. Based on the findings that students' active role (Vaz de Carvalho et

al. 2019) and reflection periods (Cleveland 2013) are beneficial in soft skill training, we identified the experiential learning theory (Kolb 1984) as a pedagogically valuable framework for structuring the videos.

The superordinated research question of this Design Science Research (DSR) project is: To what extent can SL skills be fostered through targeted integration into subject-specific content within a basic BISE lecture? This research in progress contribution describes the artifact developed within the first design cycle according to Hevner (2007). The overall goal is to implement and test the approach in a BISE lecture. The focus of this paper is on an initial learning unit integrating self-observation into a lecture addressing process modeling. The planned evaluation is described in the outlook.

2.2.3 Theoretical Background and Literature Review

The GI and WKWI published the "Guidelines for Education in BISE at Tertiary Institutions" (Jung and Lehrer 2017). These guidelines highlight certain skills, specified as subject-specific skills, social skills, and personal skills: Subject-specific skills comprise "concepts and methods that enable students to analyze, design, implement, operate, and use information systems" (Jung and Lehrer 2017, p. 192), for example, process modeling (e.g., BPMN or EPC (Ko et al. 2009)). Social skills include cooperation and communication skills. These are typically addressed in seminars (e.g., through presentation tasks) (Tartibu and Steenkamp 2020) and not the focus of this paper. Personal skills include learning skills, the ability to reflect autonomously on work experiences and to adjust behavior accordingly (Jung and Lehrer 2017; Majid et al. 2019).

With the objective of analyzing the knowledge base on integrative approaches to soft skills development in higher education, we conducted a systematic literature review. Following Vom Brocke et al. (2015), we searched sequentially in three databases and identified representative literature using the keyword search (("higher education" or universit*) AND ("soft skill*" or "personal skill*" or "self-leadership") AND ("integra*")). It results in a total of 154 articles (EBSCOhost 46; IEEExplore 88; AISel 20).

In general, BISE lectures and students value the training of soft skills (Majid et al. 2012; Schipper and van der Stappen 2018; Idrus 2017). Overall, the literature review identified the need for an integrative (Chow and Wong 2012; Majid et al. 2019), systematic and measurable (Chow and Wong 2012; Majid et al. 2012; Beard et al. 2008), and explicitly addressed (Chow and Wong 2012; Idrus 2017; Majid et al. 2019) approach which starts at the beginning of university studies (Adams 2012; Tabatabaei et al. 2020). Students

should actively take part in the learning process (Vaz de Carvalho et al. 2019; Anca et al. 2020), for example, by integrating experiential learning elements (Beard et al. 2008) with authentic activities (Herbert and Herbert 2020) in simulated environments (Forster and Hopkins 2011). None of the examined 154 articles incorporated all identified needs. So far, soft skill training is often integrated through seminars and concepts like problem-based (e.g., Ribeiro and Bittencourt 2018; Tartibu and Steenkamp 2020; Mielke et al. 2016) or project-based learning (e.g., Macedo and Pinho-Lopes 2018; Low 2006). Furthermore, soft skills are mostly integrated implicitly (e.g., Homola et al. 2017; Labenda et al. 2012). However, for effective development, soft skills should be explicitly mentioned as learning objectives (Majid et al. 2019). To ensure improvement and accountability to curriculum objectives, it is important to articulate and systematically measure soft skills (Beard et al. 2008). Our approach aims to address the identified needs:

To take up the demand to measure the effects quantitatively (Beard et al. 2008), the concept of SL is used as it addresses skills related to a positive attitude, self-motivation, and self-direction (Majid et al. 2019; Manz 1986). SL includes a set of strategies to increase personal effectiveness and performance (Neck and Houghton 2006). These strategies are related to behavior, natural rewards, and constructive thought patterns. Behavioral strategies contain self-observation, self-goal setting, self-rewarding, self-punishment, and self-cueing (Manz 1986). These strategies are designed to facilitate desirable behavior (Neck and Houghton 2006). For this research in progress contribution, we concentrate on the behavioral strategy self-observation. Self-observation allows identifying potentially unsatisfying conditions, by recognizing the current situation and making it comparable with the desired state (Furtner and Baldegger 2016).

To take up the demand for students to be in an active role (Majid et al. 2012; Vaz de Carvalho et al. 2019), we implement interactive videos, that enable students to experience training scenarios individually. The videos incorporate the experiential learning theory (Kolb 1984). This theory contains four steps (Kolb 1984). The following activities specify these steps (Morris 2020): 1) concrete experience: learners are in an active role, have responsibility for the process, and react spontaneously. 2) reflective observation: learners reflect on their experience alone or with others and foster a metacognitive perspective. 3) abstract conceptualization: learners transfer context-specific experience to abstract and contextual-indifferent levels. 4) active experimentation: learners need to test the results of the abstract conceptualization against new experiences (Kolb 1984; Morris 2020).

The result of our literature review indicates that the way we integrate soft skills into subject-specific skills is new and innovative, as no similar approach was identified.

2.2.4 Integrative Approach to Foster Self-observation

The artifact of this contribution is an interactive video that integrates self-observation into the topic process modeling. These topics are combined, due to their common aim to analyze procedures and reveal their weaknesses. The video is embedded in a BISE lecture following the flipped classroom concept, where initial knowledge transfer is enabled through self-study material (Milman 2012). In the following synchronous active plenum, students apply and test their knowledge. Students need around 30 minutes to complete the interactive video and its corresponding tasks. Our integrative approach follows the four steps of the experiential learning theory:

The first step is to create a **concrete experience** through a virtual learning scenario. Following the requirements of the experiential learning theory, the interactive video offers students the possibility to make individual decisions about the course of the video, creating the base for a self-observation experience (Morris 2020; Kolb 1984). The starting scene presents a student's desk in a first-person perspective (Figure 6**)** depicting a realistic learning scenario. It shows a computer with the open website of the university's learning management system, in particular a self-study video explaining EPC notation. Here, students can choose to start the video for self-study or use the smartphone virtually.

Figure 6: Starting Screen of the Interactive Video

During this first step, the students are given multiple decision options. Depending on students' selected paths, the duration of the interactive video differs (3-6 min). The most efficient way to complete the first step of the interactive video is to choose the option to eliminate possible distractions and then start the self-learning video that explains the EPC

notation. Other paths include checking messages and continuing to use the smartphone for distractive actions. These options prolong the duration. At the end of the first step, students are confronted with the time it took them to complete the task and the amount of time it took to complete it in the most efficient way.

In the second step, the interactive video guides students to the **reflective observation** (Morris 2020; Kolb 1984). A split-screen video provides a progress comparison created from all possible decision paths (Figure 7). It allows students to observe their decisions made in the first step and compare them to alternative paths. To illustrate the different paths, an EPC excerpt depicts the progress during the first step of the interactive video. In this way, the notation of the modeling language is repeated as well.

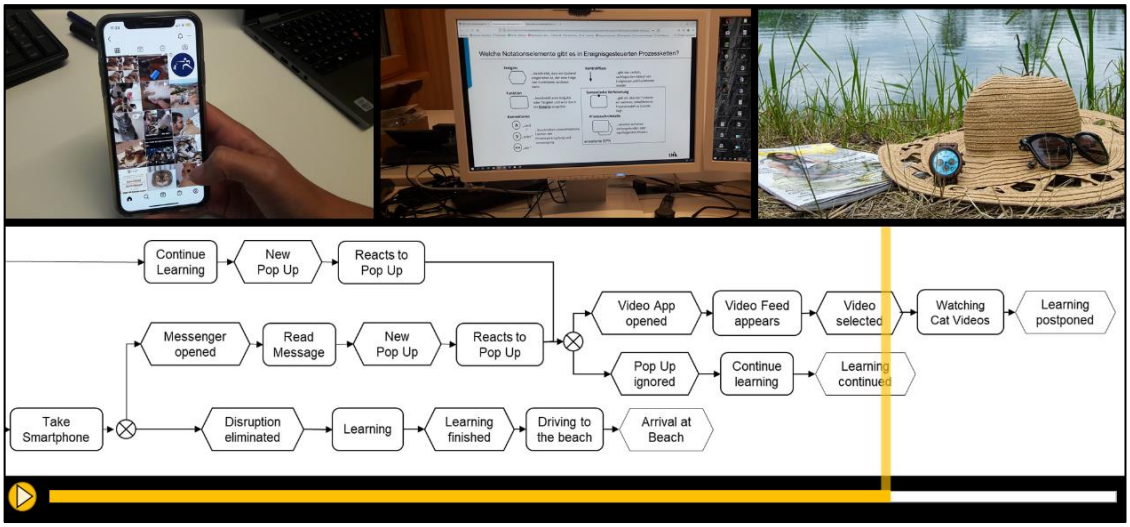

Figure 7: Abstract Conceptualization During the Interactive Video

The third step is the **abstract conceptualization**, where reflective questions guide students to review their experience on an abstract, context-indifferent level (Morris 2020; Kolb 1984). Questions are: Why is it important to observe your activities? How could you implement your findings in other aspects/activities of your life? This step also illustrates links between self-observation and organizational process documentation, as both enable to identify ineffective resource management. The students are invited to document their answers in the lecture forum, to provide lecturers and their fellow students the possibility to give feedback on their reflections and to learn from other reflective thoughts.

The last step is the **active experimentation**, where students are encouraged to make new experiences (Morris 2020; Kolb 1984). A call-to-action invites them to transfer their findings from the previous step to other actions or routines in their daily life. The goal is to document personal processes and to analyze them regarding possible inefficiencies. It is

suggested that students try to document their routines with the EPC notation, but they are also free to use another notation. The overall goal is to give food for thought on self-observation possibilities to improve routines and reduce potential inefficiencies.

2.2.5 Outlook

In this paper, we focused on the SL strategy self-observation that is integrated into a lecture unit addressing process modeling. Within the first design cycle of our DSR project, we plan to integrate all behavioral SL strategies into the addressed BISE lecture, combining the following topics in interactive videos: project-management methods and self-goal setting; process models and self-rewarding / -punishing; data management models and self-cueing. The videos are implemented as H5P modules and will be published as open educational resources.

The effectiveness of our approach will be evaluated in the winter semester of 2021/22, where we expect 70 students to participate. The revised SL questionnaire (Houghton and Neck 2002) will be used to collect quantitative data. Additional open-ended questions will provide students the opportunity to add qualitative feedback. Data will be collected at the beginning and the end of the semester. The goal is to identify significant changes in students' use of SL strategies and discover potential long-term effects. While we understand the integration of personal skills into subject-specific skill training as a valuable addition to the current BISE curriculum, we do not intend it to replace traditional soft skill courses. The aim is rather to make the previously implicit training of personal skills during BISE education more targeted and efficient. So far, our approach focuses on behavioral SL strategies. In future DSR iterations, we plan to integrate constructive thought patterns and natural reward strategies in a holistic teaching approach incorporating findings of the evaluation.

The importance of soft skill training is not limited to BISE students only, but essential in various disciplines (Grudzdev et al. 2018; Ibrahim et al. 2017). Therefore, our research addresses the overarching goal to investigate the suitability of 1) subject-specific methods serving as “carrier” for soft skill content 2) interactive videos to foster soft skills. These general findings can provide a foundation for integrative approaches in other disciplines (e.g., economics).

2.3 Essay 3: Using Hexad User Types to Identify Motivational Preferences among Learners

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2.3.1 Abstract

The Covid-19 pandemic has highlighted the long-standing problem that many students struggle to regulate their motivation in digital learning settings. There is a demand for a framework that provides concrete and tangible strategies on how to foster students' individual motivation. One framework that addresses these demands is the Hexad framework (Marczewski 2013). It defines six user types and corresponding motivational preferences. Research reports positive effects on motivation when considering the framework in information systems. This study initially investigates its context shift towards digital learning. By analyzing the fit of students' motivational preferences of their identified user types and their motivational preferences as learners, a high identification rate appears. However, while Hexad user types are clearly separable, the analysis identified an underlying group- and task-orientation among all students. Overall, the findings suggest that the Hexad framework can function as a guidance for students when selecting effective strategies to promote self-regulated motivation.

2.3.2 Introduction

The Covid-19 pandemic further revealed the long-standing problem that many students struggle to self-regulate their motivation, especially in digital learning environments (Sakkir et al. 2021; Tan 2021; Wesselborg 2020). This is alarming as an absence of motivational regulation competence is closely associated with academic procrastination and students' dropout intentions (Bäulke et al. 2018). At the same time, even elaborate learning concepts in which lecturers aim to motivate students, for example through gamification, fail without students underlying motivation (van Roy and Zaman 2017). Furthermore, the ability to motivate oneself is particularly important for students in higher education, as it is required in their later professional life (Liu and Murphy 2018; Majid et al. 2019). Therefore, students should ideally start building on their motivational regulation skills at an early stage of their studies and deepen it further on (Corpus et al. 2020).

However, based on current research, there are very few interventions and trainings that specifically address the promotion of competencies to regulate motivation in higher education (Eckerlein 2020; Tan 2021). Here, the required first step is for students to build up knowledge about self-regulated learning motivation in order to understand and be able to apply concrete advice and strategies (Steuer et al. 2019). As a result, there is a need for an underlying tangible concept, that explains motivational structures and offers concrete advice for students to foster their ability to motivational regulation. Research provides various concepts that address motivation (Sekhar et al. 2013). However, existing frameworks often rather abstractly explain motivation within an individuum (Rheinberg and Engeser 2018) or focus on complex cause-effect relationships (Eccles and Wigfield 2002), which are difficult to convey as concrete advice for students. Furthermore, models addressing motivation often only consider intrinsic motivation whereby students' motivation is also influenced by external factors (Ryan et al. 2006).

A framework that comes with the needed requirements for a tangible concept to teach students motivational strategies introduces the Hexad user types (Tondello et al. 2016). These user types are based on established motivational theories (e.g. Ryan et al. 2006) but also integrate findings of research on personality types (Nacke et al. 2014). It is easily understandable and tangible because, instead of complex cause-effect relationships, it rather presents a distinction of six user types. These six user types, come with concrete strategies for promoting motivation based on the individual motivational preferences of these user types (Tondello et al. 2016). However, this framework has been developed especially for a targeted implementation of gamification elements in information systems

(IS) (Marczewski 2013, 2015). Adapting IS according to Hexad user types shows great success and leads to increased user engagement and motivation (Passalacqua et al. 2021). In higher education, it provides educators a framework to motivate students, but so far only regarding the design of gamified IS such as learning management systems (Fischer et al. 2018). Because of its broad scope of application in various IS, as well as its broad theoretical foundation (Tondello et al. 2016), the framework could also offer great potential in differentiating students in terms of underlying motivational preferences outside gamified IS but in a learning context. Here, the Hexad user types could provide a framework that makes it easy for students to build knowledge and become aware of their own motivational preferences, while also giving educators insight into the different motivational structures of their students. To investigate the current application context of the Hexad framework we conducted an initial systematic literature review (Vom Brocke et al. 2015), which however further indicates that the Hexad user types so far have been used exclusively for the design of IS. The transfer to a learning environment outside IS seems to be novel. As the authors of the framework call for underlying research, when the framework changes context (Tondello et al. 2016) we aim to address this research gap by investigating the research question: *To what extent are Hexad user types adequate to differentiate motivational preferences of higher education students in a learning context outside of gamified IS?*

To answer this research question, we developed six different personas that represent personifications of the six Hexad user types and are characterized by their individual motivational preferences. Our goal is to identify the fit between the motivational preferences of the user types and students' motivational preferences as learners. Therefore, we first, measured students' Hexad user types and then assigned the students to a corresponding persona that is characterized according to the motivational preferences of students' corresponding user types. Based on a cooperation script, they gained experience with these motivational structures of their persona in a learning task in group work. After completion of the learning task, we conducted a qualitative written survey in which we investigated the extent to which the students could identify with the motivational structures of their persona (= their user type) in this learning scenario.

This study is the underlying step in a larger research project following Design Science Research (DSR) (Hevner and Chatterjee 2010; Hevner 2007) with the goal to design a training in a higher education context that equips students with demanded competencies to regulate their learning motivation according to their motivational preferences. Our research provides the foundation for future steps of this DSR project and insights for future

research. It contributes by investigating the fit of motivational preferences in Hexad user types and the motivational preferences of students as learners. In addition, the study also highlights identified similarities as well as differences and thereby reveals further refinements to distinguish students' motivational preferences. Based on these insights we propose concrete and systematically derived implications for future research and higher education.

2.3.3 Theoretical Background and Related Work

The initial differentiation of users into different types comes from the video game industry. Thus, various models exist to integrate motivating game elements according to different motivational preferences. The most popular ones are the Bartle's player type model which identified four player types within the game genre Multi-User Dungeons (Bartle 1996) and the BrainHex model, which was based on insights from neurobiological findings as well as the results from earlier demographic game design models (Nacke et al. 2014). However, previous models were created specifically for game contexts and should not be generalized to game design (Tondello et al. 2016). Inspired by these models, Marczewski (2013) developed the Hexad model. It is designed to address contexts beyond gaming and therefore provides a broader scope that suggests type-appropriate use of gamification in IS. The Hexad model takes up users' motivational structures and focuses on motivational preferences (Tondello et al. 2016; Marczewski 2013, 2015). It incorporates founded theories such as the Self-Determination Theory concerning the expression of both intrinsic and extrinsic motivation (Ryan and Deci 2000; Ryan et al. 2006). Here, three key intrinsic motivators are defined: 1) competence/mastery, 2) autonomy 3) relatedness (Ryan and Deci 2000). In addition, Marczewski (2013) considers Pink's drive theory, which introduces purpose as an additional motivator (Pink 2011). Thus, the Hexad framework is a well-founded model that considers established player type models with neurobiological typologies, as well as motivation theories. It also shows correlations with the Big Five personality traits (Tondello et al. 2016). Within the Hexad framework, Marczewski (2013) defines six user types, which differ in the extent to which they are motivated by either intrinsic (e.g., self-actualization) or extrinsic (e.g., rewards) motivational factors: Socializer, Philanthropist, Achiever, Player, Free Spirit and Disruptor (Diamond et al. 2015; Tondello et al. 2016). Table 4 shows the Hexad user types and their motivational preferences that formed the basis for the creation of the persona characteristics in Table 6.

Table 4: Hexad User Types with Motivational Preferences and Main Characteristics according to Marczewski (2013) and Diamond et al. (2015)

User Type and Motivation		Main Characteristics and Description	
Socializer	Relatedness	Strongly oriented towards others	Desire of being part of a group, want to interact with others and create social connections, reward lies in the interaction itself
Philanthropist	Purpose		Are altruistic and willing to give without expecting a reward
Achiever	Mastery	Like to win and tend to be self-centered	Looking for overcoming challenging obstacles, completing every possible task, learning new skills, reaching 100%, the reward is represented by a feeling of mastery
Player	Extrinsic Reward		Focusing on extrinsic rewards, which they gain through a variety of strategies
Free Spirit	Autonomy	Creative, like to do things their own way, value independence, tend to be self-centered	Looking for freedom to express themselves and act without external control, reward lies to find one's way within the given boundaries
Disruptor	Change		Tend to disrupt either directly or through others to force negative or positive changes, like to test the boundaries and try to push further, reward lies in the triggering of change

For a systematic overview of the current application context and domain of Hexad user types in literature, we conduct a systematic literature review according to Vom Brocke et al. (2015) (see Table 5):

Table 5: Systematic Overview of the Application of Hexad User Types in Current Literature

Articles	IS	Gamification	Application Domain						Distribution of User Types (in %)						
			Education	Health	Sustainability	Validation	Warehouse	Museum	Achiever	Player	Socializer	Philanthropist	Free Spirit	Disruptor	Multiple
Passalacqua et al. (2020)	■	■					■		20	20	20	16	24	0	
Passalacqua et al. (2021)	■	■					■		20	20	20	16	24	0	
Akgün and Topal (2018)		■				■									
Taşkın and Kılıç Çakmak (2020)		■				■									
Manzano-León et al. (2020)		■				■									
Li et al. (2019)	■	■		■											
Câmara and Lima (2021)	■	■						■	16	7	9	44	25	1	
Amado and Roleda (2020)	■	■	■						10	33	21	8	6	1	22
Altmeyer et al. (2020)	■	■		■					19	18	16	14	19	14	
Ardiana and Loekito (2020)	■	■	■						43	0	10	20	27	0	
Böckle and Yeboah-Antwi (2019)	■	■			■										
Tondello et al. (2016)		■	■			■			24	10	19	24	22	1	

We follow a sequential progress and use bibliographic databases as sources. With a widely defined keyword search in five interdisciplinary databases, we aim for a comprehensive coverage (Vom Brocke et al. 2015). The search string "abstract: Hexad" identified in total 26 articles: IEEExplore (9), ERIC (2), AISel (3), Pubpsych (2), WISO (10), whereby 14 articles were excluded as they did not refer to the Hexad user types. Consequently, our analysis is based on 12 articles. The oldest articles are from 2016 and 2018 whereas 10 out of 12 articles were published within the last years (2019 to 2021). Furthermore, the analysis shows that some articles (4 out of 12) initially translate and validate the Hexad questionnaire in other languages (Spanish and Turkish) or confirmed the framework's validity as a measure of user preferences towards different game design elements and the Big Five personality traits (Tondello et al. 2016). While all studies highlight the potential of the Hexad user types, the status of the Hexad research indicates its novelty. To the extent that the identified user types were captured, no clear pattern in terms of a typical distribution of user types could be identified. However, in this context, it is notable, that the Disruptor is hardly present. The literature review also shows that the Hexad user types are used for game-based IS to foster user engagement and enjoyment (e.g., Passalacqua et al. (2021)). The transferability to contexts such as healthcare or IS for museums is also demonstrated (Câmara and Lima 2021; Li et al. 2019). Three of the 12 articles use the Hexad user types similar to our approach in the context of higher education. However, while Amado and Roleda (2020) refer to a gamified IS in higher education, we investigate the use of the Hexad user types, also in a higher education learning environment, but outside IS and gamification. Overall, the literature review confirms the potential of the Hexad user types in various use cases, with current literature focusing on gamified IS. Furthermore, researchers conclude that there is a demand for research on the Hexad user types in higher education to foster students' motivation.

2.3.4 The Hexad Scale to Differentiate Students' Motivational Preferences

To answer our research question of to what extent are Hexad user types adequate to differentiate the motivational preferences of students in a learning context, we conducted a role play. Based on a collaboration script, students were instructed to solve a common learning group task and behave according to their assigned persona representing personifications of Hexad user types' motivational preferences. During this role play, they should behave according to their assigned persona. This allows students to gain concrete

experience with motivational preferences as their assigned persona in a realistic learning contest.

At the beginning of the winter semester 2021/22, we surveyed students using the Hexad Gamification User Types Questionnaire for user type differentiation as part of a first-semester seminar for IS students on soft skills. Based on their responses, students were categorized by their identified user type. To take up the motivational preferences of the user types defined within the Hexad scale we created fictional personas with corresponding characteristics. Table 6 presents user types according to the Hexad framework and their corresponding personas, their characteristics in the form of keywords, and a short description of key motivational factors.

Table 6: Personas within the Role Play and Corresponding Hexad User Types

User Type and Motive		**Personas with Characteristics and key motivational factors**	
Socializer	Relatedness	A	Open, outgoing, sociable, group-oriented. Get to know fellow students and build relationships.
Free Spirit	Autonomy	B	Charismatic, confident, creative, power-oriented. Create a particularly good presentation according to own wishes.
Achiever	Mastery	C	Determined, smart, hardworking, rational, self-oriented. Use the task to gain experience and improve skills.
Philanthropist	Purpose	D	Open, helpful, friendly, empathetic, people-oriented. Help group members and enrich others with own knowledge.
Player	Extrinsic Reward	E	Extrinsically motivated, competitive, goal-oriented. Give 100 percent when there is a reward.
Disruptor	Change	F	Rejection, innovation, influence, change-oriented Question the sense of the tasks to generate more innovative ideas.

According to their identified user types, we assigned students to the corresponding personas. We allocated students into ten groups of five to seven participants and ensured that different personas/user types were represented in each group. Before the lecture, we provided each student with a collaboration script. The collaboration script informs students about their persona and the task of the role play, whereby the role play reflects a realistic scenario of a learning group. The task of the learning group was *"Please prepare a short presentation with the topic: The history of the German business and IS engineering: essentials on the founders and the development of the discipline to the present day"*. The process of the role play is structured in three phases: In the first phase, each student should clearly express and pursue the motivation and goals of the assigned persona. In the second phase, students are instructed to further enforce their persona's goals and motivational preferences without considering the needs of others. Consequently, heated discussions

arise. Through the discussion with others, students engaged more deeply and actively with the motivational preferences of their persona as described. The third phase is about finding a conclusion within the arranged learning group, e.g., a compromise or splitting the group. The exact outcome is not part of the instructions for the role play but is left open for each student to assert themselves in different ways. The duration of the role play was 15 minutes, with five minutes per phase. After the role play, students got time to review their experience with the help of a guided reflection. We used a control group of six students in which students were randomly assigned to personas that did not match the identified user type. With this control group, we strengthen our research by allowing us to distinguish whether students' identification with persona is systematic rather than random.

2.3.5 Method

The sample consisted of a total of 57 participants and an additional control group (n =6). While 47 students could clearly be assigned to one user type, we identified ten students incorporating two or three user types. Due to the lack of uniqueness, we had to assign these students to one of their fitting user types. For the control group, the user type was randomly assigned.

The sample contains 79% male and 21% female. The ex-ante differentiation of students by user types was based on the Hexad Gamification User Types Scale according to Marczewski et al. (2013). This questionnaire is based on a 7-point Likert scale and contains 30 items from which a total of six constructs emerge that represent the six user types. Table 7 summarizes our sample according to the Hexad Gamification User Types Scale.

Table 7: Sample

Students with clear user type		Students with multiple user types		Control group	
User type	#	User types	#	Real user type	Assigned user type
Socializer	15	Socializer & Free Spirit	3	Player	Philanthropist
Philanthropist	12	Socializer & Player	2	Socializer	Free Spirit
Free Spirit	12	Socializer & Philanthropist	1	Philanthropist	Free Spirit
Achiever	7	Philanthropist & Achiever	1	Free Spirit	Achiever
Player	11	Free Spirit & Player	2	Player	Free Spirit
Disruptor	0	Player & Philanthropist & Achiever	1	Player	Philanthropist
∑ 47		∑10		∑ 6	

Within the group of students that incorporate multiple user types, Socializers and Players each occur three times in combination with others and Free Spirits are combined in two instances. Achievers and Players each occurred only once together with other user types. Therefore, in our sample Achievers and Players present the most clearly measurable user types when applying the Hexad Gamification User Types Scale. These results are consistent with Hexads' author findings that users might display a central type indicating a specific motivation driving their actions most strongly or might be represented evenly by different types portrayed by a profile (Tondello et al. 2016).

After the role play, we used a qualitative survey with the question *"What are the similarities and differences between my persona and my own personality?"*. Students explained this question in the context of a written reflection using coherent sentences on thoughts and feelings.

2.3.6 Findings

Two researchers independently coded students' qualitative data and distinguished if students could identify with the motivational preferences of their persona. The coding resulted in an interrater agreement of 92% indicating a high agreement rate. Out of the 63 statements, three statements were initially differently coded. We discussed and refined these inconsistencies. Table 8 presents students' identification rates.

Table 8: Identification Rates

Identification	Students with clear user type	Students with multiple user types	Control group
Yes	38/47 = 80 %	5/10 = 50 %	0/6 = 0 %
No	9/47 = 20 %	5/10 = 50 %	6/6 = 100 %

The analysis of the identification rate shows a clear trend. The strongest agreement of 80% is when students experience the learning scenario whereby their persona corresponds to their identified user type. Among the ten students that could not be clearly assigned to one user type, there was an identification rate of 50%. The control group showed the lowest agreement with 0 %. Thus, students who were assigned to a different user type than themselves were mostly unable to identify with the motivational preferences of their persona in the role play.

A closer evaluation of the identification rate among students with clear user type with regard to user types shows that Achievers identified 100%, while 87% of Socializers,

83% of Free Spirits, 82% of Players, and 75% of Philanthropists did identify with their persona. Regarding the identification rate of students with multiple user types, no clear pattern corresponding to individual user types occurred. Within the control group, no students could identify with the motivational preferences of their persona.

We further investigated the similarities and differences of persona characteristics in the role play and students' statements regarding their real motivational preferences as learners. Table 9 shows the results of our qualitative data analysis for students with clear user types who identified with their persona.

Table 9: Comparison of Personas Characteristics and Student's Motivational Preferences among Students with Clear User Type

User Type	Similarities	Differences
Socializer	Openness, sociability, importance of social interaction	Missed focus on productivity and task, exaggerated focus on getting to know each other
Philanthropist	Helpfulness, openness, sharing knowledge	Desire to take more task focus, group atmosphere is important but not more important than learning success
Free Spirit	Creativity, taking responsibility, prefer individual work	Need for a good group climate instead of only asserting one's own opinion
Achiever	Determined, hardworking, self-oriented	Desire to work harmoniously with fellow students; Being successful as a team is also important.
Player	Extrinsically motivated, competitive, goal-oriented	Desire to work harmoniously with fellow students; When studying, they don't necessarily need extra rewards. Good grades are also important.

Among the nine students with clear user types who did not identify with the assigned persona (see Table 8) the qualitative statements suggest that they perceived their persona characteristics as too exaggerated. Free Spirits expressed too much autonomy that comes with dominance and persuasion in the group, whereas Philanthropists claimed not to be exclusively human-oriented in learning groups but to focus more on the task. The Player sees a purely extrinsic focus in their group as unfair and emphasize the importance of intrinsic motivation and the Socializer describes themselves as rather reserved with more task focus.

Further investigations of the similarities and differences in persona characteristics among students with multiple user types who did not identify with their user type in the role play showed a clear trend. The students who embodied the Socializer combined with other user types such as Free Spirits, Players, and Philanthropists most strongly identified themselves with the motivational preferences of the Socializer independent from their assigned

persona. For example, a student with the Free Spirit and Socializer user types assigned to a persona with the motivational preferences of a Free Spirit might be more likely to identify with the motivational preferences of the Socializer. The importance of group climate and teamwork was prominent in the students' statements rather than the motivational preferences of their assigned persona. So, for students with multiple user types that include the Socializer, the Socializer prevails most reliably.

The responses of the control group were analyzed and separately summarized in Table 10. The results indicate that the identified differences in the assigned user types correspond to the main motivational preferences of students' real user types. Furthermore, students' identified similarities to the assigned user type did not present the main characteristics of user types but vague attitudes or actions.

Table 10: Comparison of Personas Characteristics and Student's Motivational Preferences among Students with Clear User Type

Real user type	**Assigned user type**	**Similarities**	**Differences**
Player	Philanthropist	Work productively with a team, openness	Desire for less human focus, because the right to determination suffers as a result, own opinion loses out to others
Socializer	Free Spirit	authority, creativity	Desire for less autonomy Missing ability to work in a team
Philanthropist	Free Spirit	Contribute good Ideas	Missing social skills and empathy, Desire for team orientation
Free Spirit	Achiever	Highly motivated, determination	Attitude that satisfaction does not only depend on achievement. Achieving one's own performance is not the focus Does not understand university a competition Dislikes comparison of performance
Player	Free Spirit	No further information	Strong desire for autonomy, power and authority disrupts the group climate
Socializer	Free Spirit	Self-confidence, Charismatic	Desire to be more group orientated with less autonomy but group

2.3.7 Discussion and Implication

Our results suggest the Hexad framework as a potential solution for differentiating students in terms of underlying motivational preferences outside of gamified IS in a learning context. That is based on the fact that we identified the fit between the motivational preferences of the user types in the form of the assigned persona in the role play and students' motivational preferences as learners. The high identification rate of 80% for the students with clear user types and the identification rate of 0% for the control group confirm that identification with the user type's motivational preferences is possible through an active learning experience. Here, the active learning experience with their user type enabled

students to reflect on their motivational preferences and to become aware of similarities and differences. Thus, we conclude that an active learning experience with the user type is the first important step in building knowledge about motivational preferences.

The fit between the motivational preferences of the user types embodied by the persona in the role play and the actual motivational preferences of the students as learners were investigated through a qualitative analysis of a written survey. To this end, we examined the similarities and differences between the persona characteristics in the role play and students' statements about their actual motivational preferences as learners. We found that for the students with clear user types, the similarities to the persona characteristics were consistent with the motivational preferences of their user types. For example, the Socializers emphasized the importance of social interaction, the Free Spirits emphasized creativity, and the Players emphasized an extrinsic focus. Students with a lack of identification address the fact that the personas were too tailored to the central motivational preference of their user type. For example, Achievers lacked group focus, while Socializers also missed the need to accomplish a task. Therefore, it should be considered that while most students can be differentiated by user types according to their motivational preferences, other essential needs in an educational context should not be neglected. For the learning context, it can be concluded that students perceive group harmony as essential to their learning success regardless of their user type and associated motivational preferences. Thus, students prefer to act for the good of the group in order to achieve their learning goal, even if this means limiting their own motivational preferences. The same pattern could be identified when analyzing the statements of the Socializers and Philanthropists. Students with these user types incorporate the motivational preferences of their user type and understand and value the importance of interaction in the learning context. However, in our learning context they also strongly aim to contribute to the learning task. Also, Players set aside their extrinsic focus as they value a good group relationship and therefore aim for a successful completion of the task. The same applies to the Free Spirit, who likes to explore creativity as a stand-alone individual without acting autonomously in a learning environment but also acts group-oriented. We also identified that Achievers, do not only focus on their own performance but also on the progress of the group.

The statements of the control group further support the applicability of the Hexad framework in the learning context for differentiating students in terms of underlying motivational preferences. Here, the data shows that students had almost nothing in common with their assigned persona. Our analysis of the students' statements regarding differences between assigned persona and their own perceived motivational preferences reveals that

students mentioned their user types' corresponding motivational preferences. For example, a Socializer that was assigned to the persona with the motivational preferences of a Free Spirit expressed the desire for less autonomy but wishes for good teamwork. With the lack of identification of our control group, we confirm the solid foundation and suitability of the Hexad framework for our application context. After all, an active learning experience does not lead to identification with an indeterminate user type, but only if the persona characteristics match the key motivational preferences of the real user type. Another key finding is that among students with multiple user types, the Socializer was the most prevalent. This can be concluded from the written survey, as students consistently mentioned the importance of group climate and teamwork, rather than emphasizing the motivational preferences of their actual persona in the role play.

From these findings, we derive the following implications for educators, learners, and researchers: An active learning experience with personas representing the Hexad framework is shown to be suitable for identifying with the motivational preferences of one's own user type. On this basis, concrete trainings can be developed for students to make them aware of their motivational preferences in order to improve their ability to regulate motivation. When designing such trainings, educators have to take into account not only the central needs of the user types. In the learning context, the final learning success is the superordinate goal, which can be achieved in the context of a learning group only by group harmony. Consequently, instructors should not exclusively consider the essential motivational preferences of the user types but rather place the group focus in the center of attention. For students, it can be deduced that learning according to the motivational preferences of their user type can be valuable and effective to raise motivation. Our findings indicate that besides the underlying desire for a good group climate, Achievers and Players are motivated by progress and achievement. For both good grades in their studies and success experiences e.g., through the achievement of self-set intermediate goals boost motivation. Players could amplify this effect by defining additional rewards. Furthermore, Socializers, as well as Philanthropists, could raise their motivation to learn through forming learning groups. And Free Spirits should be careful not to have too strict restrictions and time schedules when learning but allow enough room for creativity and innovation. Thus, students could apply the Hexad framework in self-learning phases to regulate and targeted foster their motivation. Here, further research should explore the effect of applying such strategies corresponding to the user type as well as how to raise students' awareness of their user type to enable them to apply user type corresponding motivational strategies. As an implication for future research, it is possible to investigate

the occurrence of these six user types in our application context, outside of gamified IS. It becomes evident that the user types, even though they differ in their motivational preferences, can be combined into some core profiles due to their uniform task and group orientation. The need for research is reinforced by the additional fact that we were only able to measure five of the six user types. A solid synergy will make it much easier for educators to identify user types and explore targeted training to increase awareness of motivational preferences.

2.3.8 Conclusion and Outlook

While previous research has confirmed the potential of Hexad user types for tailoring gamified IS that foster users' engagement and motivation, our study expands the application context. We investigate the fit of these user types and the motivational preferences of students outside IS. Our findings indicate a high fit and support that the Hexad user types can also differentiate students in higher education according to their motivational preferences. However, in this context, small refinements need to be considered: Our findings reveal that all students show a certain group- and task-orientation, despite their underlying real user types. While these results appear to mitigate the sharp contrast between the types of users in the educational context, they also indicate that students' group and task orientations could be interpreted as basic motivational preferences of higher education students. Next to these underlying motivational preferences of students, a differentiation according to the motivational preferences of their user types is predominantly accurate. Consequently, students' motivation can be effectively targeted if the motivational preferences of the particular type of user are taken into account.

So far, our findings are limited by the absence of the user type Disruptor. This prevents us from investigating whether the Disruptor can characterize learners based on their motivational preferences. However, other studies are also based on samples without Disruptors, suggesting that this user type is uncommon. Furthermore, the size of our sample and especially the size of the control group is limited. However, we were still able to identify clear and robust patterns in students' statements. Nevertheless, repeating the experiment with a larger control group would strengthen the results.

The generalizability of our findings is only conditionally given. While this study indicates that the Hexad user types can also identify motivational structures outside gamified IS but also in learning groups in higher education, we do not suggest that the Hexad frame-

work is transferable to all other contexts based on our findings. Furthermore, the participants of our study are all first-semester IS students. With more learning experiences at universities, motivational preferences could change as well. Considering findings on team constellations, the composition of the groups regarding user types may also have an influence on the group structure and climate (Belbin 2012). For a broader generalizability of the Hexad user types, there is a need for further research. Our study is the first contribution in a larger DSR project towards a training for motivation regulation towards motivational preferences for university students. Considering the established model of Prochaska and DiClemente (1983) we understand awareness as a fundamental step towards sustainable training for motivational regulation. The results of our initial study reinforce the idea of including the motivational preferences of Hexad user types, by investigating whether students' knowledge about their motivational structures can enable them to select suitable and target strategies for self-motivation. Building knowledge about motivational preferences is thus a fundamental step (Steuer 2019) upon which we build our further research when investigating strategies, that enables university students with demanded competencies to regulate their learning motivation according to their motivational preferences. In light of the growing trend that digital learning is emerging even outside of the Covid-19 pandemic, we understand these strategies are universal important for students learning and their later careers.

3 Essays on the Theory of Designing Behavior Change Support Systems

3.1 Essay 4: Process-based Guidance for Designing Behavior Change Support Systems: Marrying the Persuasive Systems Design Model to the Transtheoretical Model of Behavior Change

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3.1.1 Abstract

Behavior change is a topic of high relevance and widely studied in the field of psychology. Through the integration of technologies into everyday life, behavior change support systems (BCSS) are gaining attention in the field of information systems. The persuasive systems design (PSD) model of Oinas-Kukkonen and Harjumaa (2009) is a leading framework to provide a generic technical design process including 28 design principles. However, the model is lacking a clear picture regarding which of those design principles should be selected for specific implementations. Consequently, researchers and developers who implement BCSS are missing structured and evidence-based guidance. They need to invest time and cognitive resources in an underlying analysis of different design principles. Because the influence of persuasive systems is strongly linked to the processual state of behavior change, we combine the PSD model with the transtheoretical model (TTM) of Prochaska and DiClemente (1983) and elaborate a model that recommends appropriate design principles for the five transitions along the stages of behavior change.

We refined the model using a systematic literature review. The results provide a specification of the PSD model and a guideline to select effective design principles for developing BCSS.

3.1.2 Introduction

People stay in their established way of behavior even though they know that a different way of life would be beneficial. For example, many want to lead a fit and healthy lifestyle, but remain inactive and make poor eating choices. As a result, serious health problems based on unhealthy behavior are on the rise. Despite this discrepancy between desired and actual behavior, it is hard to change established behaviors sustainably. Behavior and how behavior can be influenced is widely studied in the field of psychology. Established behavioral models are, for example, the transtheoretical model (TTM) of Prochaska and DiClemente (1983), the theory of planned behavior by Ajzen (1991), or the health belief model by Siddiqui et al. (2016).

Along with the integration of technology into the individual´s everyday life, Fogg (2003) envisioned the potential of persuasive technologies to support people in changing their attitudes and behaviors. Based on Fogg's (2003) research, Oinas-Kukkonen and Harjumaa (2009) defined the concept of behavior change support systems (BCSS) and introduced BCSS as "a key construct for research in persuasive technology" (Oinas-Kukkonen 2010). BCSS include mobile apps, social media, or interactive websites with the aim to change attitudes or behaviors. BCSS are already successfully used in the context of health (e.g., Langrial et al. 2013) and environmental aspects (e.g., Shevchuk and Oinas-Kukkonen 2016). Additionally, there is further potential to employ BCSS in a working environment supporting behavioral aspects of digital transformation (Merz 2020; Nkwo 2019).

The by far most referenced technical framework in research for developing BCSS is the persuasive systems design (PSD) model by Oinas-Kukkonen and Harjumaa (2009) (Otyepka 2018). The PSD model recommends a generic design process that starts with the analysis of the persuasion context and presents multiple design principles. The PSD model proposes to select context-specific design principles, but a clear picture of how these design principles should be selected is missing (Wiafe et al. 2014). However, it is essential for persuasive systems design to select effective design principles because it is not practical to include a high number of design principles (e.g., studies apply on average

only 15 of 28 design principles of the PSD model (Merz and Ackermann 2021)). Moreover, studies highlight the importance of choosing the right design principles instead of implementing as many as possible (Wildeboer et al. 2016; Prochaska and Norcross 2001). Therefore, researchers and developers of BCSS need to invest time and energy conducting a laborious context-related analysis of users' needs and fitting design principles before implementing their projects instead of focusing their cognitive resources on the specific design of BCSS.

The aim of this work is to fill this gap between technical framework and context-related behavioral model. Because the influence of technology-enhanced behavioral interventions is strongly linked to the state in the process of behavior change (Vandelanotte and Bourdeaudhuij 2003; Oinas-Kukkonen and Harjumaa 2009; Prochaska and Norcross 2001), we combine the widely used and frequently validated stages of change of the TTM (Prochaska and DiClemente 1983; Prochaska and Norcross 2001) with the PSD model by Oinas-Kukkonen and Harjumaa (2009). As a result, we take a process perspective on the persuasion context and present a process-based model that recommends appropriate design principles defined by the PSD model. We conduct a systematic literature review to refine our conceptual model in detail and to ensure that the model is in accordance with existing research studies about BCSS.

This work contributes in a descriptive form by presenting researchers and developers of BCSS the role of the design principles of the PSD model along the process of behavior change including examples of implementations. Furthermore, this work contributes in a pragmatic form by concluding implications and guidance for developing BCSS and provides a theoretical specification of the PSD model in order to facilitate the process of designing BCSS.

3.1.3 Theoretical Background

Persuasive technology accompanies and supports the process of behavior change. It is defined as "any interactive computing system designed to change people's attitudes or behaviors." (Fogg 2003, p. 1). While persuasive technology is considered as a field of research, BCSS are research objects in this field of research (Oinas-Kukkonen 2010). According to (Oinas-Kukkonen 2013, p. 1225), a BCSS "is a sociotechnical information system with psychological and behavioral outcomes designed to form, alter or reinforce

attitudes, behaviors or an act of complying without using coercion or deception". BCSS are developed based on design principles (Oinas-Kukkonen 2010).

3.1.3.1 Design Principles

Design principles incorporate design knowledge about the design of artifacts and allow to transfer knowledge about how to achieve desired effects to different applications (Möller et al. 2020). In particular, Fu et al. (2016) derive that "design principles are created to codify and formalize design knowledge so that innovative, archival practices may be communicated and used to advance design science and solve future design problems" (Fu et al. 2016, p. 1). However, design principles are often used ambiguously and are inconsistently formulated in literature (Gregor et al. 2020) which impairs the ability to present design knowledge in an accessible form. To account for that issue, Gregor et al. (2020) suggest a Design Principles Schema for decomposition and classify design principle formulation in three categories regarding the integration of user activity: 1) design principles "about user activity", when the principle states what users can do with the artifact, 2) design principles "about the artifact", when the principle is about a feature of the artifact without directly addressing user activity, or 3) "about both", user activity and artifact, when the principle is combining design knowledge about user activity and a feature of the artifact (Gregor et al. 2020).

Based on the ability of design principles to provide design knowledge about user activities and system features, design principles are the foundation for developing information systems (Fu et al. 2016; Möller et al. 2020) and thus incorporated in frameworks as, for example, the PSD model by Oinas-Kukkonen and Harjumaa (2009).

3.1.3.2 Persuasive Systems Design Model

When developing BCSS, most researchers refer to the PSD model by Oinas-Kukkonen and Harjumaa (2009) (Otyepka 2018). The PSD model acts as a meta-level model and serves as a wide framework including generic steps and design principles for designing BCSS (Räisänen et al. 2010). In order to draw upon the most referenced and established technical framework in research for BCSS development, we build our study on those 28 design principles of the PSD model. Oinas-Kukkonen and Harjumaa (2009) group the design principles into four different categories with seven design principles each: primary task support, dialogue support, system credibility support, and social support. Table 11

shows a list of the design principles as described by Oinas-Kukkonen and Harjumaa (2009). To further specify the nature of the design principles of the PSD model as a strong foundation for our study, we added a classification according to Gregor et al. (2020) into the three categories about artifact, user activity, or both. We coded the classification independently with an interrater reliability of $\kappa = 0.96$ (Cohen's Kappa).

Table 11: Design Principles of the Persuasive Systems Design Model by Oinas-Kukkonen and Harjumaa (2009) Including Classification according to Gregor et al. (2020) regarding User Activity

Category	**Design Principle**	**Example Requirement by Oinas-Kukkonen and Harjumaa (2009)**	**User Activity**
Primary Task Support	Reduction	System should reduce effort that users expend with regard to performing their target behavior.	artifact
	Tunneling	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.	artifact
	Tailoring	System should provide tailored information for its user groups.	artifact
	Personalization	System should offer personalized content and services for its users.	both
	Self-monitoring	System should provide means for users to track their performance or status.	both
	Simulation	System should provide means for observing the link between the cause and effect with regard to users' behavior.	both
	Rehearsal	System should provide means for rehearsing a target behavior.	both
Dialogue Support	Praise	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.	artifact
	Rewards	System should provide virtual rewards for users in order to give credit for performing the target behavior.	artifact
	Reminders	System should remind users of their target behavior during the use of the system.	artifact
	Suggestion	System should suggest that users carry out behaviors during the system use process.	artifact
	Similarity	System should imitate its users in some specific way.	artifact
	Liking	System should have a look and feel that appeals to its users.	artifact
	Social role	System should adopt a social role.	artifact
System Credibility Support	Trustworthiness	System should provide information that is truthful, fair and unbiased.	artifact
	Expertise	System should provide information showing knowledge, experience, and competence.	artifact
	Surface credibility	System should have competent look and feel.	artifact
	Real-world feel	System should provide information of the organization and/or actual people behind its content and services.	artifact
	Authority	System should refer to people in the role of authority.	artifact
	Third-party endorsements	System should provide endorsements from respected sources.	artifact

	Verifiability	System should provide means to verify the accuracy of site content via outside sources.	artifact
Social Support	Social learning	System should provide means to observe other users who are performing their target behaviors and to see the outcomes of their behavior.	user activity
	Social comparison	System should provide means for comparing performance with the performance of other users.	user activity
	Normative influence	System should provide means for gathering together people who have the same goal and make them feel norms.	user activity
	Social facilitation	System should provide means for discerning other users who are performing the behavior.	user activity
	Cooperation	System should provide means for co-operation.	user activity
	Competition	System should provide means for competing with other users.	user activity
	Recognition	System should provide public recognition for users who perform their target behavior.	artifact

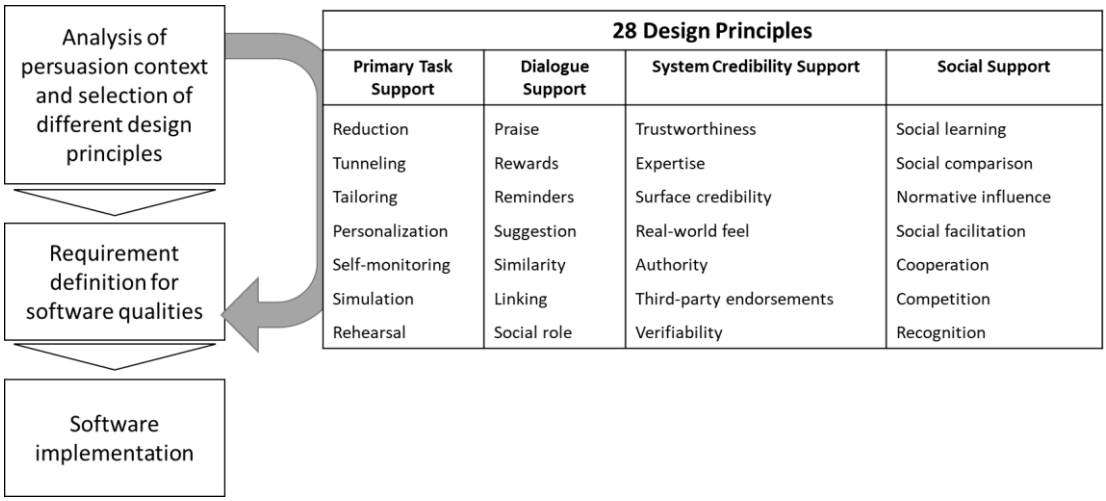
The design principles of the category primary task support "support the carrying out of the user's primary task" (Oinas-Kukkonen and Harjumaa 2009, p. 492). Applying the classifications of Gregor et al. (2020), we identified that supporting the primary tasks addresses design principles that describe system functionalities (e.g., *reduction* and *tunneling*) and design principles that also enable users to interact with the system (e.g., *self-monitoring* and *simulation*) (Oinas-Kukkonen and Harjumaa 2009). The design principle *personalization* covers two aspects: Personalized content can be content that is determined by the system for the individual user, but as well determined by preferences that are defined by the individual users themselves.

The category of dialogue support comprises design principles that provide feedback to its users (e.g., by *praise*, *rewards*, and suggestion) "potentially via verbal information or other kinds of summaries" (Oinas-Kukkonen and Harjumaa 2009, p. 493). Comprising one-way computer-human-communication, as opposed to human-computer interaction, the design principles describe system features about the artifact according to Gregor et al. (2020).

The category of system credibility support contains design principles that are able to emphasize the credibility and expertise that underlies the system, for example, using *verifiability* and *authority* (Oinas-Kukkonen and Harjumaa 2009). The design principles of credibility support describe system features without user activities (according to Gregor et al. (2020)).

The design principles of the category social support motivate users through social influence and promote an exchange of information between different users, for example, using *social comparison* and *cooperation* (Oinas-Kukkonen and Harjumaa 2009). In this category, the design principles aim to provide means to enable user activities, with the exception of the design principle recognition which describes support through system features (according to Gregor et al. (2020)).

Those 28 design principles are integrated in the PSD model (Figure 8) as follows: The first step in the development of persuasive technology is the analysis of the persuasion context and, based on the findings, a selection of persuasive design principles. After selecting design principles, the requirement definition for software qualities and the software implementation follow. While the PSD model provides generic steps and various design principles, it remains unclear how these design principles should be selected according to the context of behavior change (Wiafe et al. 2014, p. 1679). However, the model is designed to be extended by integrating suitable theories to specify certain aspects (Räisänen et al. 2010).



28 Design Principles			
Primary Task Support	**Dialogue Support**	**System Credibility Support**	**Social Support**
Reduction	Praise	Trustworthiness	Social learning
Tunneling	Rewards	Expertise	Social comparison
Tailoring	Reminders	Surface credibility	Normative influence
Personalization	Suggestion	Real-world feel	Social facilitation
Self-monitoring	Similarity	Authority	Cooperation
Simulation	Linking	Third-party endorsements	Competition
Rehearsal	Social role	Verifiability	Recognition

Figure 8: Generic Steps of Persuasive Systems Design Model with Design Principles according to Oinas-Kukkonen and Harjumaa (2009)

3.1.3.3 Transtheoretical Model

A model that specifies the context of behavior change in a structured and procedural form is the TTM of Prochaska and DiClemente (1983). The TTM is widely used in the field of psychology and describes the process of changing behavior in consecutive stages (e.g.,

Friman et al. 2017; Boff et al. 2020; Hashemzadeh et al. 2019). The six stages of change are precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska and Norcross 2001). Depending on the stage of behavior change, the addressee of persuasive technology should be supported in the behavior change in a different way (Vandelanotte and Bourdeaudhuij 2003; Oinas-Kukkonen and Harjumaa 2009; Prochaska and Norcross 2001). Therefore, these stages provide guidance and feasible context to select fitting design principles.

3.1.3.3.1 Stages of Change

Prochaska and Norcross (2001) describe the stages of change as follows: In the stage of precontemplation, people might wish to change but do not intend or seriously consider changing their behavior patterns. The behavioral problems might be unaware to them but are often known to their families, friends, or employees. In the second stage of behavior change, contemplation, people are aware of their problems and think about working on their behavior. During that second stage, people are "seriously considering changing the problem behavior" (Prochaska and Norcross 2001, pp. 443–444) but do not intend to change their behavior yet. Next, in the stage of preparation, people prepare to take action and are about to bring their intentions to visible behavior in the near future. When people show their intentions in their actions and start to modify their behavior, they have entered the stage of action. This stage is followed by the stage of maintenance where people are continuing their behavioral change and trying to prevent a relapse to their problem behavior. In the stage of maintenance, people strive to reach the last stage of termination where the process of behavior change is completed and there is no risk of relapsing into their former behavior (Prochaska and Norcross 2001).

3.1.3.3.2 Transitions

Focusing on the process of behavior change, we address the transition from one stage to the consecutive stage. This results in five transitions, which are depicted in Figure 9.

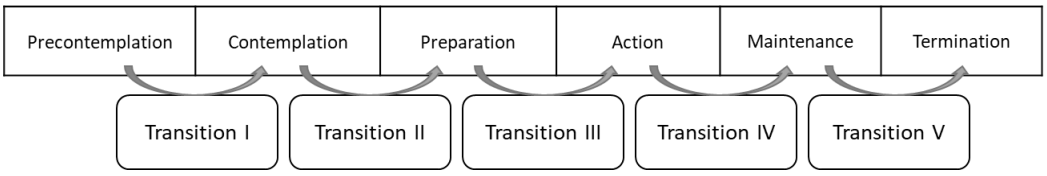


Figure 9: Transitions along the Stages of Change

In order to guide users of BCSS through the process of behavior change, developers should analyze the underlying needs of users to transition from one stage to the next. In accordance with the explanations by Prochaska and Norcross (2001), we identified the following core needs for each transition:

In transition (I) from the stage of precontemplation to contemplation, BCSS need to reveal the problem behavior to users to raise awareness of their problems. In transition (II) from contemplation to preparation, BCSS should further highlight the problem behavior and show the benefits of a changed behavior to form an intent to change. Therefore, BCSS should aim at increasing consciousness and awareness of the problematic behavior. Users in transition (III) from preparation to action need BCSS that get users to start performing the target behavior. BCSS should facilitate the initial approach of its users to adopt their intended behavior. To support users during the transition (IV) from action to maintenance, BCSS should reinforce the users' new behavior and strengthen the users' will to maintain their changed behavior. For the last transition (V) to the stage of termination, BCSS should help users to form habits and make the changed behavior their regular behavior to prevent relapses.

3.1.4 Related Work

Also, other researchers see the potential in combining persuasive technology and behavioral models. Wiafe et al. (2012) analyze the persuasion context of the PSD model with the three-dimensional relationship model between attitude and behavior (3D-RAB model), which categorizes users' state of cognitive dissonance. While they discuss how researchers can apply the 3D-RAB model to analyze the persuasion context, they do not include information on specific system design in their considerations and the link between persuasion context and the selection of design principles is still missing.

Klein et al. (2011) use the TTM to build sixteen different constructs that include some design principles, but also external factors that do not directly translate to design features (e.g. emotions, self-efficacy). In contrast to Klein et al. (2011), we concentrate on the 28 design principles of the established PSD model that can directly be implemented into BCSS.

Oinas-Kukkonen (2010) and Oinas-Kukkonen (2013) introduce the "outcome/change design matrix" which presents three behavior outcomes (forming, altering, reinforcing) and three types of behavior change (complying, behavior, attitude). While distinguishing the

behavior outcome into forming, altering, or reinforcing extends our approach, both approaches share the understanding that users' awareness of the need for a behavior change is a pre-condition for a sustainable change of behavior. Additionally, both approaches share the same goal of considering targeted forms of behavior change: The matrix shows possible forms of behavior change using the two dimensions of behavior outcomes and types of behavior change, whereas we use a process-based perspective based on the stages of behavior change. Building on the stages of behavior change allows us to examine the specific users' needs and present guidance for referring design principles, while the matrix takes a descriptive point of view. Therefore, the two approaches should not be seen as competing, but as a mutual extension due to their different characters (descriptive vs rather normative).

3.1.5 Method

Our method consists of two steps: First, we developed a model linking the 28 design principles to the stages of the TTM. Second, we refined our resulting model using a systematic literature review of research studies implementing BCSS.

3.1.5.1 Development of Model Based on Theoretical Background

In the first step, we carefully studied the original literature of the PSD model and the TTM to ensure that our model reflects the underlying models as close as possible. Two researchers independently mapped the 28 design principles to the transitions weighted by the ability of the design principle to address the users' needs (see chapter 3.1.3.3.2) of each transition. To ensure an unbiased opinion in this initial mapping, the two researchers coded the 28 design principles independently into three categories "slight recommendation" (1), "recommendation" (2), and "strong recommendation" (3). During the mapping, the researchers both identified the fourth category "no recommendation/ not applicable" (0). Table 12 shows the number of assigned categories and where the researchers agreed and diverged. To measure the interrater agreements of two independent coders with more than one exclusive category, the Cohen's Kappa Coefficient is fitting (Fleiss et al. 2003; Cohen 1960). Regarding the mapping of the 28 design principles, the Cohen's Kappa Coefficient κ is 0.445 (with p_0 =0.729, p_e=0.361) indicating a moderate agreement rate (Landis et al. 1977).

Table 12: Results of the Independent Coding

		Researcher 1				∑
		0	**1**	**2**	**3**	
Researcher 2	**0**	**24**	6	0	2	32
	1	4	**1**	0	1	6
	2	8	3	**63**	6	80
	3	2	2	4	**14**	22
∑		38	12	67	23	140

Weight	**Category**
0	Not applicable/ No recommendation
1	Slight recommendation
2	Recommendation
3	Strong recommendation

We discussed the mapping with a third, independent researcher and resolved identified inconsistencies. In sum, we concluded four levels of recommendation as follows: A strong recommendation suggests that the design principles serve the core needs of users (see chapter 3.1.3.3.2) who transition from their current stage in the process of behavior change to the next. Design principles identified as a strong recommendation should therefore be considered with high priority for the design of BCSS that support this transition. If a design principle is indicated as recommended, the corresponding design principle does not directly address users' core needs of a specific transition but supports the transition to a high extent. A slight recommendation indicates that the design principle might have positive effects on users' transition, but does not include an effect directly needed for the transition. Besides these classifications, it is possible that some design principles are not applicable or not recommended in specific transitions because there are no indications for the assumption of positive effects.

For example: The design principle *suggestion* is defined as "system should suggest that users carry out behaviors during the system use process" and that "fitting suggestions will have greater persuasive powers" (Oinas-Kukkonen and Harjumaa 2009, p. 493). Regarding the five transitions, suggestions are not able to reveal problem behavior to users, which is needed for transition (I). Therefore, *suggestion* is not applicable/ not recommended for designing a BCSS targeting transition (I). On contrary, users in the second

and third stages of behavior change need to see the benefits of a changed behavior and an approach to take the first steps of their changed behavior. Specific suggestions for behavior and actions address those core needs to transition into the stages of preparation and action (Prochaska and Norcross 2001) and are consequently strongly recommended for transitions (II) and (III). For transition (IV), when users are in the stage of action and strive to reach maintenance, users need to strengthen their will to maintain their changed behavior that they already started performing (Prochaska and Norcross 2001). Here, the design principle *suggestion* does not address the users' core needs of that transition, in contrast to design principles such as *reminders, self-monitoring,* and *competition* (Oinas-Kukkonen and Harjumaa 2009). Therefore, *suggestion* is slightly recommended for the design of transition (IV). Regarding transition (V) where users form a habit and make the changed behavior a regular behavior, the relevance of *suggestion* rises compared to transition (IV) to prevent a relapse. Consecutively, the design principle *suggestion* is recommended for transition (V) into the stage of termination.

In addition, we identified that some design principles, for example, *personalization, trustworthiness,* and *expertise*, are recommended for all transitions of the BCSS and address basic needs of users. We incorporate this finding by assigning these design principles to "basic requirements". Our understanding of a basic requirement is comparable to the concept of hygiene factors of Herzberg et al. (1959).

3.1.5.2 Refinement of Model Based on Systematic Literature Review

In the second step, we studied the role of the design principles regarding the transition phases in a systematic literature review to ensure that the model is in accordance with existing research studies about BCSS and to refine the conceptual mapping (Figure 10). A systematic literature review mitigates the risk that we disregard studies that could contradict our model, as well as the risk that we use studies that cause a biased model (Boell and Cecez-Kecmanovic 2015). Outlining the approach transparently, we defined a search protocol as suggested by Boell and Cecez-Kecmanovic (2015) and Vom Brocke et al. (2015).

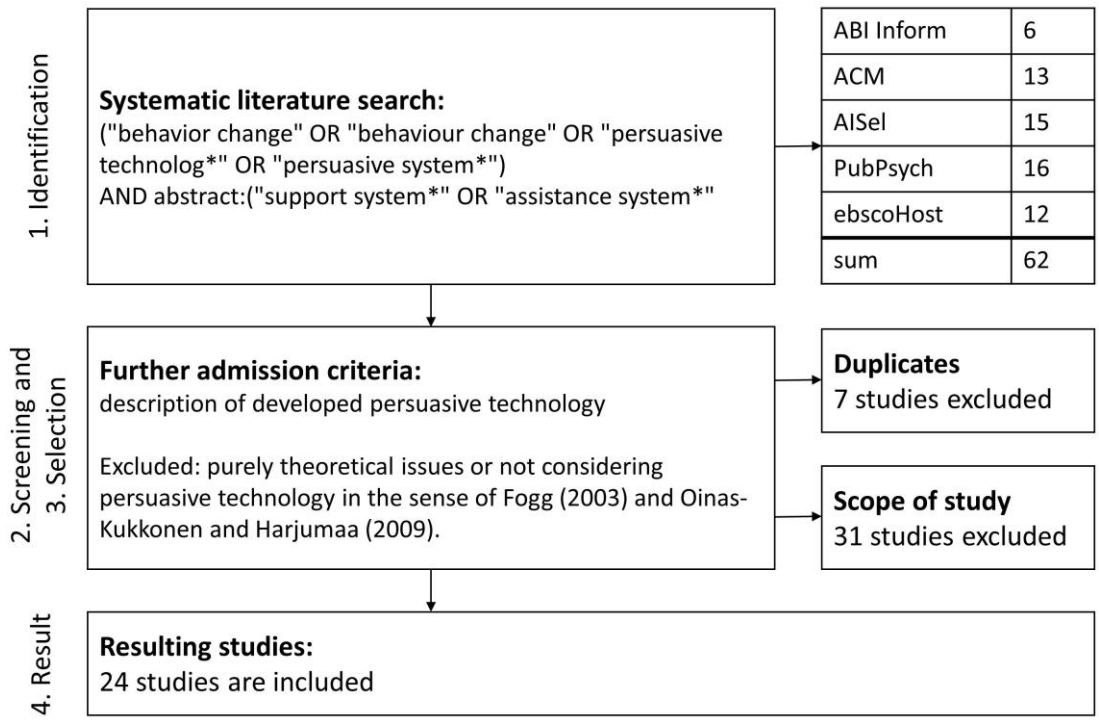


Figure 10: Flow Chart of Literature Review

To systematically identify relevant studies that introduce persuasive technologies targeting behavior change in different domains, we conducted a systematic keyword search in the databases ABI/Inform Collection, ACM, AISel, PubPsych, and ebscoHost, using the search string: *("behavior change" OR "behaviour change" OR "persuasive technolog*" OR "persuasive system*") AND abstract:("support system*" OR "assistance system*")* leading to 62 studies. Further admission criteria for the literature review is the description of developed persuasive technology in order to be able to clearly analyze the design elements. We excluded seven duplicates and 31 papers that deal with purely theoretical issues or do not consider persuasive technology in the sense of Fogg (2003) and Oinas-Kukkonen and Harjumaa (2009). Because we include all studies that were not excluded, we did not define specific inclusion criteria. Therefore, in total 24 studies are included in our literature review to refine the model.

We compared the findings of the literature review with our conceptual model looking for inconsistencies. Based on this comparison, we refined our model to ensure consistency in practical use, conceptual definitions, and understanding. Where necessary and fitting, examples of implementations were added from additional studies to elaborate the specific design principles along the transitions.

Supplementing our example from step one, based on the theoretical analysis, with insights from the literature review in step two: The design principle *suggestion* is not applicable/ not recommended for designing BCSS targeting transition (I). In fact, our literature review shows that users tend to be averse to advice when they do not experience any problems yet (Phillips and Landon 2016). Regarding transition (II) and (III), Nguyen et al. (2018) and Song et al. (2017) implement suggestions to reveal the benefits of a changed behavior and an approach to take the first steps of their changed behavior. This confirms the strong recommendation of the design principle *suggestion* for transitions (II) and (III). In transition (IV), our literature review shows that *suggestion* can act as a form of feedback and positively affect the alteration of behavior change (Wilson and Djamasbi 2017), which is in accordance with a slight recommendation. Because suggestions can help to recall target goals and present new perspectives (Nguyen et al. 2018), *suggestion* has a high impact to prevent a relapse, which indicates a recommendation for transition (V).

3.1.6 Analysis

Table 13 presents the resulting mapping of the different design principles to the five transitions of behavior change and presents the studies that we used for the refinement and our discussion. The table links the 28 design principles of the PSD model (see Figure 8) to the transitions along the stages of change of the TTM (see Figure 9).

The design principles are weighted using a scale of four color grades, from white indicating not applicable/ no recommendation to black indicating strong recommendation. A black dot indicates a basic requirement indicating underlying relevance along the whole process of behavior change. The listed studies indicate and substantiate the weighting of the referring design principle.

Table 13: Resulting Mapping of the Design Principles to Transitions of Behavior Change and Referring Studies

Category	Principle	I	II	III	IV	V	Studies (cf. chapter 3.2.4.2)
Primary Task Support	Reduction						Lehto and Oinas-Kukkonen 2013
	Tunneling						Sunio et al. 2018
	Tailoring						Liang et al. 2006; Schäfer and Willemsen 2019; Sunio et al. 2018
	Personalization			●			Kelders 2015; Klein et al. 2014; Lehto and Oinas-Kukkonen 2013, 2015a; Nguyen et al. 2018; Schäfer and Willemsen 2019; Oinas-Kukkonen and Harjumaa 2009; Wilson and Djamasbi 2017
	Self-monitoring						Harjumaa and Muuraiskangas 2013; Klaassen et al. 2015; Klein et al. 2014; Kulyk et al. 2014; Lehto and Oinas-Kukkonen 2013; Sunio et al. 2018
	Simulation						Lehto and Oinas-Kukkonen 2015a; Sunio et al. 2018
	Rehearsal						Harjumaa and Muuraiskangas 2014; Langrial et al. 2014; Lehto and Oinas-Kukkonen 2015a
Dialogue Support	Praise						Harjumaa and Muuraiskangas 2014; Lehto and Oinas-Kukkonen 2015a; Toscos et al. 2006
	Rewards						Nguyen et al. 2018; Wilson and Djamasbi 2017
	Reminders						Harjumaa and Muuraiskangas 2014; Klaassen et al. 2015; Kulyk et al. 2014; Langrial et al. 2013; Langrial et al. 2014; Lehto and Oinas-Kukkonen 2013, 2015a
	Suggestion						Lehto and Oinas-Kukkonen 2015a; Phillips and Landon 2016; Song et al. 2017; Nguyen et al. 2018
	Similarity			●			Kulyk et al. 2014
	Liking			●			
	Social role			●			
System Credibility Support	Trustworthiness			●			Lehto and Oinas-Kukkonen 2015b, 2015a
	Expertise			●			
	Surface credibility			●			
	Real-world feel			●			
	Authority			●			
	Third-party endorsements			●			
	Verifiability			●			
Social Support	Social learning						Davis 2012; Nkwo 2019
	Social comparison						Davis 2012; Lehto and Oinas-Kukkonen 2015a; Nkwo 2019; Sunio et al. 2018
	Normative influence						Kamphorst et al. 2014; Sunio et al. 2018
	Social facilitation						Nkwo 2019
	Cooperation						Divjak and Rupel 2018; Minichiello et al. 2019
	Competition						Davis 2012; Nkwo 2019
	Recognition						Davis 2012; Nkwo 2019

white: not applicable/ no recommendation, **light grey**: slight recommendation, **dark grey**: recommendation, **black**: strong recommendation, black dot: basic requirement

Of the 28 design principles of the PSD model, 11 design principles are identified as basic requirements, and 17 design principles are categorized into the four levels of recommendation. Linking the 17 design principles and the five transitions results in 85 combinations: 31 (36%) show not applicable or not recommended in the referring transition, 17 (20%) show a slight recommendation, 11 (13%) recommendation, and 26 (31%) show a strong recommendation of the design principle in the referring transition. The mapping reveals that the seven design principles of the category system credibility support act as basic requirements (Lehto and Oinas-Kukkonen 2013; Oinas-Kukkonen 2013). Most design principles are linked to transitions (IV) and (V), from action to maintenance and from maintenance to termination.

We discuss the role of the design principles of the PSD model along the process of behavior change including examples of implementations. We start with the basic requirements that are relevant to the whole transition process following with a discussion of the five transitions.

3.1.6.1 Basic Requirements

According to the analysis, 11 design principles act as basic requirements along the five transitions and should be considered regardless of the specific stage of behavior change. These design principles are *personalization*, *similarity*, *liking*, *social role* as well as the whole category system credibility support with its design principles *trustworthiness*, *expertise, surface credibility*, *real-world feel*, *authority*, *third-party endorsements,* and *verifiability*.

Researchers address *personalization* as a design principle that is relevant along the whole process of behavior change as personalized elements have a high impact to motivate users (Harjumaa and Muuraiskangas 2014) and lead to users feeling more engaged and invested (Wilson and Djamasbi 2017). Therefore, *personalization* has the potential to support people in starting their behavior change as well as preventing relapses into old and undesired behavior patterns (Schäfer and Willemsen 2019; Harjumaa and Muuraiskangas 2014). Developers of BCSS integrate *personalization* by allowing users to create their own profile with name and picture (Oinas-Kukkonen and Harjumaa 2009; Kelders 2015) or to select design features (Lehto and Oinas-Kukkonen 2015a). Personalized feedback or advice (Lehto and Oinas-Kukkonen 2013; Nguyen et al. 2018; Klein et al. 2014) as well as

personalization based on *tailoring*, by leading users to individually set their goals (Schäfer and Willemsen 2019), are additional examples.

Kulyk et al. (2014) emphasize that users of BCSS appreciate *similarity*, *liking*, and *social role*. Oinas-Kukkonen and Harjumaa (2009) address the relevance of the design principle *similarity* as they state that users of BCSS are more likely to be persuaded through systems that remind them of themselves. The design principle *liking* adds an attractive and appealing look and feel (Oinas-Kukkonen and Harjumaa 2009). Oinas-Kukkonen and Harjumaa (2009) further specify that BCSS that include the design principle *social role* act more persuasive.

Next to these design principles, the category system credibility support also serves as a basic requirement for BCSS. The category system credibility support comprises the design principles *trustworthiness*, *expertise*, *surface credibility*, *real-world feel*, *authority*, *third-party endorsements*, and *verifiability*. The consideration of these design principles during the design of BCSS does not enable user activities, however, their absence would result in dissatisfaction. *Trustworthiness*, *expertise*, and *authority* affect the persuasiveness of the BCSS, as they let the system seem truthful, fair, and unbiased as well as demonstrate knowledge, experience, and competence (Oinas-Kukkonen and Harjumaa 2009). *Surface credibility*, *real-world feel*, *third-party endorsements* affect perceptions on system credibility because these design principles provide a competent look and feel, information about the people behind the BCSS, endorsements from respected sources, and links to outside sources (Oinas-Kukkonen and Harjumaa 2009). Lehto and Oinas-Kukkonen (2014, 2015a) highlight the importance of this category as perceived credibility strengthens the intention to continue.

3.1.6.2 Transition I, Precontemplation to Contemplation

Users in the stage of precontemplation are unaware that the addressed problem exists (Prochaska and Norcross 2001). Due to the unawareness, it is difficult to reach potential users, because they are not actively looking for a behavior change and a transition to the next stage of contemplation. Therefore, only a few design principles are applicable in BCSS for transition (I). To reach users in the stage of precontemplation, other efforts outside BCSS are beneficial, for example, interventions by families, friends, or coworkers, or supplementing measures such as marketing. The most fitting design principles for transition (I) are *simulation* and *social learning* (recommendation), as well as *tunneling*

and *normative influence* (slight recommendation). These design principles are able to reveal the problem behavior to users.

Simulation enables users to observe the link between cause and effect (Oinas-Kukkonen and Harjumaa 2009). Sunio et al. (2018), for example, use *simulation* in a slideshow to present before and after pictures. The effects of certain behavior can also be revealed by *social learning* when users observe others performing the behavior (Oinas-Kukkonen and Harjumaa 2009). *Social learning* is addressed, for example, by including experience reports (Davis 2012) or by enabling the exchange of best practices (Nkwo 2019).

Tunneling guides users along the attitude change process by providing relevant information (Oinas-Kukkonen and Harjumaa 2009). Additionally, *normative influence*, *tailoring*, and *expertise* could be added as design principles in transition (I) to increase the likelihood that a person will adopt a target behavior (Oinas-Kukkonen and Harjumaa 2009; Lehto and Oinas-Kukkonen 2015a; Sunio et al. 2018).

In transition (I), *reduction, self-monitoring, rehearsal, praise, rewards, reminders, suggestion, social comparison, social facilitation, cooperation, competition,* and *recognition* are design principles that are not able to address users' needs. The design principle *suggestion* is not recommended for transition (I) because it can lead to users' rejection in the stage of precontemplation when they do not have problem awareness yet (Phillips and Landon 2016). Design principles such as *rehearsal*, *praise,* and *reminders* require a certain awareness of the problem that is not present in this stage, yet. Other design principles such as *rewards*, *recognition,* and *cooperation* are not applicable because they require the execution of the target behavior (Oinas-Kukkonen and Harjumaa 2009).

3.1.6.3 Transition II, Contemplation to Preparation

In the stage of contemplation, users are aware of an existing problem but do not actively intend to change (Prochaska and Norcross 2001). Transition (II) to the stage of preparation mostly relies on the categories primary task support and social support. In detail, the design principles *tunneling*, *tailoring*, *simulation, social learning*, and *normative influence* are strongly recommended for transition (II). These design principles are able to raise awareness for the problem behavior, show benefits of a changed behavior, and therefore to form an intent to change. In this transition (II), *tunneling* guides users and provides means for action (Liang et al. 2006). *Tailoring* refers to ensuring that information is aligned to the context and needs of the targeted user group (Oinas-Kukkonen and

Harjumaa 2009). As an example for *tunneling* and *tailoring*, Oinas-Kukkonen and Harjumaa (2009) suggest providing relevant information about the problem behavior and possible treatments and stories of peers, which are referring to different user groups. Sunio et al. (2018) apply this by reporting personalized diagnostics including a goal and directing to relevant new elements. *Simulation* is maintaining its purpose as described in transition (I) to highlight the problem behavior and to show results of behavior change (Lehto and Oinas-Kukkonen 2015a). *Social learning* and *normative influence* provide means to behavior change and motivate users by observing the results of other people performing the target behavior and gathering people with the same goal (Oinas-Kukkonen and Harjumaa 2009). *Social learning* can connect people, for example by using a shared fitness journal (Consolvo et al. 2006). *Normative influence* impacts behavior, for example by adding peer pressure (Oinas-Kukkonen and Harjumaa 2009) or by bringing the culture and environment of users into account (Kamphorst et al. 2014).

Besides these strong recommendations, the model indicates *rehearsal* as recommended. *Rehearsal* is able to raise awareness by emphasizing the benefits of changed behavior (Harjumaa and Muuraiskangas 2014) and supports the preparation of real situations (Oinas-Kukkonen and Harjumaa 2009; Langrial et al. 2014). *Rehearsal* can be implemented, for example, in the form of a role-play (Harjumaa and Muuraiskangas 2014) or a video-based exercise builder (Lehto and Oinas-Kukkonen 2015a). Additionally, the model indicates a slight recommendation for *praise*, *social comparison*, and *social facilitation* to raise motivation and strengthen the intent to change (Sunio et al. 2018; Lehto and Oinas-Kukkonen 2015a).

Design principles that are not applicable for BCSS that address transition (II) are *reduction*, *self-monitoring*, *rewards*, *reminders*, *cooperation*, *competition*, and *recognition*. As stated regarding transition (I), these design principles cannot be implemented per definition, as they require the execution of the target behavior (Oinas-Kukkonen and Harjumaa 2009) that is not yet performed during transition (II) (Prochaska and Norcross 2001).

3.1.6.4 Transition III, Preparation to Action

Users in transition (III), from preparation to action, need BCSS that help them with an initial approach (“game plan”, Prochaska and Norcross 2001, p. 445) to take first steps and form their intended behavior. Mostly the categories of primary task support and social

support are recommended in this transition, providing guidance and means for the change as well as social components emphasizing motivation to change.

The design principles *reduction, suggestion,* and *rehearsal* are strongly recommended for transition (III). *Reduction* breaks down complex behavior into simple tasks or sub-tasks (Oinas-Kukkonen and Harjumaa 2009; Lehto and Oinas-Kukkonen 2013) and therefore also lowers the barriers to do the first step of the target behavior and increases the willingness that users engage with the BCSS. *Suggestion* offers specific applications of the target behavior, for example, an exercise plan based on preferences and goals (Lehto and Oinas-Kukkonen 2015a). Advice is especially effective when users are experiencing some form of loss or the situation is comprising a low risk (Phillips and Landon 2016). *Rehearsal* explicitly supports the preparation for real situations (Oinas-Kukkonen and Harjumaa 2009) as a training technique (Langrial et al. 2014).

Besides these strong recommendations, the model presents the following design principles as recommendations: *tailoring*, *praise*, *social learning*, *normative influence*. *Tailoring* supports users to make better choices (Schäfer and Willemsen 2019). *Praise* has the ability to strengthen motivation for reaching individual goals (Toscos et al. 2006; Harjumaa and Muuraiskangas 2014). *Social learning* can supplement *tailoring* by observing the behavior of peers and helps to build an individual goal for intended behavior (Consolvo et al. 2006). *Normative influence* is able to induce active behavior by defaults. Such defaults can appear, for example, as default goals and contribute to *tailoring* by facilitating the decision process of users (Loock et al. 2013). Goal-setting is not explicitly introduced as a design principle by the PSD model. However, goal-setting is a widely studied subject that influences behavior (Locke and Latham 1991, 2002) and should be considered in the process of behavior change. Regarding the design principles of the PSD model, goal-setting may serve as a combination of *suggestion*, *reduction*, *tailoring*, and *normative influence*. Therefore, setting an individual goal has a strong potential to support the transition (III) from preparation to action.

In transition (III), the design principles *self-monitoring, rewards, reminders, cooperation,* and *recognition* are not applicable, because they are not aiming at supporting an initial approach to the target behavior. As described in transitions (I) and (II), the design principles are per definition only applicable when users already perform the target behavior (Oinas-Kukkonen and Harjumaa 2009). This is not the case during the transition (III) but in the following stage (Prochaska and Norcross 2001).

3.1.6.5 Transition IV, Action to Maintenance

During transition (IV), from action to maintenance, BCSS should reinforce users' new behavior and strengthen users' will to maintain their changed behavior. Therefore, design principles that analyze the behavior of the users are in focus. Categories that especially address these needs are dialogue support and social support.

Strongly recommended are *self-monitoring*, *praise*, *rewards*, *reminders*, *social comparison*, *social facilitation*, *cooperation*, *competition*, and *recognition*. *Self-monitoring* enables users to keep track of their performance or status and therefore supports users in achieving their goals (Oinas-Kukkonen and Harjumaa 2009). Regarding the intended continual interaction with BCSS, *self-monitoring* has the potential to raise awareness for behavior patterns. Because deviations become recognizable, the appearing links to negative consequences encourage users to make progress (Sunio et al. 2018) and serve as guidance (Kulyk et al. 2014). Furthermore, *self-monitoring* functions as a reminder, warning, advice, or assessment (Klaassen et al. 2015). Examples for implementation are calculators for own eating habits or medication (Lehto and Oinas-Kukkonen 2013; Klein et al. 2014). Displaying users' behavioral values besides the values of peers serves as a combination of *self-monitoring* and *social comparison*. *Praise* provides information-based feedback, for example, via words, images, or sounds (Oinas-Kukkonen and Harjumaa 2009), which has positive effects on individuals' motivation (Toscos et al. 2006; Harjumaa and Muuraiskangas 2014). The design principle *rewards* gives credit for performing the target behavior and is able to provide great persuasive powers (Oinas-Kukkonen and Harjumaa 2009). Therefore, *rewards* should be integrated into BCSS as soon as users get into the action phase and perform the desired behavior. *Rewards* can function as a form of positive feedback (Harjumaa and Muuraiskangas 2014), which leads users to recall their target goals (Nguyen et al. 2018) and thus affects alteration and reinforcement of behavior (Wilson and Djamasbi 2017). The design principle *reminders* is able to call the target behavior to the users' mind (Oinas-Kukkonen and Harjumaa 2009), make people remember to use the system during the intervention (Langrial et al. 2013; Lehto and Oinas-Kukkonen 2013; Langrial et al. 2014), and keep users motivated (Lehto and Oinas-Kukkonen 2015a). *Reminders* can be implemented as regular text messages (Lehto and Oinas-Kukkonen 2013; Klaassen et al. 2015) or provide impulses at opportune moments (Harjumaa and Muuraiskangas 2014), for example, as soon as the performance of the users is less than a target score (Kulyk et al. 2014).

Additionally, the integration of *competition* can be beneficial and raise social motivation (Davis 2012), however, a healthy level of competitiveness is important (Nkwo 2019). Davis (2012) and Nkwo (2019), for example, implement *competition* through *social comparison*. *Social comparison* and *social facilitation* are able to raise users' motivation and strengthen the intent to change (Sunio et al. 2018; Lehto and Oinas-Kukkonen 2015) and are highly relevant to keep users in action. Both go hand in hand, as *social facilitation* can be achieved by *social comparison* (Nkwo 2019). Additionally, *cooperation* can motivate users to adopt a target attitude or behavior as humans have a natural drive to cooperate (Oinas-Kukkonen and Harjumaa 2009). *Cooperation* is typically addressed through tasks that require teamwork (Minichiello et al. 2019; Divjak and Rupel 2018). By offering *recognition* to an individual or a group, BCSS can increase the likelihood of users adopting a target behavior (Oinas-Kukkonen and Harjumaa 2009). *Recognition* is addressed, for example, when users receive appreciative and grateful messages to reward good performance (Davis 2012; Nkwo 2019).

Besides the design principles with strong recommendation, *reduction* is recommended in transition (IV) as it is important to keep the users performing the new behavior. Slight recommendations in transition (IV) are *tailoring*, *suggestion*, and *normative influence*. *Tailoring* supports users to make better choices (Schäfer and Willemsen 2019) and *suggestion* provides specific applications of the target behavior (Lehto and Oinas-Kukkonen 2015). Both design principles are slightly recommended in transition (IV) as users already know how to adopt their new behavior. For the same reason, *normative influence* also is slightly recommended.

Design principles that are not able to address users' needs in transition (IV) are *tunneling*, *simulation*, *rehearsal*, and *social-learning*. *Simulation*, *rehearsal*, and *social-learning* are necessary during preparatory transitions but do not explicitly support users during performing the target behavior. This also includes *tunneling*, which guides "users in the attitude change process" (Oinas-Kukkonen and Harjumaa 2009, p. 492), thus the need for this effect ends after the stage of preparation.

3.1.6.6 Transition V, Maintenance to Termination

For the last transition (V), BCSS should help users to form habits and make the changed behavior their regular behavior. Therefore, it is important to continue the integration of design elements of the transition (IV), but also integrate elements of precontemplation to

address the importance of keeping up the new behavior. Comparison to users' past status can help to extend and reawake motivation. Looking at the different categories dialogue support and social support are the ones that stand out.

As well as for transition (IV), *self-monitoring, praise, rewards, reminders, social comparison, cooperation, competition,* and *recognition* are strongly recommended for transition (V). *Self-monitoring* tracks users' behavior and makes progress or new behavioral patterns visual. This can keep up motivation (Harjumaa and Muuraiskangas 2013) and visible deviations from the desired behavior remind people of negative consequences to stay on track (Sunio et al. 2018). Because the design principles *praise, rewards, social comparison, cooperation, competition,* and *recognition* are able to raise or strengthen motivation, they can be implemented in the same way as in transition (IV), but with a different focus. While the focus in transition (IV) is on motivating users to change their behavior, the focus in transition (V) lies on maintaining their motivation for long-term behavior change. Additionally, *reminders* can be used to bind users to the BCSS in the long term.

In transition (V), the design principles *tailoring, suggestion, social facilitation* are recommended. *Tailoring* and *suggestion* rise in relevance compared to transition (IV). Both design principles support users in giving advice regarding fitting exercises or impulses to simplify complex tasks of changing behavior (Song et al. 2017). Users in the stage of maintenance are already prepared and rehearsed in their actions, it is a new task to keep up with the changed behavior. Therefore, users need more support through *tailoring* and *suggestion* to facilitate the stage of maintenance. Additionally, *social facilitation* can raise motivation, strengthen the intent to maintenance, and consequently prevent relapses. Additionally, there is a slight recommendation for *normative influence, simulation,* and *social learning*.

Design principles that are not able to address users' needs in transition (V) are *reduction, tunneling,* and *rehearsal.* While they facilitate initial steps in earlier transitions, they do not affect the sustainability of behavior change that is needed to achieve the stage of termination. In particular, the definition of *tunneling* highlights the supporting effect for preparatory stages by describing its effect as bringing users "closer to the target behavior" (Oinas-Kukkonen and Harjumaa 2009, p. 492). As soon, as users perform the target behavior, this effect is no longer supporting users' needs (Prochaska and Norcross 2001).

3.1.7 Conclusion

Our model (Figure 11) presents process-based guidance for developing BCSS based on the PSD model by Oinas-Kukkonen and Harjumaa (2009) and the stages of change of the TTM of Prochaska and DiClemente (1983) and Prochaska and Norcross (2001). We introduce a tangible model for implementing fitting and effective design principles according to the targeted stages of behavior change to researchers and developers of BCSS. Figure 11 summarizes the recommendation model in a condensed form filling the gap between the analysis of the persuasion context and the selection of different design principles for the software implementation of BCSS. The model provides guidance on which design principles should be implemented in BCSS depending on the users' current stage in the process of behavior change, while not restricting individual decisions. The levels of recommendation indicate the priority for implementation differentiating between strong recommendation, recommendation, and slight recommendation; the design principles at the bottom present the basic requirements along all transitions.

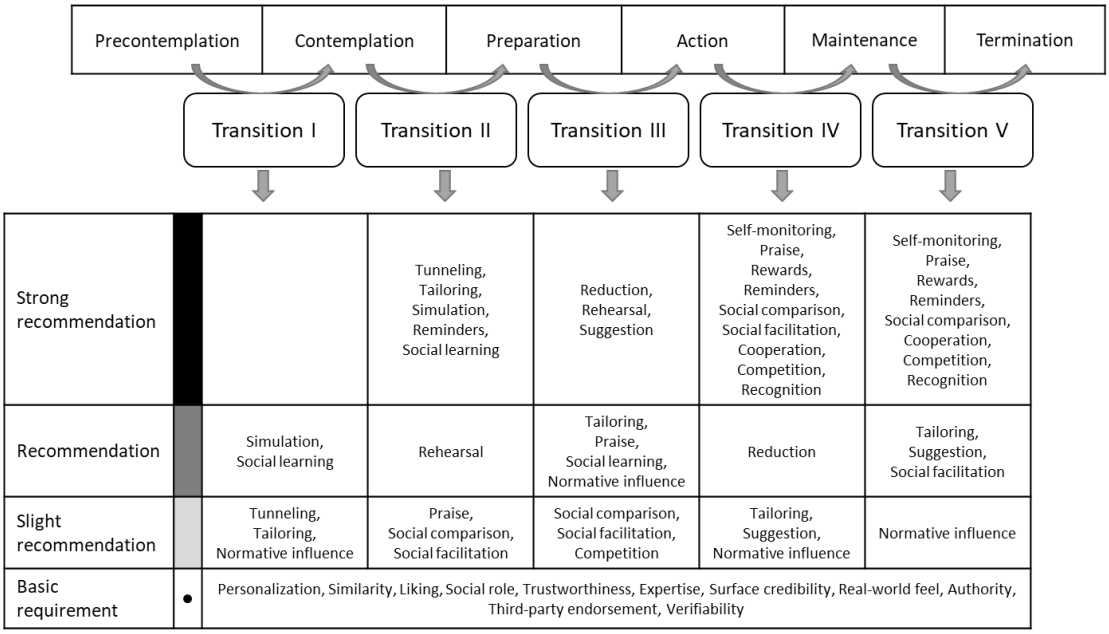


Figure 11: Model in a Condensed Form Integrated in the Process of the Persuasive Systems Design Model

The model presents the appropriate design principles regarding each transition along the stages of behavior change. It highlights and depicts in a tangible and applicable form that

it is important to choose the fitting design principles according to users' stage of behavior change and the targeted transition.

Most existing BCSS focus on users that are in the stages of action and maintenance (i.e. transitions (IV) and (V)) and target users that already have problem awareness and are preparing to change. This is in accordance with the finding that most design principles of the PSD model are categorized in the transitions (IV) and (V) (cf. Figure 11) and that it is a major challenge for BCSS to reach users in the first stage for transition (I) without intent to change behavior. Our model further indicates that BCSS by themselves may not be sufficient enough to persuade users in the first stage of behavior change of precontemplation. Other research areas as marketing have the potential to reach users and therefore to supplement BCSS for transition (I).

Addressing all transitions allows to involve a broader target audience, independent of the current stage of behavior change, and to address problem awareness to prevent relapses. When a BCSS supports multiple transitions, we propose to design the BCSS with different sections and corresponding features for each transition. An implementation example is proposed by Merz (2020) where the user passes different levels each addressing a transition in the process of behavior change. Dividing the BCSS into specific sections related to the transitions allows for a focus on selected design principles whose effects and impacts are tailored to the targeted stage of behavior change. In addition to providing guidance on choosing relevant design principles depending on the users' current stage of change, the model emphasizes integrative approaches to design persuasive systems.

Our paper is subject to several potential limitations. First, our resulting model is still quite general, despite our motivation to develop the model because the PSD model is a generic technical framework for developing BCSS. However, we decided consciously not to narrow the focus to maintain the applicability of the model in different fields of research (health, environment, work, etc.), and we still were able to develop a tangible model by specifying and facilitating the recommendation analysis and selection of design principles of the PSD model for developing BCSS. Therefore, this approach provides a starting point for future research in developing more context-specific models. Second, we decided to draw upon the stages of change of the TTM by Prochaska and DiClemente (1983) and Prochaska and Norcross (2001) to fill the gap between technical and behavioral model. The TTM was originally developed for the treatment of people with addictive behavior but has since been applied to various other situations (e.g., stress management (Velicer et

al. 1998), academic procrastination (Grant and Franklin 2007), and consumer debt behavior (Xiao et al. 2004)). There are also other behavioral models that address stages of behavior change, such as the 3D-RAB by Wiafe et al. (2011). The 3D-RAB states 12 transitions (Wiafe et al. 2012). In favor of the applicability of the model, we decided on the less complex TTM with five transitions. It could be subject to further research to specify the model using a narrower focus and a different behavioral model. Third, we may have missed potentially relevant studies in our literature search and the model is partly based on subjective coding. However, following our methodological procedure of the literature search using four interdisciplinary databases with a wide search string, we are confident that we incorporated adequate studies into our analysis for confirmation and were able to minimize potential bias as possible.

While we tried to minimize the subjective bias of our qualitative analysis using our described methodology, it should be subject to further research to validate our model and test the applicability when developing BCSS. Additionally, while we build on the PSD model as the most referenced and established technical framework for developing BCSS, there is a need for further research regarding the consistent understanding of design principles for BCSS (Gregor et al. 2020; Möller et al. 2020). Our theoretical base for the model was particularly sparse regarding our identified basic requirements, especially the category of system credibility support that is mostly neglected in existing research (Matthews et al. 2016). Therefore, future research should investigate the potentials and possible implementations of these design principles. Also, other design principles should be subject to further research and development: First, a recognizable number of studies and developments of BCSS are adding forms of feedback. For example, Wilson and Djamasbi (2017) define the design principles of *praise*, *rewards*, *reminder*, and *suggestion* as feedback. In the PSD model, the whole category of dialogue support is stated to provide system feedback. To ensure a consistent use and understanding, the concept of feedback should be elaborated further in the context of BCSS. Second, it is notable that in recent studies since the development of the PSD model the concept of gamification has become increasingly popular. So far, gamification is indirectly incorporated in the PSD model in *competition* or *cooperation*. It should be subject to further research to integrate gamification more explicitly and more elaborated. Third, we propose to integrate goal-setting into the model as an additional design principle that can strongly contribute to the process of behavior change.

3.2 Essay 5: Design Principles for Persuasive Systems: Towards a Design Framework for Developing Behavior Change Support Systems

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3.2.1 Abstract

Persuasive systems have become near enough ubiquitous in today's life and influence the attitudes and behaviors of their users. In the form of behavior change support systems (BCSS), persuasive systems aid users, for example, to change habits and pursue healthier lifestyles. While there exists a wide range of design knowledge about BCSS, there is a lack of systematic codification of this design knowledge into precise and unambiguous prescriptive statements that consider current insights into design science. Therefore, this study synthesizes existing design knowledge from theoretical and practical studies to systematically derive a concise and comprehensive set of design principles for BCSS. This adheres to the method for design principle development, as proposed by Möller et al. (2020), and applies the design principles schema of Gregor et al. (2020). This approach ensures that our methodology observes the best practices on how design principles should be developed and formulated. The value of this study is the aggregation of 125 concepts of design knowledge and the formulation of 14 synthesized design principles. Those design principles provide researchers and developers with explicitly formulated prescriptive knowledge on how to design, evaluate, and develop BCSS.

3.2.2 Introduction

Information systems (IS) and technology have become almost ubiquitous in modern life as digital products surround us in the form of various mobile and ambient technologies (Alt et al. 2021). Against the background that information technologies shape the actions, beliefs, and thoughts of their users (Oinas-Kukkonen and Harjumaa 2009; Maedche 2017), researchers investigating human-computer interaction (HCI) examine and develop meaningful IS that aim to influence their users (Mencarini et al. 2019; Noorbergen et al. 2021; Rapp et al. 2019). Oinas-Kukkonen (2010) introduces the term Behavior Change Support Systems (BCSS) to describe persuasive systems that aim to "form, alter or reinforce attitudes, behaviors or an act of complying without using deception, coercion or inducements" (Oinas-Kukkonen 2010, p. 6). Studies prove that BCSS function as valuable systems helping people to overcome problematic behavior or change their behavior, for example, to lead a healthier life (e.g., Rieder et al. 2019; Böckle and Yeboah-Antwi 2019; Lehto and Oinas-Kukkonen 2015a).

The development of diverse BCSS is increasing in recent years and grasp the potential to positively influence the behavior and daily life of users (Merz and Ackermann 2021). This is reflected in the number of practical BCSS (e.g., Salvi et al. 2018; Böckle and Yeboah-Antwi 2019; Bartlett et al. 2017), as well as in the number of research studies that compile the growing design knowledge about BCSS (e.g., in literature reviews such as Merz and Ackermann 2021; Tikka and Oinas-Kukkonen 2019; Wozney et al. 2017). Consequently, new knowledge is continuously being generated in the field of persuasive systems.

However, studies show a high ambiguity of concepts and understanding of identified design knowledge in the field of persuasive systems (Merz and Ackermann 2021; Kelders et al. 2016). While there exists a framework that is widely referenced in BCSS design that provides a codification of design knowledge in form of defined design principles, this Persuasive Systems Design (PSD) model by Oinas-Kukkonen and Harjumaa (2009) neither provides a systematic selection nor a clear presentation of its design principles (Wiafe et al. 2014; Merz and Ackermann 2021; Kelders et al. 2016). Accordingly, there are difficulties in transferring the identified design knowledge into the field of persuasive systems (Merz and Ackermann 2021). Precisely because it is important to examine aspects in detail in different contexts to capture nuances and contextual specificities, a meaningful level of abstraction and clarity in design principles is required to enable the transfer of

knowledge across contexts. Without a meaningful level of abstraction, there is detailed design knowledge in different contexts, but the existing ambiguity in formulating and understanding design principles leads to ambiguity in creating and communicating design knowledge. For example, in current research on BCSS, design knowledge is captured in overlapping and insufficiently differentiated design principles such as competition and social comparison (Oinas-Kukkonen and Harjumaa 2009). In addition, the codification of identified design knowledge also misses a standardized naming convention, as design principles such as personalization and customization address a similar concept but are listed separately (Oinas-Kukkonen and Harjumaa 2009; Orji et al. 2019c). Consequently, findings and generated design knowledge from previous studies are difficult to compile in a structured way and to transfer when implementing new systems (Merz and Ackermann 2021). Subsequently, an overview of design knowledge from which implementations for different contexts can be derived is missing (Gregor et al. 2020; Möller et al. 2020).

We address the research gap of ambiguous and insufficiently formulated design principles for BCSS development to counteract the existing variation and imprecision in formulating design principles. Our goal to create is a synthesized set of clearly formulated design principles for BCSS development that is both meaningful and systematically derived to work as a framework for designing persuasive systems. Thus, we aim to answer the research question: *What design principles form a concise and comprehensive overview for persuasive systems that provide a clear codification of design knowledge?*

In order to achieve this, we apply the method for design principle development according to Möller et al. (2020), which presents actionable steps for clear and systematic design principle development. To complement this, we employ the design principles schema of Gregor et al. (2020), which provides guidance on how to formulate design principles for technology-based artifacts in socio-technical systems, to the existing body of knowledge on persuasive systems.

Our study provides researchers and developers of BCSS with a theory of design and action as defined by Gregor (2006) (theory type five) in form of a concise but profound overview. Our findings allow researchers and developers of BCSS to communicate their identified design knowledge as well as to use our set of design principles to evaluate and extend their artifacts.

Following Design Science Research (DSR), our approach has an iterative character. This article presents the procedure and findings of the iteration in which we derive the design principles from prior literature on persuasive system research. It is structured as follows: In this first section (3.2.2), we introduced and delineated the solution objective. In the subsequent second section (3.2.3), we specify the theoretical background of BCSS and related concepts as well as the theoretical background of design principles. Third, we present the method based on the framework of Möller et al. (2020) in section three (3.2.4). And apply the procedure of design principle development in detail in section four (3.2.5). This section also includes an initial evaluation of the resulting set of design principles analyzing to which extent the set is able to provide a clear codification of design knowledge. We further discuss our findings in section five (3.2.6) and specify implications for researchers and developers of BCSS in section six (3.2.7) before we conclude the study in section seven (3.2,8).

3.2.3 Theoretical Background

3.2.3.1 Persuasive Systems

Fogg (2003) defines computer-based interactive systems that are designed to purposefully change human behavior through persuasion without coercion or deception as *persuasive technology*. Since the mode of action of these technologies is similar to human social influence on behavior and attitudes, he understands persuasive technologies as social actors (Fogg 2003). According to Fogg (2003), the success of those systems depends on the integration of individual design features that target the motivation, the feasibility, and the trigger of the desired behavioral change (Fogg 2009). Oinas-Kukkonen and Harjumaa (2008) build on this research by focusing on the prescription of compelling designs and the resulting software requirements. In this context, they use the term *persuasive systems* to describe systems that use either computer-mediated or computer-human persuasion (Oinas-Kukkonen and Harjumaa 2008). When referring to Fogg's research, Oinas-Kukkonen and Harjumaa (2008) use the term persuasive systems as a synonym for persuasive technology. In the context of this study, we address systems with such persuasive characters. Therefore, we use the term persuasive systems to refer to the research field of this study.

Within this research field of persuasive systems, BCSS are defined as the “key construct” and the “object of study within the field” (Oinas-Kukkonen 2010, pp. 4–5). BCSS include

socio-technical platforms, systems, applications for smartphones, and software designed for persuasion (Oinas-Kukkonen 2010). Researchers and designers implement BCSS in form of web-based systems, mobile applications, or social networking tools. They investigate the potential of BCSS to enable and support individuals and/or groups (Lehto and Oinas-Kukkonen 2015a).

BCSS are studied in a variety of contexts, whereby applications in the health context predominate (Merz and Ackermann 2021). Health-BCSS are of high practical value as they can address chronic disease risk factors related to lifestyle behaviors, such as diet or exercise (Lehto and Oinas-Kukkonen 2015a). Furthermore, researchers envision great potential for the application of BCSS in educational institutions (Sengupta and Williams 2021; Steinherr 2021) and work environments (Merz 2020; Nkwo 2019). BCSS are also able to contribute to society benefiting from the behavioral changes of their users, for example, by focusing on sustainable behavior (Shevchuk and Oinas-Kukkonen 2016) or waste separation (Lessel et al. 2015).

According to the socio-technical nature of persuasive systems, the theoretical foundations for the design of BCSS are twofold, comprising a psychological perspective and a technological perspective. Psychological theories in HCI research on persuasive systems include the Transtheoretical Model of behavior change, describing six stages of behavior change to proceed when altering behavior (Prochaska and DiClemente 1983; Prochaska and Norcross 2001) (e.g., Konstanti et al. (2022)), the Theory of Planned Behavior addressing relations between attitudes, intention, and actual behavior (Ajzen 1991) (e.g., Clubbs et al. (2021)), or the Goal-Setting Theory which describes the relationship between goal attributes and task performance (Locke and Latham 1991, 2002) (e.g., Cham et al. (2019)). While these psychological theories provide valuable insights into understanding behavior change processes within BCSS users, Oinas-Kukkonen and Harjumaa (2009) capture the technological perspective of BCSS and provide the PSD model as a conceptual framework to design BCSS. The PSD model describes the application of design principles in the context of persuasive systems and proposes three development phases: The PSD model describes the application of design principles in the context of persuasive systems and proposes three development phases: 1) understanding the key issues behind persuasive systems, 2) analyzing the persuasion context, and 3) designing the system qualities. For the design of system qualities (third phase), the PSD model suggests 28 design principles in the four categories of primary task support (e.g., tunneling, tailoring), dialogue support (e.g., praise, reminders), system credibility support (e.g., expertise,

verifiability), and social support (e.g., cooperation, competition). Those design principles are based on Fogg (2009) and should be considered as "requirements for software qualities" (Oinas-Kukkonen and Harjumaa 2009, p. 498). The design principles are described using an example requirement and an example implementation (see Table 14).

Table 14: Description of the Design Principle Rehearsal in the Persuasive Systems Design Model, according to Oinas-Kukkonen and Harjumaa (2009)

Design Principle Rehearsal	Example Requirement	Example Implementation
A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.	System should provide means for rehearsing a target behavior.	A flying simulator to help flight pilots practice for severe weather conditions.

The PSD model of Oinas-Kukkonen and Harjumaa (2009) is the most frequently used model for the development of BCSS (Merz and Ackermann 2021). Considering practical studies and literature reviews on BCSS, including our systematic literature review described in section 3.2.5.4, we could not identify other common frameworks or models for the development of BCSS that comprise design principles such as the PSD model. As a result, and according to our investigation, the framework developed in 2009 continues to provide the most relevant guidance and overview of codified design knowledge for BCSS implementation. Consequently, Table 15 presents the current state of research on the codified design knowledge, including the formulated design principles and the corresponding example requirements, as presented in Oinas-Kukkonen and Harjumaa (2009).

Table 15: Design Principles in the Persuasive Systems Design Model, according to Oinas-Kukkonen and Harjumaa (2009)

Design Principle	Example Requirement
Primary Task Support	
Reduction A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit/cost ratio of a behavior.	System should reduce effort that users expend with regard to performing their target behavior.
Tunneling Using the system to guide users through a process or experience provides opportunities to persuade along the way.	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.
Tailoring Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.	System should provide tailored information for its user groups.
Personalization A system that offers personalized content or services has a greater capability for persuasion.	System should offer personalized content and services for its users.

Self-monitoring A system that keeps track of one's own performance or status supports the user in achieving goals.	System should provide means for users to track their performance or status.
Simulation Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	System should provide means for observing the link between the cause and effect with regard to users' behavior.
Rehearsal A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.	System should provide means for rehearsing a target behavior.
Dialogue Support	
Praise By offering praise, a system can make users more open to persuasion.	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.
Rewards Systems that reward target behaviors may have great persuasive powers.	System should provide virtual rewards for users in order to give credit for performing the target behavior.
Reminders If a system reminds users of their target behavior, the users will more likely achieve their goals.	System should remind users of their target behavior during the use of the system.
Suggestion Systems offering fitting suggestions will have greater persuasive powers.	System should suggest that users carry out behaviors during the system use process.
Similarity People are more readily persuaded through systems that remind them of themselves in some meaningful way.	System should imitate its users in some specific way.
Liking A system that is visually attractive for its users is likely to be more persuasive.	System should have a look and feel that appeals to its users.
Social role If a system adopts a social role, users will more likely use it for persuasive purposes.	System should adopt a social role.
System Credibility Support	
Trustworthiness A system that is viewed as trustworthy will have increased powers of persuasion.	System should provide information that is truthful, fair and unbiased.
Expertise A system that is viewed as incorporating expertise will have increased powers of persuasion.	System should provide information showing knowledge, experience, and competence.
Surface credibility People make initial assessments of the system credibility based on a firsthand inspection.	System should have competent look and feel.
Real-world feel A system that highlights people or organization behind its content or services will have more credibility.	System should provide information of the organization and/or actual people behind its content and services.
Authority A system that leverages roles of authority will have enhanced powers of persuasion.	System should refer to people in the role of authority.
Third-party endorsements Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility.	System should provide endorsements from respected sources.

Verifiability Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.	System should provide means to verify the accuracy of site content via outside sources.
Social Support	
Social learning A person will be more motivated to perform a target behavior if (s)he can use a system to observe others performing the behavior.	System should provide means to observe other users who are performing their target behaviors and to see the outcomes of their behavior.
Social comparison System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others.	System should provide means for comparing performance with the performance of other users.
Normative influence A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behavior.	System should provide means for gathering together people who have the same goal and make them feel norms.
Social facilitation System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them.	System should provide means for discerning other users who are performing the behavior.
Cooperation A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to co-operate.	System should provide means for co-operation.
Competition A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to compete.	System should provide means for competing with other users.
Recognition By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behavior.	System should provide public recognition for users who perform their target behavior.

3.2.3.2 Design Principles

Möller et al. (2020) map design principles in relation to design requirements and design features according to Rhyn and Blohm (2017): While design principles are derived from design requirements (Rhyn and Blohm 2017), design features are considered another layer of specifications that result from design principles (Möller et al. 2020).

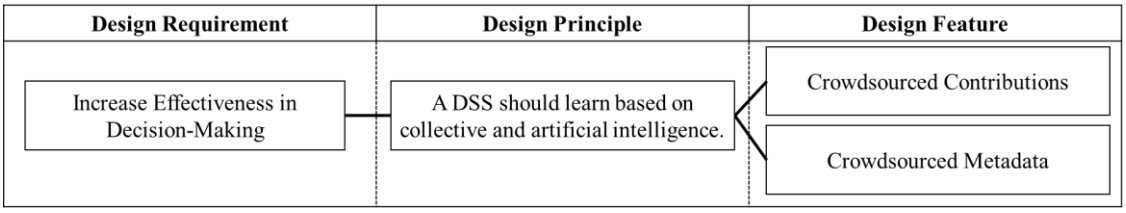

Figure 12: Conceptualization of Design Requirements, Design Principles, and Design Features with Examples according to Rhyn and Blohm (2017)

Based on the research of Meth et al. (2015), Chandra et al. (2015), Baskerville and Pries-Heje (2010), and Walls et al. (1992), Rhyn and Blohm (2017) distinguish the three terms as depicted in Figure 12: Design requirements "serve as meta-requirements" (Rhyn and Blohm 2017) and formulate general objectives of the artifact (Rhyn and Blohm 2017). While both terms (design requirements and meta-requirements) are used in the current research literature (e.g. cf. Möller et al. (2020)), we refer to design requirements when talking about this level of conceptualization of design knowledge. Design principles (Aier et al. 2011) are derived from design requirements and prescribe how the artifact should be built to address and meet the requirements (Rhyn and Blohm 2017). Design features "represent specific ways to implement design principles in an actual artifact and close the last step of the conceptualization" (Rhyn and Blohm 2017, p. 6).

Consequently, design principles are "prescriptive statements [of design science knowledge] that show how to do something to achieve a goal" (Gregor et al. 2020, p. 1622). They serve as "means of accumulating knowledge and [can be] acted on in real-world situations" (Gregor et al. 2020, p. 1622). Accordingly, clear and comprehensive design principles are required when codifying design knowledge and communicating innovative practices "to advance design science and solve future design problems" (Fu et al. 2016, p. 1).

However, besides the importance of a clear codification of design knowledge, Gregor et al. (2020) discuss a widespread inconsistency in the formulation of design principles. To address this inconsistency, they examine the use and anatomy of design principles and present a schema for formulating design principles. This design principles schema comprises five elements 1) aim, 2) actors (comprising implementers, users, and enactors), 3) context, 4) mechanism, and 5) rationale.

Explicitly addressing the mechanism when formulating design principles provides information on how an artifact should be implemented to meet the design requirements. While this concretization within formulated design principles aims towards guiding their implementation, design principles formulated according to the schema differ from design features because these design principles do not provide specific information regarding the implementation of a concrete artifact (Gregor et al. 2020; Rhyn and Blohm 2017).

The rationale within the design principles provides a "theoretical or empirical justification", however, the rationale "is probabilistic rather than deterministic" (Gregor et al. 2020): While the rationale reasons that the mechanisms within the design principles are

effective, the implementation of the design principle may not always work (Gregor et al. 2020).

To determine a systematic process by which to derive design principles from design knowledge, Möller et al. (2020) present a method for design principle development in seven dimensions, which we instantiate for this study in the third and fourth sections (3.2.4 and 3.2.5).

3.2.4 Method

Möller et al. (2020) present a method for design principle development in seven dimensions. For the purpose of this research project, we instantiate that method in Table 16 and detail them in the following.

Table 16: Taxonomy of Design Principle Development following Möller et al. (2020)

	Dimension	Characteristics				
1	Perspective	Supportive			Reflective	
2	Research Design	DSR	A(D)R		Qualitative	Case Study
3	Source of Design Requirements	Literature	Theory	Interviews	Workshops/ Focus Groups	None
4	Design Principles Design	Derived		Extracted		Responsive
5	Iterations	Single			Multiple	
6	Evaluation	Expert / User Feedback		Instantiation / Field Testing		Argumentation
7	Formulation	Free			Based on Template	

1) As we define the design principles ex-ante, we take a supportive perspective to justify future design decisions. 2) The overarching research design is DSR whereby the method in this cycle is qualitative. 3) Within this cycle, the focus is on rigor and the existing knowledge base, as defined by Hevner (2007). Accordingly, our sources of design requirements are literature and theory. 4) We derive the design requirements from practical studies and existing theories, such as the PSD model, and formulate them as a response to the identified design requirements. 5) The current research study applies a single iteration but encourages further development through additional iterations, as suggested in DSR projects. 6) We evaluate the design principles regarding their clear codification of design knowledge through instantiation by using the developed design principles as a coding schema for prescriptive design knowledge. 7) We formulate the design principles

based on the design principles schema of Gregor et al. (2020), which comprises the components implementer, aim, user, context, mechanism, enactor, and rationale.

3.2.5 Design Principle Development

In the following, we specify the seven steps proposed by Möller et al. (2020) (Figure 13) and then elaborate on them in order to systematically develop clearly formulated design principles for persuasive systems.

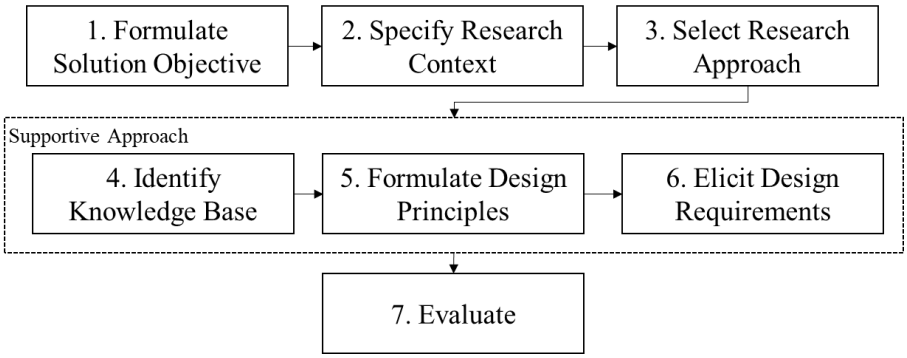

Figure 13: Process of Design Principle Development, Instantiated from Möller et al. (2020)

3.2.5.1 Formulate Solution Objective

The purpose of design principles is to support the successful design of an artifact. Considering the research gap discussed in section 3.2.2 and the definition of design principles presented in section 3.2.3, we specify our solution objective, choosing the form of a question, as follows: *What design principles form a concise and comprehensive overview for persuasive systems that provide a clear codification of design knowledge?*

In line with the presented theoretical background on persuasive systems and design principles, we consider that design principles provide a *clear codification of design knowledge* if they are prescriptive statements of a formulation by the means of Gregor et al. (2020). Further, our goal is to provide a *concise and comprehensive overview* to create a useful level of abstraction that allows transferring design knowledge across contexts without neglecting contextualized characteristics. Applying the method for design principle development of Möller et al. (2020) to the research field of persuasive systems accounts for developing design principles that are systematically and comprehensively de-

rived. The resulting synthesized set of clearly formulated design principles for BCSS development should provide a framework for the design of persuasive systems. Those design principles cover a specified research context, which we address in the following.

3.2.5.2 Specify Research Context

To identify and formulate a set of design principles that codify design knowledge in a clear and comprehensive manner, we specify the research context of our study. Our study is embedded in the emerging discipline of persuasive systems with BCSS as artifacts of persuasive systems (cmp. section 2.1). The PSD model serves researchers and developers as an initial framework for the design of BCSS, including a list of 28 categorized design principles (Oinas-Kukkonen and Harjumaa 2009). However, the design principles of the PSD model are formulated as a theoretical foundation without major existing knowledge about BCSS. Since the development of the PSD model in 2009, many researchers have created and implemented BCSS, thus, creating design knowledge about persuasive systems and design principles.

Since most researchers have used the PSD model, design knowledge is mostly codified through the design principles of the PSD model (Merz and Ackermann 2021). In addition to using the design principles proposed by the PSD model, researchers also defined their own design principles that are not mentioned in the PSD model (e.g., Asbjørnsen et al. 2019; Orji and Mandryk 2013; Valk et al. 2017).

3.2.5.3 Select Research Approach

Möller et al. (2020) distinguish between a supportive and a reflective approach: In the reflective approach, design principles are extracted from design projects of developing specific BCSS. In the supportive approach, existing design knowledge is studied and relevant design principles are derived, for example, from literature, and theory. Considering the research context, there is a large body of knowledge that has not yet been incorporated into clearly formulated design principles. Therefore, we aim to aggregate this knowledge from an existing knowledge base and, correspondingly, select the supportive approach.

Considering the research design (dimensions 2 and 5 of Möller et al. (2020), Table 16), we conduct a qualitative analysis of the existing design knowledge because the identified research gap indicates that we should focus on the formulation of the results. This study is embedded into an iterative DSR project.

3.2.5.4 Identify Knowledge Base

The next step in the systematic development of design principles is to identify a knowledge base from which to extract relevant design principles and design requirements (Möller et al. 2020). Our approach to identify a considerate knowledge base is twofold: First, given the theoretical background, we consider the PSD model of Oinas-Kukkonen and Harjumaa (2009) (described in section 3.2.3.1) to be the appropriate knowledge base from which to derive design requirements. According to the authors of the PSD model, its design principles should be understood as "requirements for software qualities" (Oinas-Kukkonen and Harjumaa 2009, p. 498). Furthermore, Condori-Fernandez et al. (2020) suggest using the PSD model to identify requirements for persuasive systems.

For the second part of our twofold approach and in view of the broad research context (section 3.2.5.2), we aim to incorporate design knowledge that was acquired through the development and study of BCSS to cover a wide understanding as well as practical insights and implications. To identify additional concepts not mentioned in the PSD model, we apply a systematic literature review in line with Boell and Cecez-Kecmanovic (2015).

This systematic literature review comprises six interdisciplinary databases covering different disciplines, which reflects the wide variety and application contexts of BCSS (see Figure 14). The search term is built to identify studies that address design principles of BCSS, including various synonyms as elaborated in section 3.2: "*Abstract("persuasive system*" OR "persuasive technolog*" OR "Behavior Change Support System" OR "BCSS") AND Abstract("design principle*" OR "persuasive system* design" OR "system feature*" OR "software architecture" OR "*requirement*")*". This narrows the focus to our research field of persuasive systems which is in accordance with our solution objective (section 3.2.5.1) and specified research context (section 3.2.5.2). With this procedure, our systematic literature review extends the prior systematic literature study of Merz and Ackermann (2021). Thus, we renewed and supplemented this study as the foundation for our systematic literature review to ensure high rigor and timeliness. Figure 14 depicts the progress of the systematic literature review.

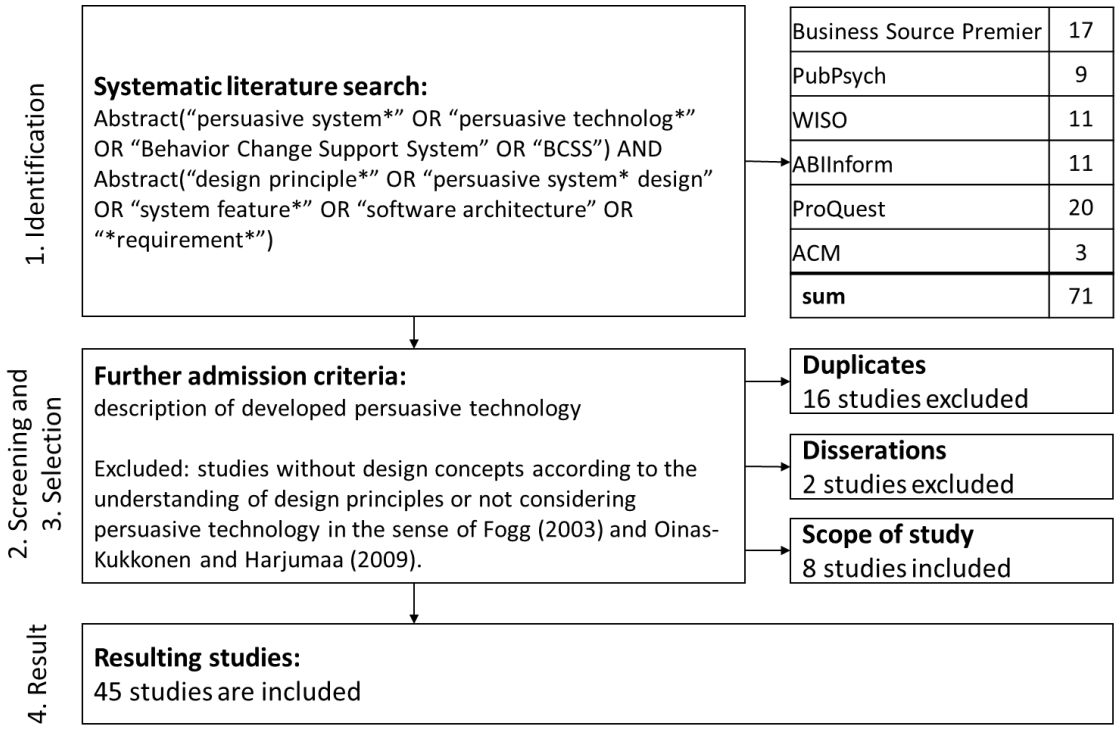

Figure 14: Process of the Systematic Literature Review

Merz and Ackermann (2021) identify 705 applications of design principles in 42 studies. Of those, 15 studies suggest further 71 concepts as design principles in addition to the design principles of the PSD model. Our supplemented renewal of their literature review yielded three additional studies (Condori-Fernandez et al. 2020; Halttu and Oinas-Kukkonen 2021; Doumen et al. 2021). In summary, we use the literature of the theoretical background as well as those 45 studies as the knowledge base for our design principle development.

Regarding the results of the systematic literature review, it is noteworthy that all identified studies are based on the PSD model and use all or some design principles of the PSD model but differ in form of their description. This is in line with the findings of Merz and Ackermann (2021), who state that " Lehto and Oinas-Kukkonen (2013) do not list self-monitoring for the design, but its implementation is mentioned by a user in the qualitative evaluation". Of all 46 identified studies within the systematic literature review, 15 studies suggest further 97 concepts as design principles in addition to the design principles of the PSD model Consequently, and to address the broad field of design knowledge we focus on the design principles within the PSD model, as well on the further identified 97 design

concepts. Thus, we carefully analyzed the underlying studies to elicit the design requirements in the next step of the method for design principle development.

3.2.5.5 Elicit Design Requirements

While Möller et al. (2020) refer to meta-requirements in the process of formulating design principles, we follow the understanding of Rhyn and Blohm (2017), as described in chapter 3.2.3.2, who define that design requirements "serve as meta-requirements". In their research, Möller et al. (2020) point out, eliciting design requirements is the upstream stage prior to formulating design principles, yet „only a few studies employ the concept [design] requirements" (Möller et al. 2020, p. 214). Therefore, and in accordance with the definition that Oinas-Kukkonen and Harjumaa (2009) provide in the PSD model, we elicit design requirements from concepts included in the identified knowledge base, whether these concepts be referred to as design principles or as requirements.

We identified 125 such concepts from which to extract certain aspects of design requirements; 28 from the PSD model and 97 additional concepts from the studies of the knowledge base. It is worth noting that none of those studies used a specific formulation schema to develop their design principles.

Two researchers with practical experience in developing BCSS (Steinherr 2021) and (Merz 2020) further classified the 125 concepts based on the four categories of the PSD model and the aim of each concept (Table 17). As the concepts of the PSD model are not systematically selected (Wiafe et al. 2014), we aggregated them with the additional concepts to form overarching design requirements grouped in accordance with their shared aims. For example, because personalization and customization "both aim to achieve the same objective of tailoring systems, although with different approaches" (Orji et al. 2019c, p. 327), we assigned them both to the design requirement of adoption. Likewise, other high-level concepts, such as tunneling and tailoring, are incorporated in other principles, such as reduction and self-monitoring. Identifying the aspects of those design requirements was an iterative process that included the formulation of meaningful design principles (section 3.2.5.6).

Table 17: Categories of the PSD Model Juxtaposed with their Aims and Aggregated Concepts

Category	Aim of the category	Aggregated aspects of design requirements
Primary task support	support behavioral change towards the target behavior	guidance, monitoring, goal-setting, adoption, simulation, and rehearsal
Dialogue support	motivate with feedback	praise, rewards, and trigger
Credibility support	make the design of a system credible	appealing visual design and trustworthiness
Social support	motivate with social influence	formation of groups, interaction, and comparison

3.2.5.6 Formulate Design Principles

Having examined the knowledge base of 125 concepts and the aggregated aspects of design requirements, we formulated 14 design principles in the four categories of the PSD model by applying the design principles schema proposed by Gregor et al. (2020). Table 18 presents the components of the design principles schema of Gregor et al. (2020) and the examples that Gregor et al. (2020) used for the purpose of demonstration. Furthermore, it shows how we applied the schema to the example of the design principle rehearsal. See Tables 20 – 23 for an overview of the sources we used for those design principles.

Table 18: Application of the Design Principles Schema

Components	Example presented by Gregor et al. (2020, p. 1635) (based on Moody 2009)	Example of design principle rehearsal
Aim and **actors** (implementer, user, enactor)	For designers and researchers (implementers) "to design cognitively effective visual notations" (aim) for use by diagram creators and diagram users (users)	For researchers and developers (implementers) to allow BCSS (enactor) to expose users (users) to possible effects of the target behavior and to give users the opportunity to gain experience (aim),
Context	in software engineering	when forming, altering, or reinforcing attitudes behavior, or act of complying without using deception, coercion, or inducements
Mechanism	ensure there is a 1:1 correspondence between semiotic constructs and graphical symbols	introduce the users to increasingly challenging experiences in a training environment
Rationale	because doing so avoids the anomalies of symbol redundancy, symbol overload, symbol excess, and symbol deficit, based on theory, including Goodman's (1968) theory of symbols.	because rehearsing a behavior can enable users to change their attitude or behavior in the real world.

Gregor et al. (2020) suggest five components of design principles: aim, actors (implementers, users, and enactors), context, mechanism, and rationale. In our application, the components actors and context are consistent across all design principles for BCSS. Therefore, the actors (i.e., implementors, users, enactors) are overarching for all suggested design principles for BCSS: we consider the implementers as researchers and developers of BCSS. BCSS themselves are enactors that "perform actions as part of the mechanisms that are used to accomplish the aim" (Gregor et al. 2020, p. 1633). This is in line with Gregor et al. (2020) who specify that enactors themselves can be systems. "Users are those whose aims are to be achieved" (Gregor et al. 2020, p. 1633), which is in this sense of the word that we regard users of BCSS.

The context specifies the "boundary conditions, implementation setting, further user characteristics" (Gregor et al. 2020, p. 1633). In our case, the context is determined for all design principles by the definition of BCSS as systems that "form, alter or reinforce attitudes, behaviors or an act of complying without using deception, coercion or inducements" (Oinas-Kukkonen 2010, p. 6).

In addition to the components actor and context, Gregor et al. (2020) emphasize the components aim, mechanism, and rationale in design principle formulation. The mechanisms are activities, actions, processes, or architectures designed to achieve or enable the aim (Gregor et al. 2020). While the design principles within the PSD model describe the mechanism in rather vague terms (e.g., "by providing means for action", Oinas-Kukkonen and Harjumaa 2009, p. 492), our design principles are detailed and provide tangible mechanisms, such as that to "introduce the users to increasingly challenging experiences in a training environment", Table 18). In order to justify the knowledge inherent in the design principles, the design principles schema demands the formulation of a rationale. Such a rationale may be based on theories or empirical justification of the design principle (Gregor et al. 2020).

The following four tables (Table 20 – Table 23) are assigned to the four categories of the PSD model (primary task support, dialogue support, credibility support, and social support) and present our 14 design principles for BCSS, formulated in accordance with the design principles schema displayed in Table 18.

Since the implementer, enactor, and context presented in Table 19 are overarching for all design principles of BCSS, we did not reiterate them in the presentation. Rather, we decided to render the knowledge base as transparent as possible by listing the references that justify each component of our design principles.

Table 19: Overarching Components of our Design Principles

Implementer	Researchers and developers of BCSS
Enactor	BCSS
Context	when forming, altering, or reinforcing attitudes, behavior, or act of complying without using deception, coercion, or inducements

Table 20: Design Principles of the Category Primary Task Support

Guidance	
To allow BCSS to reduce the users' effort of performing the target behavior,	Oinas-Kukkonen and Harjumaa 2009
guide users by providing tailored information and tasks	Harjumaa and Muuraiskangas 2014; Oinas-Kukkonen and Harjumaa 2009; Orji and Mandryk 2013; Karekla et al. 2019
because guidance reduces barriers to the acquisition of experience and brings users closer to their target behavior step by step.	Orji and Mandryk 2013; Harjumaa and Muuraiskangas 2014
Monitoring	
To allow BCSS to provide users with an assessment of their progress towards the target behavior,	Oinas-Kukkonen and Harjumaa 2009; Valk et al. 2017
track their performance and status, and present information on both past and current states	Orji et al. 2019c; Valk et al. 2017; Doumen et al. 2021
because monitoring shows users their adherence to the target behavior and encourages them to 'stay on track'.	Karekla et al. 2019; Doumen et al. 2021
Goal-Setting	
To allow BCSS to direct users to take purposeful actions toward the target behavior,	Asbjørnsen et al. 2019
recommend challenging and specific goals and/or invite users to set challenging and specific goals	Orji et al. 2019c; Orji and Mandryk 2013; Valk et al. 2017;
because, based on the goal-setting theory, specific and challenging goals lead to higher performance, consistency, and commitment.	Locke and Latham 1991, 2002; Böckle and Yeboah-Antwi 2019, 2019; Doumen et al. 2021; Halttu and Oinas-Kukkonen 2021
Adoption	
For BCSS to be tailored to the users' characteristics and preferences to reach the target behavior,	Orji et al. 2019c; Schneider et al. 2016
offer personalized content and services and/or provide opportunities to customize content and services	Karekla et al. 2019; Harjumaa and Muuraiskangas 2014
because adoption incorporates the individual needs and choices of users, which makes the system more persuasive.	Oinas-Kukkonen and Harjumaa 2009; Corbett 2013; Schneider et al. 2016; Orji et al. 2014

Simulation	
To allow BCSS to expose users to the benefits of the target behavior,	Oinas-Kukkonen and Harjumaa 2009
simulate the effects of performing a certain behavior	Orji and Mandryk 2013
because a simulation is more persuasive when it lets users observe the link between cause and effect.	Oinas-Kukkonen and Harjumaa 2009
Rehearsal	
To allow BCSS to expose users to possible effects of the target behavior and to give users the opportunity to gain experience,	Oinas-Kukkonen and Harjumaa 2009
introduce the users to increasingly challenging experiences in a training environment	Orji and Mandryk 2013
because rehearsing a behavior can enable users to change their attitude or behavior in the real world.	Oinas-Kukkonen and Harjumaa 2009

Table 21: Design Principles of the Category Dialogue Support

Praise	
To allow BCSS to give motivational feedback to users for the purpose of encouraging them to make further progress,	Asbjørnsen et al. 2019
offer praise in the form of words, images, symbols, or sounds	Oinas-Kukkonen and Harjumaa 2009; Orji and Mandryk 2013
because a system that offers praise can make users become more open to persuasion.	Oinas-Kukkonen and Harjumaa 2009
Rewards	
To allow BCSS to give credit to users when they perform the target behavior,	Harjumaa and Muuraiskangas 2014
provide virtual rewards, such as badges, special features, or scores (or, on the contrary, remove them as a form of punishment)	Oinas-Kukkonen and Harjumaa 2009; Orji and Mandryk 2013
because the prospect of reinforcement (or removement of reinforcement) strengthens the motivation to adhere to the target behavior.	Orji and Mandryk 2013
Trigger	
To allow BCSS to prompt a stimulus that elicits the target behavior from users,	Orji and Mandryk 2013
notify them with messages, reminders, alerts, and suggestions at the right time and place	Mintz and Aagaard 2012; Valk et al. 2017; Oinas-Kukkonen and Harjumaa 2009; Doumen et al. 2021
because “without an appropriate trigger, behavior will not occur even if both motivation and ability are high” (Fogg 2009 S.3).	Fogg 2009

Table 22: Design Principles of the Category Credibility Support

Appealing Visual Design	
To allow BCSS to have a competent and credible look and feel that is pleasing to users,	Condori-Fernandez et al. 2020; Karekla et al. 2019
implement the user interface, including the language and interaction design, so that it is appealing to users and corresponds to their preferences as well as their familiar environments (highly dependent on the target group)	Oinas-Kukkonen and Harjumaa 2009; Halttu and Oinas-Kukkonen 2021
because visual experience and the attractiveness of the visuals make a persuasive system more usable and likable, which increases the users' willingness to interact with it.	Böckle and Yeboah-Antwi 2019; Halttu and Oinas-Kukkonen 2021
Trustworthiness	
To allow BCSS to be perceived as credible and to provide trustworthy interventions to users,	Orji and Mandryk 2013; Oinas-Kukkonen and Harjumaa 2009; Karekla et al. 2019
present information that is truthful, fair, and unbiased, and ensure that this information is based on evidence, experience, and competence by referring to credible sources, such as endorsements by authoritative organizations or experts	Oinas-Kukkonen and Harjumaa 2009; Karekla et al. 2019; Doumen et al. 2021;
because trustworthiness firms the persuasiveness of the system more persuasive and the user more likely to comply with the target behavior.	Oinas-Kukkonen and Harjumaa 2009; Halttu and Oinas-Kukkonen 2021

Table 23: Design Principles of the Category Social Support

Formation of groups	
To allow BCSS to use elements of social influence on users,	Schneider et al. 2016; Orji and Mandryk 2013
provide the formation of (peer) groups or teams	Orji and Mandryk 2013; Oinas-Kukkonen and Harjumaa 2009
because the formation of groups has a normative influence and encourages reciprocity among users, as a result of which the likelihood of adopting a target behavior increases.	Böckle and Yeboah-Antwi 2019; Halttu and Oinas-Kukkonen 2021
Interaction	
To allow BCSS to stimulate social encouragement and social facilitation and cooperation among users,	Oinas-Kukkonen and Harjumaa 2009; Orji and Mandryk 2013
provide functions for communication, recognition, and interaction, such as messaging or sharing opportunities	Alkhushayni and McRoy 2016; Asbjørnsen et al. 2019; Harjumaa and Muuraiskangas 2014; Meedya et al. 2019; Valk et al. 2017; Oinas-Kukkonen and Harjumaa 2009
because a greater sense of human contact, appreciation, and sharing of experiences have a positive impact on motivation, accountability, and commitment.	Karekla et al. 2019

Comparison	
To allow BCSS to enable social comparisons among users,	Orji and Mandryk 2013; Oinas-Kukkonen and Harjumaa 2009
give them the opportunity to observe and compare the behaviors and achievements of others, for instance, by using competitive elements	Orji and Mandryk 2013; Oinas-Kukkonen and Harjumaa 2009; Valk et al. 2017
because comparison promotes social learning and encourages users to follow the lead of their fellow users.	Halttu and Oinas-Kukkonen 2021; Böckle and Yeboah-Antwi 2019; Oinas-Kukkonen and Harjumaa 2009

3.2.5.7 Evaluation

Considering the iterative and theory-focused nature of this study, we conclude this iteration by evaluating the synthesized set of clearly formulated design principles for BCSS development by assessing if the set of design principles enables a clear codification of design knowledge using interrater reliability. In doing so, we provide a "proof of concept", as suggested by Gregor and Hevner (2013). This allows us to demonstrate that the set of design principles, while based on theoretical work, can be applied in a practical context.

It is the goal of this study to answer the research question "*What design principles form a concise and comprehensive overview for persuasive systems that provide a clear codification of design knowledge?"*. This means we aim to provide a systematic overview of design principles for persuasive systems that is 1) concise, i.e., the set contains only design principles that should be considered in persuasive systems, 2) comprehensive, i.e., the set contains design principles that can all be considered in persuasive systems, 3) clearly codified, i.e., formulated in a way that they can be presented and communicated in a unified form without leaving room for different interpretations.

Aspects 1) and 2) are addressed by building our research on the established PSD model and enriching this knowledge with a broad literature review including further 45 studies. With respect to the underlying broad foundation and the aggregation of the 125 identified concepts and their synthesis into 14 design principles formulated according to Gregor et al. (2020), we argue for a concise and comprehensive overview.

To verify that the design principles 3) provide a clear codification of design knowledge, we perform a Cohen's Kappa interrater reliability analysis (Cohen 1960). Cohen's Kappa indicates the agreement rate of independent codings, taking into account random agreement.

To conduct a Cohen's Kappa analysis (Cohen 1960), two researchers independently used the set of design principles as a coding schema for prescriptive design knowledge related to BCSS development. While one researcher was involved in the formulation of the design principles (Researcher 1 in Table 25) , the second researcher also has practical experience in the design of BCSS (Researcher 2 in Table 25), but is considered a neutral coder without prior knowledge of the formulated design principles. As prescriptive design knowledge to be coded, we used qualitative statements from 43 university students who answered the question: "What would make me use [name of a BCSS] more regularly?" This qualitative question was part of an evaluation study of a developed Behavior Change Support System targeting students' learning behavior (Steinherr 2023).

For systematic and independent coding, both coders were given an overview of the 14 design principles and a coding schema, which is shown in Table 24. Table 24 depicts an expert of the coding of one researcher with dark markings indicating that the researcher has identified a design principle in the statement.

Table 24: Coding Schema

	Primary Task Support						Dialogue Support			Credibility Support		Social Support		
Students' qualitative statements	Guidance	Monitoring	Goal-Setting	Adoption	Simulation	Rehearsal	Praise	Rewards	Trigger	Appealing Visual Design	Trustworthiness	Formation of Group	Interaction	Comparison
1) More points or levels								■						
2) See progress, maybe little sentences to "congratulate" you when you've done something.		■					■							
3) You should somehow be able to get notifications so that you don't forget to use the app.									■					
4) A function to record one's own learning goals and list them in a kind of "To Do List". In addition, it could also be very helpful to integrate a timetable in which I can enter my milestones for my learning progress (for a specific subject).		■	■			■								
X) …														

After the two researchers independently coded the prescriptive design knowledge to the corresponding design principles, we compared the results for consensus. By scoring 43 qualitative statements on whether they addressed one or more of the 14 individual design principles, a total of 602 variables were coded. Table 25 shows the identified (dis)agreement of the two researchers who coded individually.

Table 25: Independent Coding of Two Researchers

		Researcher 2		
		DP identified in statement	DP not identified in statement	
Researcher 1	DP identified in statement	48	5	53
	DP not identified in statement	2	547	559
		50	552	602

Based on the identified (dis)agreements the Cohen's Kappa analysis identified the following values: $p0 = 0.99$, $pe = 0.07$, and $\kappa = 0.99$. $\kappa = 0.99$ is indicative for a very good (Altman 1990), almost perfect (Landis et al. 1977) interrater reliability. This high value suggests that the set of 14 design principles allows for a clear codification of design knowledge.

Looking at a more detailed level regarding individual design principles, 10 of the 14 design principles resulted in 100 % consensus. However, the coding of four design principles resulted in lower interrater agreement rates: Guidance, $\kappa=0.87$ (almost perfect); Goal setting $\kappa=0.65$ (substantial), Adoption $\kappa=0.48$ (moderate) and Rehearsal $\kappa=0.48$ (moderate) (Landis et al. 1977). While the design principles goal setting, adoption, and rehearsal have lower interrater reliability, this could also be due to vague and very short statements such as "helpful advice". In this example, one researcher identified the design principle rehearsal while the other did not. Analyzing the disagreement, the researchers concluded that they shared the same understanding of the design principle but interpreted the statement at a different level. Based on this analysis of the disagreement, we don't interpret this moderate agreement rate for the design principles of adoption and rehearsal as evidence that these design principles do not correspond to the defined objective, i.e., that they are not sufficiently clearly formulated. Nevertheless, it is important to consider the results of the evaluation and reflect on a possible concretization of the design principles

in future iterations. These iterative adjustments will also allow new research on design concepts to be incorporated into the design principles.

Overall, the initial evaluation of our set of design principles for persuasive systems indicates that although not all design principles resulted in "almost perfect" interrater reliability, the 14 design principles are able to meet our goal of creating a synthesized set of clearly formulated design principles for BCSS development that is both meaningful and systematically derived to work as a framework for designing persuasive systems. Consequently, we conclude that our set of design principles is able to provide a clear codification of design knowledge regarding BCSS development.

3.2.6 Discussion

Gregor et al. (2020) called for fellow researchers to use their design principles schema to formulate functional design principles and to observe how researchers and designers act upon their conceptual schema. To contribute to the discourse of formulating design principles, we describe our point of view: In our review of BCSS literature, we found that there is an ambiguous understanding of design principles for BCSS, and studies often fail to distinguish between their aim, mechanism, and rationale. As a result, concepts based on design knowledge lack standardization and are often governed by design principles with overlapping aims. This is in accordance with the findings of Gregor et al. (2020) as well as Merz and Ackermann (2021). In this study, we address this problem and provide to the goal to create a synthesized set of clearly formulated design principles for BCSS development that is both meaningful and systematically derived to work as a framework for designing persuasive systems. To do so we formulated design principles that form a concise and comprehensive overview and provide a clear codification of design knowledge. The resulting set of 14 design principles represents only half of the 28 design principles defined within the PSD model, but by explicitly considering their aim, mechanism, and rationale, they are able to synthesize the design principles within the PSD model as well as additional 97 design concepts identified in the BCSS literature.

The process of design principle development according to Möller et al. (2020) provided guidance for the structured development of design principles. Considering the design principles schema Gregor et al. (2020) when formulating design principles allowed us to structure identified design concepts within the BCSS literature. We found the design principles schema to be immediately applicable after we obtained a thorough understanding

of its underlying concepts and aspects of the knowledge base upon which we developed our design principles for BCSS. The components of the schema overall provide a comprehensible structure to ensure that the design principle conveys the detailed information required.

Following the process of design principle development (Möller et al. 2020), the underlying knowledge base of BCSS development revealed 125 design concepts, including 28 requirements of the PSD model. By considering the design principles schema of Gregor et al. (2020) and the defined design principle components guided us in aggregating the identified design concepts into 14 explicit design principles. This aggregation is based on their shared aim according to the components of the design principles schema of Gregor et al. (2020).

In particular, the explicit description of the design principles by addressing each component according to Gregor et al. (2020), has contributed substantially to the goal of clearly codifying design knowledge for BCSS development. In our application of the schema, we found the components of the actors and context to be consistent across all design principles for BCSS: We consider BCSS as the enactors of the mechanism, the implementors as researchers and developers of BCSS, and users as users of those BCSS. The inclusion of the aim of each design principle helped us to focus on the essence and allowed a clear distinction between the 125 design concepts identified within the systematic literature review. The mechanism provides information on what concrete design features can be implemented to address the design principles. Integrating the rationale in each formulated design principle ensures that the design principle is justified. In addition, the rationale can also inspire BCSS developers to consider integrating the design principles, as possible cause-and-effect relationships are outlined.

The initial evaluation of the resulting set of 14 design principles addresses their requirement for the clear codification of design knowledge. To identify this requirement, we used the developed set of design principles as a coding schema for design principle development. Analyzing the interrater reliability of two independent coders resulted in an "almost perfect" interrater reliability (Cohen 1960; Landis et al. 1977). This indicates that the set of design principles meets the defined need for a clear codification of design knowledge. While this evaluation does not yet reflect the actual use of the set of design principles as a framework for BCSS development, the evaluation regarding the required

clear codification of design knowledge represents an important fundamental step in the development of a framework for designing persuasive systems.

The formulated set of 14 design principles defines the components of the actors and context as consistent across all design principles for BCSS. This is reasoned by our goal to develop a set of design principles that address the comprehensive context of persuasive systems.

The users within the design principles are consistently defined as BCSS users. This allows us to formulate transferable and general applicable design principles aggregating a wide knowledge base of BCSS. However, within the design principles schema users can be addressed more concretely. It allows to differentiate the design principles and underlying components with respect to different BCSS user groups. BCSS design might benefit by differentiating their design, for example, regarding the age of the users. For example, it is plausible that the design principle of "appealing visual design" may be specified differently for young people than for senior users.

The context of the design principle constitutes an essential aspect of codifying knowledge in design principles and the design principles schema allows for different levels of abstraction of design principles. Furthermore, the schema specifically encourages to contemplate and contribute by defining that context. While we defined the context to be consistent within the set of developed design principles, we understand a more specific definition of this context as valuable. The context of BCSS design could for example be formulated more precisely by integrating the context of the application. For example, by integrating the application context health would allow specifying our more generic design principles for BCSS with regard to application-dependent aims, mechanisms, and rationales.

Considering these options for specification, our goal in this study is to develop design principles for a concise and comprehensive overview for persuasive systems that provide a clear codification of design knowledge. Therefore, we understand the consistent context and users defined within our design principles essential in promoting both transferability and usability of the codified design knowledge.

In addition to the findings based on the 14 design principles developed, the application of the design principles schema of Gregor et al. (2020) and the design principles development process (Möller et al. 2020) resulted in the following insights:

Considering the level of abstraction and the real-world usability of design principles, the schema of Gregor et al. (2020) could be extended with a new component concerning "risks". Design principles are inherently only the codification of design knowledge that requires a fitting implementation to gain effects. While the design principles schema incorporates information that points to how to implement fitting design features, such as the aim, context, mechanisms, and rationale, explicitly denoting deficiencies or problems that may occur can provide further design knowledge or indicate limitations of the application. This is especially relevant for design principles for which the literature presents diverging results: Some studies as well as the PSD model propose the design principle of competition because competition can evoke positive reinforcement in the form of increased motivation, attention, and satisfaction (Oinas-Kukkonen and Harjumaa 2009; Orji et al. 2019c; Mohadis et al. 2016). However, competition can also negatively impact users of BCSS when it induces fear or a perception of failure (Bartlett et al. 2017; Mohadis et al. 2016). The same applies to the issue of denying users their accustomed rewards as a form of punishment. While this can induce motivation, it can also have adverse effects, such as frustration or dejection (Orji and Mandryk 2013). Given the lack of consensus on these issues but following the design principles schema of Gregor et al. (2020), we did not want to accentuate competition and negative reinforcement as design principles, but we did not want to neglect them either. Hence, we concluded not to formulate specific design principles about those concepts but rather to encase them as mechanisms in the broader terms of comparison and feedback.

Möller et al. (2020) provide a method to extend the body of design knowledge by systematically developing design principles. They differentiate between two approaches: a reflective approach that extracts design principles from the design of an artifact, and a supportive approach that derives design principles from literature by studying design requirements. As Möller et al. (2020) observe, however, „only a few studies employ the concept [design] requirements while extracting design principles" (Möller et al. 2020, p. 214). Moreover, usually, design requirements are determined when designing an instantiation of an artifact (Möller et al. 2020). Therefore, we presume that requirements might be present in a reflective development approach rather than in the supportive development approach we chose for this study (described in section 3.2.5.3). Accordingly, we mainly derived the design principles based on existing concepts of design principles.

Furthermore, considering the existing knowledge base of design knowledge on persuasive systems, we observed that the literature is ambiguous in formulating design principles,

such as that it lacks standardization of names and clear differentiation between similar or overlapping principles. This observation confirms the insights of Gregor et al. (2020) as well as those of Merz and Ackermann (2021). However, when we assembled concepts and compared insights, we found a consensus on the meanings of design principles. It is this consensus on which we proceeded to aggregate all relevant aspects into 14 design principles.

3.2.7 Implications

Following a systematic approach, we present 14 design principles for persuasive systems that provide explicitly formulated prescriptive knowledge on how to design BCSS. Those design principles convey actionable mechanisms for persuasive systems in order for them to achieve their aim based on the identified rationales. This allows designers and developers of BCSS to build on our accumulated design knowledge when creating, implementing, and evaluating persuasive systems (Baskerville et al. 2018). The implications are: 1) Our findings impact the design of new artifacts as a foundation and provide guidance as to which aspects should be considered and implemented. 2) The design principles can be applied to existing systems where they can serve as an evaluation framework to identify the untapped potential of existing BCSS. Comparing the design principles with existing systems might show that the investigated system broadly comprises persuasive mechanisms – or it might reveal further aspects that were not yet considered in the original design. Consequently, 3) the design principles also provide a foundation to advance existing systems, specifically how to extend and supplement support functions in order to increase a system's effectiveness and impact. 4) The formulated set of design principles summarizes the findings of the PSD model and additional 97 design concepts identified in BCSS literature in a generic nature. This generic formulation allows a broad application context and enables the transfer of design knowledge. Besides the generic formulated design principles also provide a structure for a systematic specification, for example by specifying the user group or application context of BCSS.

Although our attention here is focused on design principles for BCSS, we want to encourage and stimulate discussions on how those design principles affect IS in general within the research field of HCI. Already, Fogg (2003) identifies computers and technology as inherently social actors that impact the decisions and behavior of their users. As of today, this is all the more true as technology is near enough ubiquitous and affecting "human behavior with values and norms" (Maedche 2017, p. 300; Richter et al. 2018). However,

other points of view consider that "persuasive systems can be supportive and engaging, but may lead to addiction" (Maedche et al. 2019, p. 540). Considering BCSS in their definition as support systems that aim to "form, alter or reinforce attitudes, behaviors or an act of complying without using deception, coercion or inducements" (Oinas-Kukkonen 2010, p. 6), we argue for the positive and encouraging role that such systems play when they enable or support users in their desired actions and behaviors. Consequently, while we consider our set of 14 design principles to be particularly significant to BCSS, we also believe them to be generally applicable to systems designed with the intent to achieve corresponding aims of the formulated design principles.

Supplementing this implication, we emphasize to thoughtfully consider persuasive features of IS in daily life. Even though persuasive systems are usually voluntary and non-coercive, systems that affect human behavior can be found in most areas of modern life (Alt et al. 2021). These systems have the power to shape many of the beliefs, thoughts, and actions of their users (Alt et al. 2021; Oinas-Kukkonen and Harjumaa 2009; Maedche 2017). Given this impact follows the responsibility to contemplate the actual and potential effects along with their long-term consequences for users and employees. While technology affects human behavior, not every behavioral change is beneficial, nor is it necessarily healthy. Among manifold other risks associated with the use of technology, it can lead to technostress (Ayyagari et al. 2011; Califf et al. 2020), addiction (Maedche 2017), and privacy and security issues (Smith et al. 2011; Price and Cohen 2019). This is true in people's private lives as well as in their working lives (Richter et al. 2018; Spiekermann 2016). Hence, systems with persuasive elements have the potential to support well-being and fitting behavior but users (including employees and managers) should become more aware of underlying persuasive mechanisms that might lead to involuntary, unhealthy, and unintended behavior. These issues are further discussed in research fields regarding responsible and ethical IT innovation (e.g., Spiekermann 2016; Alt et al. 2021).

3.2.8 Conclusion

Persuasive systems in the form of BCSS influence the attitudes and behaviors of its users as well as promote high practical values, such as personal, social, or organizational benefits. To develop meaningful and effective BCSS, however, it is critical to build on existing design knowledge. However, the research field of persuasive systems misses a sufficient systematic coding of design knowledge. This results in misunderstandings and vague guidance when BCSS developers implement design principles due to overlapping

and not sufficiently differentiated design principles, e.g., personalization or customization. Furthermore, the absence of clarity concerning design principles also aggravates the transfer of identified design knowledge.

We address this research gap by synthesizing existing design knowledge into a set of clearly formulated design principles for BCSS development. The resulting set consists of explicitly formulated design principles for the domain of persuasive systems and provides a framework for the design of BCSS. By applying the method for design principle development by Möller et al. (2020) and the design principles schema of Gregor et al. (2020), we identified 14 design principles. Those design principles provide a specification of the widely used PSD model by Oinas-Kukkonen and Harjumaa (2009) by explicitly elaborating the aim, actors, context, mechanism, and rationale regarding each design principle. Our design principles provide developers and implementers of BCSS with guidance in form of an overview and insights into the underlying aims, mechanisms, and rationales of each design principle. Furthermore, researchers can adapt and use our design principles to clearly communicate identified design knowledge as well as to evaluate and extend their designs.

Despite our best efforts to ensure the highest standard of academic rigor, this paper is subject to some inevitable limitations: First, we base our method on a literature review that might miss potentially relevant studies. However, by extending a systematic literature review that incorporates several interdisciplinary databases with a wide search string, we are confident that we cover a sufficiently wide range of articles presenting design knowledge about BCSS. Second, we evaluate the design principles only using a short argumentation and a demonstration example based on popular BCSS. This does not claim to meet the standards of a thorough evaluation but rather represents an initial proof of concept, as suggested by Gregor and Hevner (2013). Further, expert interviews, user feedback, and instantiations should augment this study as well as evaluate whether the 14 formulated design principles are understandable and useful for researchers and developers of BCSS (Möller et al. 2020). By investigating and developing design principles for persuasive systems, we envision extending and codifying current design knowledge about persuasive systems in order to facilitate the creation of meaningful BCSS.

4 Essays on the Design of a Behavior Change Support Systems towards Self-regulated Learning in a Higher Education Context

4.1 Essay 6: LANA: A Behavior Change Support System towards Self-regulated Learning

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4.1.1 Abstract

The measures to counter the COVID-19 pandemic add pressure on students to meet the challenges of digitized courses in higher education. Many suffer from these demands and fail to regulate their learning effectively. Behavior Change Support Systems (BCSSs) are a promising approach to guide students towards a successful learning behavior. Nevertheless, successful integration of the systems requires users' acceptance and intention to use. While BCSSs have been well studied in several research areas, there is insufficient evidence on the design features that promote the acceptance of BCSSs in educational contexts. This study presents LANA, a BCSS towards self-regulated learning that is designed following the Persuasive Systems Design Model by Oinas-Kukkonen and Harjumaa (2009). The evaluation using the Technology Acceptance Model by Davis (1986) shows that perceived usefulness has a significant impact on students' intention to use LANA and highlights the importance of considering the design of the user interface.

4.1.2 Introduction

The goal of this study is to identify crucial design features influencing the acceptance of a Behavior Change Support System (BCSS) towards self-regulated learning (SRL) in higher education. BCSSs accompany and guide users through the process of changing their behavior (Oinas-Kukkonen 2013). These BCSSs are successfully implemented in different research fields (Tikka and Oinas-Kukkonen 2019). Whereby a basic acceptance for technologies and an intention to use (IU) are essential prerequisites (Kim 2015).

Currently, BCSSs are successfully implemented in various fields, especially in the health care sector (Tikka and Oinas-Kukkonen 2019). Without BCSSs people often fail because the desired behavior change is mainly self-directed and therefore guidance and instruction are missing (Allan et al. 2008). Students in higher education currently face similar challenges, due to increasing digitalization that comes with the need to organize and regulate learning on their own (van Wyk 2017). Many suffer from this pressure (LeViness et al. 2019). Additionally, the COVID-19 pandemic measures further exacerbate these conditions as self-study takes on an even greater role in online-only semesters (Wesselborg 2020). Studies show that training in SRL can lower perceived stressors, prevent problems caused by bad learning behavior (La Fuente et al. 2020), and are already proven to be a valuable addition to cope with the challenges of digital semesters during the COVID-19 pandemic (Wesselborg 2020). But despite the increasing relevance of support for students, traditional trainings often do not reach their goals. Reasons are high perceived barriers regarding formal support services (Eisenberg et al. 2012; Stolzenburg et al. 2019), a normalized high level of stress in academic education (Eisenberg et al. 2012; Brown 2018), and insufficient effects, as new knowledge is quickly forgotten (Goh et al. 2012). BCSSs in form of smartphone apps can easily be integrated into students' everyday lives, provide missing guidance during digital semesters, and could therefore function as effective, scalable, low-barrier interventions to improve learning (Fogg 2003).

But although apps are typically considered attractive to students, there is still a risk that these technologies are not used or are only used with insufficient frequency (Teri et al. 2014). This underscores the fact that the successful integration of apps into educational contexts does not depend on the availability of the offerings, but rather on students' acceptance and their IU. Therefore, it is crucial for newly developed technologies to evaluate their design and structure in terms of user acceptance (Kim 2015). So far, there is still a lack of studies investigating BCSSs underlying design choices and their influence on

students' acceptance in higher education as the systems are not yet established in educational settings (Lehto and Oinas-Kukkonen 2015). Therefore, the research question underlying this study is: *How should a BCSS towards SRL be designed to foster students' acceptance, in particular their initial IU?*

To investigate this question, the BCSS LANA (Learning Analysis) is developed by drawing upon the existing knowledge base identified through a systematic literature review. The design of LANA is in accordance with the steps of the Persuasive Systems Design (PSD) model by Oinas-Kukkonen and Harjumaa (2009). To measure students' IU, the Technology Acceptance Model (TAM) (Davis 1986) is combined with qualitative feedback to identify design features influencing target users' IU. This paper provides researchers and developers of Persuasive Technologies (PT) input regarding the design of BCSSs in educational contexts.

4.1.3 Theoretical Background

4.1.3.1 Behavior Change Support Systems

Fogg (2003) highlights the potential of PT to help people during behavior change processes, as technology is already an inherent part of our daily lives. He defines PT as "any interactive computing system designed to change people's attitudes or behaviors." (Fogg 2003, p. 1). According to Fogg, the advantages of using PT include time and location independence, scalability, ubiquity, and anonymity. These advantages lower barriers to use PT (Fogg 2003). While PT names the field of research, BCSS is considered as the research object. Oinas-Kukkonen defines BCSS as an "information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception" (2013, S. 1225). A framework that addresses the development process of BCSS is the PSD model, which includes three generic steps (Oinas-Kukkonen and Harjumaa 2009): The first step is the analysis of the persuasion context. It includes the consideration of domain-specific issues based on the specific context of use, the users of the BCSS, and the underlying technology. Depending on this analysis, the second step contains an adequate selection of design principles. The PSD model defines 28 different design principles in four categories: primary task support (e.g. self-monitoring, rehearsal), dialog support (e.g. praise, reminders), system credibility support (e.g. trustworthiness, real-world feel), and social support (e.g. competition, normative influence). The final step includes the requirement definition for software qualities and software implementation (Oinas-Kukkonen and Harjumaa 2009).

4.1.3.2 Self-regulated Learning

There is a variety of established theoretical contributions that address SRL (Panadero et al. 2016). Broadly speaking, "self-regulated students select and use SRL strategies to achieve desired academic outcomes based on feedback about learning effectiveness and skill." (Zimmermann 1990, pp. 6-7). These SRL strategies refer to cognitive and metacognitive learning strategies and strategies addressing resources that are relevant during learning (Pintrich and Groot 1990): Cognitive learning strategies are focused on acquiring new knowledge and storing it in memory. Metacognitive learning strategies enable learners to reflect on their goals and adjust their learning process goal-oriented. Internal resources comprise resources that reside within the learner, while external resources provide additional help (Wild and Schiefele 1994). Table 26 presents the learning strategies for SRL.

Table 26: Self-regulated Learning Strategies according to Wild and Schiefele (1994)

Superordinate learning strategies	**Underlying learning strategies**
Cognitive learning strategies	Elaboration; critical thinking; organizing; repeating
Metacognitive learning strategies	Goal setting and planning; monitoring; regulation
Management of internal resources	Effort; attention; time
Management of external resources	Other students; literature; environment

It is part of LANA to measure students' SRL levels. Therefore, it is crucial to identify an appropriate instrument that a) covers a variety of learning strategies of SRL, b) is appropriate for higher education, and c) does not discourage students because of its scope or foreign language (students' native language: German). Different assessment procedures have been developed to measure the degree of SRL (Panadero et al. 2016), such as the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al. 1993), or the Learning And Study Strategies Inventory (LASSI) (Weinstein et al. 1987). Wild and Schiefele published a questionnaire in German to measure SRL that is called LIST. Its items are based on the understanding of the MSLQ, capture different facets of SRL, and focus on higher education (Wild and Schiefele 1994). Intending to maintain the breadth of content of the LIST while reducing the likelihood of dropout due to its length Klingsieck (2018) developed a shorter version, called LIST-K that contains 39 items. The LIST-K measures each of the 13 learning strategies listed in Table 26 with 3 items. Thus, the LIST-K can meet the requirements of an instrument for measuring SRL and is therefore integrated into LANA.

4.1.3.3 Related Work

To draw on the existing knowledge base regarding PT in educational settings, a systematic literature review is conducted. The literature review covers different research areas of BCSSs by including databases with economic, technical, educational, and psychological backgrounds. Eight databases were searched: AISel, Ebscohost, ERIC, IEEE, Proquest, PubPsych, Web of Science, and WISO. The underlying search string consists of two parts: The first part addresses the research object BCSS while “persuasive technology” and “persuasive systems” act as synonyms to broaden the search. The second part addresses the relevant application domain of BCSSs, education. The terms “learning*”, “education”, and “student*” cover this scope. The resulting search string is defined as follows: ("Behavior Change Support System*" OR "Persuasive Technolog*" OR "Persuasive System*") AND (learn* OR education OR student*).

Searching journal and conference articles’ titles and abstracts, in total 70 hits were identified, 10 of which were duplicates. Articles addressing other research fields such as health (21), environment (6), workspace safety (2), intercultural challenges (2), marketing (2), or public events (1) were excluded. Additionally, two articles were excluded because they introduce overarching theoretical models, without implications for educational settings. Four articles did not include students as their focus group and two articles did not address PT. In total 18 articles build the base for the systematic literature review.

The analysis of the identified articles shows that the PSD model is the theoretical background that is dominantly used. However, most researchers design their PT experience-based or based on psychological models without considering the technological components. This is consistent with the findings of the identified literature review by Tikka and Oinas-Kukkonen (2019), who criticize low characterization in terms of the underlying technology and persuasive design in PT research. Although the designed PT is usually not described in detail, the following patterns appear: PT occur mostly in digital learning contexts, addressing online or blended learning. PT are integrated as features in e-learning platforms (Kljun et al. 2019) or massive open online courses (Salim et al. 2019). PT are also incorporated through mobile apps (Sengupta and Williams 2021) or a web app (Orji et al. 2019a). Muller et al. (2015) envisioned the potential of wearables, while Goh et al. (2012) pick up persuasion by sending regular SMSs as reminders.

The incentive for researchers to integrate PT into learning contexts is usually students’ motivation enhancement (Sengupta and Williams 2021). Six articles even define the success of their intervention by motivation (e.g. Engelbertink et al. 2020; Orji et al. 2019a;

Lucero et al. 2006). Other goals are the raise of engagement (Kljun et al. 2019), higher involvement and attention (Widyasari et al. 2019), or students' knowledge building (Alvarez et al. 2017). Only four articles address the change in the learning behavior. The identified articles foster the improvement of individual learning strategies for example reflective learning (Muller et al. 2015), knowledge sharing (Wiafe et al. 2020), as well as social-emotional learning, growth mindset, and character development (Williamson 2017). Goh et al. (2012) also envision the potential of PT to foster SRL. Sending persuasive SMS as reminders to students, increased usage of various learning strategies. The evaluation presents a positive impact of SMS interventions on SRL strategies. While Goh et al. (2012) draw on the theoretical background of SRL, the PSD model is not considered. Also, regular SMS interventions do not meet the standard of guiding and assisting students in changing their learning behavior whenever they need support. However, BCSS should meet this claim (Oinas-Kukkonen and Harjumaa 2009).

Filippou et al. (2015) also noticed the high need for students' support in improving their learning habits. Therefore, their goal was to identify habits that impact academic performance to provide valid information about study behaviors that should be targeted through PT. As learning is a complex process, they concluded no single habit is responsible for the learning performance. However, study habits related to the management of resources, the value placed by the individual student on learning tasks, and the expectations of learning were identified to be the most impactful (Filippou et al. 2015). These strategies are also part of the concept of SRL (Zimmerman 1990; Pintrich and Groot 1990). Therefore, these findings support the idea of developing a BCSS towards SRL to improve students' learning behavior. In a second step, Filippou et al. (2015) designed PT as a mobile app that supports students in changing their learning behavior towards scheduling, preparation for class, and group study. The design principles of self-monitoring, suggestions, rewards, and reminders are implicitly addressed. However, an evaluation of the design features is still missing (Filippou et al. 2015).

Overall, the literature review indicates that PT are well received by students as they are willing to interact with PT and enjoy the integration of technologies into educational environments. The analyzed articles suggest that integrating PT into learning contexts fosters success, such as increased student motivation, greater achievement, or better learning outcomes. Research also proved that PT can change students' behavior. The need for a BCSS to promote aspects of SRL is confirmed in current research. However, research still lacks a clear picture regarding recommendations for specific design principles fostering students' acceptance. While some articles indicate that design principles within the

categories of primary task support and social support of the PSD model have a positive effect on students (Boontarig and Srisawatsakul 2020), there is still not sufficient research to understand the underlying modes of action.

4.1.4 Design and Functionality of LANA

4.1.4.1 Design and Integrated Design Principles

We designed LANA following the PSD model, including the context analysis, the selection of fitting design principles, and the implementation (Oinas-Kukkonen and Harjumaa 2009). To carry out the context analysis, the target users of LANA and their needs are examined: The target users of LANA are university students in general who are trying to meet the demands of digital semesters due to the COVID-19 pandemic. They already have some experience regarding learning, but because of the changing learning environment, they need new impulses or guidance to cope with the new requirements. Therefore, LANA is not intended to address only one target problem or a specific learning strategy, but to show students a variety of ways to improve their learning behavior. Hence, an easily accessible support system with a wide range of learning strategies and a high level of acceptance is required, which accompanies students to achieve sustainable changes in their learning behavior. Smartphone apps can meet these needs. They are quick and easy to use, as they are already firmly integrated into students' daily lives (Ataş and Çelik 2019).

The selection of fitting design principles should be linked to the specific context analysis (Oinas-Kukkonen and Harjumaa 2009). The aim to change learning behavior is complex and the mass of possibilities for improvement is huge (Filippou et al. 2015). Consequently, students who want to improve their learning behavior face the challenge to identify an effective starting point without losing track or overwhelming themselves. The design principle tunneling is integrated to support students in finding suitable starting points, as tunneling is able "to guide users through a process" (Oinas-Kukkonen and Harjumaa 2009, p. 492). To address tunneling, LANA provides students with the opportunity to compare their desired learning behavior with their current learning behavior. A high difference indicates requirements and opportunities for improvement and provides a starting point for changing the learning behavior. The context analysis also shows that learners need low barriers to use the system, therefore the design principle reduction is integrated to simplify the complex challenge of changing the learning behavior. Reduction is defined as a design principle that breaks down "complex behavior into simple tasks [to help] users

perform the target behavior, and it may increase the benefit/cost ratio of a behavior" (Oinas-Kukkonen and Harjumaa 2009, p. 492). LANA integrates reduction by providing step-by-step advice on how to improve SRL strategy usage. Besides, the design principle self-monitoring is integrated, because "a system that keeps track of one's own performance or status supports the user in achieving goals" (Oinas-Kukkonen and Harjumaa 2009, p. 492). LANA enables self-monitoring by ticking off completed tasks. The three integrated design principles are in the category of primary task support and therefore correspond to the findings of the conducted literature review, that support the integration of design principles within this category into PT for education (Boontarig and Srisawatsakul 2020; Filippou et al. 2015). Figure 15 presents the structure of LANA and the integrated design principles.

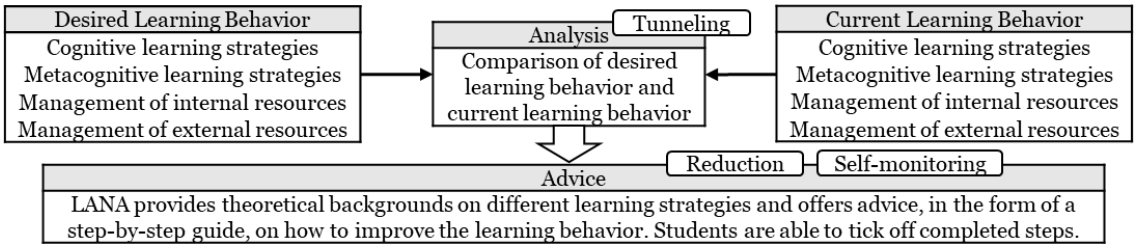

Figure 15: Structure of LANA

Following the PSD model, the final step involves the requirements definition for software qualities and software implementation (Oinas-Kukkonen and Harjumaa 2009). Using the cross-platform development kit Flutter the BCSS is developed as a web app, due to its easy accessibility for the target group, students (Ataş and Çelik 2019).

4.1.4.2 Functionality and Use Case

LANA is a BCSS that uses the questionnaire LIST-K as a basis for context-sensitive stimulus to action. These impulses in the form of low-threshold steps are adaptively adjustable and offer the possibility to accompany the individual development process of the students as they are suggested based on a repeatable reflection. Ticking off each step visualizes progress, shows students' successes in terms of mastered tasks, and thus paves the way for further SRL implementation. LANA was published in German for German university students. The screens presented in Figure 16 and Figure 17 are translated into English to match the use case explanations.

Figure 16: Screenshots of LANA (Screen 1 to 4)

After the sign-in (screen 1), LANA uses four questions to determine the desired learning behavior. Each of these questions refers to one of the four superordinate learning strategies (cognitive, metacognitive, management of internal resources, and management of external resources) (see Table 26). To represent the level of desired strategy use, LANA offers a 10-step regulator that ranges from the external point "I do not wish at all" to "I wish very much" (screen 2). By querying the desired learning behavior, students can decide to what extent they want to master different learning strategies. The current level of SRL is measured using the LIST-K with 39 items (screen 3). Based on students' input, LANA then presents the learning analysis. It shows to what extent the desired level of SRL differs from their current learning behavior for each of the four superordinate learning strategies (screen 4), where the value of the superordinate strategies reflects the mean value of the respective underlying strategies according to the structure of the LIST-K (Table 26).

The percentage displayed on the screen indicates where students can begin to improve their learning, with a high value indicating a high potential for improvement. In this case, the metacognitive learning strategy is the superordinate strategy a student wants to improve. By clicking on the button for more information the student sees to which extent s/he uses the underlying strategies concentration, regulation as well as goal-setting, and planning (screen 5).

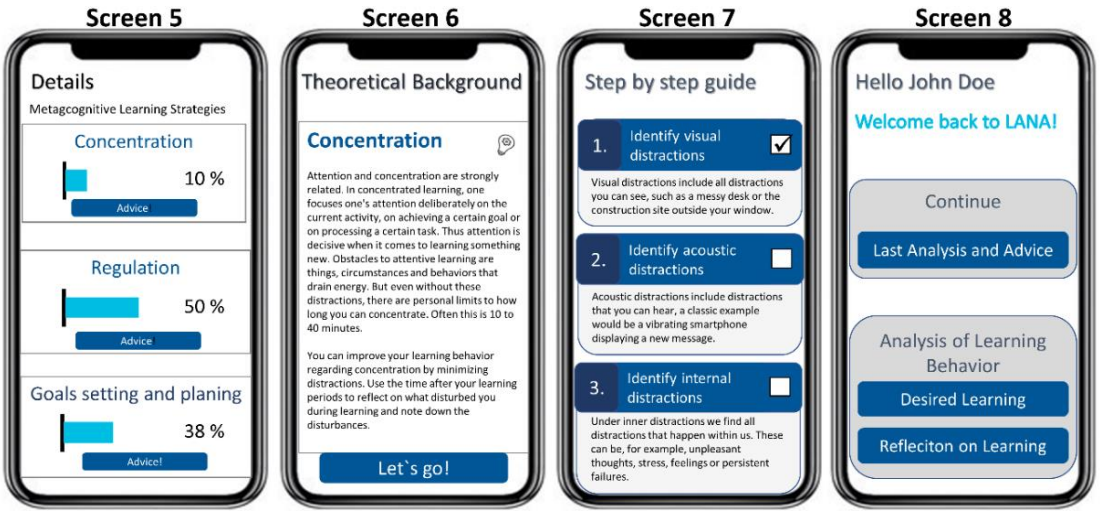

Figure 17: Screenshots of LANA (Screen 5 to 8)

In this example, strategies addressing concentration show a low level of usage (10 %; screen 5), this indicates opportunities for improvement. Clicking on the button "Advice!" LANA provides a theoretical background on that learning strategy, explaining the strategy use and highlighting its importance (screen 6). After presenting this information, LANA offers step-by-step guidance on how to use the strategy more effectively (screen 7). Students can monitor their progress by ticking off the individual steps after completion. This way, students can see which tasks have already been completed and how they can continue to work on their learning behavior. Progress is saved in individual profiles. The next time students open the LANA, the home screen presents the following options (screen 8): First, students can continue to work on specific learning strategies. To do so, they open their last learning analysis and see the difference between their desired and current learning behavior. Based on this visualization, they will get adequate advice on how to improve their learning behavior step by step. Second, students can also repeat the reflection on their desired learning behavior. Third, there is also an opportunity to reflect on the current learning behavior to identify differences. By repeating the reflection LANA adaptively adjust the recommendation for starting points and thus considers the individual development process of its users.

4.1.5 Evaluation and Results

LANA is the first prototype in a larger research project developing a BCSS towards SRL. The goal of the evaluation in the early stages is to reveal problems and quickly identify opportunities for improvement. In this way, new findings can be integrated at short notice and the prototype can be further developed in an iterative process (Hevner 2007; Hevner

et al. 2004). To identify crucial design features that affect the acceptance and IU of LANA, an evaluation with quantitative and qualitative data is fitting (Davis 1986).

The evaluation took place in the last session of a semester-long course addressing key qualifications at a German university. This course is mandatory in the first semester for the students of Business and Information Systems Engineering at their university. At the end of the last session, students could decide whether to leave the session early or to stay additional 20 minutes to test LANA. After the testing phase, a questionnaire was then used to collect evaluation data. To identify constructs influencing IU, perceived usefulness (PU), perceived ease of use (PEU), and IU, were measured with items defined within the TAM (Davis 1986). The questionnaire also includes two open-ended questions that provide an opportunity to add individual thoughts: First, *what do students like about their experience using LANA?* Second, *what are possible improvements for LANA?*

In total 24 students were given access to LANA. 20 students created an account and spent 20 minutes interacting with LANA. Out of these 20 students, 18 also completed the subsequently shared questionnaire. Since 18 of the 24 students participated in the evaluation of LANA, this results in a response rate of 75%. Students were on average 20.6 years old, with the youngest being 18 and the oldest 22 years old. 28 percent of the respondents were female, and 72 percent were male.

After the verification of the preconditions, the TAM was analyzed conducting a multiple linear regression analysis to see to which extent PU and PEU affect IU (Figure 18). Items used to measure PU, PEU, and IU showed overall good measurement characteristics (with Cronbach's Alpha ranging from .76 to .84). The multiple linear regression analysis shows that the R^2 for the overall model is .85 (adjusted R^2=.83), indicating high goodness of fit (Cohen 1988). As a result, PU is identified with a significant positive influence on IU. PEU has no significant influence on IU. However, since the importance of PEU is still emphasized in the literature, this study also addresses design features that might affect PEU.

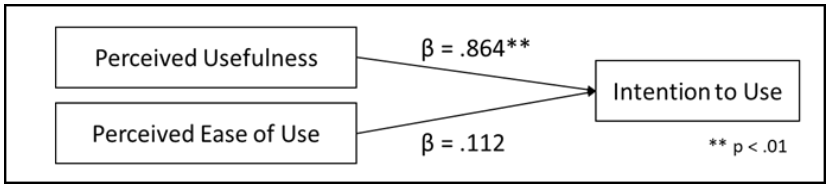

Figure 18: Regression Analysis of TAM regarding LANA

Coding of qualitative responses was conducted to identify patterns related to students' insights about how a BCSS towards SRL should be designed to foster acceptance. The

identified features were mapped to PU or PEU. Table 27 presents these design features that might have a positive influence on IU as well as possible improvements. Because the detailed student responses in some cases address more than one design feature, the total number of mentioned design features is higher than the number of students responding.

Table 27: Design Features Influencing the Intention to Use LANA

Positive	**TAM**	**#**	**Improvement**	**TAM**	**#**
Simple user interface design	PEU	6	User interface design of log-in screen	PEU	3
Design principle reduction	PU	3	Usability	PEU	3
Design principle self-monitoring	PU	3	Fewer reflection questions	PU	3
Content especially advice	PU	3	Downloadable mobile app	PEU	1
Questions for reflection	PU	3	More interaction	PEU	1
Usability and clear structure	PEU	3	More youthful language	PEU	1
Analysis and comparison	PU	1	More advice	PU	1
Web app for mobile usage	PEU	1			

The analysis of the qualitative data shows that the design of BCSSs seems to be particularly important. The user interface (UI) design is the most frequently mentioned feature in both categories. While six students indicate that they like the simple UI design, the UI design is also the most frequently mentioned area for possible improvement, in particular the login screen. Students also described design principles based on the PSD model in their responses. They liked the design principle reduction, as they value its function to cut down a complex task into smaller steps. Self-monitoring is also a design principle that students like. Students highlight the importance of the content addressing SRL, stating that advice on how to improve or use learning strategies is a relevant subject for them. Three students also note that they like the questions that guide them through reflecting on the current learning behavior by asking about different aspects of learning strategies. The following analysis that relates to current learning behavior is also a feature that is noted positively. One student also likes the fact that s/he can use the BCSS in a mobile and flexible way.

In terms of improvement, besides the UI design specifications, usability is a high requirement. Since the web app LANA is programmed from scratch, some bugs and unexpected errors still occurred during its use, which three students noticed negatively. Three students also disliked the long reflection period. They would prefer to receive practical advice

more quickly. Other improvements include a mobile app that can be downloaded from an app store, increased interaction, a more youthful language, and additional advice.

4.1.6 Discussion

The students share an overall positive attitude towards their experience with LANA. Regarding the TAM, only PU is identified with a significant influence on students' IU. The reason for this might be the high relevance of good learning behavior in students' current stage of life. Accordingly, when deciding on the use of LANA, the focus is strongly on PU. The qualitative responses indicate the same, as students value the content of LANA, especially the tangible advice as well as the guided reflection of the learning behavior. The most prominent design features in the category PU are the design principles reduction and self-monitoring. While students positively described these two design principles, the third integrated design principle tunneling was not noticed. The reason for this might be, that students were able to actively experience reduction and self-monitoring, while tunneling would rather be noticed when missing. Without tunneling, students would not get a recommendation on where to start their improvement of their learning behavior.

Although PEU was found to have no significant impact on IU, the qualitative data suggest that PEU is still important regarding the design of BCSSs for students. Students reported very different user experiences after their interaction with LANA. While some students positively highlight the perceived clear structure and the usability, others criticize occurring bugs and the lengthy reflection phase. Overall, the UI design is the feature students addressed the most and seems to be important when developing BCSSs for students. Therefore, it is crucial to address content, relevant to students and present it in a clear and structured way.

4.1.7 Conclusion and Outlook to Future Research

This study presents LANA, a BCSS towards SRL designed following the PSD model. The goal of the BCSS is to support students, particularly in digital learning environments caused by the COVID-19 pandemic, by giving advice on how to improve students' learning. The study evaluates the BCSS LANA regarding the users' initial acceptance, as a first, necessary evaluation of newly implemented technologies. It provides a descriptive and pragmatic contribution by presenting researchers and developers of BCSSs in educational contexts implications based on the current state of the art, and a description of a

BCSS towards SRL as an example implementation. The findings of the conducted literature review, as well as the evaluation of LANA, support the integration of PT in higher education, because students, in general, enjoy the interaction with these systems. The observation that of the 24 students who had access to LANA, 20 initially created an account, and 18 became more intensively involved with the BCSS indicates a high initial IU the system. As only PU is identified with a significant influence on IU, it is crucial for students to notice the benefits and relevance of BCSSs. LANA is able to fulfill this requirement by addressing the topic of SRL and by presenting tangible advice, that students can easily integrate into their current learning settings. The results also show that design features regarding UI design are the most frequently addressed features in the qualitative evaluation. Although they are not identified with a significant impact on students' IU, the frequency with which they are mentioned indicates that UI design is important to students and could influence their interaction with the system, such as long-term use or liking the BCSS.

The presented study has some limitations. First, the evaluation of LANA was conducted with a limited number of 18 participants. An evaluation within a larger group could identify additional design features. But since the participants exactly represent the target users of the BCSS LANA, the insights and feedback of these students are valuable and provide a meaningful contribution. Second, an analysis of the qualitative data is subjective. However, the manual coding involves the differentiation between two defined categories (PU and PEU), and the matching of the design features is presented transparently in Table 27, which narrows the scope for misinterpretation. Third, LANA has not yet been evaluated with respect to its goal of promoting SLR. However, BCSSs are only able to change the behavior sufficiently when an underlying acceptance is present. Therefore, it is an essential first step to identify design features that can increase students' IU in the early stages of development. These early evaluations are important because they provide early indications of underlying improvements, and misleading assumptions are quickly uncovered before they are built upon for too long. In this way, the prototype can be gradually improved in an iterative process (Hevner et al. 2004).

Our next steps in the development project for a BCSS towards SRL include fixing identified bugs. New features will be integrated to address the different preferences of users: There will be an opportunity to choose whether to begin with a reflection on current learning behavior or to directly access the advice. To address the desire for a more youthful language, the text-based theoretical background will be replaced with short video elements. The new prototype will be evaluated next winter with more participants. To avoid

bugs, more comprehensive quality checks will be performed before the release of LANA 2.0.

Overall, the study supports that the development and evaluation of BCSSs towards better learning behavior for students should be part of future research. BCSSs can serve as a valuable supplement to digitized courses, provide necessary learning skills, and help students to cope with the impact of COVID-19 measures addressing higher education.

4.2 Essay 7: Design Requirements for Behavior Change Support Systems with High Use Continuance: Insights for the Target Group of Students

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4.2.1 Abstract

To counteract the high academic stress of students and subsequent health problems, a behavior change support system (BCSS) for self-regulated learning is developed. Since use continence is a prerequisite for the system's supporting effects, this study examines design requirements that promote its use continuance. While previous studies on BCSS's use continuance are mostly quantitative using pre-defined constructs, this study additionally considers qualitative statements to exploratively identify additional requirements. Analysis of statements from 54 students and quantitative data from 25 students identifies 19 design requirements, which can be synthesized into ten meta requirements. These findings support the integration of already defined design principles, e.g., self-monitoring, but also reveal new requirements, e.g., a low-threshold character or the promotion of learning about the targeted behavior. The data also suggest that the design of the BCSS does not affect all students equally, but that perceptions of use continuance are dependent on individual preferences.

4.2.2 Introduction

This study investigates how the design of a Behavior Change Support System (BCSS) can affect students' use continuance (UC). The findings are based on a concrete BCSS that helps students improve their learning behavior to avoid emerging health problems caused by improper learning behavior. As typical for technology-based health interventions, users' UC is a necessary precondition for a positive impact (Walsh and Groarke 2019). Studies show that students in higher education perceive high stress levels with academic stressors as the main stressor (Gazzaz et al. 2018; Ramachandiran and Dhanapal 2018). This is of particular concern as sustained high stress levels lead to serious long-term problems: A high level of stress affects the students on a personal level and results in negative effects on their learning ability, academic performance, and mental health problems such as depression and anxiety, sleep disorders, as well as substance use (Pascoe et al. 2020). For years, anxiety and depression have been the most common disorders among American college students, with 34% of students that suffer from anxiety and 25% of students that are depressed (ACHA 2021). These mental health-related problems among students can lead to significant impairments in intellectual, social, and emotional functioning and increase the risk of dropping out of studies, resulting in lower educational attainment, and even suicidality (Eisenberg et al. 2007; Keyes et al. 2012; van Ameringen et al. 2003). Without sufficient skills in academic learning, students are at risk of entering a vicious cycle of failure (Patel et al. 2015).

Training in self-regulated learning (SRL) can lower perceived stressors and counteract negative consequences (La Fuente et al. 2020). But despite the high incidence of mental health problems among higher education students, students with problems, in particular, do not tend to seek formal support, nor do they seek advice from their friends (Patel et al. 2015). Reasons include a normalization of high stress levels (Brown 2018; Eisenberg et al. 2012) and high perceived barriers to support offers (Eisenberg et al. 2007; Stolzenburg et al. 2019).

Persuasive technology can provide a valuable, low-barrier supplement to academic instruction. Particularly in the form of smartphone apps, BCSS can be easily integrated into students' daily lives. They can provide missing guidance and could act as an effective intervention to help students improve their learning behavior and consequently prevent subsequent negative (mental-) health problems. However, the positive effects of the BCSS do not depend on their availability. Supporting BCSS can only achieve their full

impact if they succeed in engaging and retaining their users (Lehto and Oinas-Kukkonen 2015a). Here, research shows, that users' characteristics can influence their perceptions of BCSS features (Oduor and Oinas-Kukkonen 2021). But, so far, research on BCSS in general often understands users as a homogenous mass without considering smaller user groups (Oinas-Kukkonen 2013). Consequently targeting learning behavior change with students as user groups is not sufficient (Merz and Ackermann 2021). Besides, research on BCSS often lacks a precise description of evaluated BCSS (Oinas-Kukkonen 2013). Addressing this research gap, this study presents and evaluates a BCSS for SRL for higher education students and investigates design requirements that promote students' UC.

The underlying research question is: *How should a BCSS for SRL be designed to achieve high UC among higher education students?*

This study contributes in four ways: It 1) presents a BCSS for SRL designed following the Persuasive Systems Design (PSD) model (Oinas-Kukkonen and Harjumaa 2009), 2) evaluates the BCSS using qualitative and quantitative data, 3) derives design requirements for BCSS with students as the targeted user group, 4) synthesizes meta requirements that enable the transfer of the findings to other health BCSS with students as the targeted user group.

The development of the BCSS is embedded in a Design Science Research (DSR) project according to Hevner (2007) and Hevner and Chatterjee (2010). Accordingly, the BCSS presents the artifact that is iteratively evaluated and adopted based on feedback. In this approach, the identification of design requirements is a prerequisite for the subsequent targeted integration of design principles for the revised artifact.

4.2.3 Theoretical Background

4.2.3.1 Behavior Change Support Systems

Persuasive technology summarizes the research field of artifacts called BCSS (Fogg 2003; Oinas-Kukkonen 2013). Fogg (2003) defines persuasive technology as "any interactive computing system designed to change people's attitudes or behaviors". Within this research field, a BCSS is defined as an "information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception" (Oinas-Kukkonen 2013, p. 6). For the development of persuasive systems, Oinas-Kukkonen and Harjumaa (2009) developed

the PSD model. To date, most developers of BCSS design their artifacts accordingly (Merz and Ackermann 2021). Regarding the development process for BCSS Oinas-Kukkonen and Harjumaa (2009) define three phases: In the first phase, the consideration and understanding of issues behind persuasive systems are essential. In the second phase, developers should conduct a context analysis and define the intent, event, and strategy regarding the persuasion of the users. The final phase addresses the design of the system qualities. Besides, Oinas-Kukkonen and Harjumaa (2009) introduce 28 design principles for BCSS implementation which are grouped into four categories. Table 28 provides an overview of these categories and the 28 design principles.

Table 28: Design Principles according to Oinas-Kukkonen and Harjumaa (2009).

Design principles
Primary task support Reduction, Tunneling, Tailoring, Personalization, Self-monitoring, Simulation, Rehearsal
Dialogue support Praise, Rewards, Reminders, Suggestion, Similarity, Linking, Social role
System credibility support Trustworthiness, Expertise, Surface credibility, Real-world feel, Authority, Third-party endorsements, Verifiability
Social Support Social learning, Social comparison, Normative influence, Social facilitation, Cooperation, Competition, Recognition

4.2.3.2 Self-regulated Learning

SRL is an overarching concept that summarizes constructs that influence learning (Panadero 2017). To date, different theoretical backgrounds map SRL from different perspectives, e.g. SRL as a learning process (Landmann et al. 2015). Overall, there is an overarching understanding, that SRL comprises a set of various learning strategies (Landmann et al. 2015; Zimmerman and Schunk 2011). These SRL strategies can be categorized into four superordinate learning strategies and are depicted in Table 29: 1) Cognitive learning strategies address how learners can acquire knowledge and memorize it. 2) Metacognitive learning strategies address how learners check and regulate their learning. 3) Learning strategies on internal resources comprise the management of resources that reside within learners. 4) Learning strategies on external resources address additional support (Wild and Schiefele 1994).

Table 29: Self-regulated Learning according to Klingsieck (2018)

Self-regulated learning strategies
1) Cognitive learning strategies Elaboration; critical thinking; organizing; repeating
2) Metacognitive learning strategies Goal setting and planning; monitoring; regulation
3) Management of internal resources Effort; attention; time
4) Management of external resources Other students; literature; environment

To measure SRL, different questionnaires exist such as the LASSI (Weinstein et al. 1987), the MSLQ (Pintrich et al. 1993), and for German-speaking countries the LIST (Wild and Schiefele 1994), as well as its shorter version, LIST-K (Klingsieck 2018).

When designing the BCSS for SRL, we follow the PSD model by Oinas-Kukkonen and Harjumaa (2009). Besides we also build on the insights of Merz and Steinherr (2022). The researchers present a model, that suggests specific design features for BCSS while considering users' stage of behavior change according to Prochaska and DiClemente (1983). For users, at the beginning of the targeted behavior change, Merz and Steinherr (2022) recommend implementing design principles that allow users to learn and notice links between the cause and effect of the target behavior. Accordingly, an important step in the BCSS for SRL is also the initial transfer of knowledge about SRL strategies.

4.2.3.3 Related Work

A recent literature review on BCSS identifies the health context as the most common application context (Merz and Ackermann 2021). In this context most studies report positive effects e.g. on smoking, drinking behavior as well as stress, anxiety, or grief (Oinas-Kukkonen 2013). Health BCSS are typically implemented as web-based, interventions via SMS, social networks, or mobile apps (Oinas-Kukkonen 2013). While there are some studies on persuasive technology to improve students' learning outcomes, detailed research on BCSS in this context is missing (Steinherr 2021). Despite the different application contexts, BCSS can only achieve their full impact if they succeed to engage their

users and foster high use continence (Lehto and Oinas-Kukkonen 2015a). Here, also other researchers addressed the demand to investigate constructs affecting the BCSS' UC:

Oduor and Oinas-Kukkonen (2021) revealed that about one-third of the construct continuance intention is explained by the implemented design feature of the following constructs: computer-human dialogue support, primary task support, perceived credibility, social support, and perceived competence. Here, primary task support has the strongest effect on users' continuance intention. They further identified that users' demographic characteristics influence their perceptions of persuasive design features. The results are based on a quantitative survey with 227 respondents, representing a heterogeneous user group with an age range of more than 20 years and different educational backgrounds from high school to a doctoral degree (Oduor and Oinas-Kukkonen 2021).

Lehto and Oinas-Kukkonen (2015a) evaluate constructs' effects on UC and show that perceived credibility has a significant relationship to the users' continuance intention. Social identification has a strong connection to perceived social support, which, in turn, has a significant effect on perceived effectiveness and continuance intention. Finally, perceived effectiveness has a significant impact on UC. The results are based on a survey of 314 female participants aged 19 to 73 with heterogeneous characteristics in terms of education, occupation, and relationship status.

In earlier research, Letho and Oinas (2012) identified perceived persuasiveness and unobtrusiveness with a positive significant effect on users' intention to use the system. Again, these results are based on quantitative data analysis of a heterogeneous group (N=172). However, different from Oduor and Oinas-Kukkonen (2021) this study, showed that age, gender, and education had no significant effect on the model constructed.

Within the education context, Steinherr (2021) evaluated a BCSS using the Technology Acceptance Model by Davis (1986). Findings of this study show, that perceived usefulness has a positive significant effect on students' intention to use the system, while perceived ease of use does not. The authors conclude, that in an educational setting, the content and topic of the BCSS are the most important feature of the system to foster a high intention to use the system.

Previous research, as well as the PSD model, show that the specific context of BCSS should be considered when designing BCSS (Oinas-Kukkonen and Harjumaa 2009). Since Oduor and Oinas-Kukkonen (2021) identify user characteristics with a significant impact on the perception of BCSS, this study evaluates the designed BCSS in a smaller

but more homogeneous user group of first-semester IS students which represents the targeted user group. Furthermore, different from this study, previous research often investigates design features affecting UC by using constructs that summarize different design principles, for example, primary task support, or dialogue support. Through the qualitative addition to a quantitative questionnaire, our study can identify further effects of underlying design features within design principle categories.

4.2.4 Designing a Behavior Change Support System towards Self-regulated Learning

4.2.4.1 Context Analysis

We designed the BCSS for SRL following the suggested development process for BCSS development and initially conducted a context analysis (Oinas-Kukkonen and Harjumaa 2009). The target users of BCSS for SRL are higher education students in general who are trying to meet the requirements of their studies. The focus is on students in their first semesters who are experiencing a change in their learning environment due to the change of educational institutions from high school to higher education. Therefore, impulses or guidance to cope with the new educational environments could be beneficial. Thus, the developed BCSS aims to address the whole concept of SRL to allow students to learn about different learning strategies and then integrate them into their learning phases if the strategies seem appropriate. Therefore, a BCSS that is easily accessible to students with a wide range of SRL strategies is needed to address the wide range of students at the beginning of their studies. Considering the PSD model, we summarize the context analysis in Table 30.

Table 30: Context Analysis according to Oinas-Kukkonen and Harjumaa (2009)

The intent
Persuader: The system is designed by lecturers. After providing students access, it works autogenous.
Change type: The system is designed to foster an attitude and behavior change. Initially, it provides an impulse for initial attitude change, this in the return triggers behavior change. Based on the experienced behavior change goal is to then achieve a sustainable attitude change.
The event
Use context: The system is designed to support students to implement an improved learning behavior.

User context: Users are encouraged to reflect on their learning behavior. Based on the reflection they get advice on which learning strategies can be improved and how to do so.
Technology context: The system is designed as a web app. Students get access to the BCSS by a shared link.
The strategy
Message: The system encourages students to regularly reflect on their learning behavior and introduces learning strategies that could improve the current learning behavior. The system is based on the concept of SRL.
Route: The system implements a direct route. They are guided to start with a reflection and based on this reflection they are again guided towards specific learning strategies that can be improved.

Based on the context analysis and a previous DSR evaluation cycle of the BCSS (Steinherr 2021), we selected eight design principles out of the 28 defined design principles (see Table 28): personalization, self-monitoring, reduction, tailoring, praise, expertise, tunneling, and trustworthiness. The BCSS is named LANA (Learning ANAlysis). It is initially developed for German first-semester students and therefore in the German language.

4.2.4.2 Designed Behavior Change Support System

When opening the BCSS students are welcomed: “It's great that your path has led you here. LANA can help you improve your learning behavior. This big task is divided into small stages so that you can get closer to this big goal step by step.” The following screen introduces students to a guided reflection on their learning behavior. Here students can decide to select a detailed reflection or a short one. The guided reflection is based on the 39 items of the LIST-K, to provide students with scientifically validated results of their SRL behavior. The shorter version is reduced to 17 questions and addresses students that would shy back from long reflection phases. This way, the BCSS can be *tailored* to students’ reflection preferences. Figure 19 shows the corresponding welcoming screens when starting the BCSS. Screen 3 depictures the user interface of one reflection question. After completing the initial reflection, the BCSS praises students for example “Well done!”. After students’ initial reflection, they are guided to their learning analysis.

Figure 19: Welcoming Screens of the Behavior Change Support System

The core of the BCSS is the home feed including an app bar at the bottom of the screen. The app bar enables students to navigate through the BCSS's core functionalities: 1) the home feed, 2) the reflection, 3) the learning analysis, 4) the steps towards an improved learning behavior 5) the wiki that provides information on each SRL strategy.

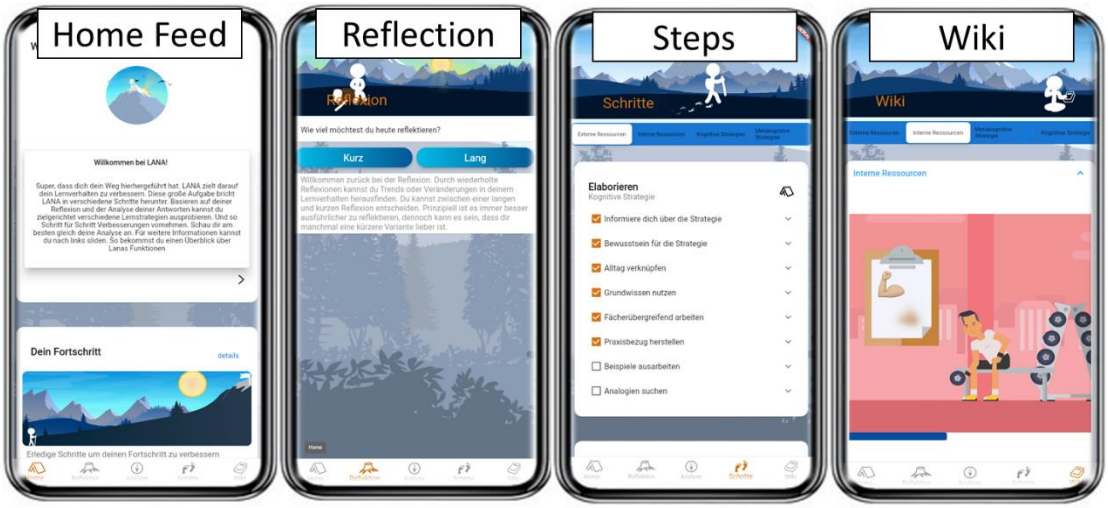

Figure 20: Screenshots of the Behavior Change Support System

The **home feed** (Figure 20) provides different tiles for students to scroll through. The first tile introduces students to the BCSS's core functionalities. Furthermore, one tile contains a progress bar, where students can monitor their steps towards an improved learning behavior. Based on students' progress, different messages appear under the visual progress bar, taking up praise, for example, "Well done, the first steps are mastered!", or "Great

job! Keep on going!". Furthermore, students can edit the home feed by adding tiles for example a certain analysis tile (Figure 22). The home feed depictures the integration *personalization* as it is adapted to students' names and progress.

The **reflection** page (Figure 20) enables students to repeat their initial reflection. The BCSS suggests students to repeat the reflection regularly in order to track changes in their learning behavior.

The app bar also includes the navigation to the **steps**. The steps comprise tangible advice on how to improve the SRL strategies step-by-step. As this functionality breaks down the huge task to improve students' learning behavior into tangible steps, *reduction* is addressed. After completing the specific tasks suggested in each step, students can check a box and mark the steps as completed. For each learning strategy, there is the same initial step "Educate yourself about the SRL strategy". Per each SRL strategy there is a short video and explanation text that introduce the strategy and its purpose to raise awareness. Listing further steps to apply the SRL strategy takes up the *tunneling*, as the BCSS guides students in the attitude change "by providing means for action that brings them closer to the target behavior" (Oinas-Kukkonen and Harjumaa 2009, p. 492).

The **wiki** (Figure 20) summarizes information on each SRL strategy by providing an overview of the different strategies including videos and explanatory texts on each strategy. Furthermore, the wiki considers *trustworthines*s and *expertise* by citing studies.

The core functionality of the BCSS for SRL is the **analysis** of students' learning behavior. The analysis integrates self-monitoring and enables students to monitor their learning behavior from two perspectives:

1) When looking at the status, students will find the following tiles shown in Figure 21.

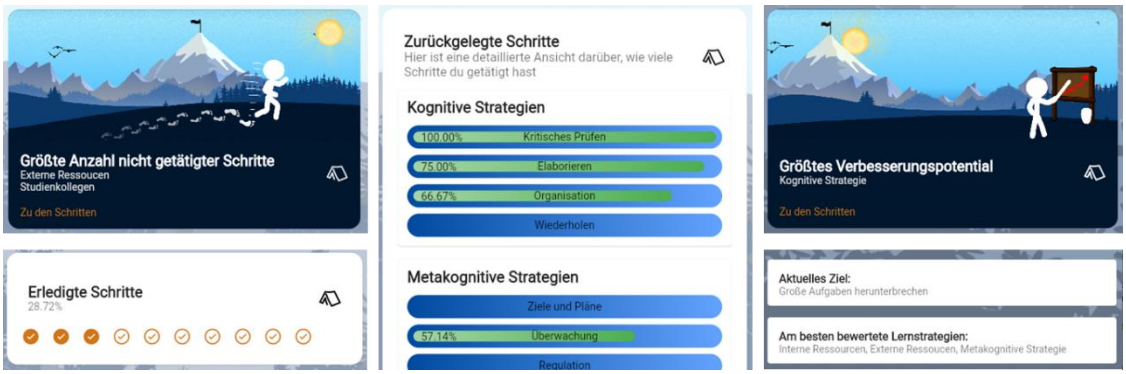

Figure 21: Tiles of the Status Analysis

The analysis of students' status depicts the status of students' reflection results and students' status of completed steps. Furthermore, they get a progress bar regarding each underlying SRL strategy. Besides the status bars, the BCSS also provides two tiles recommending concrete starting points to improve the learning behavior (the greatest potential for improvement and the largest number of steps not taken). These tiles list at least one SRL strategy students can take up. With one click on the listed strategy, students access the corresponding step-by-step advice to improve the learning strategy.

2) Students can also monitor their progress towards an improved learning behavior. Figure 22 depicts a line diagram that is based on data from conducted reflections. Two bar graphs depict BCSS usage by week.

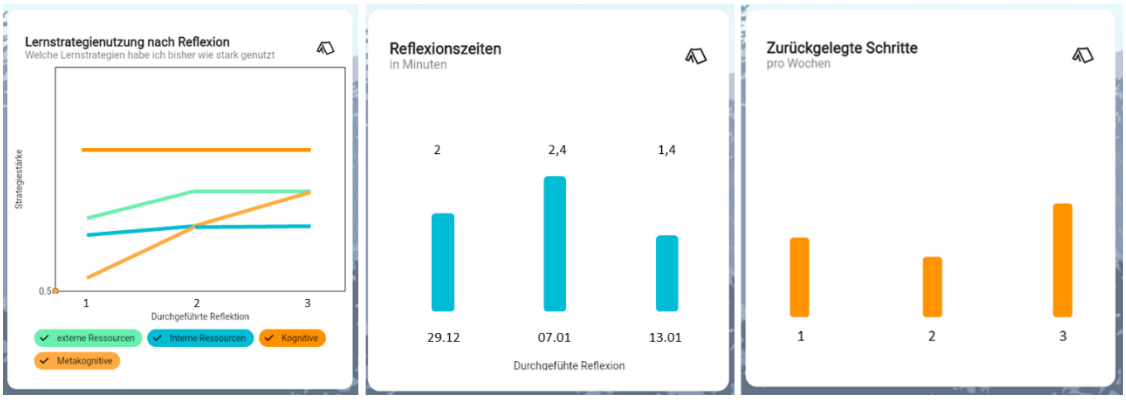

Figure 22: Tiles of the Status Analysis

4.2.5 Evaluation Design

The BCSS was presented in a mandatory soft skill course for first-semester IS students. The BCSS and its functionalities were demonstrated for 15 minutes. According to the recommendations of Ågerfalk (2013), the evaluation of the DSR artifact follows a mixed method by combining qualitative and quantitative data:

After the introduction to the BCSS, all 72 students were asked to answer the quantitative question in writing: "What should an app for improving learning behavior contain to make me use the app regularly?"

Besides, students could stay additional 15 minutes to test the BCSS by themselves and afterward evaluate the BCSS quantitatively. This quantitative questionnaire consists of two different questionnaires: To gain insight into the working mechanisms of persuasive technologies, we use the Perceived Persuasiveness Questionnaire (PPQ) presented by

Lehto et al. (2012) and measures UC using 4 items. Although the literature indicates that the PPQ is not yet a comprehensively mature and not conclusively validated questionnaire, it explicitly takes up the design of BCSS and thus enables valuable insights (Beerlage-de Jong et al. 2020). Therefore, we include the constructs of the PPQ in our questionnaire, excluding the construct social support, since no design principle of this category is implemented in BCSS so far. In addition, we add constructs of the Learning Object Evaluation Scale (LOES). It is designed to capture the impact, effectiveness, and usefulness of learning objects (Kay and Knaack 2009). This questionnaire can capture the aim of the BCSS to initially transfer knowledge about SRL to the users as an initial step towards behavior change. All constructs were measured using a 5-point Likert Scale, with 1 as “strongly disagree” and 5 as “strongly agree”.

4.2.6 Results

4.2.6.1 Qualitative

In total 54 students answered the qualitative question (9 female; 45 male). Table 31 presents an exemplary identification of design requirements obtained from the content analysis.

Table 31: Exemplary Students’ Statements

Reward(-system)
Student #1: "You could introduce a reward system, where you get rewards for using it every day, and then you get some kind of prize when you reach certain point totals."
Student #2: "I would be motivated if you can reach different levels in the app and linked with a small reward "
Student #3: "I would especially like a reward feature, i.e., when you reach a goal or master a challenge"
…
Clear design and structure
Student #4: “I find a clear design and the simple control of such apps very important.”
Student #5: “It should have a nice and clear design. It should also be intuitive to use.”
Student #6: “The app has to be easy to use and I should be able to use it quickly and familiarize myself with it. I should be able to use it quickly.”
…

Overall, 19 design requirements can be identified in students' answers. As detailed answers can address more than one design requirement, the number of mentioned requirements is higher than the number of participating students. Table 32 summarizes the findings.

Table 32: Design Requirements for High Use Continuance

#	Design Requirement (DR)	Mentions
1	(Push-)notification	15
2	Reward(-system)	12
3	Clear design and structure	9
4	Downloadable smartphone app	7
5	Game elements (levels, challenges)	5
6	Progress bar	4
7	Goal setting	4
8	Integrated learning plan	4
9	Subject-specific information	3
10	New content regularly	3
11	Social support	2
12	Integrability with university platforms	2
13	Expertise	2
14	Positive experience in first minutes	1
15	Helpful applicable advice	1
16	Blocking other apps when used	1
17	Less scientific terminology	1
18	Social comparison	1
19	Colorful design	1

The design requirement most students recommend is (push-)notifications. Students explain that notifications should appear on the smartphone screen and enable them to easily access the BCSS with one click. Topics of these notifications can be reminders e.g., to use the app at a certain moment, or notifications that new content is uploaded to the BCSS. Besides, many students suggest rewards within the app or a whole reward system that

comes with a logical structure to earn rewards e.g., after completing specific tasks. Further, for students to use the BCSS regularly a clear design and structure should be recognizable in the BCSS. They demand an easy and intuitive handling of the BCSS functionalities. Complex or overloaded structures would discourage students to use the system. Seven students suggest that the BCSS should be a downloadable smartphone app instead of a web app. They request the BCSS to be easily reachable with as few clicks as possible. A smartphone app with an icon on the phone's screen can fulfill this request. Besides, five students suggest adding game-design elements to the BCSS as a way to increase their motivation to use and interact with the BCSS. Mentioned game-design elements are levels, and challenges like daily quests. Furthermore, four students would like to see an additional progress bar, as a visualization of their behavior encourages them to further progress. While the BCSS already provides such self-monitoring options students suggest even more visual depictions of their progress. In conjunction with the desire for progress bars, students often request setting or targeting goals. Some students suggest linking the progress bar to set goals and monitoring progress toward those goals. Another design requirement students take up is a timetable or a learning plan. This plan should provide an overview of learning tasks and enable students to see when, how, and what new content should be learned. Besides this learning-specific request, students also wish for subject-related learning advice. As the participating students are IS students, they ask for concrete advice on how to study certain topics, for example, informatics, or math. Three students state that regularly updating new content would have a positive effect on their UC. They explain that updates and new information keep students interested when using the BCSS. Besides students suggest design requirements related to social support. They take up exchange opportunities with fellow students and networking functions to get in contact. Students also state that the integrability of the system is important. They recommend an interface to the university's learning management system. Two students state that perceived expertise regarding the functionality of the BCSS fosters their UC. In addition to these requests made by various students, the following design requirements are stated by single students.

One student suggests designing the BCSS so that users have a positive experience in the first minute of use. Another student suggests integrating a feature that blocks other apps when using the BCSS to prevent distraction. Furthermore, one student requests easy language in the app. Scientific terms such as "metacognitive" can harm UC. One student suggests adding social comparison e.g., by including the comparison of progress bars of

other users. Besides, one student requests a colorful design of the BCSS to stand out from other digital learning environments, e.g., the university's learning management system.

4.2.6.2 Quantitative

The data is based on the answers of 25 students (7 female; 18 male). Table 33 shows the descriptive statistics of the PPQ.

Table 33: Descriptive Statistics and Cronbach's Alpha of the PPQ

PPQ	PT	U	PP	PE	UC	DS	PC	PEf
α	.82	.77	.84	.89	.88	.50	.50	.66
Mean	3.5	3.5	3.3	3.2	3.5	3.5	3.7	3.4
Min	1.7	2.3	1.3	2.0	1.0	2.3	2.5	2.0
Max	4.7	4.8	4.7	5	5.0	5.0	4.8	4.7
PT = Primary Task Support; U = Unobtrusiveness; PP = Perceived Persuasiveness; PE = Perceived Effectiveness; UC = Use Continuance; DS = Dialogue Support; PC = Perceived Credibility; PEf = Perceived Effort								

Three constructs of the PPQ did not meet the acceptance criteria for internal consistency (Cronbach's Alpha < 0.70). Therefore, the constructs of perceived credibility, perceived effort, and dialogue support are excluded from further analysis. Overall, the mean values of the PPQ are good. Especially perceived credibility and unobtrusiveness are rated positively among most students. Students' UC is rated between a span of 1 and 5 showing the highest differences among the perceptions of individual students for all constructs. Table 34 shows the descriptive data of the LOES.

Table 34: Descriptive Statistics and Cronbach's Alpha of the LOES

LOES	L	Q	E
α	.83	.73	.70
Mean	3.7	3.8	3.7
Min	1.8	2.3	2
Max	4.6	4.8	5
L = Learning; Q = Quality; E= Engagement			

Overall, the mean values of the LOES are good. Most students agree, that the BCSS functions as a valuable learning object, that transfers knowledge about SRL in an engaging way with high quality. To identify significant correlations, we investigate Spearman's rank correlation coefficient. Table 35 presents an overview of significant correlations.

Table 35: Correlation Matrix

	PT	U	PP	PE	UC	L	Q	E
PT	1							
U	.59**	1						
PP	.74**	.71**	1					
PE	.75**	.75**	.68**	1				
UC	.64**	.63**	.59**	.46**	1			
L	.83**	.73**	.75**	.77**	.63**	1		
Q			.41*			.43*	1	
E	.80**	.60**	.76**	.61**	.82**	.80**		1
** The correlation is significant at the .01 level * The correlation is significant at the .05 level								

The exploratory data analysis shows that all constructs of the PPQ are significantly positively correlated with each other. As for the LOES, learning, and engagement show a highly significant correlation with students' UC.

4.2.7 Discussion

While the analysis indicates concrete design requirements for BCSS for SRL, the following discussion synthesizes these concrete context-related requirements into more abstract but therefore more transferable meta requirements (Kaiya 2018).

Based on the identified 19 design requirements within the qualitative data we can derive seven meta requirements, which are presented in Table 36. Table 36 also transparently presents the consolidated design requirements for each meta requirement (for DR # see Table 32).

Table 36: Meta Requirements Identified Through Qualitative Data

To foster students' use continuance a BCSS…	
Meta requirement	DR #
needs low-threshold nature	1, 3, 4, 12
needs to motivate through incentives	2,5
needs to provide means for self-monitoring	6,7,8
needs to get students hooked to the system	10,12,14,16
needs to integrate social support	11,18
needs to provide clearly defined content	9,13,15,17
needs to have a friendly look and feel	17,19

The first meta requirement is the low-threshold nature of BCSS. This is picked up in students' suggestions for (push-) notifications, which enable access to the app with one click. This is also addressed by the request for a downloadable smartphone app with a displayable icon on the home screen and the desire for a clear design and structure of the BCSS so that students can quickly get an overview of the app's functionalities and modes of operation without having to familiarize themselves with it. In addition, the integrability of the BCSS and interfaces to other systems students already use can help to provide students with easy and low-threshold access to the BCSS. Besides, students request incentives for example in the form of rewards systems or further game elements. Here, for example, studies such as Sailer et al. (2014) provide an overview of game elements that can also be integrated into systems such as BCSS. Self-monitoring is also taken up as a meta requirement. Progress bars, but also visible (self-)set goals or a learning plan enable students to plan their behavior and monitor progress. Students also indicate that it is important to become "hooked" when using the system. Specifically, they want new content regularly or an initial positive experience in the first few minutes of using the BCSS. Also, the suggestion to block other apps when using the BCSS, can minimize disruption and fosters the possibility of "getting hocked". Another meta requirement is social support. Here students pick up exchange and networking with fellow students, but also social comparison. Further, the advice towards an improved learning behavior should be clearly defined. This is based on students' desire for expertise and tangible, applicable advice. The effect on the applicability is also connected to subject-specific information. The final

meta requirement we identified in the qualitative statements is the friendly look and feel. This is based on students' wish for less scientific terminology and a colorful design.

By analyzing the quantitative data three further meta requirements are identified. Table 37 summarizes the three additional identified meta requirements.

Table 37: Meta Requirements Identified Through Quantitative Data

To foster students' use continuance the BCSS…
needs options for tailoring
needs to foster learning about the target behavior
needs to engage students

Students' UC is identified as the construct with the greatest differences in students' perceptions. While some rated the highest value of 5, others rated the lowest value of 1. This may indicate that students' perceptions of UC are dependent on personal preferences and design decisions do not resonate with all students in the same way. It empathizes the demand for options for tailoring. This way the systems can adapt to students' preferences. This seems to be especially important for design principles that are controversial, such as reminders. While some students see them as a way to promote the low-threshold nature of the system, others explain that pop-up reminders would make the BCSS seem annoying.

Analyzing the quantitative data of the PPQ, using a Spearman's rank correlation coefficient predicts interactions among the measured constructs. Consequently, cause-and-effect statements cannot be derived from individual constructs. This underscores the relevance of the context analysis in BCSS design, as design features appear to influence not only one construct but could also influence students' perceptions of the BCSS as a whole.

Besides its character as persuasive technology, the goal of the BCSS is also to transfer knowledge about the target behavior. Regarding the constructs of the LOES, learning as well as engagement correlate positively and with a high significance level with UC. However, the construct quality shows no significant relation to UC. Consequently, an engaging knowledge transfer could have a positive effect on students' UC. This goes in line with earlier identified research that identified that perceived usefulness has a significant positive effect on students' intention to use a BCSS (Steinherr 2021).

These findings and design recommendations are based on students' statements and evaluations following their experience with BCSS for self-regulated learning. Although the design requirements are derived based on a specific context of use, the meta requirements might also apply to BCSS with students as a defined target group for BCSS outside educational contexts.

4.2.8 Conclusion

This study presents a BCSS for self-regulated learning, that is designed following the PSD model by Oinas-Kukkonen and Harjumaa (2009) and insights of Merz and Steinherr (2022). The overarching goal for the BCSS is to counteract the current high levels of students' stress and stress-related (mental) health problems that are caused by improper learning behavior. Because students' UC is a precondition for the system to guide students toward sustainable learning behavior improvement, this study aims to identify design requirements to promote students' UC. The qualitative data of 54 students present results in a list of 19 identified design requirements. With (push-)notification, a reward (system), and a clear design and structure as the most addressed ones. Furthermore, the quantitative evaluation reveals that students' perception of their UC with the system differs strongly. This indicates that personal preferences might also influence their UC. Besides, a Spearman's rank correlation coefficient analysis reveals, that multiple constructs of the PPQ are positively and highly significantly correlated to students' UC. These constructs summarize primary task support, unobtrusiveness, perceived persuasiveness, perceived effectiveness, dialogue support, perceived credibility, and perceived effort. Adding the LOES to the quantitative analysis, identified, that students' perceptions of learning and engagement, when interacting with the BCSS, are significantly positively correlated with their UC. Analyzing the identified design requirements reveals ten meta requirements to foster a high UC of students. Above all, the findings highlight the importance of a thoughtful selection of appropriate design principles, as single design features of the BCSS influence students' perceptions not only of individual constructs, but of several, and thus of perceptions and intentions to use the whole system.

4.2.9 Outlook and Future Research

The BCSS for SRL is designed following the PSD model (Oinas-Kukkonen and Harjumaa 2009) and presents an artifact within a DSR project (Hevner 2007). Consequently,

the research project follows an iterative approach. Based on the findings of this study, the BCSS will be further revised. Considering the identified meta requirements for incentives and social support, we will incorporate the design principles rewards and social comparison. We also plan to evaluate different versions of the BCSS in an experimental setting, with each version of the BCSS integrating a single additional design principle. In this way, we aim to identify the cause-effect relationship in students' perceptions of the BCSS concerning individual additional design principles. In the long term, the impact of the BCSS on students' behavior, as well as its preventive effect on students' health, will be investigated.

While the ten identified meta-requirements were derived based on feedback from university students, they could also provide insights for related user groups such as higher education students or trainees in a company. However, following the PSD model and Lehto and Oinas-Kukkonen (2015a), we recommend an underlying context analysis when developing new BCSS, rather than assuming overly homogeneous user groups.

The quantitative findings of the study are limited by the exploratory analysis. While we identified significant correlations, causality has not yet been investigated. The evaluation of the quantitative results is also subject to a certain degree of subjectivity. By showing an example of coding, we aim to demonstrate a certain transparency and comprehensibility. In addition, the applicability of the PPQ was not fully given. As three constructs did not meet the acceptance criteria for internal consistency, our analysis is based on five constructs. This might be due to the number of participants. Out of 54 students, only 25 also completed the quantitative questionnaire. In future projects, we aim for a higher number of participants. Following the findings of Beerlage-de Jong et al. (2020), we also support the demand for future research towards a more standardized and validated scale to measure the effects of BCSS.

Furthermore, while current research often analyzes the cause-effect relationship of design principle categories, future research could also investigate how the integration of single design principles affects users' perceptions of the system.

Future BCSS research could also consider whether the integration of design principles has a different effect on different user groups, as previous research has already indicated (e.g. Oduor and Oinas-Kukkonen (2021)). The distinction between user groups could be made not only according to demographic aspects but also, similar to targeted gamification, according to the personality traits and motivational structures of the users (Tondello

et al. 2016). If there are significant correlations between users' characteristics and perceptions of individual design principles, this could provide a systemic framework for a targeted implementation of the design principles tailoring and personalization.

4.3 Essay 8: Development of a Behavior Change Support System Targeting Learning Behavior: Examining the Effects of the Design Principles Rewards and Social Comparison

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4.3.1 Abstract

The increasing prevalence of digital and blended learning scenarios in higher education fosters the need for students to have strong self-regulated learning competencies. However, in particular, in digital learning environments, many students struggle to develop effective learning behaviors but often avoid seeking support. To address this issue, Behavior Change Support Systems (BCSS) in form of smartphone apps can provide valuable guidance towards self-regulated learning. While BCSS have been successfully implemented in the health context, research in the educational context is limited. This study addresses this research gap by presenting the development of a BCSS targeting self-regulated learning and investigating its ability to promote students' use continuance through two motivational design principles (*rewards* vs. *social comparison*). Using the Perceived Persuasiveness Questionnaire, significant differences in students' perceived effectiveness and perceived social support of the BCSS versions are found. *Social comparison* is identified as more effective than *rewards* for high use continuance.

4.3.2 Introduction

The progressive digitization of higher education reveals a range of new opportunities to enhance learning, with innovative digital or blended learning scenarios on the rise (Bizami et al. 2023; García-Morales et al. 2021). However, providing digital learning environments for students requires students to be able to handle disturbances and procrastination and show a high level of self-regulation to manage their own learning processes (Reinecke et al. 2018). The lack of self-regulation often results in dysfunctional student behavior that in turn negatively affects students' engagement, performance, and well-being in digital learning environments (Michinov et al. 2011). Against this background, research shows that students who are good at self-regulated learning profit more in digital learning settings than students with low self-regulated learning competencies (Sutarni et al. 2021; Anthonysamy et al. 2020). Self-regulated learning describes a learning behavior in which learners set their own learning goals, plan their progress, and monitor and adapt their learning behavior in a target-oriented manner (Zimmerman and Schunk 2011; Boekaerts 1999). Although there are some training programs available to assist students in developing self-regulated learning skills, students who are struggling often fail to seek support or advice (Patel et al. 2015). This may be due to the normalization of high-stress levels in higher education (Brown 2018; Eisenberg et al. 2012) and the perception of significant barriers to seeking help (Eisenberg et al. 2012; Stolzenburg et al. 2019). In addition, due to the individual needs of students, there is a need for a supportive intervention that can be tailored to students to enable customized learning (Wong et al. 2019).

One promising intervention targeting students' learning behavior is in form of Behavior Change Support Systems (BCSS). These systems are easily integrable into students' lives in the form of smartphone apps and have the potential to provide low-barrier support (Singh and Samah 2018). BCSS are defined as socio-technological systems designed to form, change, or strengthen user behavior (Oinas-Kukkonen 2010). These persuasive systems offer the potential for multiple behavioral improvements that benefit individual users (e.g., by improving learning behavior), society (e.g., by preventing disease), and the environment (e.g., by promoting waste separation) (Lehto and Oinas-Kukkonen 2015a; Merz and Ackermann 2021).

Along with the growing relevance and interest in those persuasive systems also the number of research studies has been increasing over the last years (Merz and Ackermann 2021). Consequently, the research field of persuasive systems covers studies on the effects of implemented BCSS (e.g., Bartlett et al. (2017), Böckle and Yeboah-Antwi (2019),

Salvi et al. (2018)) as well as research studies that accumulate corresponding design knowledge in literature reviews (e.g., Merz and Ackermann (2021), Tikka and Oinas-Kukkonen (2019), Wang et al. (2018)). While studies emphasize the beneficial effects of BCSS, researchers also highlight the precondition of an appealing and fitting design (Merz and Steinherr 2022). To effectively influence users and achieve the desired benefits, BCSS need to engage their users and promote high usage (Lehto and Oinas-Kukkonen 2015b). A basic requirement for successful information systems in general, including the success of BCSS, is therefore a design that is convincing from the first use and thus promotes a high intention to use (Hsieh, Po-An J. J. and Wang 2007; Bhattacherjee 2001; Lehto and Oinas-Kukkonen 2015b).

In this context, researchers highlight the importance of individual design features for the success and effectiveness of persuasive systems (Merz and Steinherr 2022; Fogg 2002; Lehto and Oinas-Kukkonen 2015a). For a targeted and systematic design of BCSS Oinas-Kukkonen and Harjumaa (2009) suggest a development process and list 28 design principles, for example, *personalization*, *reminders*, or *self-monitoring* (Oinas-Kukkonen and Harjumaa 2009). These individual design principles along with their effects on users as well as their opportunities and risks should be considered when designing BCSS (Merz and Steinherr 2022). While unsuitable design choices can demotivate or even hurt users (Orji and Moffatt 2018), motivating features such as *social comparison* or *rewards* can motivate users to engage with the systems (Richter et al. 2015; Steinherr and Reinelt 2022). Consequently, those defined 28 design principles provide a framework for evaluations of BCSS and enable the generation and consolidation of design knowledge at a detailed and tangible, design principle level (Oinas-Kukkonen and Harjumaa 2009). However, current research on the influence on BCSS related use continuance mostly concentrates on more superficial cause-effect relations and structural models by addressing only superordinate design principle categories (e.g. Oduor and Oinas-Kukkonen (2021), Lehto and Oinas-Kukkonen (2015b)). Consequently, only vague design recommendations can be drawn without implications on a tangible, design principle level.

This paper addresses this research gap by examining the initial impact of two versions of a BCSS towards self-regulated learning in terms of students' perceived use continuance. To do so, each version of the BCSS incorporates one different additional design principle. To cover diverse facets, we choose two design principles that address different motivators. Therefore, the BCSS versions include either the design principle *rewards*, which

targets external motivation or, in contrast, the design principle *social comparison*, which targets social motivation (Richter et al. 2015).

The underlying research question is: *To what extent can the persuasive design principles rewards and social comparison foster students' perceived use continuance for a BCSS towards an improved learning behavior?*

This study is embedded in a larger Design Science Research (DSR) project according to Hevner (2007) and Hevner and Chatterjee (2010). The artifact of this project is a BCSS designed to guide students towards an improved learning behavior based on the concept of self-regulated learning. The artifact has already been evaluated in previous evaluation cycles and iteratively adapted in design cycles based on previous user feedback (relevance cycle) and related research (rigor cycle). This paper presents the current design cycle (third iteration), which aims to identify the influence of two different design principles and to provide conclusions regarding the design of BCSS for a high use continuance. Consequently, this paper contributes in a descriptive form by presenting researchers and developers of BCSS the developed BCSS targeting learning behavior including one implementation of each of the design principles *rewards* and *social comparison*. It contributes in a pragmatic form by concluding implications and guidance for developing BCSS to foster use continuance. Furthermore, this paper provides a theoretical contribution in form of design knowledge related to the modes of action of the two design principles defined within the PSD model.

4.3.3 Theoretical Background

4.3.3.1 Persuasive Systems for Behavior Change

The research field of persuasive technology or persuasive system addresses computer-based interactive systems that are designed to change human behavior through persuasion without coercion or deception (Fogg 2003). Fogg (2002) established the research field using the term persuasive technology. He identified that the success of these technologies relies on the integration of individual design features that affect the motivation, feasibility, and trigger of the desired behavior change (Fogg 2003). Oinas-Kukkonen and Harjumaa (2008) expand upon this prior research by emphasizing the specification of persuasive designs and the consequential software requirements. In this regard, they use the term persuasive systems as a synonym for persuasive technology to characterize systems that

use either computer-mediated or computer-human persuasion (Oinas-Kukkonen and Harjumaa 2008). Within this research field, BCSS are defined as a "key construct" and "object of study of the field" (Oinas-Kukkonen 2010). BCSS summarize socio-technical platforms, systems, smartphone applications, and software designed for users' persuasion (Oinas-Kukkonen 2010). BCSS can be implemented in form of web-based systems, mobile applications, or social networking tools (Lehto and Oinas-Kukkonen 2015b).

4.3.3.2 Design Principles for Behavior Change Support Systems

4.3.3.2.1 Persuasive Systems Design Model

When developing BCSS, the most used design framework is the Persuasive Systems Design (PSD) model (Merz and Ackermann 2021; Otyepka 2018) that guides the systematic development of BCSS (Oinas-Kukkonen and Harjumaa 2009) For developing BCSS, Oinas-Kukkonen and Harjumaa (2009) emphasize the value of an underlying context analysis when designing BCSS. We follow these steps to develop the BCSS targeting students' learning behaviour. The detailed process for the development is described in chapter 4.3.4.

Besides the process of developing BCSS, Oinas-Kukkonen and Harjumaa (2009) also provide concrete features that can be implemented in BCSS defined as 28 design principles. These 28 design principles are grouped into four categories: The first category is primary task support. It summarizes design principles that enable the execution of the systems' primary tasks. The dialogue category support includes design principles that target system feedback. This feedback can be in the form of textual, as well as graphical, or auditory information. The category credibility support includes design principles that promote trust and reliability, and thus also the persuasiveness of the systems. The category of social support summarizes design principles that exert social influence on users. Table 38 lists these four design principle categories as well as their corresponding design principles according to Oinas-Kukkonen and Harjumaa (2009).

Table 38: Design Principles for Behavior Support Systems according to Oinas-Kukkonen and Harjumaa (2009)

Category	Design Principle	Example Requirement by Oinas-Kukkonen and Harjumaa (2009)
Primary Task Support	Reduction	System should reduce effort that users expend with regard to performing their target behavior.
	Tunneling	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.
	Tailoring	System should provide tailored information for its user groups.
	Personalization	System should offer personalized content and services for its users.
	Self-monitoring	System should provide means for users to track their performance or status.
	Simulation	System should provide means for observing the link between the cause and effect with regard to users' behavior.
	Rehearsal	System should provide means for rehearsing a target behavior.
Dialogue Support	Praise	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.
	Rewards	System should provide virtual rewards for users in order to give credit for performing the target behavior.
	Reminders	System should remind users of their target behavior during the use of the system.
	Suggestion	System should suggest that users carry out behaviors during the system use process.
	Similarity	System should imitate its users in some specific way.
	Liking	System should have a look and feel that appeals to its users.
	Social role	System should adopt a social role.
System Credibility Support	Trustworthiness	System should provide information that is truthful, fair, and unbiased.
	Expertise	System should provide information showing knowledge, experience, and competence.
	Surface credibility	System should have competent look and feel.
	Real-world feel	System should provide information of the organization and/or actual people behind its content and services.
	Authority	System should refer to people in the role of authority.
	Third-party endorsements	System should provide endorsements from respected sources.
	Verifiability	System should provide means to verify the accuracy of site content via outside sources.
Social Support	Social learning	System should provide means to observe other users who are performing their target behaviors and to see the outcomes of their behavior.
	Social comparison	System should provide means for comparing performance with the performance of other users.
	Normative influence	System should provide means for gathering together people who have the same goal and make them feel norms.
	Social facilitation	System should provide means for discerning other users who are performing the behavior.

	Cooperation	System should provide means for co-operation.
	Competition	System should provide means for competing with other users.
	Recognition	System should provide public recognition for users who perform their target behavior.

4.3.3.2.2 Design Principles "Social Comparison" and "Rewards"

The artifact of this manuscript is an already developed and evaluated BCSS that guides students towards an improved learning behavior. The analysis of the effects on students due to different additional design principles is the focus of this paper. Based on a previous evaluation cycle and students' feedback (see chapter 4.3.4), we implemented the design principles *rewards* and *social comparison*. Both design principles are defined within the PSD model and grouped into different categories (see Table 38). While the design principle *rewards* lies within the category of dialogue support, *social comparison* is defined within the category of social support. Besides their definition within the PSD Model, those design principles are also common in gamification literature (Richter et al. 2015; Abdul Rahman et al. 2018; Toda et al. 2019). Within the model of motivation in games by Richter et al. (2015), the design principles *rewards* and *social comparison* address different motivational backgrounds. While *social comparison* addresses social motivation, *rewards* target extrinsic motivation within individuals.

Table 39 depicts these different motivational categories and refers to the corresponding BCSS versions.

Table 39: Model of Motivation according to Richter et al. (2015)

Intrinsic	**Social**	**Extrinsic**
Needs based	Social based	Rewards based
Basic BCSS functions	BCSS with design principle *social comparison*	BCSS with design principle *rewards*

While the design principles *rewards* and *social comparison* are also subjects of gamification research, in the context of this study, we understand them primarily as persuasive design principles due to the research context of persuasive technology and their implementation within a BCSS.

4.3.3.3 Improving Learning Behavior

The BCSS, evaluated in this study, is designed to influence students' behavior towards an improved learning behavior. To target this goal systematically and evidence-based, the

theoretical background of self-regulated learning provides a valid and tangible concept. Appling self-regulated learning strategies is often referred to as a target behavior for higher education students because it is associated with many positive impacts such as better learning outcomes (Schneider and Preckel 2017), more satisfaction during studies, (Liborius et al. 2019), and lower stress rates (La Fuente et al. 2020).

While different models and concepts capture this learning behavior (Landmann et al. 2015), research shows a clear picture regarding certain learning strategies self-regulated learners apply (Zimmerman and Schunk 2011; Pintrich and Groot 1990). These learning strategies can be divided into four superordinate learning strategies and 13 underlying learning strategies (Wild and Schiefele 1994; Klingsieck 2018). Table 40 provides an overview of these strategies.

Table 40: Self-regulated Learning Strategies according to Wild and Schiefele (1994) and Klingsieck (2018)

Cognitive strategies	Elaborating: Linking relationships between what has been learned and existing knowledge
	Repeating: Regular repetition of learning content
	Organizing: Structuring of learning content
	Critical Testing: Critical examination of learning content
Metacognitive strategies	Targeting and planning: Goal-setting and target-oriented planning
	Regulation: Adaptation of learning behavior if current strategies do not work sufficiently
	Controlling: Checking whether what has been learned has really been understood
Internal Resources	Effort: Awareness and willingness to make an effort
	Concentration: Avoiding distractions and focusing on learning
	Time management: Schedule to record the duration of learning
External Resources	Literature: Use of literature to deepen learning content or to eliminate uncertainties
	Learning with fellow students: Formation of learning groups to study together
	Learning environment: Creation of a suitable learning environment

These 13 listed self-regulated learning strategies form the foundation for the targeted learning behavior change within the developed BCSS.

4.3.3.4 Related Work

A recent literature review summarized the broad application context of BCSS and identifies the ongoing growth of the research field (Merz and Ackermann 2021): While the health context is so far the most common context for BCSS (Orji et al. 2019c), there are

also studies investigating their potential towards an improved learning behavior, a more sustainable behavior, or behavior in work environments (Merz and Ackermann 2021). However, regardless of the different application contexts, BCSS can only impact users if they succeed in engaging their users by promoting high usage continuity starting at the initial use (Bhattacherjee 2001; Hsieh, Po-An J. J. and Wang 2007; Lehto and Oinas-Kukkonen 2015b).

A literature review on BCSS in an education application context underlines the potential of the systems in higher education (Steinherr 2021). It also shows that students overall enjoy the interaction and that the persuasive systems are able to promote student motivation, achievement, or learning outcomes. Regarding recommendations of specific design principles, some articles indicate that design principles within the categories of primary task support and social support of the PSD model have a positive effect on students (Boontarig and Srisawatsakul 2020). A recent study on BCSS targeting learning behavior analyzes the potentials of universities learning management systems to persuade students (Ahmad et al. 2022). While the authors emphasize the potential of already established systems to influence users, the functionalities and integrable design principles are limited, and currently minimal persuasive design principle implementation is present. In the educational context, Steinherr (2021) evaluated a BCSS using Davis' (1986) technology acceptance model. The study reveals that perceived usefulness has a positive significant effect on the students' intention to use the BCSS. However, perceived ease of use has no significant effect. Correspondingly, it appears that in the educational context, the subject and targeted behavior of the BCSS is crucial (Steinherr 2021). The study's findings suggest that BCSS targeting self-regulated learning is highly valued by students and that the perceived usefulness has a positive significant effect on students' intention to use the BCSS while perceived ease of use has no significant effect.

Studies of BCSS use continuance in general (outside the education context) are often large studies with numerous participants that aim to identify structural models. Persuasive features are often assessed on a high level such as categories of design principles and do not consider individual design principles. Previous research on users' intention to use a BCSS identified perceived persuasiveness and unobtrusiveness with a positive significant effect on users' intention to use the system (Lehto et al. 2012). Following up on this study Lehto and Oinas-Kukkonen (2015b) investigate how design features further influence BCSS users' use continuance. In this study, they identify primary task support, credibility

support, and social support with a significant and positive relationship to the users' continuance intention. Moreover, the construct of social identification has a strong significant relation to perceived social support, which, in turn, has a significant effect on perceived effectiveness and continuance intention. Finally, perceived effectiveness has a significant impact on use continuance. Within the resulting structural model, social support, perceived credibility, perceived effort, and perceived effectiveness together explain 46% of the variance of continuance intention (Lehto and Oinas-Kukkonen 2015b). Analyzing different BCSS features and their effects on continuance intention, Oduor and Oinas-Kukkonen (2021) identified computer-human dialogue support, primary task support, perceived credibility, social support, and perceived competence with an positive significant influence.

In conclusion, the findings of related literature reveal that primary task support, credibility support, and social support have a significant positive impact on use continuance intention. In addition, also unobtrusiveness, perceived persuasiveness as well as perceived usefulness positively influence users' intention to use. Besides these direct significant positive relations related work indicates the importance of all design choices when targeting a high use continuance. This is reasoned by the fact that the measured constructs correlate positively in structural models if they are interrelated. For example, even though, social identification is not identified with a significant relation to continuance intention, it has a strong connection to perceived social support, which, in turn, has a significant effect and continuance intention (Lehto and Oinas-Kukkonen 2015b). Consequently, when designing BCSS it is not only essential to target a high value of constructs directly affecting use continuance but to consider all facets of the systems.

While a consistent picture of individual constructs and their effect on use continuance is presented, the question remains to what extent the integration of different design principles can affect the perceptions of a BCSS, and to what extent the inclusion of individual design principles affects the assessment of the system as a whole.

4.3.4 Designing a Behavior Change Support System towards an Improved Learning Behavior

4.3.4.1 Iterative Development Process Following Design Science Research

This study is embedded in a larger DSR project (Hevner 2007; Peffers et al. 2008). It presents the third iteration. Each iteration follows the development process of DSR artifacts according to Peffers et al. (2008). Figure 23 depicts this process.

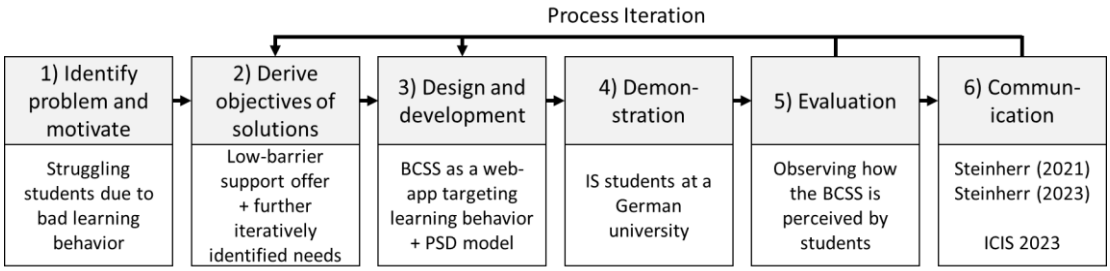

Figure 23: Development Process of the Behavior Change Support System Targeting Self-regulated Learning Following Design Science Research according to Peffers et al. (2008)

The project team consists of three BCSS designers, a researcher with a research background in persuasive systems (Steinherr 2023; Steinherr et al. 2022) as well as a pedagogical education, and two assistants with experience in programming systems.

The project started in 2019 with 1) the identification of the problem space, revealing a missing low barrier support intervention for students struggling with their current learning behavior. 2) as the main reasons include high perceived barriers to existing support interventions, we identified BCSS in the form of a web application as a promising approach. 3) the design and development process follows the PSD model (Oinas-Kukkonen and Harjumaa 2009). 4) due to the local placement of the project members, our target group covers university students in Germany, consequently, the BCSS was also demonstrated to this target group. 5) the first prototype was evaluated using the Technology Acceptance Model (Davis 1986) to identify factors influencing students' intention to use the system. 6) following DSR, the results of the first evaluation were communicated (Steinherr 2021) and used as an evidence-based refinement of the BCSS. Based on these findings, the visual design, structure, and form of the learning strategy content were adjusted. In addition, the second iteration was strongly influenced by the COVID-19 pandemic. The pandemic further emphasized the need for a low-barrier intervention to support students in adopting

good learning behaviors, as students' self-regulated learning competencies determined their ability to cope with digital semesters (Sutarni et al. 2021; Wesselborg 2020).

Consequently, the second iteration resulted in a thoroughly revised second prototype. We evaluated this prototype with a focus on factors influencing students' persistence in using the BCSS. The results of the second evaluation were again communicated (Steinherr 2023) and used as an evidence-based refinement of the BCSS. Overall, the second iteration showed that the second prototype was able to meet students' needs and was perceived as useful overall. However, qualitative feedback from students highlighted a desire for additional features, with *rewards* or *social comparison* the most frequently mentioned suggestions for improvement.

This article presents the third iteration of the DSR project. Within the third iteration, we consistently address the problem of struggling students in higher education due to bad learning behavior. Our derived objective of solution is a low-barrier support offer, including demands on the visual design identified through students' feedback as well as features of a support intervention. Additionally, we identified students' desire for the integration of a *reward* system or *social comparison.* To identify the effects of the two additional design principles, we created two different prototype version, one BCSS with the integrated design principle of *rewards,* and one prototype version with the integrated design principle of *social support.*

4.3.4.2 Design Process

4.3.4.2.1 Context Analysis

The underlying step when designing BCSS is the analysis of the persuasion context. The PSD model (Oinas-Kukkonen and Harjumaa 2009) divides this context analysis in three aspects, as depicted in Figure 24.

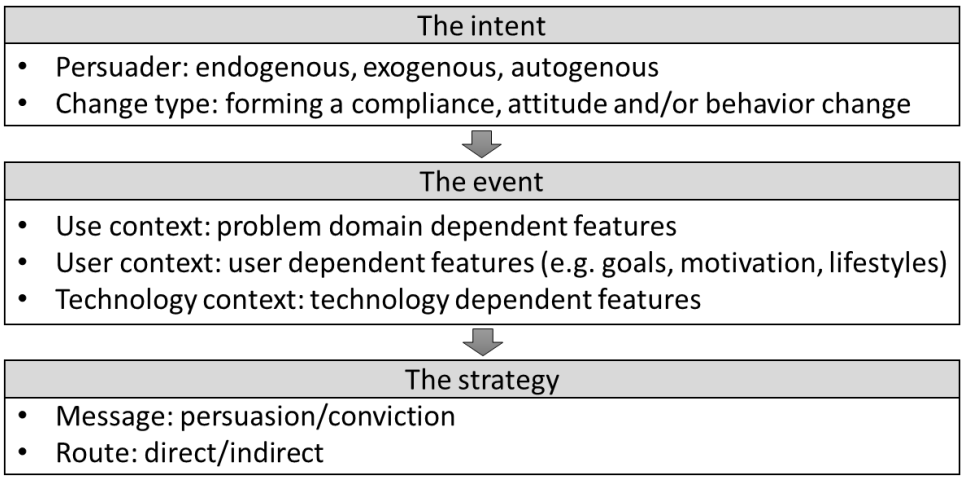

Figure 24: Context Analysis as an Underlying Step in Designing Behavior Change Support Systems

The Intent

Persuader: Based on Fogg (1998) Oinas-Kukkonen and Harjumaa (2009) list three different sources of intentions. 1) Designers and developers of the BCSS with endogenous intentions, 2) those who distribute or share access to the BCSS with exogenous intentions, and 3) users of the BCSS with autogenous intentions. Within this study, the designers and developers overlap with the distributors, which are lecturers at a German university, that develop the BCSS to support students (users) in improving their learning behavior.

Change type: Regarding the change type, the Outcome/Change Design Matrix by Oinas-Kukkonen (2013) differentiates between the change types 1) forming a new compliance (C-change), 2) changing users' behavior (B-change), and/or forming users' attitude (A-Change). Besides Oinas-Kukkonen (2013) also differentiates different outcome types 1) formation (F-outcome), 2) alteration (A-Outcome), or reinforcement (R-outcome). Table 41 presents the instantiation of the Outcome/Chance Design Matrix.

Table 41: Outcome/Change Design Matrix according to Oinas-Kukkonen (2013)

Outcome / Change	C-Change	B-Change	A-Change
F-Outcome	Forming a compliance (F/C) Not in focus	Forming a behavior (F/B) The BCSS targeting learning behavior shows users how to form their learning behavior step-by-step with tangible advice	Forming an attitude (F/A) The BCSS targeting learning behavior provides background information on multiple learning strategies including potentially new strategies
A-Outcome	Altering compliance (A/C) Not in focus	Altering a behavior (A/B) The BCSS targeting learning behavior monitors students' learning behavior and suggests opportunity improvements	Altering an attitude (A/A) The BCSS targeting learning behavior provides background information on multiple learning strategies reasoning the application
R-Outcome	Reinforcing compliance (R/C) Not in focus	Reinforcing a behavior (R/B) The BCSS targeting learning behavior monitors students' progress in improving their learning behavior and shows developments	Reinforcing an attitude (R/A) The BCSS targeting learning behavior provides background information on multiple learning strategies reasoning the application

The Event

Use context: The context of the application is the higher education environment. In this environment learning is the overarching task for students to pursue.

User context: The targeted users of the BCSS are higher education students. Due to local circumstances, the initial target group of the BCSS is German information system (IS) students. This target group is typically characterized by a high smartphone use in general. Besides, the target group of higher education students is relatively homogenous regarding goals and age. In their educational environment, they typically pursue the goal pass all exams, however, students differ regarding learning behavior and self-regulated learning strategy usage. Furthermore, students often perceive high barriers to support offers.

Technology context: Smartphones are well-established along the target group. Most students use social media apps and have experience with fitness trackers. Besides, especially in the target user group of IS students most students also use a computer for learning. Consequently, a web-based support system seems easily accessible for the target group of higher education students.

The Strategy

Message: The message to persuade is visual through monitoring strengths and weaknesses of current learning behavior, nudging towards a behavior change, but also conviction through theoretical background explaining and reasoning the application of different learning strategies.

Route: BCSS can persuade users in a direct or indirect way. While the direct way typically uses messages with argumentation, the indirect way uses simple cues. While both can work stimulatingly, Oinas-Kukkonen and Harjumaa (2009) recommend a direct route when users can evaluate and understand the content of the persuasion message because direct persuasions tend to be more effective. Consequently, we use a convincing message on a direct route, with theoretical information on why the students should apply different learning strategies. This information is based on empirical findings of self-regulated learning.

4.3.4.2.2 Selection of Fitting Design Principles

After analyzing the persuasion context, the selection of the design principle follows. Building on the findings of the context analysis, and considering the recommendation model for design principle selection (Merz and Steinherr 2022), we implement the following design principles in the BCSS targeting learning behavior:

Reduction: The design principle *reduction* involves breaking down complex behaviors into simpler tasks or subtasks (Oinas-Kukkonen and Harjumaa 2009). In the case of the developed BCSS, the primary objective is to break down the significant challenge of improving learning into manageable steps.

Tunneling: The design principle *tunneling* provides "means for action that brings them closer to the target behavior" (Oinas-Kukkonen and Harjumaa 2009, p. 492). *Tunneling* is addressed by the BCSS function to guide students with small tasks towards the application of learning strategies.

Self-monitoring: The design principle *self-monitoring* empowers users to monitor their progress or current status, which in turn, aids them in achieving their desired objectives (Merz and Steinherr 2022). It can therefore assist users in gaining a deeper understanding of their behavior patterns and encourage progress. In the developed BCSS, students can monitor their application of learning strategies as well as their progress of completed tasks towards the application of different learning strategies.

Personalization: Incorporating *personalization* as a key design principle has been emphasized by researchers to drive user motivation and engagement throughout the behavior-change process. Such personalized elements have the potential to aid individuals in both initiating and maintaining behavior change, thereby preventing relapses into unwanted patterns of behavior (Merz and Steinherr 2022). Therefore, the developed BCSS is adapted to students' names and progress.

Tailoring: Tailoring refers to ensuring that information aligns with the context and the targeted user group's needs (Merz and Steinherr 2022; Oinas-Kukkonen and Harjumaa 2009). The developed BCSS considers students' individual needs and demands through different options that students can select, for example, it provides a long reflection phase as well as a short one.

Praise: The design principle *praise* has the ability to strengthen individuals' motivation to reach their goals (Merz and Steinherr 2022). The developed BCSS praises students for completing steps, for example after completing the initial reflection, or further tasks.

Expertise and trustworthiness: Both design principles foster the BCSS' persuasiveness as they let the system seem truthful, fair, and unbiased and demonstrate knowledge, experience, and competence (Merz and Steinherr 2022). These design principles are incorporated in the wiki page of the BCSS which explains the theoretical background of self-regulated learning (see chapter 4.3.4.3).

While these design principles are included in both versions of the BCSS, we have added one of the following two design principles to each version of the BCSS. The result is one BCSS version with *rewards* and one version with *social comparison*. While the need for both design principles is driven by the findings of the previous iteration, the implementation of the design principles is also justified as follows:

Social Comparison: This design principle compares the performance of users with others and therefore can raise motivation and strengthen the intent to change (Merz and Steinherr 2022; Oinas-Kukkonen and Harjumaa 2009). The developed BCSS incorporates *social comparison* by comparing students' performance regarding completed tasks within the BCSS with peers.

Rewards: This design principle gives credit for performing the target behavior and therefore can provide great persuasive powers (Oinas-Kukkonen and Harjumaa 2009; Merz and Steinherr 2022). The developed BCSS addresses *rewards* by providing digital collectible coins when completing tasks within the BCSS.

4.3.4.3 Implemented Behavior Change Support System

The targeted behavior change is an improvement in students' learning behavior based on the theory of self-regulated learning. The BCSS initially starts with reflective questions that are in accordance with the concept of self-regulated learning. After completing the reflection, students get information regarding their current application of different self-regulated learning strategies. Based on this information students can identify self-regulated learning strategies they already use as well as learning strategies with poor application. The BCSS then guides students step by step towards applying new self-regulated learning strategies or improving self-regulated learning strategies that are currently applied poorly. Within these steps towards an improved learning behavior, students get small tasks to complete in order to apply a self-regulated learning strategy. After completing one task, students can tick off the task and monitor their progress. Besides these functionalities, the BCSS also incorporates a wiki page with information in form of short videos and text for each self-regulated learning strategy. Figure 25 depicts the core functionalities of the BCSS.

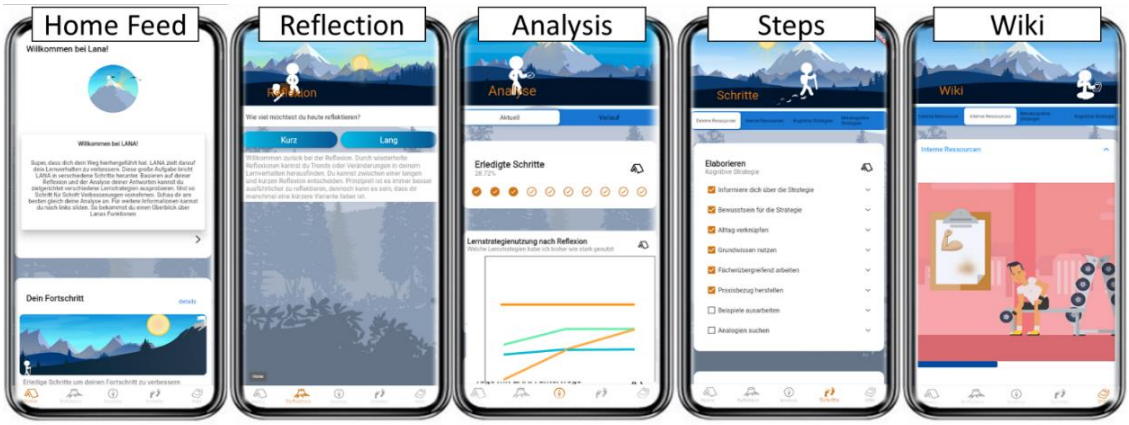

Figure 25: Core Functionalities of the Implemented Behavior Change Support System

While these functionalities describe the core functionalities of the BCSS, we then implemented two versions of the BCSS. Both versions of the BCSS have the same functionalities and design, however, they differ regarding the home feed. Each version of the BCSS depicts one additional tile in the Home Feed. While the original BCSS (including both versions) is published in German, we adopted the screenshots in English for the purpose of presentation within this study.

In the first version, we included the persuasive design principle *rewards*. In this version of the BCSS, students can collect visual digital awards for competing tasks, e.g., completing the initial reflection phase. Figure 26 depicts the design principle *rewards*.

Figure 26: Implementation of the Design Principle *Rewards*

In the second version of the BCSS, we implemented the persuasive design principle *social comparison*. In this version of the BCSS students can track their own progress while also seeing the progress of two fellow students. This progress is based on students' completed and ticked-off tasks within the steps towards an improved learning behavior. The design principle *social comparison* is depicted in Figure 27.

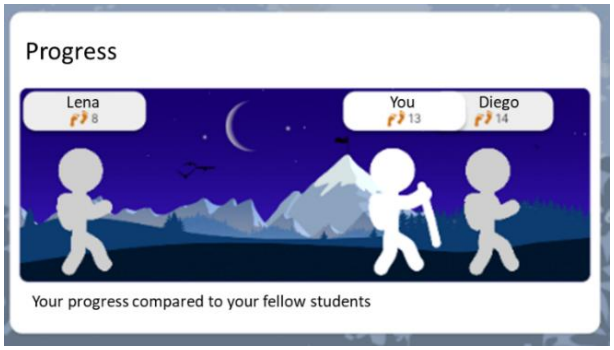

Figure 27: Implementation of the Design Principle *Social Comparison*

4.3.5 Evaluation Design

We announced the experiment in two different IS courses for bachelor students. We introduced the experiment as a scientific study that involved testing and evaluating an app. As compensation, participants receive a voucher for 5 euros. Those interested could sign up for one of two digital sessions. The sessions were both scheduled for one hour. Both events were held digitally. We shared a QR code for students to access the BCSS. The first group got access to the BCSS with *rewards*. The second group got access to the

BCSS with *social comparison*. All students got 30 minutes to test and interact with the BCSS. After interacting with the BCSS students were asked to complete a survey on their experience with the BCSS. Table 42 summarizes the demographic data of both groups of students.

Table 42: Demographic Statistics of Participants

		Rewards	Social comparison	Total
Gender	Female	12	11	23
	Male	10	10	20
Age	18-20	10	8	18
	21-22	10	6	16
	23-25	2	7	9
Total		22	21	43

Besides the demographic data, the survey contained the perceived persuasiveness questionnaire (PPQ) that was initially presented by Lehto et al. (2012): The questionnaire was developed to gain insight into the operating mechanisms of persuasive technologies. It includes 27 items that are assigned to 9 different constructs. It measures use continuance using 4 items. Although current literature indicates that the PPQ is not comprehensively mature and not thoroughly validated, we included it in the survey. This is reasoned, as it is explicitly formulated to capture the design of BCSS and thus provides valuable insights regarding individual design choices (Beerlage-de Jong et al., 2020). In the survey, the participating students rated the individual items of the PPQ using a 5-point Likert scale, where the value 5 represents "strongly agree " and the value 1 "strongly disagree". Table 43 presents the reliability of the measured PPQ constructs.

Table 43: Cronbach's Alphas of the PPQ

Constructs	Short form	Cronbach's Alpha	Decision
Use continuance	CONT	0.77	Included in further analysis
Dialogue support	DIAL	0.60	Excluded in further analysis
Perceived credibility	CRED	0.52	Excluded in further analysis
Perceived effort	EFFO	0.58	Excluded in further analysis
Perceived effectiveness	EFFE	0.70	Included in further analysis
Primary task support	TASK	0.70	Included in further analysis
Perceived persuasiveness	PERS	0.64	Excluded in further analysis
Unobtrusiveness	UNOB	0.64	Excluded in further analysis
Social support	SOCI	0.70	Included in further analysis

Most of the constructs of the PPQ were not able to meet the acceptance criteria for internal consistency (Cronbach's Alpha $\geq 0{,}70$) (Ponterotto and Ruckdeschel 2007). Based on this requirement we excluded dialogue support, perceived credibility, perceived effort, perceived persuasiveness, and unobtrusiveness. Consequently, only four constructs are included in the further analysis: Use continuance, perceived effectiveness, primary task support, and social support.

4.3.6 Results

The presentation of results is divided according to the two BCSS versions (*rewards* vs. *social comparison*). Table 44 reports the descriptive statistics of the BCSS with *rewards*.

Table 44: Descriptive Statistics of the Group "Rewards"

Rewards (N=22)	**Min**	**Max**	**Mean**	**SD**
Use continuance	2.50	4.75	3.6023	.57559
Perceived effectiveness	3.00	4.67	3.5909	.50324
Primary task support	2.25	4.75	3.5909	.65258
Social support	1.50	5.00	3.2273	.79772

The results of the PPQ within the group that got access to the BCSS with *rewards* indicated that students overall enjoy the interaction with the systems, as no mean value is below 3. Use continuance is rated the best, followed by equal ratings of perceived effectiveness and primary task support. Social support shows the lowest value. Table 45 presents the descriptive statistics regarding BCSS with *social comparison*.

Table 45: Descriptive Statistics of the Group "Social Comparison"

Social comparison (N=21)	**Min**	**Max**	**Mean**	**SD**
Use continuance	2.50	5.00	3.6071	.54527
Perceived effectiveness	2.67	4.67	3.9365	.46689
Primary task support	2.50	4.75	3.7381	.45741
Social support	1.50	4.50	3.5952	.68226

The results of the PPQ for the group that rated their experiences with the BCSS that incorporated *social comparison* also indicate that these users overall liked the interaction with the systems. The highest rating is perceived effectiveness followed by the primary task support of the system. Use continuance is rated slightly higher than social support.

Comparing the results of both groups indicates that students overall preferred the interaction with the BCSS that incorporates *social comparison* over the system that incorporates *rewards*. This is depicted, as all mean values of the PPQ constructs for the BCSS with *social comparison* are higher than those of the BCSS with *rewards*.

While this comparison only descriptively presents differences regarding mean values, we conducted further analysis to identify significant relations. In our dataset, the independent variable is nominally scaled (*rewards* vs. *social comparison*) and the dependent variables (use continuance, perceived effectiveness, primary task support, and social support) are at least ordinal scaled. Besides, the two independent groups to be analyzed do not show a normal distribution. Since the two independent groups are formed by 22 and 21 participants, respectively, we cannot argue about the central limit theorem either. Therefore, we performed the Mann-Whitney-U test to identify significant differences regarding the constructs' mean values. Table 46 depicts the ranks according to the Mann-Whitney-U test and Table 47 shows the statistics of the Mann-Whitney-U test. For the assignment of the abbreviations in Table 47 please see Table 43.

Table 46: Rank Table

	BCSS version	**Mean rank**	**Sum of**
Use continuance	Rewards	22.30	490.50
	Social Comparison	21.69	455.50
Perceived effectiveness	Rewards	18.16	399.50
	Social Comparison	26.02	546.50
Primary task support	Rewards	21.77	479.00
	Social Comparison	22.24	467.00
Social support	Rewards	18.32	403.00
	Social Comparison	25.86	543.00

Table 47: Statistics of Mann-Whitney-U Test

	CONT	**EFFE**	**TASK**	**SOCI**
Mann-Whitney-U	224.500	146.500	226.000	150.000
Z	-.165	-2.217	-.123	-2.032
Asymptotic significance (2-sided)	.869	.027	.902	.042
Exact significance (2-sided)	.875	.027	.909	.040

The Mann-Whitney-U test identified two significant group differences. The first difference is regarding students' perceptions of use continuance: There is a statistically significant difference in use continuance between both groups, $U = 224.500$, $Z = -.165$, $p < .05$.

Besides, there is a statistically significant difference regarding social support between both groups, $U = 150.000$, $Z = -2.032$, $p < .05$.

Even though the comparison of mean values also indicates differences regarding perceived effectiveness and primary task support, the Mann-Whitney-U test revealed no significant differences, between the groups using the BCSS with *rewards* compared to the BCSS with *social comparison*.

To gain insights regarding the influence of individual design choices on students' use continuance of the BCSS a multiple linear regression analysis was conducted. The prerequisites for the test have been checked and are found to be given. The model has no auto-correlation as the value of the Durbin-Watson statistic is 1.914. The R^2 for the overall model was .265 (adjusted $R^2 = .208$), indicative of a high goodness-of-fit according to Cohen (1988). Students' perceptions of the measured design features can statistically predict use continuance, $F(3, 39) = 4.675$, $p < .01$. Table 48 presents the multiple linear regression analysis.

Table 48: Findings of the Multiple Linear Regression Analysis towards Use Continuance

	Regression coefficientB	**Std. error**	**Beta**	**T**	**Sig.**
(constant)	1.392	.641		2.172	.036
Perceived effectiveness	.276	.122	.320	2.270	.029
Primary task support	.178	.096	.265	1.840	.073
Social support	-.093	.082	-.159	-1.126	.267

The multiple linear regression analysis identifies that perceived effectiveness has a significant and positive influence on use continuance but at the high significance level of $p > .10$. Primary task support also has a significant and positive influence on use continuance. This relationship is significant at the $p > .05$ level. For a concise overview of the results, we map these results in Figure 28.

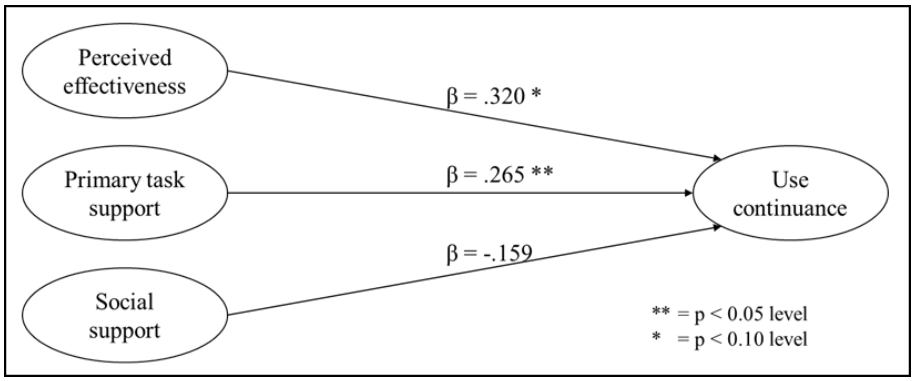

Figure 28: Linear Regression Model of Constructs Influencing Students' Use Continuance

4.3.7 Discussion

The design principle *social comparison* positively influences the evaluation of the BCSS compared to the design principle *rewards*. This is reflected in the fact that students using the BCSS with *social comparison* rated all mean values of the assessed constructs higher than students interacting with the BCSS with *rewards*. The analysis of the significant differences identifies two significantly higher mean values: perceived effectiveness and social support. In the case of perceived effectiveness, the mean values increased from 3.6 to 3.9, and in the case of social support from 3.2 to 3.6. There is no rating of measured constructs that performs worse in the group using the BCSS with the design principle *social comparison* compared to the BCSS with *rewards*. Correspondingly, the integration of the design principle *social comparison* seems to be superior to the integration of the design principle *rewards* regarding all measured constructs.

It appears evident that the students using the BCSS with *social comparison* rated the construct social support higher than the students interacting with the BCSS including *rewards*. According to the PSD model, the design principle *social comparison* is assigned to the category social support (Oinas-Kukkonen and Harjumaa 2009). Consequently, the higher rating of social support shows that the students are aware of the integrated design principle. The lower rating of social support in the BCSS with *rewards* is therefore attributable to the fact that this version of the BCSS contains fewer design principles of the social support category. To conclude, the integration of a design principle of the design principle category social support results in a stronger perception of the category.

In addition to this finding, it also emerges that the students using the BCSS evaluate the BCSS as more effective through the visual *social comparison*. This finding is consistent with previous research. Besides to this study, also Lehto and Oinas-Kukkonen (2015b)

identified a significant positive relationship between social support and perceived effectiveness. Based on the findings of Hwang et al. (2010), the researchers argue that social support motivates, encourages, and promotes information sharing among users, which in turn then increases perceived effectiveness (Lehto and Oinas-Kukkonen 2015b). Consequently, the integration of the design principle *social comparison*, which is categorized within social support, is able to promote the perceived effectiveness of BCSS.

Comparing the results of this study with related work shows predominantly consistencies. In accordance with the study by Lehto and Oinas-Kukkonen (2015b), primary task support shows a significant positive influence on users' intention to continue. While perceived usefulness was identified as significant in our study, albeit at a level of $p < 0.1$, previous research further suggests a significant relationship as it identified it at a significance level of $p < 0.01$. However, different from previous studies, the linear regression analysis conducted in this study was not able to identify significant relationships between social support and use continuance as reported in previous work.

While the findings of this study suggest the superiority of the design principle *social comparison* over *rewards*, it is noteworthy to address possible effects on students' perceptions besides persuasive effects surveyed by the PPQ. Research on socially-driven persuasive design emphasizes the positive effects of *social comparison* on behavior change by highlighting the subtle and empowering peer pressure (Orji et al. 2019b). However, Orji et al. (2019b) also warn of unwanted side effects on users such as "unnecessary stress, tension, pressure and make people anxious". BCSS developers and designers should therefore not only focus on design principles that foster a high use continuance but also consider possible negative side effects on users.

4.3.8 Conclusion

In the digital learning environment, self-regulated learning is crucial for students' academic success and well-being (Wesselborg 2020). However, research shows that many students struggle in digital learning environments and perceive high barriers to support (Eisenberg et al. 2012). Therefore, we present an alternative, low-barrier support service in the form of a BCSS that supports students in developing self-regulated learning behaviors. Since information systems that aim to change behavior in the long term require a high level of commitment, this study focuses on the influence of two different persuasive design principles on students' use continuance. For this purpose, an already implemented BCSS is used and created as two versions. The first version integrates the design principle

rewards, which primarily addresses external motivation. In contrast, there is a second version of the BCSS in which the design principle *social comparison* is included. The analysis of the mean values regarding the assessment of both BCSS versions shows significant differences in students' perceived effectiveness and social support. The students, that got access to the BCSS that integrated *social comparison* perceived the BCSS as more effective and as a system with more social support compared to the students that interacted with the BCSS that *rewarded* certain activities within the system. Analyzing data towards constructs that influence use continuance, primary takes support and perceived effectiveness are identified with a positive significant influence on use continuance.

Summarizing both findings indicates that the integration of the design principle *social comparison* is more beneficial than the integration of the design principle *rewards*. *Social comparison* does not only positively affect perceived effectiveness and social support, but as perceived effectiveness has a positive significant influence on use continuance, *social comparison* might also lead to a higher engagement of students with the system. Consequently, when designing BCSS that foster a high use continuance the integration of *social comparison* seems superior over the implementation of the design principle *rewards*.

4.3.9 Outlook to Future Research

This paper summarizes the development process and the evaluation of a BCSS in higher education to support students towards self-regulated learning. This represents an innovative approach, as while BCSS are established in other application contexts such as health, BCSS are not established in the field of higher education (Merz and Ackermann 2021). However, because the impact of information systems depends on the continuance of users' engagement, the focus of this study is to investigate design principles that influence students' use continuance. While previous research on the use continuance of BCSS users mostly focuses on structural models and explains the effects of design principle categories on use continuance, this study addresses the, so far neglected, examination of the integration of individual design principles. Investigating differences in users' perceptions of the design principles *rewards* and *social comparison* identified that users perceive the BCSS with *social comparison* overall as more effective and with more social support. As the perceived effectiveness was identified with a positive significant influence on use continuance, the integration of the design principle *social comparison* seems to be superior to

fostering use continuance. Our findings base on the evaluation of one implemented BCSS towards an improved learning behavior and the assessment of bachelor IS students. However, as research indicates that the perception of BCSS is related to user characteristics (Oduor and Oinas-Kukkonen 2021), our findings might also be transferable to other BCSS designed for the target group of higher education students.

The findings of the study are limited by the small number of constructs of the PPQ that were subject to our analysis. Out of the nine defined constructs, only four were able to meet the criteria for internal reliability. Consequently, only significant relations between these four constructs could be investigated. The missing internal reliability within the constructs might be reasoned by the number of participating students (Ponterotto and Ruckdeschel 2007). However, this finding is also consistent with previous research that identified a lack of maturity of the PPQ (Beerlage-de Jong et al. 2020). An additional limitation of our findings is the duration of the experimental setting. By surveying students after 30 minutes of interaction with the BCSS, it is only able to predict first impressions and initial assessments of the system. For reliable statements on use continuance, the measurement of actual usage behavior would be a valuable supplement to this study. Although these first impressions may not yet precisely predict the user's long-term interaction with the system, the initial experience with the system is a critical prerequisite for user engagement (Bhattacherjee 2001). Consequently, these early evaluations already reveal important information on design choices (Hsieh, Po-An J. J. and Wang 2007).

Within the research field of persuasive systems, multiple research demands emerge. First, we encourage further research towards a measurement tool to capture the persuasive effects of BCSS: Although the PPQ can address different facets, we agree with Beerlage-de Jong et al. (2020) that a more mature questionnaire is needed to capture the effects of persuasive systems. Second, we also encourage further research on cause-effect relations of individual design principles in BCSS. This way detailed design knowledge could be systematically generated and consolidated. Third, especially literature reviews foster a more precise formulation of persuasive design principles (Wang et al. 2018; Merz and Ackermann 2021). While the design principles within our study *rewards* and *social comparison* are clearly distinguishable, we understand the difficulties that arise when design principles such as personalization and tailoring seem to be overlapping. For a systematic generation of design knowledge in the research field of persuasive systems, a precise formulation of design principles is required. Fourth, participating students in the evaluation of the BCSS overall enjoyed and valued the developed BCSS as a support system for

improving their learning behaviors. Based on these findings, we encourage further approaches to design persuasive systems in educational settings with the goal of supporting students in finding effective learning behaviors. These support systems could enrich higher education by promoting important self-regulation skills, while higher education lectures and seminars focus on teaching subject-specific competencies.

5 Conclusion

The essays in this dissertation contain contributions to the design of a BCSS for self-regulated learning as a supplement to university education to equip students with learning competencies. This corresponds to the title of "Development and Evaluation of a Behavior Change Support System Targeting Learning Behavior: A Technology-Based Approach to Complement the Education of Future Executives Using Persuasive Systems in Higher Education" and answers the superordinate research question: "*How should a BCSS be designed to support higher education students in changing their behavior towards self-regulated learning?*". To answer the research question, the essays present various research methods and approaches which are summarized in Table 49.

Table 49: Methods and Approaches of this Dissertation in Numbers

Systematic Literature Reviews Comprising **272** Studies	Independent Coding of **1.038** Variables	Assessment of **34** Quantitative Constructs
Considering **11** Theoretical Foundations	Development of a **BCSS** for Self-regulated Learning	**4** Iteratively Developed Prototype Versions
Quantitative Insights of **149** Users Representing the Targeted User Group	**10** Implemented Design Principles in the Developed BCSS	Qualitative Insights of **178** Users Representing the Targeted User Group

In sum, the essays of this dissertation present:

272 studies in systematic literature reviews reveal the needs for BCSS content and design

- **Essay 1:** 154 studies on soft skill training at higher education
- **Essay 2:** 19 studies of digital leadership and 19 studies on crisis leadership
- **Essay 3:** 12 studies summarizing the application context of the Hexad framework of Marczewski (2013)
- **Essay 4:** 24 studies for systematically refining the developed recommendation model for design principle selection
- **Essay 5:** 45 studies as knowledge base for the design principle development
- **Essay 6:** 18 studies on behavior change support systems in education

Independent coding of **1.038** variables providing insights into BCSS design

- **Essay 2:** Coding of 288 individual mentions of required leadership competencies
- **Essay 3:** Coding of 63 qualitative statements of LANA users
- **Essay 4:** Mapping 85 links between design principles and the stages of change
- **Essay 5:** Coding of 43 qualitative statements regarding 14 design principles, resulting in 602 individual variables to be coded

Assessment of **34** quantitative constructs providing insights for the BCSS development

- **Essay 3:** 6 constructs representing 6 Hexad user types
- **Essay 6:** 3 constructs of the TAM (Davis 1986), 13 constructs surveyed within LANA based on the LIST-K (Klingsieck 2018)
- **Essay 7:** 8 constructs of the PPQ (Lehto et al. 2012), 3 constructs of the LOES-S (Kay and Knaack 2009)
- **Essay 8:** 1 additional construct of the PPQ (Lehto et al. 2012)

Consideration of **11** theoretical foundations as evidence-based fundament of the BCSS

- **Essay 1:** Experiential learning theory (Kolb 1984) and self-leadership (Manz 1986)
- **Essay 2:** Digital leadership (Eberl and Drews 2021) and crisis leadership (Wu et al. 2021)
- **Essay 3**: Hexad framework (Marczewski 2013)
- **Essay 4**: PSD model (Oinas-Kukkonen and Harjumaa 2009) and transtheoretical model (Prochaska and DiClemente 1983)
- **Essay 5:** Method for design principle development (Möller et al. 2020), and design principles schema (Gregor et al. 2020)
- **Essay 6:** Self-regulated learning (Zimmerman 1990; Pintrich and Groot 1990)
- **Essay 8:** Motivation in games model (Richter et al. 2015)

Quantitative insights of **149** users representing the target group of the developed BCSS

- **Essay 3:** 63 first-semester BISE students
- **Essay 6:** 18 first-semester BISE students
- **Essay 7:** 25 first-semester BISE students
- **Essay 8:** 43 bachelor students in BISE-related courses

Qualitative insights of **178** users representing the target group of the developed BCSS

- **Essay 3:** 63 first-semester BISE students
- **Essay 6:** 18 first-semester BISE students
- **Essay 7:** 54 first-semester BISE students
- **Essay 8:** 43 bachelor students in BISE-related courses

10 implemented design principles within the developed BCSS named LANA

- **Essay 6:** Implemented design principles: tunneling, reduction, self-monitoring
- **Essay 7:** Expanded with: personalization, tailoring, praise, expertise, trustworthiness
- **Essay 8:** Expanded with: social comparison or rewards

Based on preceding methods and analysis **4** iteratively developed prototype versions

- **Essay 6:** Introduction of the initial prototype of a BCSS for self-regulated learning
- **Essay 7:** Presentation of the second fundamental redesigned prototype
- **Essay 8:** Presentation of the third prototype including two different BCSS versions

5.1 Descriptive Contributions

This dissertation makes a descriptive contribution by investigating the environment of future executives as higher education students, in particular, with regard to existing problems and approaches to solutions. Against this background, the dissertation examines how the current changing environment requires universities to develop an increasingly holistic approach to educating students, incorporating the training of subject specific skills as well as social and personal skills. While previous research often analyzes the required competencies only in relation to specific single areas, this dissertation provides an overview of the competencies identified in the research area of digital leadership as well as in the research area of crisis leadership. The systematic analysis of both research areas shows that generic competencies such as communication, decision-making, and learning are particularly important in the current environment. These competencies are not only important on a business level (subject-specific skills) but are also crucial for self-management (personal skills) as well as leading a team (social skills). By listing and explaining the impact of identified 21 competence areas, the dissertation provides an overview and reasoning on important educational content towards a more holistic training of future executives.

In addition to examining the relevant competencies that higher education institutions should incorporate into their study programs, the dissertation also describes the current state of educational practice in BISE-related programs based on published research articles. This indicates that while subject-specific competencies are already often in focus of university education, the teaching of social and personal competencies seems to be neglected. Against this background, the dissertation provides insights into the requirements for effective training of social and personal skills in higher education. Based on a systematic literature review, an integrative, systematic, and measurable approach appears valuable. Within such an approach, it seems important to explicitly address the targeted skills, and students should actively participate in the learning process. Furthermore, the training in social and personal skills should start at the beginning of university studies.

Since students' participation in the learning process is crucial for the development of relevant personal and social competencies, lectures and seminars at universities need to motivate students to actively participate. This is particularly important as students often focus on the subject-specific competencies needed to pass end-of-semester exams and neglect the development of personal and social competencies. A framework that could provide guidance on how to motivate students to actively participate in seminar and lectures could be the Hexad user types. The Hexad framework (Marczewski, 2013) defines six

user types with corresponding motivational preferences and gamification strategies to address them, for example, rewards or leadership boards. Therefore, it seems to be a useful advice on how to design more motivating lectures or seminars for students. As this framework is not yet established in educational settings, this dissertation provides a systematic overview of the current application contexts and domains of the Hexad user types in the literature. The application of the search string "abstract: Hexad" in five databases reveals a total of 12 applications of the framework. Furthermore, it shows that most of the applications are in the context of information systems, where different features are implemented to address users according to their underlying user types (for example, collectible points for the user type "player"). In addition, the literature review identified three studies that provide examples of how the Hexad framework is integrated into information systems in the context of higher education and that this is effective in promoting student engagement. This suggests that the framework can inspire lecturers to integrate different gamification strategies in higher education to address the different motivational preferences of their students and motivate them to actively participate.

In addition to descriptive contributions addressing the higher education environment, the dissertation focused specifically on BCSS as a valuable component for promoting higher education student learning. Multiple essays investigate the current state of research on BCSS. They show a clear picture regarding the application field of the systems. BCSS are mostly applied in the health context, targeting regular intake of medication, but also promoting users' fitness levels. In addition, the context of application is constantly expanding, with BCSS being used in areas such as environmental protection, workplace safety, cross-cultural challenges, and marketing. In the context of higher education, persuasive technology is mostly addressed in digital learning environments, for example as specific features in e-learning platforms. Implementing persuasive technology in the educational context usually aims towards students' enhanced motivation, engagement, involvement, attention, or knowledge building. While there is also research on BCSS that explicitly addresses student learning behaviors, it is still limited, and well-founded design knowledge is still missing.

In addition to the application contexts and the focus on the educational context, this dissertation also generates descriptive design knowledge about concrete BCSS implementations in various areas. It provides an overview of concrete implementation examples of the 28 defined design principles of the PSD model. For example, in research articles, the design principle of *normative influence* is integrated into BCSS by adding peer pressure or incorporating features that lead users to consider their culture and the environment of

the users. The design principle *rewards* is considered in BCSS by unlocking "badges, special features, or scores (or, on the contrary, remove them as a form of punishment)" (Essay 5). Besides the description of concrete implementation examples for each of the 28 design principles of the PSD model, the dissertation also provides reasoning for implementing the design principles based on research. For example, the design principle *comparison* "promotes social learning and encourages users to follow the lead of their fellow users" (Essay 5).

In conclusion, the descriptive contribution of the dissertation comprises insights into the current challenges and opportunities in the higher education environment with regard to a more holistic education considering necessary subject-specific, social, and personal competencies. Drawing on the literature, valuable approaches to promoting social and personal competencies in particular are described, and insights are provided on how to design such approaches to motivate students. Since BCSS have the potential to meet the identified requirements for a complementary intervention to promote necessary competencies, this dissertation synthesizes findings from the current research field of persuasive technology with a focus on BCSS in the higher education context.

5.2 Theoretical Contributions

The dissertation expands the theoretical knowledge base of BCSS design in the field of persuasive systems research by introducing new synthesized design knowledge as guidance for BCSS development. When designing new BCSS, the existing knowledge base is currently mainly based on the PSD model, which introduces a generic development process and defines 28 design principles. Following the generic steps for BCSS development of the PSD model, researchers need to conduct a laborious context analysis and then select appropriate design principles based the findings of the context analysis. However, guidance regarding a context-specific selection of design principles is missing. This is crucial because the selection of design principles can significantly influence users' perception of the whole BCSS. This dissertation addresses this research gap of missing guidance for design principle selection by enriching the PSD model with insights into the transtheoretical model for behavior change. The transtheoretical model complements the more technical background of the PSD model by structuring the context of the BCSS. It accomplishes this by defining different stages of behavior change and the psychological needs of users as they progress through these stages. By combining the PSD model with insights into the stages of change, we present a model that recommends specific design principles based on their ability to support users in their current stage of behavior change as they

transition to the next stage. For example, for Transition II, we identify that users are already aware of an existing problem behavior but do not actively intend to change it (Prochaska and Norcross 2001). Based on the systematic literature review, we identify design principles in the categories of primary task support and social support as particularly appropriate to promote users Transition II. Many of the design principles of primary task support and social support can increase the awareness of the problem behavior, demonstrate the benefits of changing the behavior, and thus enhance the intention to change. In addition to these general findings, we provide details on how individual design principles can be implemented to support transitions. Our findings are synthesized into a recommendation model that depicts the degree to which individual design principles are recommended for each stage of behavior change. This model provides developers of BCSS with guidance when selecting appropriate design principles for the context of their BCSS.

Besides the guidance for designing BCSS while considering users' needs during behavior change processes, we also address the need for a clear codification of design knowledge generated within the research field of persuasive systems. While the PSD model lists and defines 28 design principles, these do not provide a clear codification of design knowledge. For example, the design principles *personalization* and *tailoring* share overlapping concepts. *Personalization* is defined as "A system that offers personalized content or services has a greater capability for persuasion", while *tailoring* is defined as "Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group". Other design principles are formulated vaguely such as *rewards*. This design principle is purely defined by "systems that reward" without providing further information for concrete implementations. Besides, we identify that BCSS designers suggest further design concepts such as goal setting, which are currently missing in the PSD model. This leads to the conclusion that the PSD model suffers from unclear descriptions, overlapping design concepts and missing design concepts. This is problematic when designing new BCSS, presenting developed BCSS, and evaluating existing BCSS, as newly identified design knowledge cannot be uniquely assigned to a specific design concept. The unclear formulation of design principles within the PSD model leads to a diluted documentation of the generated design knowledge.

This dissertation addresses the research gap for a clear codification of design knowledge when designing BCSS by first investigating the state of the art of design knowledge and second aggregating this design knowledge into 14 explicitly formulated design principles. The development process of these design principles follows the framework of Möller et

al. (2020) and corresponds with the demands of clearly defined design principles as defined by Gregor et al. (2020). The recommended decomposition of design principle components into aim, actors, context, mechanism, and rationale allows for a clear formulation of the design principles. Deriving design principles from the aim provides a clear separation of concepts. This allows to connect design concepts that have the same target and to separate design concepts that have different targets. Actors and context explicitly address the environment of the BCSS, and including underlying mechanisms provides concrete implementable features. The rationale provides additional reasons for integrating each design principle into the BCSS. Consequently, the developed design principles provide a clear codification of design knowledge by addressing the components defined by Gregor et al. (2020). For example, the new design principle *adoption* comprised the essence of *personalization* and *tailoring* and is formulated: "For BCSS to be tailored to the users' characteristics and preferences to reach the target behavior, offer personalized content and services and/or provide opportunities to customize content and services, because adoption incorporates the individual needs and choices of users, which makes the system more persuasive". Besides, the newly formulated design principles also enrich existing design principles such as *rewards*, that is now formulated: "To allow BCSS to give credit to users when they perform the target behavior, provide virtual rewards, such as badges, special features, or scores (or, on the contrary, remove them as a form of punishment), because the prospect of reinforcement (or removement of reinforcement) strengthens the motivation to adhere to the target behavior". Furthermore, new design concepts identified in the BCSS literature were formulated as additional design principles, for example *goal setting*: "To allow BCSS to direct users to take purposeful actions toward the target behavior, recommend challenging and specific goals and/or invite users to set challenging and specific goals because, based on the goal-setting theory, specific and challenging goals lead to higher performance, consistency, and commitment". Researchers and developers in the research field of persuasive systems can apply the 14 newly developed design principles when implementing, presenting, evaluating, and communicating the generated design knowledge of persuasive systems.

Besides the essays with a clear focus on contributing to the knowledge base in the research field of persuasive systems, also the essays evaluating the newly designed BCSS (Essay 6 - 8) contribute to design knowledge. This design knowledge addresses concepts that influence users' acceptance and use continuance when interacting with BCSS. Especially when changing the application context of BCSS, it is crucial to first access the acceptance of the target users. Research shows that BCSS are currently not firmly integrated into

educational contexts, therefore this dissertation addresses this demand for design knowledge and investigates factors that influence the acceptance of BCSS in an educational setting. The instantiation of the TAM for the evaluation of the BCSS targeting self-regulated learning identifies significant and positive effects of perceived usefulness on users' intention to use the system, while perceived ease of use did not show a significant relation to the intention to use the BCSS. As these initial findings are consistent with other studies (e.g. Merz (2020)), they also emphasize the importance of perceived usefulness in generating theoretical knowledge about the effective design of BCSS. On a design principle level, the dissertation recommends the integration of reduction and self-monitoring when designing BCSS addressing learning behavior, as the assessed data suggests, that these design principles positively influence perceived usefulness, which in turn positively influences the intention to use the BCSS. In addition to the content of the evaluated BCSS, self-regulated learning strategies are perceived as valuable by students and thus positively influence their perceived usefulness.

While the dissertation identified that users show a high acceptance for BCSS in the educational context, the success of BCSS is often limited by users' engagement with the systems. Against this background, existing research analyzes BCSS users' use continuance mainly on a high level of abstraction, mostly by structural models with constructs summarizing categories of design principles. This dissertation provides insights on factors influencing BCSS users' use continuance on a more detailed level by analyzing qualitative statements of users (students). This results in ten meta-requirements. These meta-requirements highlight the importance of existing design principles, for example, "To foster students' use continuance a BCSS, needs to provide means for self-monitoring", or "To foster students' use continuance a BCSS, needs options for tailoring". However, the more exploratory qualitative approach also identified meta-requirements extending predefined design principles such as "To foster students' use continuance, a BCSS needs low-threshold nature" (e.g., in form of a smartphone app or as an integrative element of an existing system), or "To foster students' use continuance a BCSS, needs to provide clearly defined content" (e.g., the concept of self-regulation based on theoretical and practical findings).

Besides these meta-requirements, the dissertation investigates the effects on use continuance by comparing two versions of the BCSS, LANA, with either the additional implemented design principle *social comparison* or *rewards*. The evaluation based on the Perceived Persuasiveness Questionnaire shows that both BCSS versions promote a high per-

ceived use continuance after users' the initial contact. Differences in the quantitative accessed data on the use continuance only occur in the third decimal place. Accordingly, there are no significant differences caused by the design principles *social support* and *rewards*. Besides effects on use continuance, also users' assessment of primary task support of the BCSS does not show significant differences. However, the design principle *social comparison* promotes a significantly higher assessment of the BCSS' perceived effectiveness and social support. These results show that neither *social support* nor *rewards* discourage or encourage users to use the BCSS, but the design principle of *social comparison* appears to be superior in terms of perceived effectiveness and social support. However, when implementing *social comparison*, BCSS designers should also consider the impact on users beyond system-related aspects, as relevant research identified possible negative effects on user well-being.

In conclusion, the theoretical contribution of the dissertation comprises synthesized design knowledge in form of frameworks and prescriptive design knowledge in form of meta-requirements and cause-effect relationships regarding specific BCSS characteristics and users' assessment of the BCSS. The frameworks include a model that recommends specific design principles based on the user's stage of change and a set of design principles for persuasive systems. The prescriptive design knowledge provides insights into how to foster users' intention to use a BCSS as well as on users' use continuance.

5.3 Pragmatic Contributions

The pragmatic contributions of this dissertation address the development of the central artifact, the BCSS towards self-regulated learning. This BCSS, called LANA, is developed in three iterations. While research articles on BCSS often lack a clear presentation of the design process and reasoning for implemented design features, this dissertation presents the iterative development process of the BCSS according to the PSD model. The PSD model defines three generic steps for developing BCSS comprising **1) the context analysis** including the selection of fitting design principles, **2) the requirement definition for software qualities** and, **3) the software implementation**.

In order to perform **1) the context analysis**, the target users of LANA and their needs are examined. The target group of the BCSS LANA is defined as higher education students, who represent future executives (Chunoo and Osteen 2016). The target behavior of the BCSS is the learning behavior of the students. Learning is identified as a crucial competence needed to cope with the changing environment, characterized by digitalization and

crisis. Besides, in particular students during their first semesters at universities are experiencing a change in their learning environment due to the change of educational institutions from high school to higher education. Therefore, impulses or guidance to cope with the new educational environment appear as a valuable addition to their studies. Against this background, it is important to provide students with a set of learning strategies to foster valuable learning behaviors that are applicable in different contexts, including lectures and seminars on different topics but also in future work environments. In this context, the theoretical background of self-regulated learning provides this needed set of learning strategies that are beneficial in both, academic as well as professional environments. In addition to this theme-based contextual analysis, the dissertation also includes an analysis of the underlying intent, event, and strategy of the developed BCSS according to the PSD model. To complement this mostly literature-based context analysis, in iteration two and three users' feedback is also considered before revising the BCSS.

Based on the findings of the context analysis, we implemented the artifact in three iterations. The first BCSS iteration includes three literature reasoned design principles (tunneling, reduction, and self-monitoring). Based on the insights of the evaluation of this iteration, the second and revised artifact incorporated five additional design principles (personalization, tailoring, praise, expertise, and trustworthiness). Again, the evaluation of the second iteration provides further insights into users' requests for a BCSS targeting the learning behavior. Consequently, the design principles *social support* and *rewards* were implemented.

Based on the underlying context analysis and selection of design principles, we **2) formulate requirements for software qualities**. Since one of the main reasons for the failure of traditional interventions to support students' learning competencies is high perceived barriers, a low perceived barrier is crucial for the BCSS. Consequently, a support system in the form of an easily accessible web application seems promising as smartphones are firmly integrated into students' daily lives. The web application is optimized for access via smartphone, but the user interface design is also suitable for interacting with the application via computer.

Considering this requirement **3) the software implementation** follows. The implementation process involved three contributors, one research assistant and two student assistants. For a structured approach, we developed a project plan with short- and long-term goals under the guidance of the research assistant. In weekly meetings we discussed the current progress of the project and distributed tasks. The initial step in the software implementation was the selection of the development environment: To ensure ease of access

for the target group of students, we developed BCSS as a web application using Flutter. Flutter is a user interface software development kit that enables the use of a single code base for both iOS and Android applications. For building, testing, and deploying BCSS, we utilized Android Studio as our development environment and Dart as the corresponding programming language.

The developed web application LANA has been provided as a supportive supplement for multiple courses, including the seminars “Schlüsselqualifikationen 1” in two consecutive years as well as “Management-Support-Systeme (Forschungsseminar)”, and the lectures “Wirtschaftsinformatik 1 (Einführung in die Wirtschaftsinformatik für Ingenieure I)”, “Management Support Systems”, and “Datenschutz und Informationssicherheit”. Students got access to LANA via a shared link and a QR-code. When students open LANA, they are first guided to reflect on their current learning behavior based on the concept of self-regulated learning. Based on the students' responses during the reflection phase, LANA provides an analysis of their current learning behavior. The analysis shows information about the extent to which the different learning strategies are used and highlights self-regulated learning strategies with the greatest potential for improvement. Based on the analysis, LANA recommends starting points for improving students' learning behavior using learning strategies. When students select a learning strategy to work on, LANA provides a step-by-step guidance on how to use the corresponding strategy in the learning phases, starting with a brief theoretical background of the learning strategy and concrete application examples. While using LANA, students can track their progress through the number of steps they have completed. In addition to this progress, LANA displays the time spent in LANA and the progress of reflections on the student's learning behavior.

Across all three iterations, the evaluations have shown that students value the BCSS, which focuses on self-regulated learning, as a valuable addition to their university studies. This is evidenced by quantitative data showing high scores for intention to use, primary task support, unobtrusiveness, use continuance, and dialogue support. In addition, users perceived the BCSS as useful, persuasive, effective, credible, and with low effort to use. Consistent with the quantitative findings, qualitative statements also indicate that students appreciate the content of the BCSS, which includes information about diverse self-regulated learning strategies as well as concrete advice on how to apply the strategies.

Since the BCSS is developed as a Flutter-based web application, it is possible to integrate the entire web application or individual elements into other web-based systems, such as university learning management systems. In the summer term of 2022, elements of LANA

were integrated into the seminar “Projektstudium Wirtschaftsinformatik” for BISE bachelor students via the learning management system. The learning management system already provided students with files, the corresponding timetable, and communication functions for students. Via the index tab "Courseware", students could also access the content of LANA within the learning management system and receive an overview, theoretical background, and application examples of all self-regulated learning strategies.

In conclusion, the pragmatic contribution of the dissertation lies in the development of the central artifact, the BCSS, LANA, promoting self-regulated learning. The development follows the design process according to the PSD model. In terms of content, the BCSS provides a wide range of learning strategies including corresponding explanations and concrete advice on how to implement the strategies in students' everyday life. The BCSS is implemented as a web application that is easily accessible for students and can also be integrated into other web-based systems, including the learning management systems of universities.

5.4 Limitations

The findings and contributions of the dissertation are limited by the following constraints. Six of the eight essays included in this dissertation are based on systematic literature reviews. In these literature reviews, we cannot ensure that all relevant articles were identified. In addition, we mostly coded the identified knowledge manually. This does not eliminate the possibility of bias. To address these limitations, we used multiple databases from different disciplines in each literature review and presented our defined explicit and general search terms in each study. Furthermore, in all but one of the systematic literature reviews, two researchers worked on the codification of the knowledge to ensure a certain degree of interpersonal traceability.

Besides the literature review limitations, the artifact evaluation studies are also limited because we could only reach a limited number of participants. Therefore, in addition to quantitative measurements, we have also included qualitative feedback in the assessments to increase the contribution identified. In addition to pure numbers that clearly express the students' feedback, qualitative statements open up the possibility to explain the quantitative findings. These qualitative statements reveal clear patterns in the participant groups so it can be assumed that a slight increase in the number of participants would not have led to a major change in the results.

Due to the limited time frame of the dissertation project and the iterative nature of the design research project, no long-term studies of the students' user behavior while interacting with the prototypes were conducted. Therefore, the effects of the BCSS on the actual learning behavior of the students were not evaluated. However, the initial contact with the BCSS and the resulting intention to use the system are crucial for the overall perceptions and possible long-term use of the system. Therefore, we consider the studies concerning the first impressions of the target group of students to be a necessary fundamental step in the development of a newly designed BCSS. This is in particular the case when the BCSS is transferred to a new context such as the educational context for the first time.

In addition, the results of the evaluation may be subject to some positive bias. This is due to the fact that students often perceive new methods and variety in general as positive. In addition, students may have considered that by participating in the evaluation, they can make a supportive contribution to their lecturer's research. These two aspects may have influenced the students' positive attitude towards the new BCSS.

5.5 Outlook towards Further Research

The contributions of this dissertation provide starting points and indicate needs as well as the potential for further research.

First, the descriptive studies of the dissertation that address the current needs of the targeted environment and the rigorous results obtained through literature reviews could be enriched and validated by conducting additional expert interviews with practical outcomes. This would enable a more holistic perspective, e.g., on currently needed leadership competencies.

Second, we identified a research gap in persuasive systems research regarding the evaluation of individual design principles. To date, user impact has mostly been evaluated based on overall perceptions of the BCSS, without considering potential differences due to the integration or exclusion of individual design principles. Studies that address the impact of individual design principles would provide new insights into the design at a more detailed level. Based on our 14 formulated design principles, following the framework of Gregor et al. (2020), newly generated design knowledge could be systematically documented within the rationale of each design principle.

Third, based on related work, BCSS have been found to have a high potential to support higher education students, but empirical evidence is still lacking. Thus, the results of this

dissertation can provide directional recommendations for the development of BCSS that fundamentally promote sustainable use by the targeted student population and meet the identified design requirements. These findings should be extended through studies that examine the actual use of the systems in addition to students' intentions to use them. Thus, we emphasize the need for further longitudinal studies of BCSS use as a basis for measuring the impact of BCSS on self-regulated learning behaviors.

Fourth, based on the identified needs of students, this dissertation provides starting points for further research on support systems in higher education targeting student behavior. In all essays evaluating the developed BCSS, students requested that the support system should be easily accessible and have an integrative character or even an interface to the university's learning management system. Therefore, it might be beneficial to understand the demand for BCSS in a higher education context as an integrative element of the already regularly used and established learning management systems of universities. In this way, barriers caused by additional new systems will be eliminated.

Fifth, in the course of this dissertation we identified the design principles schema of Gregor et al. (2020) as a valuable framework to codify design knowledge. By explicitly formulating the aim, implementer, and user, as well as the context, mechanism, and rationale, the generation of design principles for information technology-based artifacts in sociotechnical systems provides a detailed and tangible level of design knowledge. Consequently, these design principles provide descriptive knowledge that can guide the implementation as well as the evaluation of artifacts. While the design principles developed within this dissertation are based on literature reviews on BCSS in different contexts and with different users, further research investigating the effects of design principles for information system-based behavioral interventions in different contexts or target users could reveal more detailed context- or user-specific design knowledge. Particularly in the context of higher education, there is a need for research on design principles that differentiate the target group of students, for example, in terms of different motivational types or learning styles. For example, when formulating design principles, design knowledge could be documented on whether certain characteristics, such as motivational preferences, can influence the impact of design principles, such as *rewards* or *social comparison*. Essay 3 already provides first indications that, for example, students who can be assigned to the Hexad user type *socializer* might prefer *cooperation*, while *players* prefer *rewards*. Design principles formulated according to Gregor et al. (2020) allow to include such differentiation by specifying users. This in turn would allow for a more detailed formulation of design principles.

6 Summary

In summary, this dissertation extends prior design knowledge about designing BCSS targeting students learning behavior. From a DSR perspective according to Hevner (2007), the development and evaluation of the central artifact contributes to the addressed environment as well as to the theoretical knowledge base.

The essays make a descriptive contribution by providing a competence overview for executives in a crisis-ridden and digitized environment, by identifying demands for effective trainings on needed personal and social competencies, and by characterizing learners based on motivational preferences. As a theoretical contribution, the dissertation provides a theoretically based framework guiding a targeted selection of design principles when developing BCSS according to users' current state of behavior change. Besides, the 14 formulated design principles for persuasive systems provide guidance for researchers when designing and evaluating BCSS as well as enable a clear communication of generated design knowledge. Additionally, several descriptive statements about BCSS design are formulated based on the qualitative and quantitative findings of the presented evaluations. Integrating these findings, as pragmatic contribution we present a newly developed BCSS addressing an essential competence for students in their current academic education and their future work environments by targeting self-regulated learning. This BCSS presents the central research artifact. Since the BCSS is based on Flutter, the pragmatic contribution also comprises transferable modules addressing self-regulated learning. These modules are accessible via the web application LANA but can also be integrated into universities learning management systems.

With its descriptive, pragmatic, and theoretical contributions, this dissertation enriches both, the field of persuasive systems and the field of higher education as a training institution for future executives.

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