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Development of a Behavior Change Support System that Targets Learning Behavior: Examining the Effect of Rewards and Social Comparison

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Completed Research Paper

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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 are found in students' perceived effectiveness and perceived social support of the BCSS versions. Social comparison is identified as more effective than rewards for high use continuance.

Keywords: Persuasive Systems, Behavior Change Support System, Learning Analysis, Higher Education

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 as well as 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 which 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 benefit more in digital learning settings than students with low self-regulated learning competencies (Anthonysamy et al. 2020; Sutarni et al. 2021). 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 (Boekaerts et al. 2000; Zimmerman and Schunk 2011). 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 (IS) in general, including the success of BCSS, is a design that is convincing from the first use and thus promotes a high intention to use (Bhattacherjee 2001; Hsieh and Wang 2007; Lehto and Oinas-Kukkonen 2015b).

In this context, researchers highlight the importance of individual design features for the success and effectiveness of persuasive systems (Fogg 2002; Lehto and Oinas-Kukkonen 2015a; Merz and Steinherr 2022). 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). Consequently, these 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 continuity. The BCSS is the central artifact of a Design Science Research (DSR) project (Hevner and Chatterjee 2010). According to this method, the BCSS is developed evidence-based and iteratively adapted in response to evaluations with user feedback. Since a previous evaluation revealed students' desire for rewards or social support within the system, the newly developed BCSS versions include either the design principle of *reward*s, which aims at external motivation, or, in contrast, the design principle *social comparison*, which aims at social motivation (Richter et al. 2015). Thus, the underlying research question of this study 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?*

As mentioned before, this study is embedded in a larger DSR project according to 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. Following the socio-technologist research paradigm that is corresponding to DSR, the focus of this paper is on presenting the development the BCSS, the description of the BCSS itself and its impact on users with the goal of improving the BCSS (Weber 2010). Consequently, this paper contributes in a pragmatic form by concluding implications and guidance for developing BCSS

to foster students' use continuance. It 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*. Furthermore, this paper provides a theoretical contribution in form of design knowledge related to the modes of action of two design principles.

Theoretical Background

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).

Design Principles for Behavior Change Support Systems

When developing BCSS, the most commonly used design framework is the Persuasive Systems Design (PSD) model (Merz and Ackermann 2021) which guides the systematic development of BCSS (Oinas-Kukkonen and Harjumaa 2009). For the development of 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 the section "Behavior change support system towards an improved learning behavior".

In addition to 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 category dialogue 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.

The focus of this paper is to elevate the design principles *rewards* and *social comparison*. 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 (Abdul Rahman et al. 2018; Richter et al. 2015; 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 1 depicts these different motivational categories and refers to the corresponding BCSS versions.

Intrinsic	**Social**	**Extrinsic**
Needs based	Social based	Rewards based
Basic BCSS functions	BCSS including *social comparison*	BCSS including *rewards*

Table 1. Model of Motivation according to Richter et al. (2015)

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.

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. Applying 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 improved 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 (Pintrich and Groot 1990; Zimmerman and Schunk 2011). These learning strategies can be divided into four superordinate learning strategies and 13 underlying learning strategies (Klingsieck 2018; Wild and Schiefele 1994). Table 2 provides an overview of these strategies.

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
Meta-cognitive 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

Table 2. Self-regulated Learning Strategies according to Wild and Schiefele (1994) and Klingsieck (2018)

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

Related Work

A recent literature review summarizes 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. 2019b), 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 have an impact on users if they succeed in engaging their users by promoting a high use continuity starting from the first use (Bhattacherjee 2001; Hsieh and Wang 2007; Lehto and Oinas-Kukkonen 2015b).

A literature review on BCSS in the context of educational applications highlights the potential of the systems in higher education (Steinherr 2021). It also shows that students generally 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, there is minimal implementation of persuasive design principles. 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 are crucial (Steinherr 2021). The results of the study 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 of 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. In 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 a positive significant influence. In addition, Steinherr (2023) also identifies that primary task support positively correlates with use continuance. Furthermore, in this study, also unobtrusiveness, perceived persuasiveness, and perceived effectiveness are identified with a positive and significant relationship.

In conclusion, the findings of the 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 also 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 due to the fact that the measured constructs correlate positively in structural models when they are interrelated. For example, although, 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 on continuance intention (Lehto and Oinas-Kukkonen 2015b). Consequently, when designing BCSS it is not only essential to target a high value of constructs that directly affect use continuance, but also 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.

Besides research on BCSS' use continuance, there is also related research in the gamification literature. Berger et al. (2023) investigated the effects on BCSS users by evaluating different gamification features. The researchers found that gamification features providing feedback are the most preferred ones, followed by rewards and social support. However, the researchers state that these findings are in the context of stress management and are based on mock-ups rather than users' actual experiences. Consequently, they suggest further research on the impact of individual design features in BCSS in different contexts (Berger et al. 2023).

Behavior Change Support System for an Improved Learning Behavior

Iterative Development Process Following Design Science Research

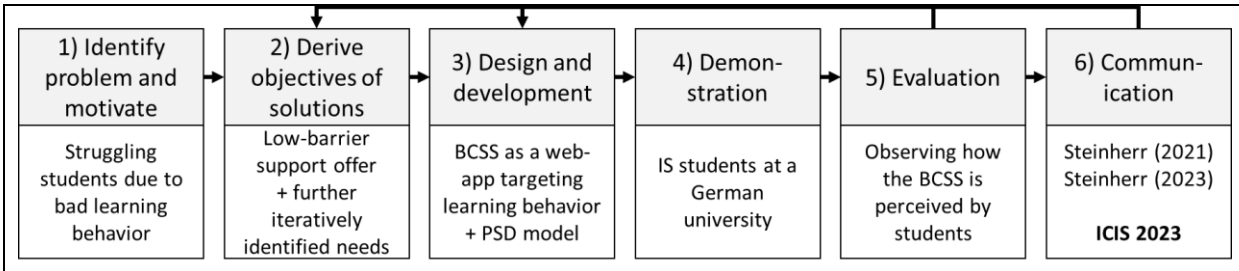

Figure 1. Development Process of the BCSS targeting Self-regulated Learning following Design Science Research according to Peffers et al. (2008)

The BCSS, which focuses on students' learning behavior, is developed following DSR (Peffers et al. 2008) (see Figure 1). Therefore, the project has an iterative character. The project team consists of three BCSS designers, a researcher with a research background in persuasive systems (Steinherr 2023) and pedagogical education (Steinherr and Vay 2022), 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 determine 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 that influence 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 indicated a desire for additional features, with *rewards* or *social comparison* the most frequently mentioned suggestions for improvement.

This paper presents the third iteration of the DSR project. Within the third iteration, we consistently address the problem of students struggling 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 and features of a support intervention. Additionally, we identified students' desire for the integration of a *reward*s or *social comparison*. To identify the effects of the two additional design principles, we created two different prototype versions, one BCSS with the integrated design principle of *rewards*, and one prototype version with the integrated design principle of *social support*.

Design Process

Context Analysis

The initial step when designing BCSS is the analysis of the persuasion context. The PSD model (Oinas-Kukkonen and Harjumaa 2009) divides this analysis into three aspects: the intent, event and strategy.

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. In this study, the designers and developers overlap with the distributors, who are lecturers at a German university, who develop the BCSS to support students in improving their learning behavior (users).

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). In addition, Oinas-Kukkonen (2013) also differentiates between the outcome types 1) formation (F-outcome), 2) alteration (A-Outcome), or reinforcement (R-outcome). Table 3 presents the instantiation of the Outcome/Chance Design Matrix. As the BCSS aims towards the B-change and A-change, the C-change is not in the focus of this paper.

	B-Change	**A-Change**
F-Outcome	Forming a behavior (F/B) The BCSS shows users how to form their learning behavior step-by-step with tangible advice	Forming an attitude (F/A) The BCSS provides background information on multiple learning strategies including potentially new strategies
A-Outcome	Altering a behavior (A/B) The BCSS monitors students' learning behavior and suggests opportunity improvements	Altering an attitude (A/A) The BCSS provides background information on multiple learning strategies reasoning the application
R-Outcome	Reinforcing a behavior (R/B) The BCSS monitors students' progress in improving their learning behavior and shows developments	Reinforcing an attitude (R/A) The BCSS provides background information on multiple learning strategies reasoning the application

Table 3. Outcome/Change Design Matrix according to Oinas-Kukkonen (2013)

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 IS students. This target group is typically characterized by 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 of passing all exams, however, students differ in terms of learning behavior and self-regulated learning strategies. Furthermore, students often perceive high barriers to support services.

Technology context: Smartphones are well-established in the target group. Most students use social media apps and have experience with fitness trackers. In addition, 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 toward behavior change, but also conviction through theoretical background that explains and justifies the application of different learning strategies.

Route: BCSS can persuade users in direct or indirect ways. 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 about self-regulated learning.

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 & Harjumaa, 2009). 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, helps 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 to the context and the needs of the targeted user group (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 & 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 into the Wiki of the BCSS which explains the theoretical background of self-regulated learning.

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: The design principle *social comparison* compares the performance of users with others and can therefore increase 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. The design principle *rewards* gives credit for performing the target behavior and can therefore provide great persuasive powers (Merz and Steinherr 2022; Oinas-Kukkonen and Harjumaa 2009). The developed BCSS addresses *rewards* by providing digital collectible coins for completing tasks within the BCSS.

Implemented Behavior Change Support System

The targeted behavior change is an improvement in students' learning behavior based on the theory of self-regulated learning. Figure 2 depicts the screens of the BCSS. 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. The BCSS starts with reflective questions that are in accordance with the concept of self-regulated learning. After completing the **reflection**, students proceed to the **analysis** 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.

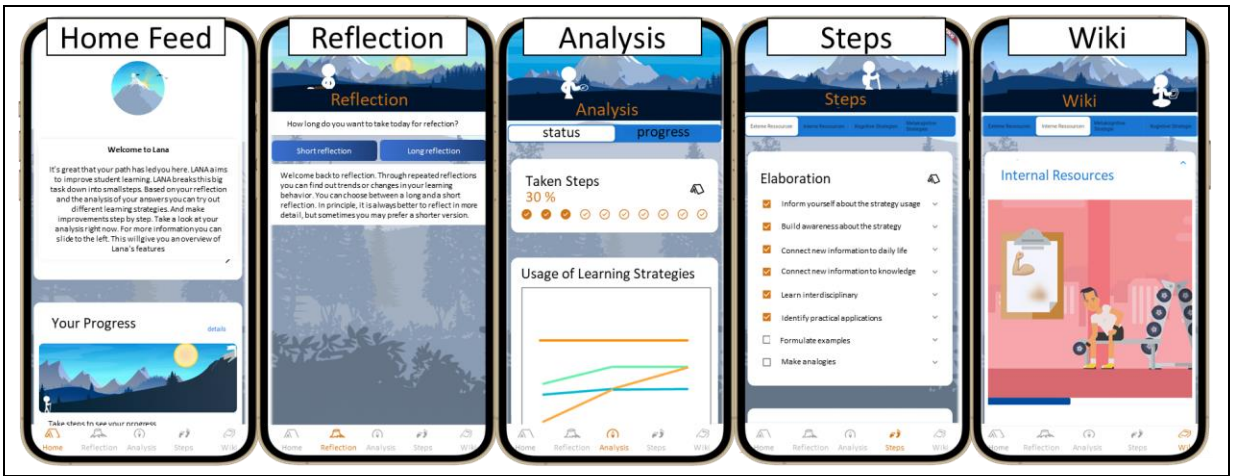

Figure 2. Core Functionalities of the Implemented Behavior Change Support System

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**, where each version of the BCSS depicts one additional tile (see Figure 3).

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. 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. The additional files (rewards vs. social comparison) are depicted in Figure 3.

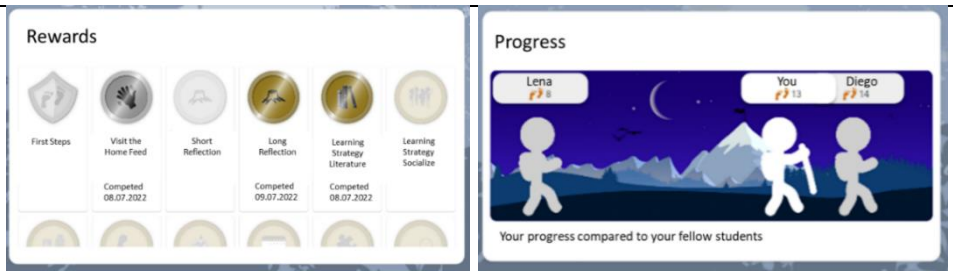

Figure 3. Implementation of the Design Principle Rewards vs Social Comparison

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 would receive a 5 euros voucher. Those interested could sign up for one of two digital sessions. The sessions were both scheduled to last one hour. 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 were given 30 minutes to test and interact with the BCSS. After interacting with the BCSS students were asked to complete a survey about their experience with the BCSS. Table 4 summarizes the demographic data of both groups of students.

		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

Table 4. Demographic Statistics of Participants

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 contains 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, because 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 5 presents the reliability of the measured PPQ constructs.

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

Table 5. Cronbach's Alphas of the PPQ

Most of the constructs of the PPQ were not able to meet the acceptance criteria for internal consistency (Cronbach's alpha ≥ 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.

Results

The presentation of results is divided according to the two BCSS versions (*rewards* vs. *social comparison*). Table 6 reports the descriptive statistics.

	Rewards (N=22)				Social Comparison (N=21)			
Rewards (N=22)	Min	Max	Mean	SD	Min	Max	Mean	SD
Use continuance	2.50	4.75	3.6023	.57559	2.50	5.00	3.6071	.54527
Perceived effectiveness	3.00	4.67	3.5909	.50324	2.67	4.67	3.9365	.46689
Primary task support	2.25	4.75	3.5909	.65258	2.50	4.75	3.7381	.45741
Social support	1.50	5.00	3.2273	.79772	1.50	4.50	3.5952	.68226

Table 6. Descriptive Statistics

The results of the PPQ in 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 highest, followed by equal ratings for perceived effectiveness and primary task support. Social support has the lowest value. 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 the dataset, the independent variable is nominally scaled (*rewards* vs. *social comparison*) and the dependent variables are at least ordinal scaled. Besides, the two independent groups to be analyzed do not have a normal distribution. Therefore, we performed the Mann-Whitney-U test to identify significant differences regarding the constructs' mean values. Table 7 depicts the ranks according to the Mann-Whitney-U test and Table 8 shows the statistics of the Mann-Whitney-U test. For the assignment of the abbreviations in Table 8 please see Table 5.

	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 7. Rank Table

	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**

Table 8. Statistics of Mann-Whitney-U Test

The Mann-Whitney-U test identified two significant group differences. The first difference concerns 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 9 presents the multiple linear regression analysis.

	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

Table 9. Multiple Linear Regression Analysis towards Use Continuance

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 4.

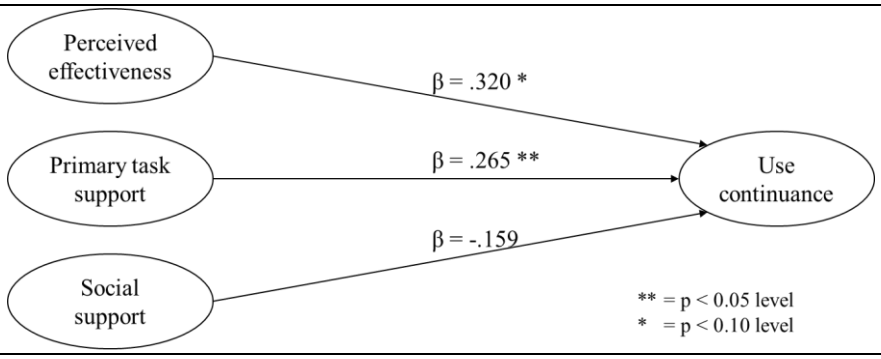

Figure 4. Linear Regression Model

Discussion

The design principle *social comparison* has a positive effect on the evaluation of the BCSS compared to *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 the 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 students using the BCSS with *social comparison* rated the construct social support higher than students interacting with the BCSS including *rewards*. According to the PSD model the design

principle *social comparison* belongs 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. In addition to this study, Lehto and Oinas-Kukkonen (2015b) also identified a significant positive relation 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, unlike previous studies, the linear regression analysis conducted in this study was not able to identify significant relationships between social support and use continuity.

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. 2019a). However, Orji et al. (2019a) 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.

Moreover, besides the implementation within this study, *rewards* can appear in different forms. While we have chosen *rewards* in the form of visual badge (as typical in BCSS), there are various other forms. E.g., also the voucher for participating in this study might function as a form of a reward for using the BCSS. The the effect of *rewards* could also depend on its form and its attractiveness to the particular user.

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 IS 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* addressing social motivation 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, who 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 who 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* seems 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*.

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 IS 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, previously neglected, analysis 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. Since 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 are based 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 could be explained 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 possible to predict first impressions and initial assessments of the system. In order to make 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 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 (Merz and Ackermann 2021; Wang et al. 2018). 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, the effectiveness of individual BCSS features might also be person depended and individual preferences might influence the effects of design features on use continuance. Further research could for example consider the hexad user types (Tondello et al. 2016), that characterize six different IS users based on their motivational preferences. Fifth, 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.

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